

Determination of Multi Elemental profiles of road side soil for the purpose of Soil Mapping

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Abstract: Soil as a physical evidence is, more often than not, obtained as trace evidence. The present experiment aims at creating a soil mapping within the state of Gujarat. It was conducted to relate and map different types of soil and its elemental composition. For the analysis purpose, the morphological and physical properties of soil were probed by collecting 150 soil samples from 50 equidistant locations in 5 districts within the state. The physical properties i.e. the basis of textural properties, grain constituents, pH values were determined using microscopes and sieve test analysis as per ASTM standards and elemental composition i.e. marking of concentration of major, minor and trace elements in soil samples were determined using Energy Dispersive X-ray Fluorescence Spectroscopy. The result demonstrates the presence of metal oxide content in the soil samples and composites the similarities and differences of the experimented soil samples. From the observations, it was found that SiO_2 , Fe_2O_3 , Al_2O_3 and CaO were the major oxides while TiO_2 , K_2O and SO_3 were the minor oxides identified. Concluding the present work,

1.Introduction

Soil, which is natured by sedimentation of rocks shows difference in organic, inorganic and elemental compositions. The presence of foreign material may impart the soil with characteristics that will make it unique to a particular location. When this material is collected accidentally or deliberately in a manner that will associate it with crime under investigation, it becomes a source of useful physical evidence.¹ Thus, the type of soil found could help locate the

region of its origin or source, which can be done, provided a profile is available for comparison. The low amount of soil makes it difficult to conduct routine bulk analysis. In such situations, EDXRF is the best non-destructive technique that can be employed for elemental analysis, which provides fast, easy and accurate results which can be easily interpreted.² Furthermore, ED-XRF results for soil can be likened to fingerprint comparisons. In other words, each type of soil has a unique elemental composition which makes it an ideal criterion for comparison and identification purposes.

In recent years, soil science technology has advanced dramatically and has become very specialized and, for this reason, scientists and police investigation units are not using soil information as much as they did. Currently, soil analyses are generally performed in investigations of serious crime and usually where human DNA analyses or analyses of other more commonly used types of trace evidence were not possible. Consequently, there is an opportunity for the application of soil analysis in the forensic examination of soil from a wider spectrum of routine forensic investigations.³ Soil evidence can be analyzed by methods like microscopy, fluorometry, density gradient analysis, particle size analysis, mineralogical analysis, UV spectrophotometry, FTIR technique, Neutron activation analysis, SEM-EDS analysis, X-ray techniques, Plasma emission spectrometry, ICP technique, HPLC and many chemical tests.⁴

2. Material and Methodology

2.1 Description of study area

For the study, road side surface soil were collected from different regions of Gujarat. The 5 districts from where the samples were taken are namely: Banaskatha, Surat, Junagadh, Gandhinagar and Navsari.⁵ The samples collected were marked as GJ8, GJ5, GJ 11, GJ 18 and GJ 21 for the district they are collected and later on mapped as A1 A2 B1 B2 to classify them according to the regions. The figure below shows the map from where the samples were collected.

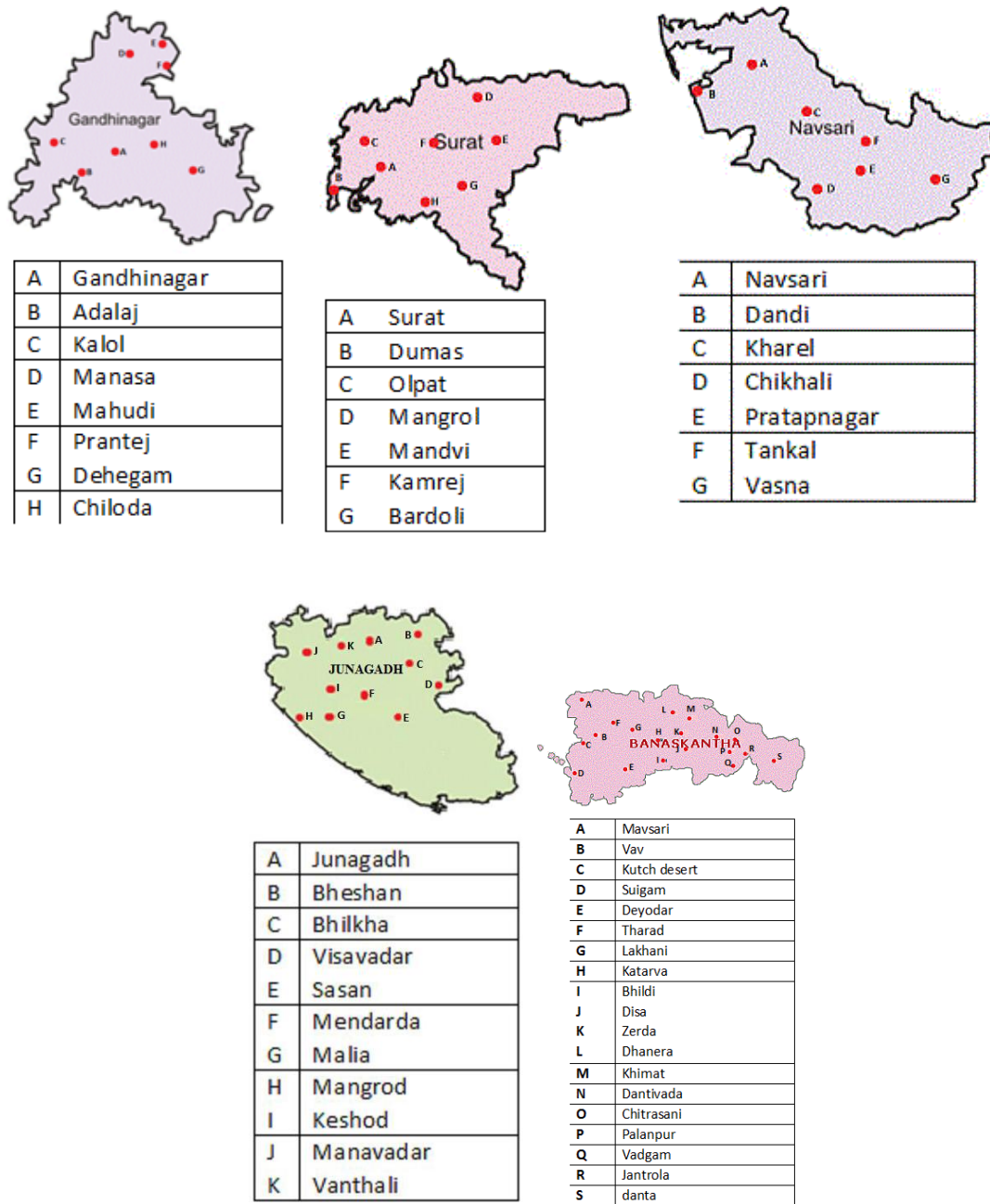


Figure 1: Maps of districts from where soil was collected

2.2 Soil sampling

Soil samples were taken from surface as well as at a depth of $\frac{1}{2}$ and 1 feet from roadside areas only. At the location, a photograph of the soil surface was taken along with a scale and appropriately labeled as mentioned earlier. Approximately, 250g of soil was collected in a zip lock bag from each selected sites.⁶ The second sample was collected from pit of approximately 1/2 sq.ft. was dug up to a depth of $\frac{1}{2}$ feet approximately of the same amount as surface soil

samples. Further, the pit was dug up to 1 foot and same amount of soil was collected at this depth as well. Precautions were taken to avoid contamination. Samples were stored in a cool and dry place.

2.3 Laboratory analysis

2.3.1 Physical Examination

The physical examination of the samples was carried using high powered stereo and comparison microscopes. The samples were note of the physical properties like colour, type and the presence of foreign particles.⁷

2.3.2 Sieve test

Motor-driven sieve shaker machine was used for the sieve analysis. The set of sieves was arranged in numerical order with the smallest number (largest mesh size = 1mm) at the top and the largest number (smallest mesh size = 0.150mm) at the bottom. Mesh size: 1.00mm – 0.60mm – 0.30mm – 0.15mm.⁸ Each samples were also to pass through the arrangement. After sieving, each fraction was weighed separately on a weighing balance. The fraction obtained from the bottommost sieve (0.150mm) was used for further analysis.



(a)



(b)

Figure 2: Sieve analysis – before (a) and after (b)

2.3.3 Instrumental Analysis

The test sample were analyzed using Energy Dispersive X-Ray Fluorescence Spectrometer (EDX-7000) as a non destructive technique.⁹ The fraction of soil obtained from the bottommost sieve (0.150mm) after sieving was taken in a Petri dish and heated in an oven at 105°C for 1 hour to remove all the moisture content. It was then cooled to room temperature and then analyzed in EDXRF by placing the sample over Mylar sheet in the sample holder. The results of the qualitative analysis of placed sample can be determined.

3. Results and Discussion

3.1. Sieve analysis observation

The results of the sieve analysis test performed on all the collected samples illustrates the type of soil as per ASTM standards.¹⁰ Table 1 shows the percentage of soil retained on sieves of the samples collected from Gandhinagar District labeled as GJ18.

Table 1: Soil retained on Sieves in GJ18 Samples

SAMPLE	^1.00mm	^0.600	^0.300	^0.150	v 0.150	TOTAL	ERROR
GJ 18 A1	28.27	5.002	16.465	20.173	30.09	100	0
GJ 18 A2	6.553	2.018	16.7229	29.819	44.888	100.0009	-0.0009
GJ 18 A3	0.254	0.54	18.45	37.667	40.73	97.641	2.359
GJ 18 B1	71.258	2.646	7.115	1.409	4.44	86.868	13.132
GJ 18 B2	28.136	28.001	42.385	0.418	1.083	100.023	-0.023
GJ 18 B3	62.547	11.791	14.135	0.639	0.2	89.312	10.688
GJ 18 C1	27.003	9.567	18.614	11.352	33.464	100	0
GJ 18 C2	7.175	2.071	28.109	25.145	36.015	98.515	1.485
GJ 18 C3	30.149	11.638	18.875	14.022	22.555	97.239	2.761
GJ 18 D1	6.219	4.611	18.1	27.097	43.702	99.729	0.271
GJ 18 D2	57.225	12.202	18.133	5.731	4.733	98.024	1.976
GJ 18 D3	46.972	22.826	24.042	3.295	1.263	98.398	1.602
GJ 18 E1	6.731	3.279	11.746	14.255	64.06	100.071	-0.071
GJ 18 E2	6.701	4.274	14.501	13.581	59.537	98.594	1.406
GJ 18 E3	20.768	9.062	11.564	13.909	42.633	97.936	2.064
GJ 18 F1	1.926	2.035	16.49	30.894	48.218	99.563	0.437
GJ 18 F2	2.601	1.934	23.044	32.363	39.407	99.349	0.651
GJ 18 F3	10.936	5.952	25.492	28.327	27.037	97.744	2.256
GJ 18 F4	5.289	4.215	26.295	33.533	29.942	99.274	0.726
GJ 18 G1	31.602	9.149	13.444	9.845	36.375	100.415	-0.415
GJ 18 G2	30.687	11.373	12.744	7.412	37.555	99.771	0.229
GJ 18 G3	62.882	9.665	8.238	4.434	12.842	98.061	1.939
GJ 18 H1	6.786	2.494	27.89	20.378	41.119	98.667	1.333
GJ 18 H2	30.169	14.731	33.227	9.185	10.556	97.868	2.132
GJ 18 H3	62.017	19.554	14.28	1.036	0.072	96.959	3.041
GJ 18 H4	63.922	18.607	13.818	1.06	0.278	97.685	2.315
GJ 18 H5	35.069	11.266	41.439	7.391	4.256	99.421	0.579
GJ 18 I1	4.003	2.363	10.043	15.645	67.798	99.852	0.148
GJ 18 I2	7.234	1.738	5.877	15.434	69.422	99.705	0.295
GJ 18 I3	5.047	1.097	4.876	16.009	72.109	99.138	0.862
GJ 18 J1	3.978	2.641	8.808	20.946	65.532	101.905	-1.905
GJ 18 J2	0.968	1.036	7.161	27.252	63.268	99.685	0.315
GJ 18 J3	0.076	0.122	5.523	32.87	60.327	98.918	1.082
GJ 18 K1	50.002	33.884	11.343	0.403	0.205	95.837	4.163
GJ 18 K2	73.96	20.064	2.582	0.088	0.052	96.746	3.254
GJ 18 L1	9.831	6.113	14.394	15.527	54.222	100.087	-0.087
GJ 18 L2	80.425	1.766	3.518	3.713	10.343	99.765	0.235
GJ 18 L3	74.859	7.849	5.859	3.816	6.403	98.786	1.214
GJ 18 L4	24.716	7.77	29.463	20.443	15.544	97.936	2.064
GJ 18 M1	22.702	9.893	23.325	15.164	28.591	99.675	0.325
GJ 18 M2	23.372	7.633	20.3	14.956	32.605	98.866	1.134

Where,

GJ 18	GANDHINAGAR DISTRICT	LAT.	LOG.
A	GANDHINAGAR CITY NH-8C	23.211365	72.667281
B	GANDHINAGAR CITY SABARMATI RIVER (SARITA)	23.200113	72.66374
C	GANDHINAGAR CITY (INFOCITY)	23.195395	72.631324
D	GANDHINAGAR CITY (POWER PLAN)	23.243511	72.673331
E	GIDC GANDHINAGAR (KOLAVADA- GANDHINAGAR ROAD)	23.254769	72.631942
F	GANDHINAGAR CITY (PATHIKA SECTOR 11 GROUND)	23.216296	72.645385
G	ADALAJ CHOKADI NH-8C	23.172521	72.579546
H	KALOL	23.247566	72.501936
I	MANSA GIDC	23.440594	72.6559493
J	MAHUDI	23.492944	72.776807
K	SABARMATI RIVER (NEAR PRANTIJ VILLEGE)	23.444832	72.809925
L	GETCO (CHILODA-DAHEGAM ROAD)	23.184562	72.794515
M	CHILODA CIRCLE NH-8C	23.230171	72.724307
1	SURFACE		
2	1\2 ft.		
3	1 ft		
4	2ftS.		
5	APRROX. 12-15 fts.		

From the above table 1, it can be seen that the percentage of the soil retained on the sieves was not found to be consistent at different depths even for the same site. This is probably due to the high amounts of inter and intra-variation in soil. No conclusive result can be deduced from this data. Table 2 illustrates the types of soil classified for each selected region after sieve analysis of the soil samples from the different districts.

Table 2: The types of soil obtained after sieve analysis of the soil samples

DISTRICT	TYPE OF SOIL
SURAT	Deep Black Clayey soil
BANAS KANTHA	Sandy loam to sandy soils
JUNAGADH	Shallow medium black calcareous soils
GANDHINAGAR	Sandy loam to sandy soils
NAVSARI	Deep Black Clayey soil

From the above table 2, it can be seen observed that the type of soil can be retained from physical and sieve test analysis. The samples collected showed varied difference in the type of soil and districts can be mapped determining the type of soil under observation.

3.2. EDXRF analysis observation

After analyzing the samples in the EDXRF, from the values obtained the concentration was laid on the oxides components. From the observations, it was seen that all the samples contained the components **SiO₂, Al₂O₃, CaO, and Fe₂O₃** as the major constituents. Table 3 illustrates the results of oxides present in soil sample of GJ5.

Table 3: Final Results Of Oxides Present In Soil Sample GJ 5

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	TiO ₂	K ₂ O	SO ₃	MnO
AVERAGE	58.47995	18.24221	12.84489	5.067632	2.848111	1.036053	0.848316	0.201421
MAX.	66.217	27.765	18.168	12.685	6.7141	1.747	2.234	0.3
MIN.	48.699	11.21	9.349	0.881	1.769	0.543	0.558	0.117
MEDIAN	59.471	17.592	12.362	4.628	2.446	1.041	0.731	0.186
STD.	4.804199	3.755511	2.298939	3.175236	1.207634	0.322385	0.362408	0.059486

From the above table, the components **SiO₂, Al₂O₃, CaO, and Fe₂O₃** are found to be major constituent of soil samples. Other than this, components **TiO₂, SO₃, K₂O and MnO₂** are found in trace amount within the range of **0.20 to 2.85** with the median values as **2.446, 1.041, 0.731 and 0.186** respectively. It was also observed, that **SiO₂** has values in the range of **66.217 to 48.699** and the standard deviation **4.804199** because the sample was collected from different areas of district. The charts below shows the average values of oxides:

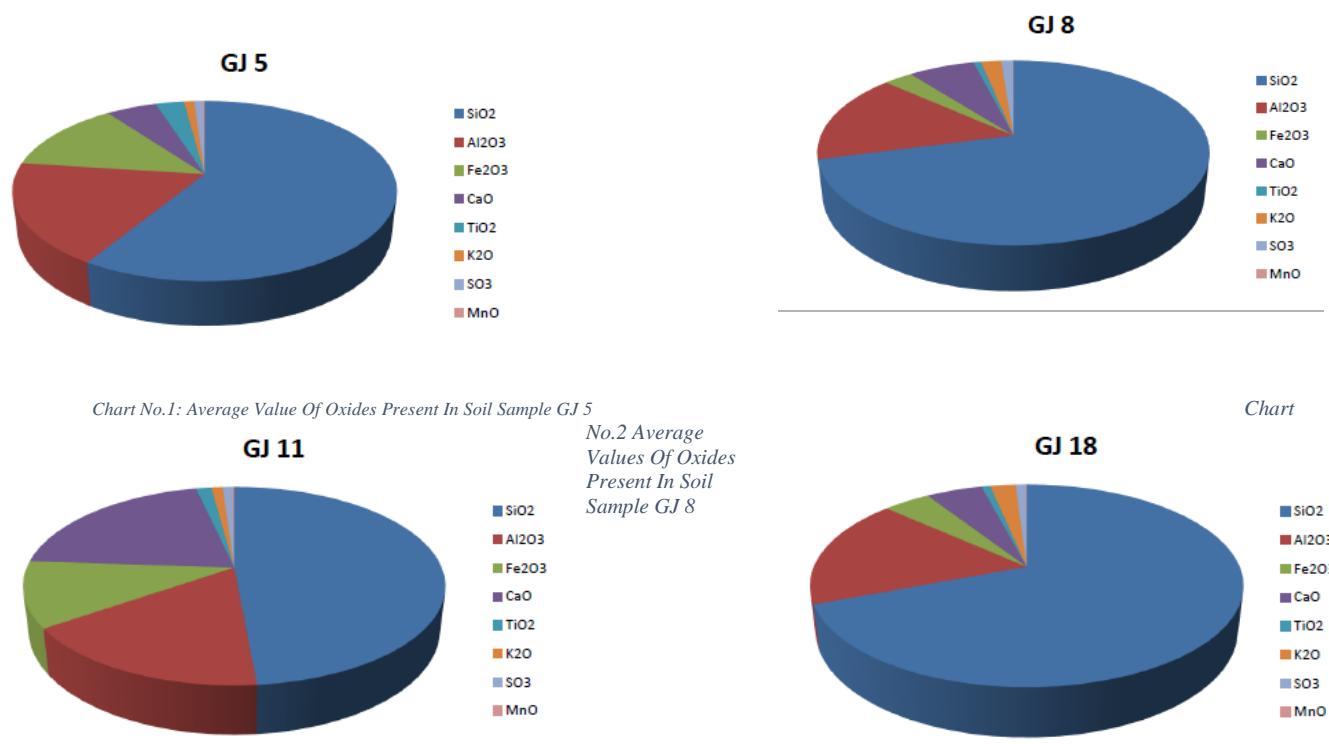


Chart No.1: Average Value Of Oxides Present In Soil Sample GJ 5

No.2 Average Values Of Oxides Present In Soil Sample GJ 8

Chart

Chart No.3: Average Values Of Oxides Present In Soil Sample GJ 11

Chart No.4: Average Values Of Oxides Present In Soil Sample GJ 18

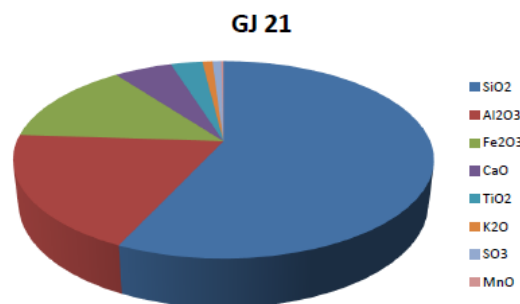


Chart No. 5: Average Values Of Oxides Present In Soil Sample GJ 21

From the chart no. 1, 2, 3, 4 and 5, it is observed the components **SiO₂**, **Al₂O₃**, **CaO**, and **Fe₂O₃** are found to be major constituents of the samples. Other than this, components **TiO₂**, **SO₃**, **K₂O** and **MnO₂** are found in trace amount within the range of **0.20 to 2.85**, **0.06 to 1.99**, **0.19 to 1.4**, **0.23 to 2.89** for each district respectively. . It was also observed, that the presence **SiO₂** has values in the range of **66.21 to 48.69** for **GJ5**, **79.32 to 54.33** for **GJ 8** , **48.79 to 50.22** for **GJ11**, **21.79 to 71.22** for **GJ 18**, **53.68 to 61.73** for **GJ 21**..

The table below shows the comparative average values of oxides for each district.

Table no. 3: Average Values of OXIDES PRESENT IN SOIL SAMPLES PER REGION

DISTRICT	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	TiO ₂	K ₂ O	SO ₃	MnO
GJ 5	58.47995	18.24221	12.84489	5.067632	2.848111	1.036053	0.848316	0.201421
GJ 8	70.97628	15.76521	2.847487	6.535128	0.745487	1.987	0.89841	0.060179
GJ 11	48.40653	16.70829	10.69697	20.36362	1.4025	1.038294	0.868412	0.188588
GJ 18	69.24524	17.57548	4.238286	5.02431	0.785905	2.270762	0.919158	0.083024
GJ 21	56.77329	19.12343	13.69164	5.3285	2.894429	0.934429	0.791071	0.225143

From the above table, is can be observed that the average values of oxides in the different samples differ because they are from different regions. The values of district GJ5 and GJ21 show similarities which are probably due to their geographical proximity.¹¹ GJ11 shows maximum CaO content owing to the presence of limestone in the district. Other oxides like ZrO, ZnO, SrO, CuO, Rb₂O, Y₂O₃, Cr₂O₃ were also found in all the sample but in trace amounts (less than 0.05).

4. Conclusion

It is concluded from the present study that the nomenclature and type of soil differs within the range of 20km due to intra- and inter-variation. In the present study, 150 samples were collected from 50 locations of 5 different districts. On conducting sieve analysis, the results showed some distinctions but conclusive results could not be drafted. To differentiate soil on measures of sample size, a more rigorous sieve analysis must be implemented and the current procedure must

be improved. For precise qualitative and quantitative analysis, which is also non-destructive in nature, we chose ED-XRF which gave reliable results for the study. The major oxides obtained were SiO₂, Fe₂O₃, Al₂O₃ and CaO while the minor oxides obtained were TiO₂, K₂O, MnO₂ and SO₃. Other oxides like ZrO, ZnO, SrO, CuO, Rb₂O, Y₂O₃, Cr₂O₃ were found in trace amounts.

Further characterization of soil can be done with respect to the inorganic content and microbial profile. The same soil samples can be monitored to check for significant changes, if any, in their elemental oxide composition and the trend can be studied. The other districts of Gujarat can be similarly profiled and this can be further extended to the national level. A holistic profile can thus be created which will play an important role in future forensic investigation.

5. References

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