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# X-ray Diffraction and Mineralogical Study of Coastal Soils and Sediments

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Clay minerals containing soil samples were collected from Mumbai and Surat. The samples were precipitated and concentrated by centrifuge method for the extraction of clay. X-ray diffraction (XRD) and scan electron microscopy (SEM) analyses were carried out for these samples. The investigation indicates that the clay samples contain quartz, kaolinite, illite and little amount of smectite minerals. Beside the above analyses the physico-chemical parameters of the soil samples have also been evaluated.

**Key Words: Clay minerals, X-ray diffraction, Scan electron microscopy, Indian coastal areas.**

## INTRODUCTION

Due to increasing urbanization and industrialization the soils of nearby coastal areas are getting polluted[1–3]. These pollutions contain a variety of organic and metallic moieties[4, 5]. Such moieties alter the texture and quality of the soil[6]. Finally, these hazardous moieties pollute the underground and sea water[7].

A considerable amount of work has been reported[8–10] in Western laboratories on XRD and clay mineralogy of soil[11, 12] near the coastal areas as well as the plains. In Mumbai and Surat coastal areas, the surrounding soils are also being contaminated due to indiscriminate disposal of sewage and industrial effluents.

## EXPERIMENTAL

Top profile soil samples were collected nearer to Mumbai and Surat coastal areas. Samples were dried, ground, sieved through > 2 m sieve and stored in glass bottles for further study.

### Extraction and concentration of clay

50.0 g fine powdered soil sample was taken in a 1 L measuring cylinder and mixed with 1 L of distilled water through mechanical shaking for 30 min. Kept this measuring cylinder overnight and next day the supernatant liquid was separated with the help of a pipette into a plastic bottle. This liquid sample was concentrated by centrifugation at 2500 rpm for *ca.* 10 min. The centrifuged (*i.e.*, concentrated) samples were stored in glass bottles.

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### Preparation of sample for XRD

The separated clay samples slide for XRD study was prepared by following the millipore filter method-11 by using vacuum filter apparatus. The separated clay fraction on the slide was analyzed using X-ray diffractometer and CuKα radiation. Evaluation of clay mineralogy of the sample was carried out.

### Scanning Electron Microscopy

SEM analysis was carried out on Phillips XL-30 electron microscope equipped with energy dispersive mirco-analysis system.

The physico-chemical characteristics of soil and sediment samples were determined by using standard methods[12].

## RESULTS AND DISCUSSION

The results obtained during the course of the present study are given in Tables 1 and 2 and XRD diffractogram and SEM photographs are being presented in Figs. 1 to 3.

TABLE-1
GENERAL CHARACTERISTICS AND MINERALS OBSERVED BY XRD ANALYSIS

| Sample No. | Site of sample collection | General characteristics | Main mineral observed |
|---|---|---|---|
| 1. | Near Girgaon Chaupati, Mumbai | Depth 15 cm | Quartz, kaolinite, a little smectite |
| 2. | Near Dumas, Surat | Depth 15 cm | Quartz, kaolinite, illite |

TABLE-2
PHYSICO-CHEMICAL ANALYSIS OF SOIL SEDIMENT

| S. No. | Site of sample collection | Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | pH | EC | TDS | WES | $Cl^-$ | TA | $SO_4^{2-}$ | OM | COD |
| 1. | Soil sediment from Girgaon, Mumbai | 8.6 | 700 | 1200 | 1413 | 415 | 112 | 600 | 1175.0 | 48.7 |
| 2. | Soil sediment from Juhu, Mumbai | 8.7 | 670 | 1250 | 1508 | 500 | 114 | 598 | 1418.0 | 49.0 |
| 3. | Soil sediment from Dumas, Surat | 8.8 | 796 | 1300 | 1475 | 496 | 160 | 610 | 2116.0 | 52.0 |
| 4. | Aq. sediment from Girgaon, Mumbai | 7.9 | 800 | 1400 | 1275 | 306 | 104 | 504 | 1162.4 | 57.6 |
| 5. | Aq. Sediment from Juhu, Mumbai | 8.1 | 816 | 1390 | 1306 | 317 | 107 | 600 | 1400.0 | 74.8 |
| 6. | Aq. sediment from Dumas Surat | 8.1 | 850 | 1412 | 1347 | 390 | 114 | 587 | 1157.8 | 88.0 |

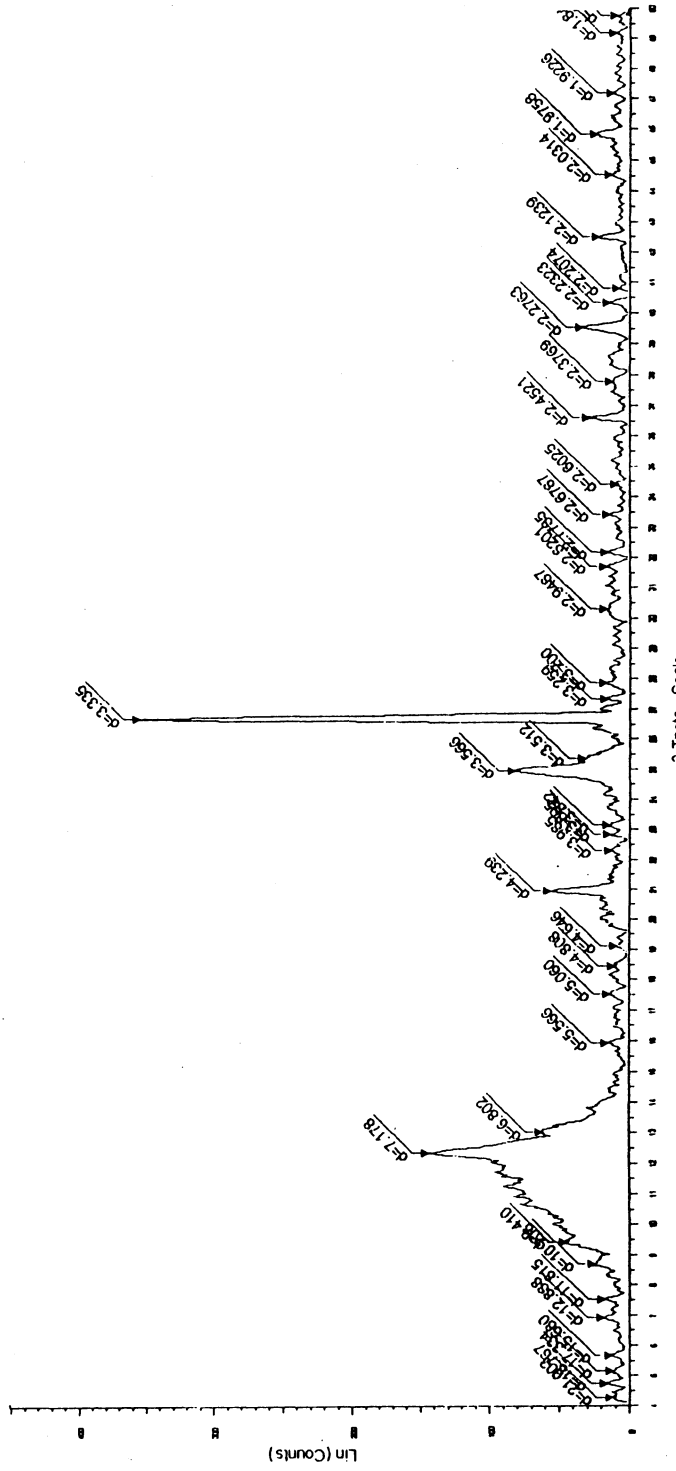


Fig. 1. XRD diagram of the surface fraction of sediments clay of Mumbai coastal region

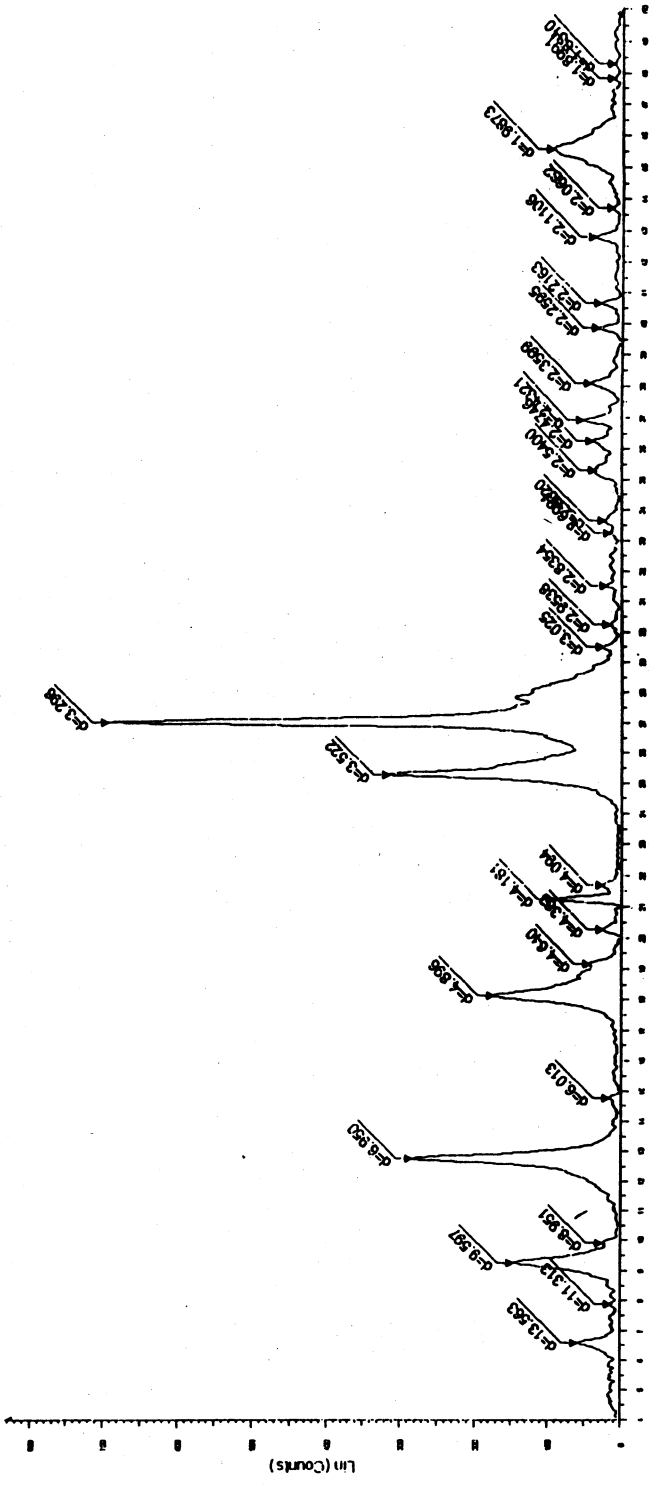


Fig. 2. XRD diagram of the surface fraction of sediments clay of Surat coastal region.

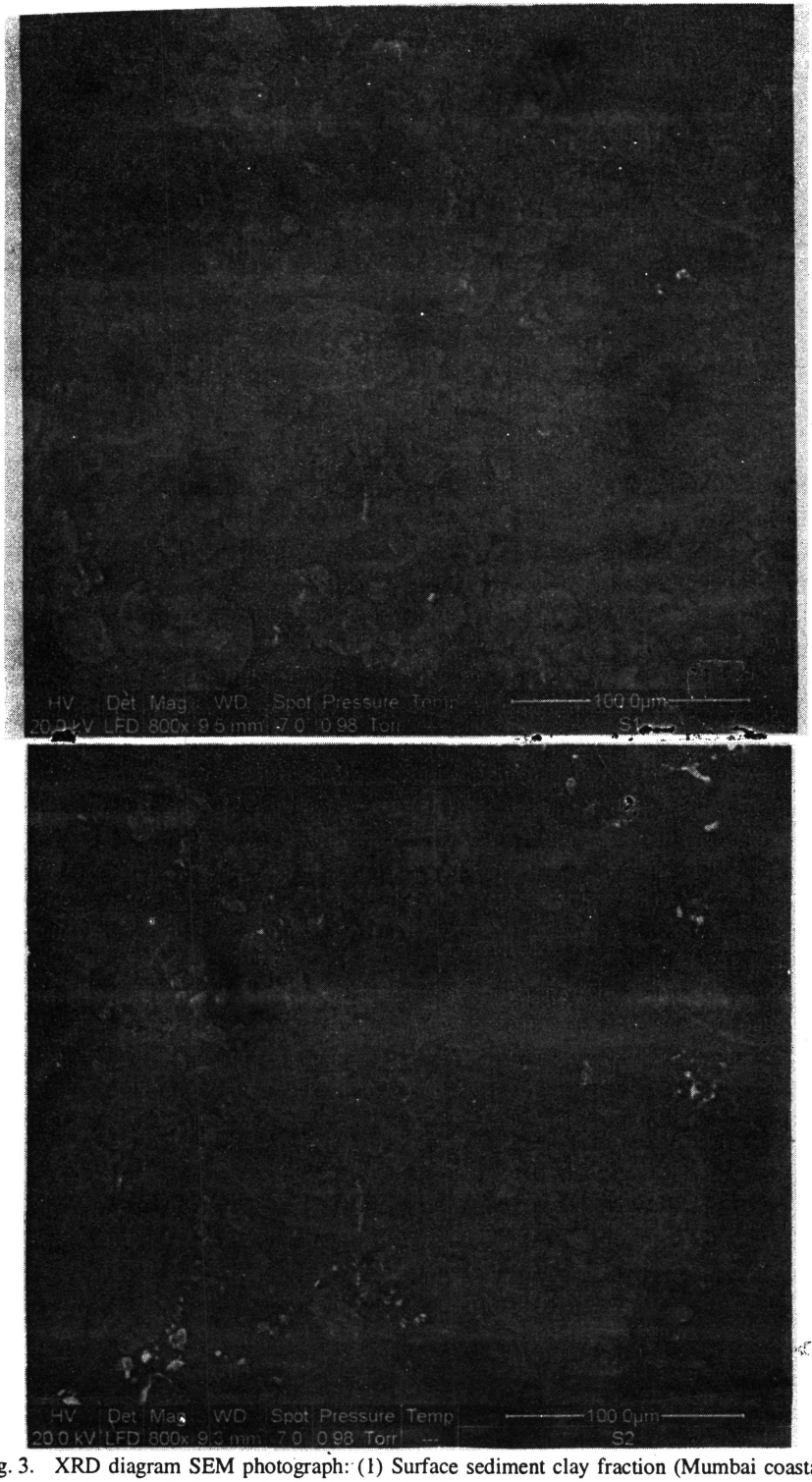


Fig. 3. XRD diagram SEM photograph: (1) Surface sediment clay fraction (Mumbai coastal region), (2) Surface sediment clay fraction (Surat coastal region)

**X-Ray diffraction:** The XRD results of these clay samples indicated that the main constituents are quartz, kaolinite, illite and a very small amount of smectite. The scan of the clay extract for all the samples is more or less similar and is shown in Figs. 1 and 2. All the diffractograms show a broad quartz peak centred from 3.3–3.5° 2θ. A sharp asymmetric peak at about 9.178°, 2θ and a slightly asymmetric kaolinite peak observed at 6.9–0.1° 2θ using the Diffrac-plus software were fitted to the pattern; one is for quartz and kaolinite and the other in the region of light reflection. A slightly asssymetric peak spacing of 9.597° 2θ and much more asymmetric peak with its maximum range of escaping from the 8.951–9.6° 2θ. Comparison with the calculated pattern for interstratified illite/smectite using the NEWMODS[13] indicates that both the observed asymmetry and peak maximum for illite/quartz component match reasonably well with the calculated pattern for the illites: illite 80–90%, quartz 20–10% in the interstratified face. By comparing the integrated peak intensities to calculate profilesit was possible to estimate the proportion of each clay type.

Kaolinite mineral can be found by neosynthesis from the product of hydrolytic decomposition of feldspar and other primary minerals[14, 15] and by the conversion by smectite or varmicullite to kaolinite following hydroxy interlayering in the expandable mineral or mixed layering between 2 : 1 and 1 : 1 layers[16, 17]. This latter process involves random interstratification of smectite/vermicullite and kaolinite.

In the past, the smectite mineralogy of shrink well soils (vertisols and vertic integrates) was considered to be beidellite nontronite type[18] on the basis of calculation of smectite formula. XRD analysis of a large number of smectites dominated fine clays of shrink well soils[19] indicating the presence of small to moderate amount of hydroxy interlayer materials in the smectites.

**Scan Electron Microscopy (SEM):** Out of the XRD analysis of the samples we have scanned clay samples for scan electron microscopy analysis. The arrangement of the particle size average of the obtained liquid phase was investigated by SEM. Fig. 3 shows the microscopy of typical clay particle sizes from different soils; there are different spacings (different clay minerals) in the same crystals, confirming the presence of interstratified clays. SEM photographs clearly indicate the presence of quartz, kaolinite, illite and a little smectite minerals. These results also demonstrate the goodness of the particle size separation methods.

For the chemical status of caachment aresa nearer to the Mumbai and Surat coasts the soil sediment mixtures were analyzed and the results achieved are being presented in Table-2. This analysis clearly reveals that some of the parameter values have been found to be higher. Also this analysis supports the presence of detected minerals.

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