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# Analysis of Soil Quality Using Physico-Chemical Parameters with Emphasis on Fluoride from The BackfilledMining Areas of Sanu Mines, Jaisalmer, Rajasthan, India.

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***Abstract: Soil samples from were collected for analysis from the dumping areas of Sanu mines, district Jaisalmer, Rajasthan. Inhabitants, cattle and some crop species which are sensitive to fluoride toxicity of this tehsil suffer from fluorosis. Soil samples were collectedrandomly from given dumping areas. Total 15 samples (randomly) were analysed. Selected ion meter was used for estimation of fluoride. Fluoride ion concentration in soil samples varied from 1.0ppm to 8.23ppm.***

***Keywords: Fluoride; Physico-Chemical; Parameters; Subsoil Water; Soil Dumps***

## 1. INTRODUCTION

Soil is a vital component, medium of unconsolidated nutrients and materials, forms the life layer of plants. Soil developed as a result of paedogenic processes through weathering of rocks, alteration of soil strata, consisting of inorganic and organic constituents, possessing definite chemical, physical, mineralogical and biological properties, having variability from depth to surface of the earth, and provides a medium for plant growth Thakre [1]. Soil physic-chemical properties influence the behaviour of soil and hence, knowledge of soil property is important Sumithra [2]. Soil testing is the only way to determine the available nutrient status in soil and the only way we can develop specific fertilizer recommendations. Soil properties that are sensitive to changes can be used as indicators to improve soil quality. Analysis of soil is carried out for the studies of various parameters like total Organic Carbon, Available Nitrogen (N), Phosphorus ($P_2O_5$) and Potassium [$K_2O$], pH, Electrical conductivity, soil texture, bulk density, chloride, fluoride and % moisture content. The fertility of the soil depends on the concentration of N, P, K, organic and inorganic materials, conductivity. The physicochemical properties such as moisture content, Nitrogen, phosphorus and organic matter required for the growth of plant. Potassium is used for flowering purpose, it is also required for building of protein, photosynthesis, fruit quality and reduction of diseases and phosphate is used for growth of roots in plants.

### Study Site

The study site, RSMML (Rajasthan State Mines and Minerals Limited) was located near village Sanu about 56 Km from Jaisalmer on Jaisalmer – Ramgarh road (Rajasthan) at Latitude: 27016’43” to 27019’40” – N and Longitude: 70033’52” to 70035’00” – E. The restored backfilled area had covered in 135.92 Hectares and the restoration is more than 20-year-old. The climatic condition is very harsh.It is typically sub-tropical, dry and windy. It is characterized by large extremes of temperature and erratic rainfall. The temperature goes as high as 50$^{O}$C in summer and 0$^{O}$C in winter. Average rainfall is below 200mm.The mining activity is being carried out by opencast method. Since the reclamation process is running since year 1988, the backfilling and Reclamation in the mined-out area will be concurrent with the mining operations. There is no overburden in the area. Limestone bed is directly exposed on the surface. The inter burden comprising of fine soil mixed with pebbles of limestone will be generated, which will be concurrently backfilled in mined out area.

### Distributionof Fluoride in Soil

The main source of fluoride in soil is Pegmatite Pneumatolytic deposits as vein deposit in rocks or Pegmatite & metamorphosed limestone, higher concentrations (1,000 g/kg) can occur in soils by anthropogenic inputs, such as phosphate fertilizers Kabata [3]. Mostly fluorine presents as oxy-hydroxides, only a few parts dissolved in the soil solution. Fluoride mobility in soil soil’s sorption capacity is positively correlated, and sorption capacity depends on pH and soil salinity Cronin [4]. Fluoride contaminated soil are more acidic or alkaline, the risk of fluoride toxicity in shoots of plants would increase with increasing concentration of fluoride in soil Stevens [5]. Fluoride at high concentration in soils toxic not only for plants but also for grazing animals who feed in such soils Clark, O’Hara and Cordes, Cronin Loganathan.

## 2. MATERIALS AND METHODOLOGY

### Selection of Sampling Sites

For the purpose of this study soil samples were collected randomly from of the given dumping areas. In total 15 samples from given mine dump areawere collected. All soil samples at 0-15 cm depth were collected randomly from mining area.

### Soil sampling Procedure

In order to collect soil samples (0-15 cm depth) first removed grasses, litter and other plant residues from soil surface and collect soil samples by using soil collection tools. In each case, a triangular block was marked and soil samples were collected in plastic bags, which were sealed, and labelled properly. Soil samples were brought to the laboratory for analysis. Before analysis, the samples were hot air dried and homogenized, sieved through a 2mm sieve to ensure homogeneity. The samples were preserved in clean sealed polythene bags for analysis (Table 1)

Table 1: Soil Properties under Study with Their Methods of Measurement.

| S. No. | Soil Property | Analysis Method | Unit |
|---|---|---|---|
| 1 | Bulk density | Core sampling method | Gm/cm3 |
| 2 | Texture | Robinson’s pipette method | - |
| 3 | Temperature | Soil thermometer | |

| | | | |
|---|---|---|---|
| 4 | Moisture content | Oven drying method | In Percentage |
| 5 | pH | pH meter | - |
| 6 | Organic matter | Titrimetric method (Walkley and Black, 1934). % Soil organic matter =% organic carbon x 1.724 | In Percentage |
| 7 | Available Nitrogen | Micro Kjeldhal Method | Kg/ha |
| 8 | Available Phosphorus | Spectrophotometric method | Kg/ha |
| 9 | Available Potassium | Flame photometer method (1986) | Kg/ha |
| 10 | EC | Digital portable water analyser kit (Model 161 E) | m mhos |
| 11 | Chloride | Volumetric titration | mg/100gm |
| 12 | Fluoride | Selective Ion meter | ppm |

**Soil Quality Parameters and Methodology**
For analysis of physicochemical parameters of the soil samples first we prepared soil suspension in distilled water (1:4 w/v) and allowed to settle down the particles. Main focus was on those soil quality parameters which influence the movement and retention of water that contribute to store and supply of nutrients. In this study some selected physical and chemical parameters were determined.

**Physical Parameters:** Temperature, Texture, Bulk density, Moisture content.
**Chemical Parameters:** pH, Organic matter, Available Nitrogen, Available Phosphorus, Potassium, Electrical Conductivity, Chloride, Fluoride.
**Fluoride Estimation:** Fluoride estimated by ion selective meter (Mettler Toledo MA 235 pH /ion analyser), Standard procedure was followed APHA [6] to get satisfactory results; total Ionic strength adjustment buffer (TISAB) was used to maintain a suitable ionic strength and also to avoid complex formation (Figure 1).

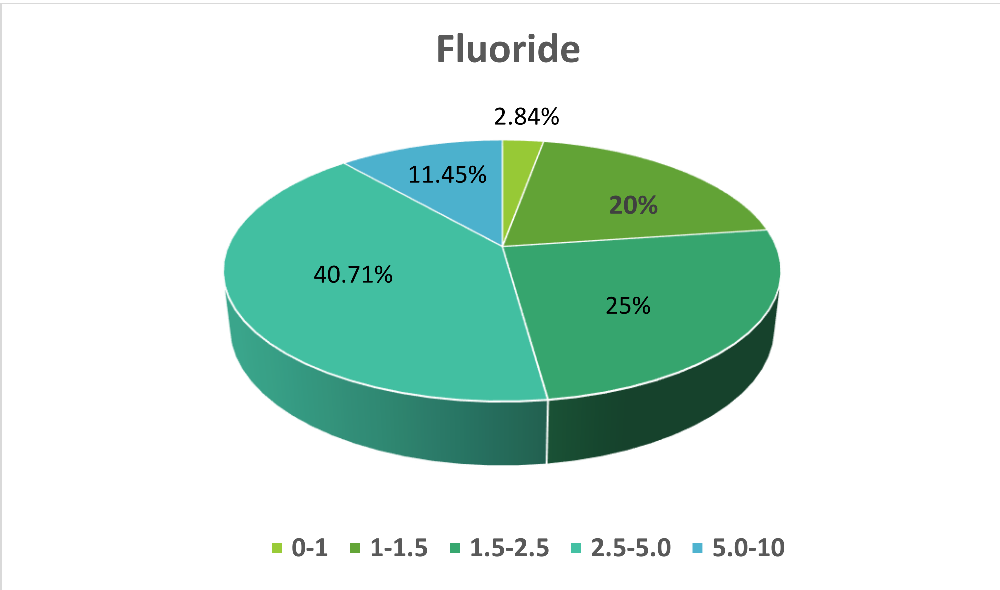


Figure 2: Fluoride Distribution Percentage in different dump areas of Sanu mines.

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**Statistical Analysis**

In the present study Mean and Standard Deviation have been calculated for each pair of soil quality parameters by using Excel spreadsheet (Table 2). The standard formulae were used in the calculation for statistical parameters are as follows:

**Mean (μ) = Σ X ÷ N**

x = Value of Observation,N = Number of Observation

**Standard Deviation =** $\sqrt{\sqrt{n\Sigma} \times 2 - (\Sigma x)2 / n(n - 1)}$

x = Values of Parameter, n = Number of Observations

Table 2: Standard Soil Classification

| Soil Test | Range | Classification |
|---|---|---|
| **pH** | <4.5 | Extremely acidic |
| | 4.51-5.50 | Very strongly acidic |
| | 5.51-6.00 | Moderately acidic |
| | 6.01-6.50 | Slightly acidic |
| | 6.51-7.30 | Neutral |
| | 7.31-8.50 | Moderately alkaline |
| | 8.51-9.00 | Strong alkaline |
| | >9.01 | Very strong alkaline |
| **Salinity, Electrical conductivity (mmhos)** | Up to 1 | Average |
| | 1.01-2.00 | Harmful to germination |
| | 2.01-3.00 | Harmful to sensitive crop |
| **Organic Carbon%** | Up to 0.20 | Very less |
| | 0.21-0.40 | Less |
| | 0.41-0.50 | Medium |
| | 0.51-0.80 | On an average sufficient |
| | 0.81-1.00 >1.00 | Sufficient |
| | | More than sufficient |
| **Nitrogen (kg/ha)** | Up to 50 | Very less |
| | 51-100 | Less |
| | 101-150 | Good |
| | 151-300 | Better |
| | >300 | Sufficient |
| **Potassium (kg/ha)** | 0-120 | Very less |
| | 120-180 | Less |
| | 181-240 | Medium |
| | 241-300 | Average |
| | 301-360 | Better |
| | >360 | More than sufficient |
| **Phosphorus (kg/ha)** | Up to 15 | Very less |
| | 16-30 | Less |
| | 31-50 | Medium |
| | 51-65 | On an average sufficient |
| | 66-80 | Sufficient |
| | >80 | More than sufficient |

## 3. RESULT

The basic Physico-chemical soil properties are given in Table 3. The analysed chemical and physical properties show the wide variation range, as can be seen in the results. The pH of all soil samples was found to be ranged in between 7.04 to 8.3 which indicate the slight alkalinity of soils. Electrical conductivity of soil samples range between 0.026 to 1.967m mhos, in most of the samples except some hilly soil samples moisture content was in proportionate level between 7.02percent to 25.71 percent; moisture content varies in different season. Organic matter was varied widely among the various cultivated soils horizons selected for the study from 0.188 to 3.14percent. Chloride is generally mentioned as a hydrological and chemically inert substance. Chloride concentration in soil generally shows the salinity of soil, chloride concentration in soil samples ranged from 3.52 to 24.14mg/100gm. Most important factor which decide the soil productivity is N:P:K ratio. Available nitrogen found in soil samples between 13.8 to 218.60 kg/ha. Phosphorus considered as micro nutrient, is utilized by plant in the form of $H_2PO_4$- & $HPO_{4-2}$ species. Appropriate concentration of phosphorus (P) is necessary for maintaining a balance between the other plant nutrients and ensuring the normal growth of the crop. Previous researches have already reported the importance of phosphorus Leonardi [7]. Available phosphorus ranged in cultivated soil samples of study area between 54.72 to 2984kg/ ha.

Table 3: Physico-chemical Analysis of Soil Samples from dumping areas ofSanumining.

| S. No. | $P^H$ | EC | Soil Texture | Bulk Density | Moisture Content | Chloride | Fluoride | % Carbon | % Organic Matter | N | P | K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.5±0.01 | 1.882±0.003 | Light brown | 1.41±0.21 | 21.29 | 6.39±0.926 | 1.5±0.41 | 0.311±0.029 | 0.517±0.092 | 91.2±12.08 | 100.4±20.81 | 364.2±9.35 |
| 2 | 7.1±0.24 | 0.487±0.164 | Sandy loam | 0.98±0.08 | 13.47 | 10.65±0.392 | 3.1±1.01 | 0.842±0.112 | 1.448±0.261 | 123.0±54.62 | 98.43±34.66 | 402.8±17.99 |
| 3 | 8.3±0.14 | 0.536±0.12 | Brown | 1.02±0.54 | 12.08 | 14.91±2.98 | 2.5±0.97 | 0.948±0.154 | 1.634±0.385 | 151.2±38.29 | 162.3±25.04 | 423.1±12.58 |
| 4 | 7.6±0.23 | 0.24±0.006 | Dark brown | 0.64±0.29 | 7.9 | 22.01±3.045 | 3.0±1.21 | 0.744±0.029 | 0.749±0.095 | 138.7±47.24 | 120.4±15.54 | 382.6±29.02 |
| 5 | 7.9±0.06 | 0.847±0.431 | Light brown | 1.09±0.72 | 10.47 | 17.75±2.091 | 2.09±0.45 | 0.435±0.023 | 1.209±0.189 | 102.4±29.05 | 125.4±21.43 | 310.5±25.43 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6** | 7.9±0.25 | 0.026±0.059 | Light brown | 1.21±0.38 | 24.01 | 22.01±2.038 | 6.19±2.10 | 0.701±0.104 | 1.282±0.231 | 98.3±42.84 | 97.8±31.05 | 242.5±62.01 |
| **7** | 7.3±0.93 | 0.869±0.073 | Sandy loam | 0.86±0.47 | 18.52 | 7.1±0.837 | 2.30±1.52 | 0.645±0.374 | 1.112±0.137 | 190.5±25.96 | 154.7±10.42 | 528.4±36.18 |
| **8** | 8.1±0.53 | 0.424±0.026 | Sandy brown | 0.74±0.91 | 12.15 | 4.26±1.021 | 3.01±1.04 | 0.095±0.002 | 0.164±0.056 | 117.2±38.27 | 102.9±21.04 | 374.6±19.26 |
| **9** | 7.4±0.36 | 0.481±0.174 | Sandy loam | 0.92±0.39 | 19.21 | 12.07±2.112 | 4.0±2.01 | 1.124±0.537 | 1.938±0.118 | 87.5±12.57 | 74.25±32.33 | 251.2±59.08 |
| **10** | 7.9±0.42 | 1.86±0.046 | Sandy brown | 1.23±0.24 | 7.02 | 5.68±0.984 | 8.23±2.11 | 0.178±0.097 | 0.307±0.106 | 184.7±9.02 | 196.2±25.09 | 362.4±31.55 |
| **11** | 7.4±0.29 | 1.58±0.095 | Light brown | 0.69±0.40 | 23.12 | 21.3±3.102 | 6.72±1.89 | 0.273±0.100 | 0.470±0.142 | 70.2±22.65 | 142.3±24.07 | 217.6±44.02 |
| **12** | 7.2±0.84 | 1.96±0.11 | Sandy loam | 1.05±0.33 | 17.15 | 19.17±1.292 | 3.12±0.95 | 0.246±0.039 | 0.424±0.098 | 170.2±18.09 | 101.4±55.97 | 402.9±17.42 |
| **13** | 7.8±0.34 | 0.750±0.027 | Sandy brown | 0.83±0.49 | 9.05 | 7.81±0.573 | 1.10±0.45 | 0.560±0.104 | 0.966±0.055 | 99.4±24.67 | 110.2±21.48 | 273.5±22.98 |
| **14** | 7.5±0.93 | 0.920±0.103 | Sandy loam | 1.40±0.12 | 19.17 | 4.97±0.953 | 1.15±0.23 | 0.701±0.074 | 1.209±0.564 | 134.5±10.41 | 145.2±32.61 | 504.2±14.38 |
| **15** | 8.2±0.06 | 0.326±0.007 | Brown | 1.20±0.98 | 22.85 | 14.21±2.054 | 2.40±1.04 | 1.397±0.153 | 2.41±0.135 | 162.75±13.004 | 114.1±28.04 | 495.1±53.22 |

Generally, fluoride concentration in soil depends on the groundwater and rocks type in the area. Previous research explained this- The first reason is its inherent availability in the soil and the gaseous fluorine in the atmosphere. Fluoride is a mobile ion and its retention in the soil correlated with the amount and rate of water percolating into the soil zone which depends on the soil permeability. High permeability leads to high water content infiltration thus causing the ion to move deeper into the water table where it is retained. Fluoride can also be absorbed by some cations, radicals and oxides of metals to form complex compound. Fluoride levels were varied widely 1.0 to 8.23ppm among the various cultivated soils horizons selected for the study (Table 4).

Table 4: Tabular Correlation Coeff.86 DF5% =0.248, Tabular Correlation Coeff.86 DF1% =0.323.

| | $P^H$ | EC | Bulk Density | Moisture Content | Chloride | %Carbon | %Organic Matter | N | P | K | Fluoride |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$P^H$** | 1 | - | - | - | - | - | - | - | - | - | - |
| **EC** | -0.234 | 1 | - | - | - | - | - | - | - | - | - |
| **Bulk Density** | 0.076 | 0.023 | 1 | - | - | - | - | - | - | - | - |
| **Moisture Content** | -0.324 | -0.075 | 0.276 | 1 | - | - | - | - | - | - | - |
| **Chloride** | -0.01 | -0.061 | -0.006 | -0.105 | 1 | - | - | - | - | - | - |
| **%Carbon** | 0.094 | -0.266 | 0.103 | -0.075 | 0.162 | 1 | - | - | - | - | - |
| **%Organic Matter** | 0.1 | -0.258 | 0.099 | -0.087 | 0.167 | 0.998 | 1 | - | - | - | - |
| **N** | 0.097 | -0.026 | 0.119 | 0.041 | 0.104 | 0.363 | 0.374 | 1 | - | - | - |
| **P** | -0.185 | 0.223 | -0.147 | -0.186 | 0.285 | 0.296 | 0.3 | 0.216 | 1 | | |
| **K** | -0.034 | -0.105 | 0.226 | 0.12 | -0.139 | 0.278 | 0.283 | 0.732 | -0.089 | 1 | - |
| **Fluoride** | 0.207 | 0.166 | -0.12 | -0.165 | 0.093 | -0.082 | -0.079 | 0.025 | 0.174 | 0.017 | 1 |

## 4. DISCUSSION

pH can affect the availability of nutrients and activity of many essential micro-organisms, and most of the sample found alkaline, high alkalinity is not good for microbes. Several researchers showed that the texture of soil remain a major constraint to crop production. In

this context, Nyabyenda [8] reported that the production of grain legumes had been low due to declining soil fertility as a result of soils impoverishment in organic matter content and corresponding texture. In present study variability in soil texture may contribute to the variation in nutrient storage and availability, water retention and transport and binding and stability of soil aggregates. As we can see black loamy soil has good N:P:K ratio. Soil texture directly or indirectly influences soil functions such as soil erosion, water availability Adhikari [9]. The sandy soil can quickly be recharged but its holding capacity is not good. As texture becomes heavier, the wilting point increases because fine soils with narrow pore spacing hold water more tightly than soils with wide pore spacing Thakre. In the present study most of the samples were loamy. The bulk density depends on compaction, consolidation of the soil but it is negatively correlated to the organic content. According to Micheni [10] the soil organic matter plays an important role in maintaining soil quality.
Everyday falling down of leaves may increase the soil organic carbon and thus the total organic matter. In the study area soil organic matter content varies from very less to more than sufficient and its directly influenced by soil texture and moisture content. Chloride is an undesirable content but it’s unavoidable, because it is a essential micronutrient for optimal growth. Both potassium and Chloride play the main role to neutralize the charges, and as the most important inorganic osmotic active substances in plant cells and tissues. The association of potassium and Chloride is related to the opening and closing of stomata Oberg [11], Talbott [12], Fixen PE [13]. In most of site soil samples potassium content was in average range. Potassium is known to affect cell division, cell permeability formation of carbohydrates, translocation of sugars, various enzyme actions and resistance of some plants to certain diseases Miller and Turk [14]. Soils are basically categorized on behalf of soil fertility and presence of micro nutrient. In present findings site soil is less nutrient so farmers use more fertilizers and phosphate fertilizer shows the positive correlation with the presence of fluoride content in soil.
Chemical-intensive practices in agricultural fields increasing fluoride contamination and other pollution problems of a magnitude that exceeds normal limits. Plants take up fluoride through fine hair rootlets from the soil. Plants absorb more fluoride from sandy than from clay soil. The most prominent factors that dictate the amount of F in most soils are the quantity of clay minerals, the soil pH and the concentrations of Ca and P in soils Abida [15]. Same results found in the study of Larsen and Widdowson [16], Perroilt and Chhabra [17], Omueti and Jones [18] high adsorption of fluoride by soil mineral components is at about pH 6 to 8 [19-33].

## 5. CONCLUSION

The results of the study reveal the values or percentages of Physicochemical parameter, physicochemical study of soil is important to agricultural chemists for plants growth and soil management. Fluoride is generally present in soils in the form of cryolite ($Na^3AlF^6$), flurapatite ($Ca^5 (PO_4)^3F$) and other phosphate rocks. The results of present study will help to identify the type and degree of soil related problems and to suggest appropriate reclamation measure, and also to find out suitability for growing crops. It will also help to study the soil genesis. On the basis of this study farmers can get an approx idea about the amount of which fertilizers and nutrients needed to soil for increase the percentage yield of crops.

**Expected future work**

First, it is necessary to explore the factors that influence restoration flexibility.To properly repair and protect the ecosystem, we should further studyeach system's own level of resilience. The core is to sort out and summarizethe formation mechanism, size, factors, functions, and constructionmethods of the specific and general levels of resilience of theland space ecosystem. The key step in understanding general restorationis to understand the various attributes of general restoration, such asopenness, diversity, and slow variables. Only through quantitative assessmentcan the main impact factors of resilience be extracted, therebyproviding a basis for ecosystem management (Carpenter et al., 2001;Scheffer et al., 2001) [34]. One of the core tasks of the next step is to furtherexplore the factors that influence ecological resilience and continue toimprove and enrich the indicator system. It is worth learning that thequantitative measurement method based on the principle of generalresilience is sometimes called the surrogate theory in academic circles;that is, to find the attributes related to resilience that can be measuredin the ecosystem, one needs to select indicators from them as alternatives(Brand, 2008; Walker and Salt, 2012) [35] such as ecological redundancy,response diversity, or ecological storage (Nystrom, 2006) [36].
Second, it is necessary to explore how resilience guides ecologicalrestoration. Through the research in this paper, it can be concluded thatfuture research should aim to summarize the optimal site selectionscheme for ecological restoration projects based on resilience(Bellwoodet al., 2004) [37]. In the future, the scientific basis for carrying out ecologicalrestoration work will be ecological resilience. Through empiricalresearch in China, it is found that most of the conservation ecologicalprojects at this stage are located in areas with low and medium levels ofresilience, with high investment levels and slow recovery effects. Ecologicalrestoration in these areas requires long-term investment andmanagement.

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