# RECONNAISSANCE AND METHODOLOGY FOR ASSESSMENT OF SOIL QUALITY AROUND MINING AREA OF CHANDRAPUR DISTRICT (MAHARASHTRA), INDIA

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## ABSTRACT

Mining of minerals is non-renewable and non-replaceable. The resources are limited and arise only in geological circumscribed zones. The insufficiency of minerals is expected as the whole world is demanding minerals next to the food grains. Our country's economy has been given a strong foundation due to resource mining. Minerals are beneficial not only for the industrial sector but also for making jewelry, construction materials, ceramics, etc. Industrial revolution has become possible in our country due to minerals mining activities. However, these activities are causing environmental degradation. Considering the implications created through mining activities though it is necessary for the nation to utilize resources for developmental activities and economic growth, these activities should be in a sustainable manner especially in terms of agricultural activities around it which are dependent upon the soil quality, fertility status and products which helps for the growth of crops for the survival of mankind and human life. It must run simultaneously without disturbing each other. It is, therefore, necessary to think about the application of technological aspects and the scientific ways of mining to keep the views of the mining areas in a very aesthetic point of view and not in a degradable way. This particular paper highlights the methodology adopted for soil quality assessment through reconnaissance around the mining activities in Chandrapur district and to study the implications on soil productivity and related issues.

*Keywords*: Reconnaissance, Methodology, Assessment, Mining Area, Chandrapur, Minerals, Soil quality.

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## INTRODUCTION

Mining is the most important resource next to agriculture. Mankind has always used minerals and has become increasingly dependent upon them during its cultural, scientific, and technological evolution. This indicates the importance and dependency according to the necessity to society. Over centuries, there is an increased demand for minerals of greater varieties according to the need of the population. Besides the need for minerals and the increased scale and intensity of exploitation of mineral resources, increasing population and social development have resulted in concern over the side effects of mineral industries. In another way, the mining of mineral activities is the main that not only utilizes the nonrenewable resources but also the environment [1]. Mining activities for the exploitation of minerals are a need of modern society and no country can sustain itself without it. However, it is impossible to sustain the unsustainable and renew the nonrenewable but it is possible to make or execute the activities in a compatible manner considering the adoption of technology and to keep the area in an aesthetic point of view feasible for mankind and keeping the environment safe [2]. So, the activities should have been sustainable to run the development by keeping the environment safe as the mining activities created major implications on the environment in the form of acquisition of forest land and deforestation, changes of drainage pattern during excavation of open and underground mining and thereby shifting of the underground aquifer, creation of overburden and dumps, soil erosion and loss of surface soil, creation of pond due to unscientific mining, environmental pollution and aesthetics of surrounding.

## STATUS OF MINING IN THE REGION

Vidarbha in the state of Maharashtra comprises two divisions Nagpur and Amravati and is known for oranges and cotton production. It is also known for mineral resources like coal and manganese. The maximum mineral production is from Chandrapur district in Maharashtra as compared to other districts in the Vidarbha region and Maharashtra. The Chandrapur district is well known for coal mining and is spread over Chandrapur, Majri, Wani, Wani North, Ballarpur and Umrer. In between all these, some mines are underground and some are open-cast mines.

## IMPACT OF MINING ACTIVITIES ON THE ENVIRONMENT

Mining of minerals is very important from the viewpoint of economic development of the country; however, it has several drawbacks if not operated in a scientific way or manner. Though it is a major resource, it has certain implications for the environment and the ecological point of view. Mining of minerals is operated with the excavation of soil whether open or underground creates major problems of land sliding, erosion of soil, emission of dust particles containing several toxic metals depending on the type of mine and the minerals to be extracted, disposal of mine water on land or in water bodies creating pollution by deteriorating soil/land and water quality due to mineral/metal contamination. Formation of overburden and their erosion and spread/deposition on land/soil surface deteriorating productivity of the soil/land. Deforestation and change in landform are the major problems with the changes in the ecological system and reduction in biodiversity [3].

Resources are very important for the economic development of the country. There is a great need to consume these resources in a limited way. Land/soil is a very important resource in which mankind is dependent in terms of the production of food and other necessities made for their day-to-day needs and survival. Therefore, the management of land/soil is very essential concerning conservation and restoration to maintain the resource for future generations. The degradation through immense use of this resource will have to be maintained for the protection of the ecological balance by avoiding ecological damage [4]. It is reported, that there are very limited research works carried out on the quality characterization of soil in the mining areas [5].

## BACKGROUND OF THE STUDY

The study was carried out in and around the mining (coal and non-coal) areas near Chandrapur district through reconnaissance to find out or observe the present status of mining activities and their implications concerning physiography, land use/land cover, soil types, surrounding environment, implications due to mining, agricultural activities and produce, etc. and accordingly decided upon the methodology to be adapted for the soil quality characterization in terms of soil quality parameters.

## METHODOLOGY

### Selection of Study Area

In Maharashtra State, Chandrapur is the district located in the east of Vidarbha region and surrounded by districts Nagpur, Bhandara and Wardha in the north, Yavatmal and Gadchiroli in the North and east respectively. The rivers Wainganga and Wardha are flowing through the district. The area measuring 11,443 $km^2$ is nearly 3.72 percent of the total area of the Maharashtra State. The district Chandrapur is famous for mining minerals through the strip and open pits for Coal, Iron ore, and Limestone.

## SOIL TYPES AND QUALITY INDICATORS

Soil is the surface thin layer of the earth's crust containing rocks, sand, silt, and mineral compounds complexed with fulvic and humic organic acids with inherent air and water in the micro / macro pores contributing support with the help of soil microbes in-situ for the plant growth with the help of nutrients and organic matters.

Indian land is characterized by different types of soils i.e. black cotton, laterite, alluvial, mountain, and desert soils depending on the physiography of the region and each type of soil has having capacity to produce different/specific types of crops. Out of the above different types of soils, black cotton and alluvial soils are usually used for the agricultural purpose of producing different types of agricultural produce.

All types of soil have their fertility status and thereby the productivity for different crops/plants depending on the soil composition, status of nutrients, like carbon, nitrogen, Sulphur, phosphorus and organic matter, moisture content, texture, and microorganism availability. The interaction takes place within the soil matrix with the help of microorganisms resulting in oxidation and reduction and supporting the plant/crop growth. However, it also depends on the soil quality as a whole mostly in the form of soil quality indicators like pH, conductivity, bulk density, porosity, exchangeable cations, available nutrients, and the essential metals as supporter nutrients for the plant/crop growth.

Soil is useful for agricultural production and is a non-renewable source for the human time frame. The change in the quality of soil creates problems in the fertility status and thereby the productivity of crops. The change in soil quality is linked with sustainable agriculture and is having a major effect on the agriculture system [6]. Thus, the maintenance of soil quality is a prerequisite to the sustainability of agriculture. As per the United States Department of Agriculture (USDA), the indicators of soil quality are generally expressed in terms of ecological, economic, and social points of view and considered according to the quality of soil and the associated crops in response to the dynamic changes in agro-systems.

Soil contamination with hazardous and toxic chemicals is a serious problem due to unmanaged disposal of solid and hazardous waste materials, leaching and mixing of leachate into the soil matrix imposing toxic effects and decreasing plant/crop productivity due to physiological, morphological, and textural damage/effects. Maintenance and restoration of good quality soil are of prime importance as it may threaten human health through its effect on air and water quality as well as cause environmental pollution [7 and 8]. However, these properties usually change on a time scale (decade) due to the weathering effect depending on the type of soil which is too long for measurement purposes. The movement and the mobility of pollutants from anthropogenic activities to the atmosphere and their ultimate effect on plants, animals, and human beings due to direct/indirect contact or through the food chain is also important.

**RECONNAISSANCE**

In Chandrapur district agriculture is the main source of occupation. The mining activities are also grown in the district creating employment to the people of the study area. Agriculture is carried out in two seasons, i.e., kharif and Rabbi. The main kharif crops are Paddy, Cotton, Soybean, and Tur, and in Rabi, Wheat, Gram, Jowar, and Linseed are the main crops. The vegetables are also grown in the winter and summer seasons. As per the meteorological data collected for the area, the climate is subtropical with an average rainfall of 1277.3 mm. The average temperature of the district is 28.25°C. The mean summer and winter soil temperatures are 30°C and 22°C respectively confirming the hyper thermic region of soil taxonomy. The hot season starts in early April month with an increase in day temperature. The temperature rises to 48°C during the summer season.

## NATURAL VEGETATION

The natural vegetation of the study area is mostly dry deciduous mixed type. The thin and scanty vegetation mostly shrub types is observed on an undulating upland and subdued hill. The common species of vegetation are observed as Tress: Mangoes (*Manifera Indica*), Babul (*Acacia arabica*), Neem (*Azadirachta Indica*), Moh (*Madhuka Latifolia*), Sitaphal (*Annona synamosa*), Chinch (*Tamaridus Indica*), Jambhul (*Syzyguium cranini*), Piple (*Ficus religiosa*), Bor (*Zyzapus jujube*), Shrubs: Sadapuli (*Vinca rosea*), Dhotra (*Daturafa strosa*), Grasses: Harali (*Cynadan dactylon*), Morvel (*Dichantium annulatus*).

## PHYSIOGRAPHY

The district area is almost flat with little topographic undulation and a few hillocks are present. The overall relief is gentle and south-easterly. Irai is the main river in the area. The surface drainages are moderate to moderately slow. The major part of the district area is covered by thick soil cover formed on Piedmont and associated deposits of the river bank.

## LAND USE PATTERN

Agriculture is a major activity in the villages, more than 51% of land is under cultivation. The irrigated agricultural land covers 2.43 percent of crop production. Only 14.65 percent of land comes under culturable waste including Goucher and groves.

## CRAPPING PATTERN

Paddy, Jowar, Soyabean, Cotton, Tur, and vegetables are grown in the kharif season. Wheat, Mung, Udid, Jowar, Linseed, Channa, and Vegetables are the prominent crops grown in the Rabbi season. Paddy is the major crop in the kharif season and Jowar and wheat are the prominent crops in the Rabbi season. Vegetables, viz. Brinjal, Tomato, Cabbage, Cauliflowers, Chilies, and Leafy vegetables are grown in the majority of the villages.

## SURROUNDING LOCATIONS WITHIN THE STUDY AREA

The following villages are located within the study area:

1. Junona, 2. Asengaon, 3. Gauri, 4. Borgaoun, 5. Gughus, 6. Ukni, 7. Adhari, 8. Panchgaon, 9. Mahurli, 10. Dewara, 11. Sawari, 12. Datala, 13. Murwa, 14. Chichpali, 15. Sonegaon, 16. Godpeth, 17. Sakhar Wahi, 18. Hingala, 19. Marnla, 20. Chicholi

## PRELIMINARY DATA COLLECTION

The following information in the study area was collected as the preliminary step:

- Soil type and texture
- Type of rocks in the area
- Climatic condition
- Availability of water sources and quality
- Availability of water sources and quality
- Groundwater potential and depth of the groundwater table
- Crops grown in the area
- Nature of cultivation and practices applied by the farmers
- Sources of irrigation water and Irrigated area available

**PLANNING AND SELECTION OF SAMPLING PROGRAMME**

The selection of an appropriate sampling site during the monitoring program has an important role in the evaluation of impact. Depending on the nature of pollutants impacting the land environment, i.e. solid, liquid, and gaseous, the field was categorized into different sectors i.e. (i) area affected due to solid waste dumping directly and indirectly, (ii) area affected due to discharge of liquid waste and (iii) area affected due to air emissions. Moreover, the site is affected indirectly due to wastewater discharged in the stream upstream and the use of contaminated water for irrigation downstream. Therefore, the site within the impacting zone was divided into contaminated and uncontaminated zones through a soil resistivity test and subsequently, the sampling points were fixed.

For selecting sampling points, a preliminary reconnaissance of the study area was carried out concerning soil type, texture and fertility, land use/land cover, and soil management before and after harvesting. Non-irrigated soil was considered as reference soil for comparison between irrigated and non-irrigated soils with wastewater to observe the Impact.

**SOIL QUALITY MONITORY**

Soil quality monitoring was carried out before and after harvesting the crops. This is essential to observe and assess the changes in the quality of the soils after harvesting the crops and accordingly its management.

Soil samples were collected before and after the rainy season to get an idea about the leaching and accumulation of salts leading to the quality of the soil related to sodic and pH. The soil samples were collected with the help of a spade and a soil auger. A proper sampling procedure was adopted to ensure and represent the actual soil conditions [9]. Before the collection of the soil samples, the unwanted materials were removed from the place where of samples were to be collected. The soil samples up to the plow layer depth (15-20 cm) from each pit (1m × 2m × 1.5m) of the sampling location by excavating through auger and spade were collected. About 500 to 1000 grams of soil samples were collected for soil quality analysis to make one composite sample from each location [9]. After the collection of samples, an appropriate mixing was made to make one composite sample which represents the location and its proper preservation, labeling, and storage were made after the collection of samples. The representative composite soil samples were then brought to the laboratory for analysis of different parameters for soil quality. The same sampling procedure was adopted for other selected locations. Proper precautionary measures were taken during the transporting of the collected soil samples with handling and storage to avoid any mixing or changes in soil quality [10].

After bringing the collected composite samples from each location, the samples were air-dried for conditioning, pulverized, and sieved through a 2 mm sieve to make the particle size uniform to get proper analytical results while estimating different soil quality parameters to get definite and representative soil quality of that particular location.

## METHODS OF ANALYSIS

Selection and adoption of the most appropriate analytical methods depend upon the types of soil to be analyzed. Proper analytical methods (Standard Methods) as shown in **Table 1** were selected for the estimation of various physical-chemical parameters required for soil quality.

Before analysis, instruments/equipment were checked and recalibrated in the laboratory. All significant parameters for soil quality were estimated and recorded to evaluate the results and understand the consistency of the results. The results were evaluated to assess the soil condition of the study area and its comparison with the reference soil.

## RESULTS AND ASSESSMENT OF SOIL QUALITY EVALUATIONS

The reconnaissance made and the information collected during the sampling and analytical results observed were correlated for interpretation of the soil quality as per **Table - 2** (ICAR manual for soil testing) with the relative significance of the soil quality parameters and thereby the land productivity. Some significant parameters as shown in **Tables 2 & 3** like pH, cation exchange capacity (CEC), exchangeable sodium percentage (ESP), electrical conductivity (ECe), and heavy metals content were used to draw some conclusions in evaluating the soil quality in the study area and classification of soil was made to delineate any specific management is required or not to control the landform and improve the soil productivity.

## CONCLUSION

The impact on soils was explained based on the evaluation of soil quality considering the significant parameters for soil quality related to (i) road development and construction activities (ii) loss of productive soil (iii) Erosion (iv) Destabilization of slopes (v) types of mass movement, and contamination through spoil materials, water flow diversions and management to control or reduce the impact on soil quality was suggested as mentioned below:

- Investigation of the original (pristine) condition of soil.
- Collection of activities, data of the surrounding areas from different sources related to activities, landform, type of soil, vegetation availability, and land use and land cover.
- Investigation and examination of possible feasible solutions to reduce Impacts.
- Training to the farmers related to soil treatment and management before and after crop harvesting.
- Information about health risks of plants, animals, and human beings.

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**Table 1 : Analytical methods adopted for soil quality**

| Sr. No. | Soil Quality Parameters | Sample Vol./Wt. | Type of Sample | Frequency of sampling per annum | Methodology | References |
|---|---|---|---|---|---|---|
| 1. | Bulk density | -- | Undisturbed soil core | Twice | Density bottle | Jackson, 1973 |
| 2. | Infiltration rate | -- | Undisturbed soil core / in situ | Twice | Double cylinder infiltro-meter method | Jackson, 1973 |
| | | | **Chemical** | | | |
| 1. | pH of soil (saturation extract) | 250 g | Soil saturated paste | Twice | pH meter, electrometric method | Jackson, 1973 |
| 2. | Electrical conductivity (ECe), us/cm at 25°C | 100 g | Saturation extract | Twice | Conductivity meter, potentiometric method | Jackson, 1973 |
| 3. | *Calcium (Ca.) meq/l | 20 ml | Saturation extract | Twice | EDTA complexometric method | Jackson, 1973 |
| 4. | *Magnesium (Mg.) meq/l | 20 ml | Saturation extract | Twice | EDTA complexometric method | Jackson, 1973 |
| 5. | Sodium (Na.) meq/l | 20 ml | Saturation extract | Twice | Flame photo-meter method | Jackson, 1973 |
| 6. | *Carbonate ($Co_3$) and bicarbonate ($HCO_3$), meq/l | 20 ml | Saturation extract | Twice | Titration method/potentiometric method | Jackson, 1973 |
| 7. | *Chloride (Cl) meq/l | 20 ml | Saturation extract | Twice | Titration method (Argentometric) | Jackson, 1973 |
| 8. | Total exchange able cations meq/100 g | 5 to 10 g | Air dried and sieved | Twice | Ammonium acetate method | Jackson, 1973 |
| 9. | * Exchangeable Na and K, meq/100 g | 25 to 50 g | Air dried and sieved | Twice | Photometric measurement | Jackson, 1973 |
| 10. | *Exchangeable Ca and Mg meq/100 g | 25 to 50 g | Air dried and sieved | Twice | Complexometric method | Jackson, 1973 |
| 11. | *Exchangeable Sodium Percent (ESP) | - | - | Twice | By calculation | By using formula for calculation Jackson, 1973 |
| 12. | **Available Nitrogen (N) ppm | - | - | Twice | Kjeldahl method | Jackson, 1973 |
| 13. | **Available phosphate, ($P_2O_3$) ppm | 5 to 10 g | Air dried and sieved | Twice | Ammonium acetate extraction and Flame Photometric determination | Jackson, 1973 |
| 14. | **Available potassium ($K_2O$) ppm | 5 to 10 g | Field moist | Twice | Ammonium acetate extraction and Flame Photometric determination | Jackson, 1973 |
| 15. | Organic carbon © in percentage | 0.5 to 2 g | Air dried 0.2 mm sieved | Twice | Wet digestion, Walkley and Back method | Jackson, 1973 |
| 16. | Organic Matter | 1.0 gm | Air dried 0.2 mm sieved | Twice | Gravimetric method | Jackson, 1973 |

Note * - Unit meq/l could be converted into mg/kg by back calculating form the extract prepared from gm of sample taken to prepared fixed volume of the extract.

** - Unit PPM could be converted into mg/kg from the extract leachate of CEC prepared and further could be converted in to kg/ha.

**Table 2 : Soil quality through some significant interpretation**

| pH of Saturation Paste | | Cation Exchange Capacity (CEC), meq/100g | | Exchangeable Sodium percent (ESP) | | Electrical Conductivity (ECe), mmhos/cm at 25°C | | Heavy metals in soils |
|---|---|---|---|---|---|---|---|---|
| Less than 4.2 | To acidic for most crops to do well | Less than 10 | Sandy Soil (limited adsorption) | Less than 4 | Very Good | Less than 2 | No salinity problem | Heavy Metals in soils like (B, Cd, Cu, Cr, Co, Fe, Mn, Ni, Pb, Se, Zn, etc. should be estimated. There is no guideline related to the health risk, however important because of movement of dust particles through winds, dissolution, percolation in ground waters and mixing through runoffs in surface and ground waters and also toxicity effects on plants, animals and humans due to consumption and accumulation through Ingestion, inhalation and adsorption |
| 4.2-5.5 | To acid-tolerant crops | 11-20 | Silt loam (moderate adsorption) | 4-10 | Satisfactory | 2-4 | Restricted to salt sensitive crops | |
| 5.5-8.4 | Suitable for most crops | Greater than 20 | Clay and organic soils (high adsorption | 11-20 | Reduced permeability in fine textured soils | 4-8 | Restricted growth of many crops | |
| Greater than 8.4 | Too alkaline for most crops indicates a possible sodium hazard | | | Greater than 20 | Reduced permeability in coarse textured soils | 8-16 | Restricted growth of all but salt tolerant | |
| | | | | | | Greater than 16 | Only a few salt tolerant crops experience satisfactory growth | |

*Source : ICAR manual for soil testing*

**Table 3 : Classification of soil quality based on ECe, ESP and pH**

| Sr. No. | Soil Parameters | | | Soil Class and Associated Problems |
|---|---|---|---|---|
| | **pH** | **ECe** | **ESP** | |
| 1. | 8.5 | 4.0 | 15 | Saline soil, salt concentration interferes with the growth of most crops, exchangeable sodium does not alter physical soil characteristic, soil generally flocculated |
| 2. | 8.5 | 4.0 | 15 | Sodic soil (non-salme alkali soil), high exchangeable sodium interferes with growth of most crops, drainage and aeration and poor, soils are mostly dark brown in colour and deflocculated |
| 3. | 8.5 | 4.0 | 15 | Saline sodic soil; high concentration of soluble salts and exchangeable sodium, interferes with crop growth. |

*Soruce : ICAR Manual for soil testing*

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