Original Research Article

Effect of UG coal mines on the soil quality of sohagpur area of Shahdol MP, India

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Abstract

This paper deals with the studies on soil quality parameters of Shagpur area of Shahdol affected by acid mine drainage of coal mines from January 2016 to March 2016. Discriminant analysis on normalised major and trace element data of soil, mining site samples suggested a clear discrimination between chemical data of soil, ore and phyllite samples. It has been observed that the soil quality in mostly affected areas have relatively pH (6 ± 7.3), low nutrients (nitrogen, phosphorus and potassium) content, organic carbon (0.30 ± 1.50) and which has decreased gradually from coalmine unaffected and affected areas. Certain heavy metals in high concentration (Fe, Zn, and B) were also detected from soil of the area. Soil damage and environment degradation during surface mining is inevitable as vegetation and top soil have to be removed and waste rocks are to be shifted to a new location. Mining leads to loss of grazing and fertile land, soil erosion, sedimentation or siltation, danger to aquatic life, damage to flora and fauna as well as water and soil pollution.

Key Words: Soil quality parameters, chemical data, soil damage, Coal Mines.

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INTRODUCTION

Shahdol district is predominantly a tribal district, situated in the eastern part of Madhya Pradesh. This district is situated between 23°00' N and 24°18'N latitude and 81°00' E to 82°00' E longitude, extending 100 Kms. from East to West and 141 Kms. from North to South. The District is located in the north-eastern part of the Deccan Plateau. It lies at the trijunction of Maikal Ranges of the Satpura Mountain, the foot of the Kaimur Range of the Vindhyan Mountain. In between these hill ranges lies the narrow valley of the Son and its tributaries. Physiographically, structural landforms, represented by plateau and low lying plains with average altitude of 450m to 500m above MSL, are developed in northern, northeastern and northwestern and central parts of the district. In the southern part of the District, hills and highlands of Maikal Range and high to medium level (500m to 990m) plateau and flat topped, step like terraces are developed. Fluvial Land Forms represented by flood plains are present along the western boundary of the district. The maximum elevation of the area is 1123m above mean sea level at Singingarh Hill (23°03’40”: 81°27’37”) in Satpura hills, in southern part of the district. The soils in the area are generally of clayey loam types with sandy loam soil in some areas. In the northern and central parts of the District, the undulating plateau with mounds are covered with slightly deep soil, well drained, fine to fine loamy soils on gentle slopes marked by moderate erosion. The southern hilly region is covered by very shallow loamy soils, some- what excessively drained. The soils developed on moderately steep slopes are marked by severe erosion. The soils have been classified as Ustocherpts/ Ustorthents/ Rhodustalfs/ Haplustalfs/ Haplusterts, as per pedological taxonomy. Sohagpur coal field is the main coal mining area of the district. There are 71 village which fall in the various coal fields of the district. South Eastern Coalfields Limited (SECL) is the largest coal productivity company of India. It is one of the eight fully owned subsidiaries of Coal India Limited (CAL). The Company has its head Office at Bilaspur. The Coal reserves of South Eastern Coalfields Limited are spread over two states namely CG and MP and the company is operating 89 mines, 35 mines in the state of M.P. and 54 mines in the state of CG. Beside a coal carbonization plant namely Dankur Coal Company (DCC) at Dankuni in West Bengal on lease basis from Coal India Limited. Due to improper and unscientific management as well as exploitation of forest to yield high revenue, there has been a regular degradation in forest quality and its coverage during the pre independence period. Deforestation has been also caused by large scale mining of coal through open cast system and rehabilitation and construction of residential colony surrounding mine area. In Shahdol district there has been tremendous depletion of the forest cover in the recent past due to heavy human interference. After Independence, survey and demarcation was carried out but the ecological degradation could not be controlled due to natural influence of unfavorable geological formation and human interference. Underground and opencast excavations behave as large sinks and create hydraulic gradient towards the mine. Mine water is pumped out for trouble free mining operations. Continuous withdrawal of water from Coal mines for their mining activities is causing adverse impact on soil quality of the area which ultimately results in declining physico-chemical properties of soil of surrounding area.

Study Area: Sohagpur Coalfield is located in Shahdol district in the Indian state of Madhya Pradesh in the basin of the Son River. Sohagpur area is one of the prestigious area of SECL. The area head Office is location in Shahdol district Post Office Dhanpuri. Sohagpur coalfield is spread over an area of about 3,100 Square Kilometers (1,200 Sq. mi) and has estimated reserve of 4,064 million tones. The sohagpur coal mines are a 5 million ton-per-annum (MTPA) network of mines on the sohagpur coalfield in M.P. State India. The Sohagpur coal field comprises 6 sub areas

1. Amlai-Bangwar and Damni Sub area
2. Dhanpuri Open cast Mine.
3. Amlai Open Cast Mine.
4. Sharda Open Cast Mine.
5. Rajendra and Navgma UG Mine.
6. Burhar Sub-area.

Sampling Site: The present study area belongs to Sohagpur Coal field Shahdol under South Eastern coalfields Limited (SECL) M.P. India. The study has been carried out in two underground coal mines and their adjoining areas. This study area falls within the survey of India is bounded within co-ordinates 23^{0}9'48"N, 81^{0}26'24"E. The soil samples are collected from the Damini UG Coal mines and Bangwar UG Coal mines. The details of the sample collected are as presented in table

Table 1: Soil Samples with their respective Location and Identity

Sr. No.	Location	Sample ID	Date of Collection
1	Damini UG Coal Mine	S_1	08/02/2016
2	Damini UG Coal Mine	S_2	08/02/2016
3	Damini UG Coal Mine	S_3	08/02/2016
4	Bangwar UG Coal Mine	S_4	09/02/2016
5	Bangwar UG Coal Mine	S_5	09/02/2016
6	Bangwar UG Coal Mine	S_6	09/02/2016

MATERIAL AND METHODS

Soil Sampling And Handling:

1. Divide the field into separate units depending on variation in slope, colour, texture, crop growth and management.
2. Remove the debris, rocks, gravels etc from the surface before collecting soil sample.
3. Make a V-shape cut into the soil to a depth of sampling (0-15 cm) and obtain 2 to 3 cm thick vertical slices along the depth.
4. Collect 10-15 samples from each field randomly in zig-zag manner.
5. Mix the samples by quarterly method and approximate 500 g of soil samples is to be retained.
6. The samples must be kept in a clean cloth or polythene bag.
7. Label it with suitable description and identification marks.
8. Send the soil samples to soil testing laboratory along with the information sheet.

B: Preparation Of Soil Sample For Testing:

1. Spread the sample for drying on clean, cloth, and plastic or brown paper sheet.
2. Remove the stone pieces, roots, leaves and other un-decomposed organic residues etc. from the samples.
3. Large lumps of moist soil should be broken.
4. After air drying, the samples should be crushed gently and sieved through a 2mm sieve.
5. About 250 g of sieved sample should be kept in properly labeled sample bag for testing.

C: Precautions To Be Taken During Collection Of Soil Sampling

1. Remove add debris from surface before collection of soil sample.
2. Avoid taking sample from upland and low land areas in the same field.
3. Take separate sample from the areas of different appearances.
4. In row crop take sample in between rows.
5. Keep the sample in a clean bag.
6. A sample should not be taken from large area.

7. Sample for micro-nutrient analysis must be collected by steel or rust free Khurpi/auger and kept in clean polythene bag.

The Laboratory and its premises should be kept clean to avoid any type of contamination. The tap water supplied to the analytical laboratory should be completely free from soluble and insoluble matters. This can be safely used for general purposes and for certain analyses like physical properties of soil. For micronutrient analyses, double or triple distilled water produced from all glass stills, free of metals should be used. Methods used in the analysis of Soil are as follows-

1. **Determination of Soil pH:** pH meter with reference and glass electrode or combine electrode.
2. **Determination of Electric Conductivity:** The electrical conductivity is measured with the help of Saltbridge and conductivity meter.
3. **Determination of Organic Carbon:** WALKLEY-BLACK METHOD (WALKLEY AND BLACK 1934).
4. **Determination of Available Nitrogen in Soil:** ALKALINE POTASSIUM PERMANGANATE METHOD (SUBBIAH AND ASIJA 1956)
5. **Determination of available Phosphorus:** P in the soil extract is determined calorimetrically using a photoelectric calorimeter after developing blue colour, the intensity of which various with the P concentration.
6. **Determination of Available Potassium:** The available potassium that is water soluble and exchangeable potassium is determined by extracting soil with neutral normal ammonium acetate. The estimation of potassium in extract is carried out by flame photometer.
7. **Determination of Available Sulphur in soil:** The So_4–S in soil extract is determined calorimetrically by developing $BaSO_4$ turbidity in the presence of salt buffer.
8. **Determination of Available Zinc in soil:** DTPA Method. Diethylene Triamine Penta Acetic acid (DTPA) a suitable chelating agent is able to extract zinc in a manner absorbed by the crop plants. The quantitative determination of Zinc is carried out by atomic absorption spectrophotometer.
9. **Determination of Available Boron in Soil:** Azomethine H forms colored complex with H_2BO_3 in aqueous media. Over a concentration range of 0.5 to 10 ug B/ml the complex is stable at pH 5.1. Maximum absorbance (Spectrophotometer) occur at 420 nm with little of no interference from a wide variety of salts. This technique is rapids, reliable and more convenient to use than traditional procedure employing carmine, curcumin or quinalizarin (John *et al*, 1975).
10. **Determination of Available Iron in Soil:** DTPA Method. Flame the standard on an atomic absorption spectrophotometer wavelength of 248.3 nm (Fe line of the instrument).

OBSERVATION AND RESULTS

Table 2: Standard values for soil according to IISS bhopal

Parameters	Low	Normal	medium	Good	High
pH		6.5-7.5			
EC		Less than 1%dsm^{-1}			
OC	Less than 0.5%		0.5%-0.75%	More than 0.75%	
Available Nitrogen	Less than 250kg/ha.		250-400		400-600
Available Phosphorus	Less than 10kg/ha		10-20 Kg/hg		>25kg/ha
Available Potash	Less than 140kg/ha		140-280		280
Available Sulphur	Less than 10ppm		10-15ppm		>15ppm
Available Boron	<0.5ppm			>0.5ppm	
Available Zinc	<0.6ppm			>0.6ppm	
Available Iron	<5ppm			>5ppm	

Table 3: Chemical Properties of mine Soil in proposed Coal Mine area

Parameters	pH Units %	OC %	E C %
S_1	6.6	0.30	1.3
S_2	7.3	0.90	0.41
S_3	7.2	0.60	0.25
S_4	5.7	1.20	0.16
S_5	5.3	1.50	0.15
S_6	7.2	0.60	0.20

Table 4: Available nutrient in Mine Soil of proposed Coal mine Area

Parameters	Available N	Available S	Available P	Available K
Units	$Kgha^{-1}$	ppm	$Kgha^{-1}$	$Kgha^{-1}$
S_1	143	157	1.64	425.6
S_2	315	3.88	1.19	429
S_3	240	11.6	0.34	436.8
S_4	360	6.75	0.84	309.1
S_5	413	13.3	2.49	440
S_6	240	2.65	2.93	308

Table 5: Micronutrient of Mine Soil in Proposed Coal Mine Area

Parameters	Available Fe	Available Zn	Available B
Units	ppm	ppm	Ppm
S_1	22.1	1.08	1.15
S_2	2.91	0.22	0.82
S_3	6.15	0.33	0.64
S_4	29.6	0.36	0.46
S_5	32.2	0.14	0.80
S_6	19.0	0.72	0.01

RESULTS AND DISCUSSIONS

The effect of soil pH is great on the solubility of minerals or nutrients. Hydrogen ion concentration during the period of soil testing ranges from 5.3- 7.3. The soil sample 1st (S_1) has the lowest value of pH while the highest value recorded for S_2. S_4 and S_5 belongs to acidic soil category as observed by graph having pH value 5.7 and 5.3 repectively. Amount of soluble salts in a sampe is expressed in terms of the electrical conductivity (EC). The standard value of EC is less than on (<1% dsm^{-1} normal). By analysing soil samples it has been found that, EC ranges from 0.2- 1.3 dsm^{-1}. As clearly seen in graph that only sample first is showing slight increase in EC against the Standard Value other than that all samples belongs to below the range of standard. Organic Carbon place a major in deciding biological activity as well as fertility of the soil.Standard value of organic carbon is 0.5% to 1.0%.OC % for all analyzed samples is ranges from 0.3 – 1.5. this result shows that all collected samples are rich in Organic Carbon except sample first which has the lowest OC% as shown in graph.This sample is indicating about the deficiency condition of OC%. Sulphur occurs in soil in both organic and inorganic forms but only a fraction of it is available for crop growth. Direct uptake of sulphur by plants occurs largely as inorganic sulphate. Avail S concentration for all samples ranges from 3.88- 157 mg/kg. A great variation in Avail. S has been observed for collected samples against the standard value. S_2, S_4,S_6 belongs to low category of soil in terms of avail. S while S_3 and S_5 is showing adequate availablity of S. Apart from all that S_1 is showing drastic increase in S concentration which is surely at the toxic level. This is beause of coal mininig activity.

Table 6:

Iron	Rating
<4.50	Low
4.51-9.0	Medium
>9.0	High

The standard value of iron from 4.5 to 9.0 $mgkg^{-1}$. Avail. Fe concentration for all samples ranges from 2.91 – 32.2 mg/kg. a remarakble variation has been shown in Fe concentration for all samples. S_2 has low conc of Fe while S_3 belongs to medium.S_1, S_4, S_5, S_6 has very high concentration of which is not an indication of Healthy soil. It is clearly observed that as by produt Fe is emmiting through mining activities and polluting soil at very large extent and also harmful for plant and human health.

Table 7:

Zinc	Rating
<0.30	Very low
0.31-0.60	Low
0.61-1.20	Medium
>1.20	High

The standard value of zinc is 0.61mg/kg^{-1} to 1.20 $mgkg^{-1}$. Available zinc value ranges of from 0.14 $mgkg^{-1}$ to 1.08$mgkg^{-1}$. Availibilty of Zn is not adequate for samples S_2,S_3,S_4,S_5 as required by plants. These sites are showing Available Zn defeciency. Only S_1 showing incresement in Zn Concentration which is due to the mining effect. Soil Nitrogen in the soil is the most important element for plant development. It is required in large amounts and must be added to the soil to avoid a deficiency. Ideal soil should have quality of nitrogen in soil is 250/$Kgha^{-1}$ to 400 $kgha^{-1}$ this range in medium range.Sample S_3 and S_6 showing slight deficiency of N availabilty. Sample S_2,S_4,S_5 belongs to good N availibity soil category which is good for plant health. Only Sample 1 is showing remarkable deficiency of avail. N. the possible reason of deficiency is that other elements prohibiting the free availbity of N to Soil. Phosphorus is one of the major nutrients required for plant growth. It originates in the soil both in the inorganic as well as in the organic form plants absorb phosphorus in ionic form from soils. It is available in different ionic form in the soil solution.The standard range of available phosphorus is 11-20 $Kgha^{-1}$. Avail P concentration ranges from 0.34- 2.93 kg/h for all analyzed samples.By observation of result and graph it has been found that all collected samples are highly defiecient in Avail. P concentration compared to standard value for good soil. In soil potash is found in four form that is water soluble exchangeable, non-exchangeable and lattice potash. Out of these first two are easily available to the plants and constitute approximately 1.0% of the total Potassium present in the soil.Availlable Potassium value for all collected samples ranges from 308-440 kg/h. The standard limit of K for healthy soil is 140 kg/h. recorded data showing that all samples have very high concentration of K in soil which is not that good for soil. The standard value of Boron is 0.50 to 1.00 mg/kg. The recorded for avail B ranges from 0.01 -1.15 mg/kg for all soil samples.Sample S_2 –S_5 belongs are showing adequate B concentration but S_6 has extream deficiency stage of avail zn while S_1 has high concentration than prescribed limit and compared to other samples.

CONCLUSION

The soil samples from two UG coal mines and surrounding area was analyzed and compared to the prescribed limit for interpreting the soil health and status of nutrient. Most of the parameters in the samples are either very less and very high as per the standards. The available phosphorus quantity in the all over soil samples are in the very low range. It has been found by observation of reslut that soil around mining area is not showing a good and healthy picture of soil. All parameters are showing variation but they are not following any regular pattern in variation.Soil of collected area showing contamination of Sulphur, Iron, Potassium as they are recorded in very high concentration after analysing soil samples. Sample site 1 is showing significaant variation for almost all samples which indicating that this site is highly affected by mining activities of surrounding areas.So after the results of soil quality monitoring we can say that the soil quality around the UG coal mines is degraded day by day due to the mining activity so we should take some steps for save the quality of soil. Soil erosion in general occurs when rains are heavy and flow of water through the field occurs with high velocity. This erosion by water is accelerated due to defective method of cultivation, burning or destruction of forest for shift cultivation, excessive grazing by animals, inadequate precipitation etc. As a result. Vegetation cover is reduced and soils are exposed to erosion. Thereby fissures and gullies are formed within cultivated areas through which rain water flows and carries away the fertile soil. There is thus a need for a scientific approach for implementing soil conservation measures. To begin with the task of reviving unproductive land into productive land, proper and improved technology of plantation vis-a-vis protection of land against varieties of erosion can lead to a successful programme of afforestation in this district. Vast tract of waste land needs reclamation.

Health Effects of Mining: Pneumoconiosis, black lung disease or CWP, is caused when miners breathe in coal dust and carbon, which harden the lungs. Estimates show that 1,200 people in the US still die from black lung disease annually. The situation in developing countries is even worse. Cardiopulmonary disease, chronic obstructive pulmonary disease, hypertension, lung disease, and kidney disease have been found in higher-than-normal rates among residents who live near coal mines according to the study. Toxic levels of arsenic, fluorine, mercury, and selenium are emitted by coal fires, entering the air and the food chain of those living nearby. Mine collapses and accidents kill thousands of workers around the world every year.

Suggestions: Mining activities decreses the soil quality by altering nutrient concentration and by increasing metal concentration in soil of surrounding areas. Here are some suggestion to improve soil quality:

1. Nitrogen fixing leguminous plants like Acacia Auriculiformis show rapid growth by broad casting seeds of shrubs and grasses around mining dumps and helps in improve soil quality.
2. To minimise matallurgical effluent affect on soil, pickling operations and ion-exchanges promise the recovery of metals from wastes.
3. Support in afforstation, fuel wood conservation and sociel fencing help in soil reclamation.
4. By acccelarating natural regeneration.
5. By storing of top soil.
6. By recycling of all metallic wastes and promotion of acceptable substitute will reduce the potential hazard and help to achieve sustainability in the long run.
7. By planting soil indicator plants :-
8. Soil indicator plants indicate or reveal the nature of the soil on which they grow.

Alkaline soils are indicated by the presence of Anabasis saisa microphylla and others halophytes conataining more Na^+, K^+, than Cl^- and $SO_4{}^{2-}$ ions. Plants species such as agrotis, festuca, and impatiens are used as mettalic tolerence indicator.

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