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Impact of open cast coal mining on physico-chemical characteristics of soil in Jharia coalfield and its comparative study with the soil of non-mining areas (Baliapur and Sindri) of Dhanbad, Jharkhand

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Abstract : Jharia coalfield is one of the most important source of prime coking coal in our country. Coal is being considered as the very important fossil fuel resource that is found in Jharia. Coal has a major role in fulfilling the energy requirements. Open cast mining is used on large scale for coal extraction but open cast mining activities involve so many harmful activities which affect the top soils very badly. Due to blasting, drilling and quantity of explosives used for open cast mining activities the nutrients quality and microbial activities of the soil system gets highly disturbed. Open cast mining also causes the loss of bio-diversity as it releases huge amount of mining wastes to the upper part of the land surface as overburden dump materials. It is also the reality that in our country most of the coal production takes place just due to open cast mining. The open cast mining activities cause various kinds of environmental degradation, loss of soil fertility and ecological changes as well. This paper presents the results of the study carried out in mining areas i.e. Bastacola and Lodna. The soil characteristics have been compared with soil characteristics found in non-mining areas like Baliapur and Sindri. It has been observed that the soil quality of mining areas have comparatively low pH, low moisture content and high electrical conductivity. The present comparative study of soil are very vital to understand that how open cast mining activities are damaging the ideal physico-chemical characteristics of soil. The obtained results are also very beneficial for planning the rehabilitation programmes for Jharia coalfield.

Keywords : Overburden materials, Coal mining, Open cast mining, Bulk density, Top soil

INTRODUCTION

India is the 3rd largest producer of coal in the world. It has also the 4th largest reserve of coal in the world (approx. 197 billion tons). Generally two types of mining methods are being adapted. One is open cast mining and the other is underground mining method. Both are responsible for degradation of ecological balances. Due to open cast mining the upper most layer of soil gets highly affected. Open cast mining causes the formation of overburden dumps. Overburden dumps are environmentally very unstable and become the source of pollution if suitable controlling measures are not taken (Maity 2005). Natural rocks and soils are drastically destroyed due to open cast mining activities. Open cast mining causes adverse ecological impact by the depletion of flora as well as faunal population by the loss of fertile soil, as the original vegetation is completely disturbed. Due to open cast mining activities the natural vegetational succession becomes very slow if compared with areas where soil layers are in the natural sequence(Bradshaw & Chadwick 1980, Marrs et al 1981 & Roberts et al 1981)

It is estimated that approximately 750 hectare land per year is required for overburden dumps around mining areas (Kundu & Ghosh 1994). In recent years increasing emphasis on open cast mining has resulted in and unprecedented increase in waste dumps in India. Mine spoil causes adverse conditions for soil microbes and plant growth due to their low levels of organic matters and other

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essential nutrients, unfavorable soil chemistry poor structure (either coarse or compact) and isolation from vegetation (Meyer 1973 & Mckell 1979). The overburden dumps change the natural topography. It also affects the drainage system of soil and prevent natural succession of plant growth. Due to open cast mining dump materials are left over the land in the form of overburden dumps which occupy large amount of land. Due to this the affected land looses its original utility and the quality of the affected soil also gets degraded (Barpanda et al 2001) . It has been observed that due to the impact of overburden materials the soil usually have great deficiency of major nutrients. Thus the affected areas do not support ideal conditions for plantation. The physico-chemical properties of mining areas are site specific hence they differ from one sampling site to another due to different geological deposit of rocks.

MATERIALS AND METHODS

Study ares

Jharia coalfield is the only store house of prime coking coal in our country. Jharia coalfield is not only important for us but it has great international recognition as well. Mining of coal in the coalfield was started in 1894. Jharia coalfield has been extensively explored and exploited. Presently it is still one of the leading contributors to India's coal production.

By 1923, the importance of Jharia coalfield was identified and structure of this coalfield was investigated. C.F. Fox mapped the coalfield in detail during 1926. Later A.B.Dutt, P.K.Gosh and K.Balu of GSI surveyed different parts of the coalfield during 1946-49. Jharia coalfield is the most attractive area for mining because it has one of the highest concentrations of thick coal seams in the world ranging from 50cm. to 30cm. in thickness at relatively short depth. The mining area which are occupied in Jharia coalfield are of 7.2% of the total area (Raju 1999). The map of study area is shown in fig.2

Bastacola area no. ix and Lodna area no. x of Jharia coalfield have been selected to study the impact of open cast coal mining for the physico-chemical characteristics of the soils. From Bastacola Area No.IX, five sampling sites have been selected. From Lodna Area No. X again five different sites have been selected to study the impact.

Baliapur and Sindri were also selected to study the physico-chemical characteristics of the soil. These two areas are belonging to non-mining area. From Baliapur and Sindri again five different sites have been selected to study the physico-chemical characteristics of the non-mining soil.

Sampling of mining and non-mining soils

The soils of mining areas i.e. Bastacola and Lodna include sand stone and various other impurities. To collect soil samples from mining areas following tools were needed-

a. Soil auger- It may be a tube auger, post hole or screw type auger or even a spade for taking samples.
b. A clean bucket or a tray or a clean cloth for mixing the soil and sub-sampling.
c. Cloth bags or polythene bags of specific size.
d. Copying pencil for markings and tags for tying cloth bags.
e. Soil sample information sheet.

The samples from mining and non-mining areas were collected manually by using above mentioned tools. The soils were collected by digging it upto the depth of 0-20cm.The collected soil samples were very carefully brought to the laboratory situated at B.I.T. Sindri, Dhanbad ,Jharkhand for physico-chemical analysis. The samples collected were air dried, cleaned, crushed in mortar and pestle and passed through 2mm mesh sieves and then analyzed very minutely.

Analysis of mining and non-mining soils

Gravimetric method was prominently used to determine the bulk density for both mining and non-mining soils. pH and electrical conductivity were determined by pH meter and conductivity meter respectively. The organic matter present in the soils of mining and non-mining areas was determined by using the Walkley Blake Method (Nelson & Summer, 1982). The available Nitrogen was determined by the alkaline potassium permagnet method (Keeney & Bremer, 1966). The available phosphorus contents for both mining and non-mining soils was also determined by Bray method (Bray & Kurtz, 1966).

RESULT AND DISCUSSIONS

The table given below describe the physico-chemical analysis for both mining and non-mining areas-

KOCP GOCP NTOCP STOCP

FIG.1. Over burden dumps of JCF(KOCP-Kuiya Open Cast Project, GOCP-Ghanuadih Open Cast Project, NTOCP-North Tisra Open Cast Project, STOCP-South Tisra Open Cast Project.

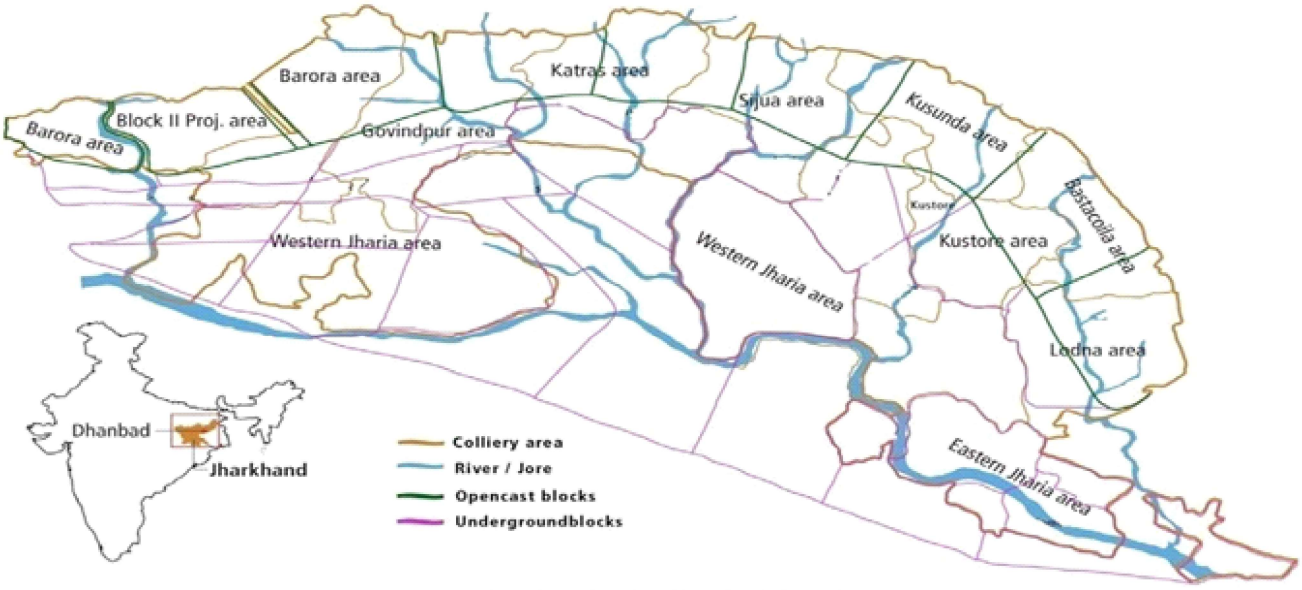

FIG.2. Map showing the details of mining sites of JCF

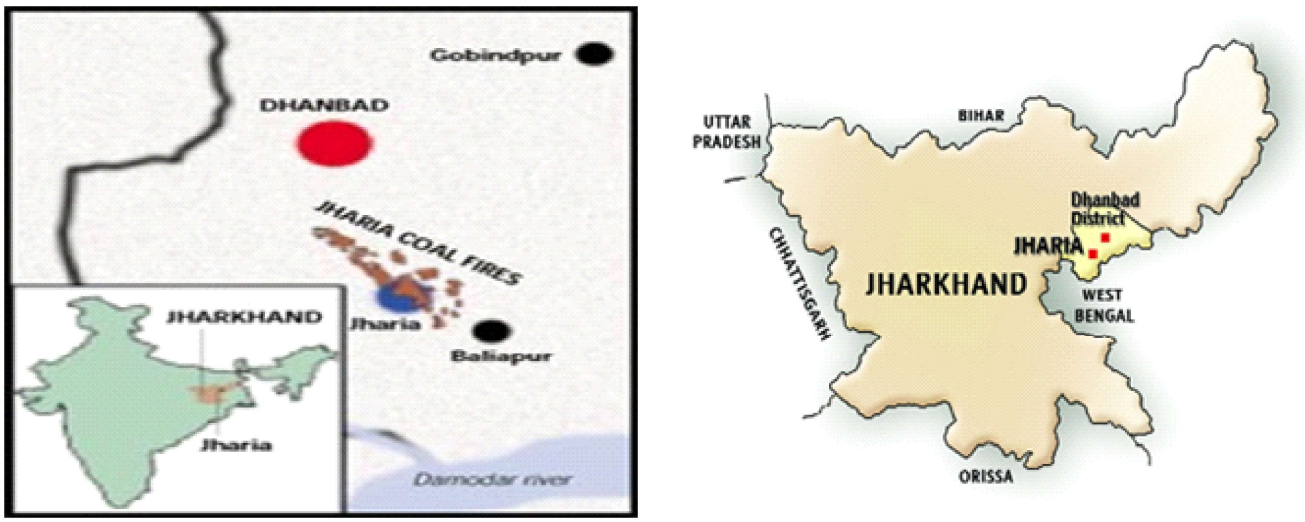

FIG.3. Collecting samples from mining and non-mining areas.

SAMPLE CODE	LOCATION	AREA	BULK DENSITY (gm/cc)	pH	EC (mmhos/ cm)	ORGANIC MATTER (%)	PRESENCE OF NITROGEN (kg/ha)	PRESENCE OF PHOS PHORUS (kg/ha)	SITE DETAILS
MS1	KUIYA OPEN CAST AREA, BASTACOLA AREA NO. IX	JHARIA COALFIELD	1.55	4.7	0.64	0.22	62.22	3.68	POOR VEGETATION
MS2	GOLAKDIH OPEN CAST, BASTACOLA AREA NO. IX	JHARIA COALFIELD	1.58	4.1	0.62	0.31	66.72	3.89	POOR VEGETATION
MS3	BERA OPEN CAST, BASTACOLA AREA NO. IX	JHARIA COALFIELD	1.53	4.4	0.69	0.26	71.21	4.67	POOR VEGETATION
MS4	GHANUADIH OPEN CAST, BASTACOLA AREA NO.IX	JHARIA COALFIELD	1.61	4.2	0.77	0.29	87.34	4.12	LOW VEGETATION
MS5	KUSUNDA OPEN CAST, BASTACOLA AREA NO. IX	JHARIA COALFIELD	1.69	4.9	0.86	0.36	68.65	3.31	LOW VEGETATION
MS6	GINAGORA OPEN CAST, LODNA AREA-X	JHARIA COALFIELD	1.59	5.5	0.89	0.19	72.44	5.17	POOR VEGETATION
MS7	SOUTH TISRA OPEN CAST, LODNA AREA NO. X	JHARIA COALFIELD	1.60	5.3	0.81	0.28	63.42	4.98	POOR VEGETATION
MS8	NORTH TISRA OPEN CAST, LODNA AREA NO. X	JHARIA COALFIELD	1.67	5.2	0.74	0.34	79.12	3.82	POOR VEGETATION
MS9	KUJAMA OPEN CAST, LODNA AREA NO. X	JHARIA COALFIELD	1.54	5.4	0.63	0.20	73.48	4.61	LOW VEGETATION
MS10	CENTRAL SURUNGA OPEN CAST,LODNA AREA NO. X	JHARIA COALFIELD	1.63	5.8	0.90	0.40	82.67	5.42	POOR VEGETATION
NMS11.	D.A.V. SCHOOL,RANGAMATI, BALIAPUR	BALIAPUR (NON-MINING AREA)	0.44	5.8	0.30	0.49	102.31	5.62	VERY GOOD
NMS12.	BAGHMARA VILLAGE, BALIAPUR	BALIAPUR (NON-MINING AREA)	0.51	6.1	0.35	0.58	97.48	5.98	EXCELLENT
NMS13.	KRISHI VIGYAN KENDRA, BALIAPUR	BALIAPUR (NON-MINING AREA)	0.46	5.9	0.38	0.61	121.22	4.42	EXCELLENT
NMS14.	SAMLAPUR VILLAGE, BALIAPUR	BALIAPUR (NON-MINING AREA)	0.53	6.3	0.29	0.79	108.72	6.13	VERY GOOD
NMS15.	HAWAIPATTI, BALIAPUR	BALIAPUR (NON-MINING AREA)	0.42	6.6	0.31	0.72	113.61	5.87	EXCELLENT
NMS16.	ROHRABANDH,SINDRI, F.C.I. HOSP.	SINDRI (NON-MINING	0.71	7.1	0.36	0.47	95.71	6.89	VERY GOOD

		AREA)							
NMS17.	MANOHARTAND VILLAGE, SINDRI	SINDRI (NON-MINING AREA)	0.77	6.4	0.40	0.81	112.65	6.57	GOOD
NMS18.	S.P.M. COLLEGE, SINDRI, DOMGARH	SINDRI (NON-MINING AREA)	0.80	6.9	0.33	0.77	129.32	5.97	VERY GOOD
NMS19.	P.D.I.L.,SINDRI, SAHARPURA GATE	SINDRI (NON-MINING AREA)	0.81	6.8	0.41	0.64	89.68	6.01	GOOD
NMS20.	SINDRI BASTI, SINDRI	SINDRI (NON-MINING AREA)	0.79	7.3	0.43	0.82	126.81	6.98	EXCELLENT

Table.1 Showing physico-chemical analysis for both mining and non-mining areas.(MS-Mining sample, NMS-Non-mining sample,EC-Electrical Conductivity.)

BULK DENSITY OF MINING AND NON-MINING SOILS

The bulk density is the mass of soil content per unit volume. In mining area the bulk density varied from 1.53 gm/cc to 1.69 gm/cc.

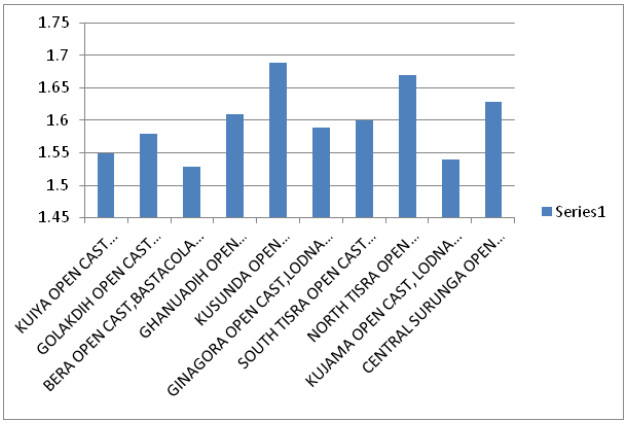

FIG.4.(Graph showing the bulk density of mining areas)

Similarly we found that bulk density in non-mining soil samples varied from 0.42 gm/cc to 0.81 gm/cc.

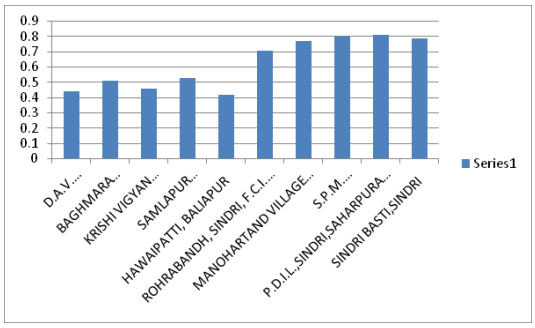

FIG.5. (Graph showing the bulk density of non-mining areas)

In mining area the minimum value (1.53 gm/cc) of bulk density was observed at Bera open cast, Bastacola Area no. IX site. This is just because of high organic matter content present in collected sample (Leelavathy et al 2009). The maximum value (1.69 gm/cc) of bulk density was found in Kusunda open cast , Bastacola Area No. IX of mining area. The high bulk density is due to the presence of movements of heavy earth moving machinaries (HEMMs), big dumpers water tankers and less amount of grass cover.

The bulk density of soils collected from mining areas show high bulk density in comparison to the bulk density

of the soils of non-mining areas. The high bulk density value of the soils can not be used for proper vegetation and plantation growth.

pH OF MINING AND NON-MINING SOILS

The pH of the soil solution is of great importance because soil solution carries nutrients like nitrogen, potassium and phosphorus which are needed in appropriate amount by the plants to grow properly. The pH of collected soil samples from mining areas found to be low. In mining areas the pH ranges in between 4.1 to 5.8. The acidic nature of the soils found in mining areas create problems for the plants to grow ideally.

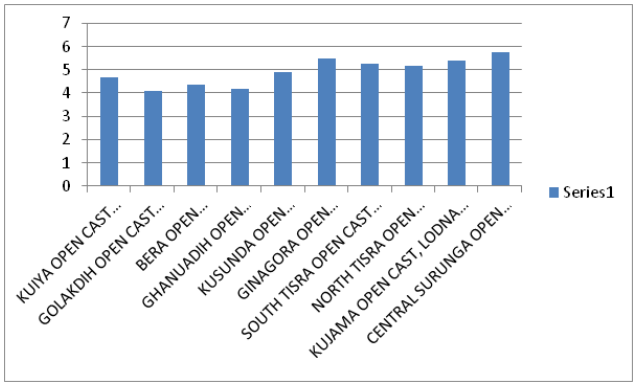

FIG.6. (Graph showing pH of mining areas)

Similarly, the pH value of collected soil samples from non-mining areas show variation from 5.8 to7.3. The pH of the soils found in non-mining areas indicate good availability of nutrients for the plants.

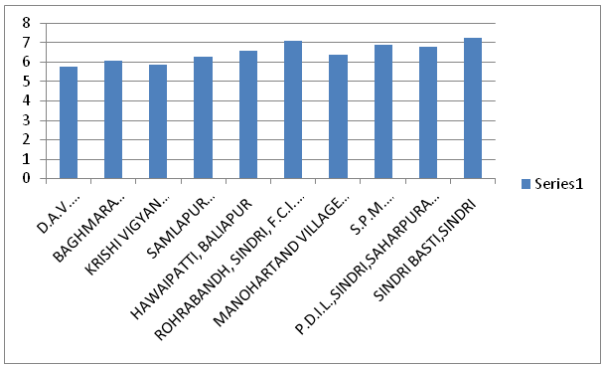

FIG.7. (Graph showing pH of non-mining areas)

When the soil solution becomes very acidic then plants fail to utilize N, P, K and other nutrients which they require. In mining areas we observe that due to acidic soil plants take toxic metals and as a result of that they die of toxicity.

ELECTRICAL CONDUCTIVITY

It is the ability of an aqueous solution to carry an electric current. The soil of mining areas i.e. Bastacola and Lodna have rock compositions which affect the electrical conductivity because the rock composition determines the chemistry of the soil. The lime stone present in the soil of mining areas leads to higher electric conductivity because of the dissolution carbonate minerals. The higher value of electrical conductivity in mining area is due to upward migration of different salt. The lower value was due to lower amount of salt present in the soil samples. The electrical conductivity in mining areas was found to be in between 0.62 mmhos/cm to 0.90 mmhos/cm in selected soil samples of Jharia coalfield. The highest value of electrical conductivity was found in soil sample collected from Central Surunga open cast, Lodna Area No. X and in the soil of Golakdih open cast, Bastacola Area No. IX lower value of electrical conductivity was found.

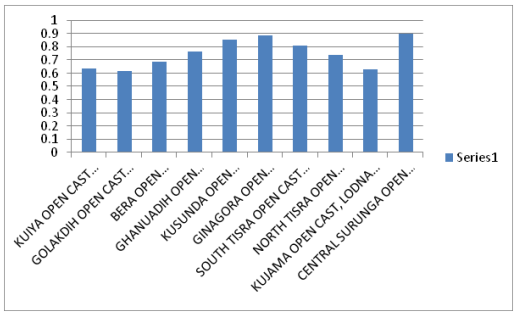

FIG.8.(Graph showing Electrical Conductivity of soils found in mining areas)

Similarly, the electrical conductivity of soils of non-mining areas were obtained. The value of electrical conductivity varied in between 0.29 mmhos/cm to 0.43mmhos/cm.

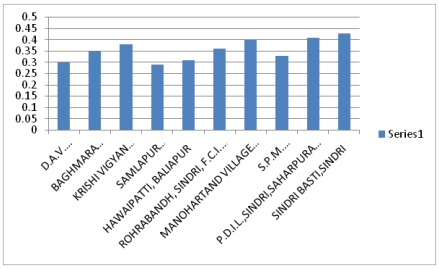

FIG.9.(Graph showing Electrical Conductivity of soils found in non-mining areas)

The higher electrical conductivity was found at Sindri Basti, Sindri and its lower value was found at Samlapur village, Baliapur.

ORGANIC MATTER

It comprises of living biomass of micro organisms, fresh and partially decomposed residues and humus. The organic matter found in soils of mining areas were ranging from 0.19% to 0.40% which indicate very less accumulation of humus matter in the selected areas of Jharia coalfield.

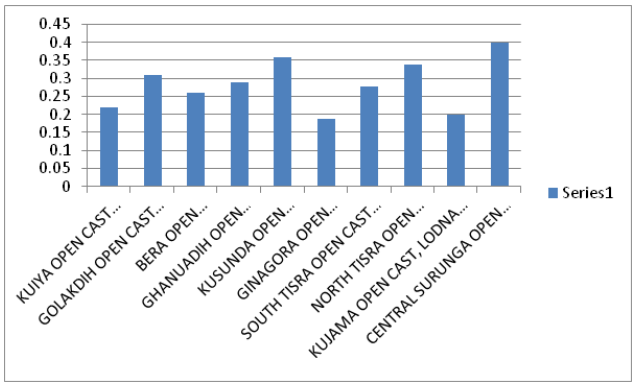

FIG.10.(Graph showing organic matter found in the soils of mining areas)

The soils of non-mining areas have more accumulation of humus matter. Hence it ranges from 0.47% to 0.82%. In non-mining areas the organic matter is present in good percentage in comparison to soils of mining areas.

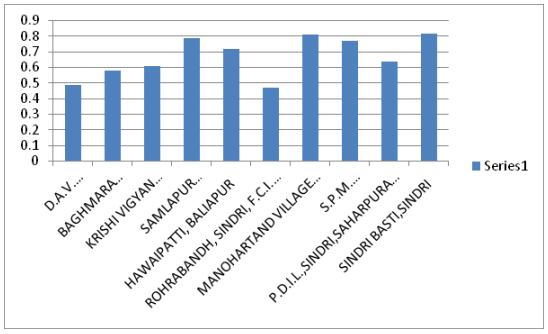

FIG.11.(Graph showing organic matter found in the soils of non-mining areas)

PRESENCE OF NITROGEN

The nitrogen is the very important element which influence the plant productivity. In the present study nitrogen was found to be ranged from 62.22 kg/ha to 87.34kg/ha in selected areas of Jharia coalfield. The available nitrogen content is found to be maximum (87.34 kg/ha) at Ghanuadih open cast Bastacola Area No, IX and lower value (62.22kg. /ha) was recorded at Kuiya open cast Bastacola Area No. IX. The available nitrogen content was found to be maximum at above mentioned site due to higher amount of mineralizable matter present in the sample. The lower value was recorded at above mentioned site due to lower rate of mineralization of the samples.

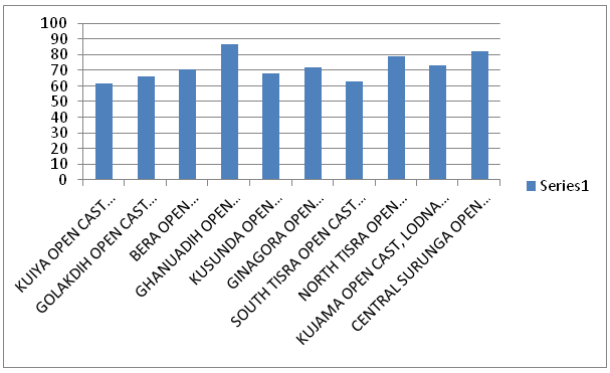

FIG.12.(Graph showing the presence of Nitrogen in the soils of mining areas)

Due to decreasing trend of organic carbon the availability of nitrogen remains poor in the soil of mining areas in comparison to the soils of non-mining areas. The soils of non-mining areas show maximum availability of nitrogen near S.P.M. College,Sindri(Domgarh) and minimum near P.D.I.L.Sindri,Saharpur Gate.

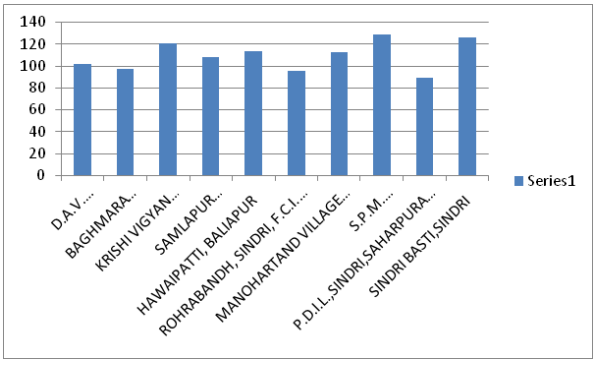

FIG.13.(Graph showing the presence of Nitrogen in the soils of non- mining areas)

The organic material and the organic carbons are found in large quantity in the soils of non-mining areas in comparison to soils of mining areas.

PRESENCE OF PHOSPHORUS

The available phosphorus of mining soils were recorded in low amount(3.31kg/ha) at Kusunda open cast, Bastacola Area No.IX. This might be due to slight acidic nature of sample which restricted the microbial action activities resulting in very poor mineralization and organic decomposition process in the mining samples.

The available phosphorus of the mining samples were recorded in high amount(5.42 kg/ha) at Central Surunga open cast Lodna Area No. X due to higher organic decomposition process in the samples.

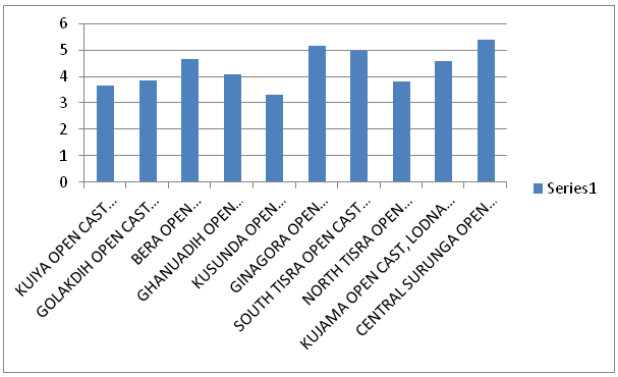

FIG.14.(Graph showing the presence of phosphorus in the soils of mining areas)

The non-mining areas were the microbial activities of the soils resulting in better mineralization and organic decomposition process. Normally in non-mining areas higher organic decomposition process is found in comparison to the soils of mining areas. So the percentage of phosphorus content is better in these soils of non-mining areas than that of mining areas.

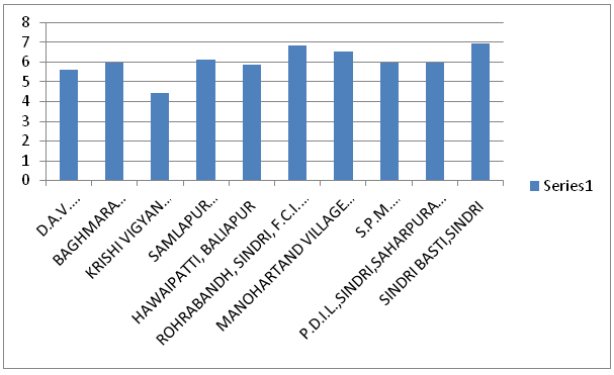

FIG.15.(Graph showing the presence of phosphorus in the soils of non-mining areas)

The phosphorus content varied in non-mining areas in between 4.42 kg/ha to 6.98 kg/ha.

CONCLUSION

When the physic-chemical characteristics of the soil of mining and non-mining areas were compared to each other then following things were observed:

1. The soil samples collected from coal mining areas are poor in organic carbon, available nitrogen and available phosphorus in comparison to the soil samples taken from non-mining areas due to lower amount of microbial activities in the soil samples collected from mining areas.
2. The microbial activities in the soil samples collected from non-mining areas are far better than the microbial activities of the soil taken from mining areas.
3. The bulk density of the soil samples taken from mining areas are of medium range which is not suitable for ideal plantation purposes but when bulk density of soil collected from non-mining areas were studied it is found that the soils are suitable for plantation purposes even without addition of fertilizers.
4. The pH value of all the sampling sites is slightly acidic in nature due to which the ideal growth of plants get severely affected in mining area but in non-mining areas such condition is not found.
5. The soil taken from mining areas are deficient in N,P, & K which require addition of extra fertilizers and manures to make the soils suitable for plantation purposes but soil of non-mining areas show moderate availability of N,P, & K.
6. The soils taken from non-mining areas are far suitable for plant growth than that of mining areas.

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