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Physico-Chemical Properties of Spoil of Different Age Series of Coalmine Overburden Dumps in Sonepur Bazari Coalmine Area, Raniganj, West Bengal

Chanchal Kumar Biswas
Assistant Professor,
Deptt. of Botany,
Banwarilal Bhalotia College,
Asansol, West Bengal.

Abstract

Physico-chemical properties are very important factors for soil health. Natural succession of plants and also microbial colonization are fundamentally depends on soil physico-chemical properties. The nature always tries to stabilize the physico-chemical parameters of disturbed land like coal mine over burden dumps for successful colonization of different biological communities. The present work deals with the Physico-chemical parameters of spoil collected from six different age series coal mine over burden dumps in Sonepur Bazari area, West Bengal, India. An age series of six over burden dumps (OBD) which were 0 (Fresh mine spoil), 4, 8, 12, 16 and 20 years old were selected and named accordingly. The amount of sand and clay was found to increase with the age of spoil, subsequently increasing water holding capacity and bulk density of the same. Initially the pH was found to 3.8 which are gradually increased to 6.32 in OBD-20. On the contrary the electrical Conductivity was gradually reduced in older OBDs. Organic carbon and total nitrogen content was increased in older OBDs. Other essential plant nutrient also increased significantly with the age of over burden dump. In conclusion it was observed that natural reclamation process is going on in the coal mine over burden dumps over a period of time.

Keywords: Colonization, Reclamation, Biological Communities, Overburden Dumps (OBD), Coalmine, Age-Series,

Introduction

Coal is the most abundant fossil fuel resource in India. The mining of Coal was started in 18th century in our country. It has a high importance for the economical growth of a country. It has been envisaged that coal demand may further increase to 620 Mt and 780 Mt in the year 2012 and 2017 respectively (Chaoji, 2002). According to the report of coal minister Piyush Goyal it is further rise by 7.5% (900 Mt) in March 2018 and in 2019 it will be increased by 10% further. Currently more than 80% of coal demand is being met by open cast mining thus disturbance of land is unavoidable. In the recent past the open cast coal mining has been creating enormous perturbations in the coal belts of West Bengal. The eventual land degradation and pollution have been damaging the vegetation as well as human health. The surface mining methods produce a dramatic change in the landscape due to large scale excavation, removal of overlying vegetation cover, topsoil and its supportive life-forms (Dash 2001). The coalmine debris is heaped in the form of dumps around the mining area and is called spoil. These dumps change the total landscape of that area and affect the drainage system of the mining area (Chaulya *et al.* 2000). The adverse physico-chemical properties tend to inhibit soil forming process and plant growth. This spoil is hostile to the growth of both plants and microbes because of impoverished organic matter content, detrimental pH, and draught arising from coarse texture or oxygen deficiency caused by compaction (Biswas *et al.* 2012). Due to the adverse physico-chemical and biological properties of mine spoil (Juwarkar *et al.* 2004), natural succession of plant species on these dumps is often prevented (Das *et al*., 2013; Ekka and Behera, 2011). Lack of vegetation cover on such dumps often leads to acute problem of soil erosion and environmental pollution (Gairola and Soni, 2010). The nature tries to restore normally by operating plant succession on spoils after certain interval of time (Borpujari 2008).

Aim of the Study

The main objective of the present study is to characterize the physico-chemical properties of over burden material of different age series of Sonepur Bazari coal mine area and to identify the changing pattern of the different physical and chemical parameters with age of the over burden dumps.

Materials and Methods

The study was carried out in Sonepur Bazari area which is covered by the surface Coal Mine Project and located in eastern part of Raniganj Coalfields, Burdwan, West Bengal, India. The geographical location of this site is at 23^0 48'' North Latitude and 87^0 47" East Longitude, the topography of which is slightly undulating and rolling marked by small ridges and valleys. The climate is tropical monsoonal with very high summer average temperature of 42^oC and a cold winter often experiencing temperature as low as 6^oC. The average rainfall amounts to 1450 mm/year. Total land acquired for this project is 2404.85 Ha including the land for over burden dumps. The average height of these dumps ranged from 0 to 50 m and excavation depth from 60 to 70 meter.

In the area of study, a series of 6 over burden dumps of different ages, was selected and named suffixing the respective age as OBD-0, OBD-4, OBD-8, OBD-12, OBD-16 and OBD-20. The over burden spoil samples were collected manually operated split tube (coring tube) from different age series OBDs during post monsoon season in the year 2018. These samples were properly packed and brought carefully in the laboratory of Department of Botany and Department of Environmental Science, B. B. College, Asansol. The samples were air dried, cleaned, crushed with mortar and pestle and then passed through 2 mm mesh sieve and then subjected to physico-chemical analysis. Porosity and Bulk density was determined as per Piper, (1966). The grain size distribution was calculated by gravimetric method by taking a fixed amount of sample passed through the sieve with, 4.75 mm, 2.00 mm, 1mm, 0.425 mm, 0.212 mm, 150 micron and 75 micron porosity, divided by the total weight of the sample (Ranjan and Rao 2000). Soil hydrological regime includes determination of water holding capacity and moisture level was carried out by the following method of Hesse, (1971). Electrical conductivity and pH was determined in soil and water suspension (1:2.5) with pocket type electrical conductivity meter (HAANA HI 98303) and pocket type pH meter (HANNA HI 98107) respectively. The organic carbon was determined by the Walkley & Blake method (Nelson and Summers, 1982). Total Nitrogen and Phosphorus estimation is done according to Jackson, (1958).

Review of Literature

Several reports are available regarding the physico-chemical properties of coalmine spoil. Malakar *et al* (2015) showed that physico-chemical properties like electrical conductivity, moisture content, water holding capacity and organic carbon content improved favouring vegetation growth while working in some mining area of Raniganj Coalfields. Sufian *et al* (2015) observed that unscientific open cast coal mining and poor post mining practices severely altered the native soil properties. The spoil soil became highly acidic and nutrient deficient which is detrimental to the growth and establishments of the plants in the Ledo colliery as open cast mining, Tinsukia, Assam, India. Pasayat *et al* (2015) showed that Physico-chemical characterization of seven age series iron mine overburden spoil revealed progressive improvement in soil texture, water holding capacity, moisture content, organic C, total N and extractable P over time while working in Thakurani iron mining area located at Noamundi in the revenue district of West Singhbhum, Jharkhand, India. Kar and Palit (2017) while working in some open cast mining area of Raniganj coalfield area showed that the coalmine overburden spoils is very poor in nutrient content and a clear seasonal variation found in physico-chemical parameters like pH, conductivity, particle density, soil porosity, organic carbon, available nitrogen, available sodium and available phosphate phosphorous. Li *et al* (2014) observed that physical Properties coal mine spoils varied largely due to its complex lithological origination. They also observed that geogenic salts and salts from rapid weathering of spoil minerals are important sources of salts in coal mine spoils. The findings of Whitlock *et al* (2015) was that several physical properties of a coal mine spoil have significant influence on the spatial distribution of vegetation classes at the study site near Llwydcoed, South Wales. Gudadhe and Ramteke (2012) studied that that *Gossypium herbaceum, Pisum sativum* and *Azadirachta indica* have maximum favorable impact on modifying physical and chemical properties of coal mine spoil.

Results

The grain size analysis showed that maximum amount of dump material is made up of gravel and sand, where as percentage of silt and clay are very low in all OBDs but increasing in relatively older OBDs. In the present study sand contribute maximum amount of grain in all OBDs followed by gravel, silt and clay (Table-1). Bulk density of dump material increased from 1.40±0.1 g/cc in OBD-0 to 1.84±0.1 g/cc in OBD-20 (Table-1). The water holding capacity also increased gradually from 24.6±2.4% in OBD-0 to 62.4±8.2% in OBD-20 (Table-1) and subsequently the porosity was also significantly increased from 32.4±3.6% in OBD-0 to 81.4±3.5% in OBD-20 (Table-1).

Table-1 Physical Characteristics of coalmine spoil collected from different age series over burden dumps.

Parameters		OBD-0	OBD-4	OBD-8	OBD-12	OBD-16	OBD-20
Texture	Gravel (%)	36.6±3	38±2.9	38±4.2	37.8±3.7	32.4±3.9	31.2±2.3
	Sand (%)	57±4.3	53.4±3.2	52±3.9	49.4±4	48±4	48.4±3.1
	Silt (%)	4.9±1.6	6.16±1.3	7.6±1.1	9.8±2	13.3±1.6	12.2±3
	Clay (%)	1.5±0.8	2.44±0.9	2.4±0.9	3±0.5	6.3±1.1	8.2±0.8

Bulk Density (g/cc)	1.4±0.1	1.42±0.2	1.50±0.04	1.52±0.2	1.76±0.1	1.84±0.1
Porosity (%)	32.4±3.7	41.6±4.7	52±4.9	62.6±4.	76.4±4.7	81.4±3.5
Water Holding Capacity (%)	24.6±2.4	41.2±2.8	41.44±7.7	42.44±7.2	48±3.7	62.4±8.2

The spoil pH also gradually increased with the age from 3.88±0.6 in OBD-0 to 6.6±0.65 in OBD-20 (Table-2) with a trend from acidic to neutral. Spoil electrical conductivity was gradually decreased with increase age of over burden dumps from 0.28±0.02 in OBD-0 to 0.13±0.03 dSm^{-1} in OBD-20 (Table-2). Organic carbon content is measured as 0.23±0.03% in OBD-0 which gradually increased to 0.52±0.06% in OBD-20 (Table-2). The total nitrogen content are measured as 0.06±0.01%, 0.06±0.01%, 0.09±0.02%, 0.15±0.02%, 0.36±0.01% and 0.57±0.09% in OBD-0, OBD-4, OBD-8, OBD-12, OBD-16 and OBD-20 (Table-2) respectively. The value drastically increased from OBD-16. As far the available phosphorus and potassium are concerned they are 28±5.36 ppm and 14.4±4.21 ppm in OBD-0 and which gradually increased to 46.2±5.26 ppm and 54.2±3.7 ppm in OBD-20 (Table-2).

Table-2 Chemical Characteristics of coalmine spoil collected from different age series over burden dumps.

Parameters	OBD-0	OBD-4	OBD-8	OBD-12	OBD-16	OBD-20
pH	3.88±0.6	4.2±0.27	4.2±0.27	4.3±0.50	5.2±0.38	6.6±0.65
EC (dSm^{-1})	0.28±0.02	0.26±0.02	0.2±0.02	0.18±0.02	0.14±0.02	0.13±0.03
Organic Carbon (%)	0.23±0.03	0.23±0.05	0.32±0.05	0.36±0.4	0.36±0.04	0.52±0.06
Total Nitrogen (%)	0.06±0.01	0.06±0.01	0.09±0.01	0.15±0.02	0.36±0.1	0.57±0.09
Phosphorus (ppm)	28±5.36	28.8±4.32	34.8±4.27	34.8±5.02	43.4±4.51	46.2±5.26
Potassium (ppm)	14.4±4.21	22.4±4.36	22.2±3.97	30.6±3.19	48.4±3.7	54.2±3.7

Discussion

The distribution of grain size of the spoil play important roles in natural plant succession. It maintains water holding capacity and bulk density of the substratum. The present analysis showed that maximum amount of dump material is made up of gravel and sand, where as percentage of silt and clay are very low in all OBDs but in increasing order in older OBDs. The low percentage of sand and clay may be due to presence of rock forming minerals. Due to higher amount of gravel and sand, the spoil of over burden dumps allow water to move downward through infiltration (Ghosh, 2002). Silt is an intermediate in size between sand and clay, but it is easily detached and transported. Clay minerals are hydrous aluminosilicates with other metallic ions. The particles of clay are very small and flaky in shape and with sufficient surface area (Ranjan and Rao 2000). The increase of bulk densities will be preventing on the growth of deep rooted plants like *Saccharum spontanium*. The increasing pattern of bulk densities may be due to vibration of heavy machinery with in mining area. Initial acidic pH may be due to leaching of basic cations. In these acidic condition H^+-ion toxicity, high availability of Al^{3+} and Mn^{2+} and scarcity of Mo are the principal plant deterrent (Suzuki *et al* 1999) in the newly dumped over burden. On the other hand the neutral pH of the older OBDs are suitable for nutrient uptake (Dutta & Agarwal 2002) and increased plant growth. Soil electrical conductivity (EC) is a measure of the amount of salts in soil (salinity of soil). It is an important indicator of soil health. The decreasing pattern of EC is a good sign for plant establishment and successful succession (Maharana and Patel 2013).

The quality of spoil with respect to organic carbon is gradually increasing as we move from younger to older OBDs. This trend may be due to accumulation of litter and their decomposition to form humus (Rai *et al.* 2011). According to Quilty & Cattle (2011) the organic carbon level less than 0.4% is considered as poor quality of soil and greater than 0.8% as good quality of soil. The nitrogen content drastically increased from OBD-16. It is a major soil nutrient for plant productivity and is generated due to various factors such as increase in organic matter content in the soil, external application of fertilizers and due to legume plants (Maiti *et. al.* 2002) which bear Rhizobia in their root nodule. Here the increased amount of nitrogen must be due to increased organic content and presence of quite a few legume spp like *Desmodium trifolium, Tephrosia purpurea, Cajanus scarabaeoides, Butea monosperma* and *Dalbergia sissoo* as there was no external application of fertilizers. The available low phosphorus content in fresh spoil may be due to acidic nature of spoil which interfere with microbial activities resulting in poor mineralization and organic decomposition of the spoil and higher value on older OBDs may due to reverse action i.e. higher decomposition of spoil (Rai 2011) or may be precipitation from atmosphere (Kacorzyk *et al*. 2012). It has been estimated that available potassium at 100 ppm is sufficient for plant growth, 50-100 ppm is moderately deficient range and less than 50 ppm indicates further high deficiency (Gammel 1990). In this case also the available potassium is 57.2 ppm in OBD-20 which indicates that spoil is moderately deficient in available potassium; though it was very low at fresh mine spoil.

Conclusion

This study indicates that the fresh mine spoil maintain a physico-chemical characteristics i.e. not conducive for the plant growth. However with increase the age of these spoils showed the improvement of the physico-chemical characteristics for supporting growth of the vegetation. Thus such natural reclamation process over a period of time is helpful for transforming hostile coal mine spoil to soil with all ameliorate properties for sustaining below and above ground plant growth and diversity.

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