PHYSICO-CHEMICAL PROPERTIES OF OVERBURDEN DUMPS OF DIFFERENT AGES AT SONEPUR BAZARI COALMINE AREA, RANIGANJ, WEST BENGAL (INDIA)

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INTRODUCTION

Coal is one of the most important fossil fuel resources of India and plays a vital role in the economical growth of our country. It has been reported that the annual demand of coal in India which was 620 Mt in the year 2012, may increase up to 780 Mt in 2017 (Chaoji, 2002). Currently more than 80% of this demand is being met by open cast mining. Such surface mining methods produce a dramatic change in the landscape in coal mine areas due to large scale excavation and removal of overlying vegetation cover along with its topsoil and supportive life-forms (Dash, 2001). In the recent past the open cast coal mining has been creating immense 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 coalmine debris is heaped in the form of dumps around the mining area and is called spoil. These dumps change the normal land topography and affect the drainage system of the mining area (Chaulya et al. 2000). The soil of the dumps is acidic in nature, along with higher concentration of metals. Other adverse physico-chemical factors include high stone content, lack of moisture, higher compaction, shortage of fine soil forming materials and organic matter, which tend to inhibit soil forming process and plant growth (Maiti, 1994; Maiti and Saxena, 1998). This mixture is hostile to the growth of both plants and microbes (Sethy and Behera, 2009) because of impoverished organic matter content, detrimental pH and drought arising from coarse texture or oxygen deficiency caused by higher compaction (Agarwal, et al. 1993). Due to the adverse physico-chemical and biological properties of mine spoil (Iwarkar et al. 2004) natural succession of plant species on these dumps is very slow (Singh et al., 1996, Ebka and Behera, 2011). The absence of any vegetation on such dumps leads to further problem of soil erosion and environmental pollution (Singh et al., 1996). The nature tries to restore normally by operating plant succession on spoils after certain interval of time (Borpujari 2008; Hazarika et al. 2006). The main objective of the present study was to characterize the physico-chemical properties of overburden material dumped in the mining site and observe the change in the physico-chemical properties of the dumps, over an age series of time, through the natural process of reclamation.

MATERIALS AND METHODS

Study site

This study was carried out at 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 23º48’’ North Latitude and 87º47’’ East Longitude, the topography of which is slightly undulating.

ABSTRACT

The present work deals with the study of changes in physico-chemical parameters of spoil (overburden dumps) with age of the spoil. Soil samples were collected for estimation of their different physico-chemical parameters from six different age series of coal mine overburden dumps at Sonepur Bazari area, West Bengal, India. The selected age series of Over Burdened Dumps (OBD) were 4, 8, 12, 16 and 20 years old respectively. The study revealed that the bulk density and percentage of gravel and sand in soil gradually decreased and the other physical parameters like the percentage of silt, clay, porosity and water holding capacities increased with increase in the age of the OBD. The pH of the soil which was found to be in the acidic range (pH 3.8) in the freshly dumped overburdening (OBD-1) gradually increased to 6.32 in OBD-20. On the contrary the Electrical Conductivity of the soil started decreasing with increase in age of OBDs. Organic carbon, total nitrogen, available phosphorus and nitrogen content were observed to increase with the age of the OBDs. The study thus reveals that the physico-chemical characteristics of the freshly laid OBD, which is non-conducive for establishment of any vegetation undergoes considerable changes over time due to natural reclamation process and become favorable to support above and below ground biodiversity.

KEY WORDS

Physicochemical property
Overburden dumps (OBD)
Coalmine reclamation.
and rolling marked by small ridges and valleys (Fig. 1). The climate is tropical monsoonal with high summer with an average temperature of 42°C and a cold winter often experiencing temperature as low as 6°C. The average annual rainfall amounts to 1450mm/year. Total land acquired for the mining project is 2404.85 ha including the land for lying over burden dumps. The average height of these dumps is 50m and the quarry depth is 60 to 70m.

In the study site, a series of 6 Over Burdened Dumps of different ages, henceforth referred to as age-series, 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 soil samples were collected by manually operated split tube (coring tube, depth 0-20 cm) from different age series of OBDs. These samples were properly packed and brought carefully to the laboratory of Department of Botany and Department of Water and Environmental Management, B. B. College, Asansol. The samples were air dried, cleaned, crushed with mortar and pestle and then passed through 2 mm size 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 sieves of 4.75mm, 2.00mm, 1mm, 0.425mm, 0.212mm, 150 micron and 75 micron porosity, divided by the total weight of the sample (Ranjan and Rao 2000). Soil hydrological regime included determination of water holding capacity and moisture level which was estimated following the method of Hesse (1971).

Electrical conductivity and pH of the soil was determined in soil water suspension (1:2.5) with an Electrical Conductivity Meter (HANNA, HI 98303) and pH meter (HANNA, HI 98107) respectively. The organic carbon was determined by the Walkley and Blake method (Nelson and Summers, 1982). Total Nitrogen and available Phosphorus estimation was done according to Jackson, (1958).

RESULTS AND DISCUSSION

The physical characteristics of coalmine spoil samples collected from different age series over burden dump of Sonepur Bazari coalmine area has been presented in Table 1. The textural analysis of the samples showed that the gravel and sand together constituted a substantial portion of dump material. The percentage of silt and clay were observed to be very low in all the samples. An inter comparison of the textural data between different age series over burden material showed that with increasing age of the dump there was a gradual decline in gravel and sand along with an increase in silt and clay percentage. Clay minerals are basically hydrous aluminosilicates and being small and flaky in shape maintains sufficient surface area (Ranjan and Rao, 2000). The importance of the clay for the maintenance of soil structure has also been emphasized by Brady (1990). Hence increasing clay and related small sized silt in the ageing over burden dumps spoil can be considered as an indication of conversion of spoil to soil.

As further noted from the Table 1 the bulk density showed
also a decreasing trend from OBD-0 (1.81g/cc) to OBD-20 (1.39g/cc). Since the bulk density is considered as an index of compactness, declining bulk densities with increase in age of the dumps, as noticed in the present study have contributed towards development of soil formation with appropriate porosity. This has also been ascertained from the porosity data which exhibited maximum value in OBD-20 spoil. The data for water holding capacities exhibited minimum value in the fresh dump, OBD-0 (25.56%) and showed gradual increase in to reach maximum level in OBD-20 (61.8%). The trend showed that along with increase in percentage of silt, clay and porosity, the spoil samples gradually developed capacity to maintain appropriate hydrological regime, conducive for the sustenance of soil organisms and plant growth. The relationship between the finer textural particles i.e. silt and clay, bulk density, porosity and water holding capacity as noted in the present study is conceptually in agreement with views of Brady (1990). Improvement in soil physical and chemical structure and gradual establishment of vegetation in the dumps with increase in the age of the OBDs has also been reported by Ekka and Behera (2012). Hence the findings of the present study are in confirmatory with them.

The chemical characteristics of coalmine spoil samples collected from different age series over burden dumps of Sonepur Bazari coalmine area has been presented in Table 2. As revealed from the data the fresh OBD-0 spoil showed a distinct acidic pH (3.48) and with increase in age of the spoil the pH also exhibited an increasing trend towards neutrality. The spoil of OBD-20 exhibited a maximum pH value of 6.32. Report about the acidic pH of the fresh over burden dump spoil may be due to the leaching of basic cations (Foy, 1974). Usually in such acidic condition high availability of Al$^{+3}$ and Mn$^{+2}$ and scarcity of Mo are the principal detrimental factors for the development of plants (Foy, 1974) and this could be the reason for the absence of vegetation on the fresh mine spoil. Development of the near neutral pH in OBD-20 spoil on the other hand may promote appropriate plant growth due to suitability of nutrient uptake (Brady, 1990). The electrical conductivity data showed a decreasing pattern with increase the age of the OBDs. Being an indicator of the progressive successional process (Beer, 1964), the decreasing pattern of electrical conductivity therefore is a positive indicator for the plant establishment on relatively older spoil dumps.

Organic content of different over burden dump spoil varied from 0.23% to 0.46% with minimum value in OBD-0 and maximum value in OBD-20. The increasing trend of organic carbon data showed gradual accumulation of organic carbon in the spoil sample. The same trend was also noted with respect to total nitrogen, available phosphorus and available potassium. These trends are in agreement with the findings of Maiti et al. (2002) and Rai et al. (2011). According to Rai et al. (2011) organic carbon deposition in mine spoil is due to accumulation of litter and its decomposition which happens due to activity of soil organisms which develop with the increase in age of the dump. Increasing total nitrogen content in older dump could be due to symbiotic rhizobial nitrogen fixation by the leguminous plants, as has been explained by Maiti et al. (2002). In the present study few legume species like Desmodium trifolium, Tephrosia purpurea, Cajanus scarabaeoides, Butea monosperma and Dalbergia sissoo were noted in relatively older dump. Hence their nodular nitrogen fixation could have contributed to the total nitrogen in the spoil. The level of available phosphorus and potassium though noticed to increase with increase in age of spoil, their level is still low, as a result of which the spoil can be considered as moderately deficient in available phosphorus and potassium. However the increasing trend of these two nutrients with increase in age of the dumps showed that these spoil if allowed to progress under natural plant succession may be self sufficient in these two nutrients.

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

**REFERENCES**


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