https://doi.org/10.33451/florafauna.v28i1pp63-66
FLORA AND FAUNA ISSN 2456 - 9364 (Online)
2022 Vol. 28 No. 1 PP 63-66 ISSN 0971 - 6920 (Print)

Coal mining in sub-humid forest : effect on microbial biomass Carbon, Nitrogen, Phosphorous and Nutrient flux

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Received : 02.02.2022; ***Accepted*** : 08.03.2022

ABSTRACT

The effect of open-cost mining for coal on microbial C, N and P in sub-humid tropical forest environment was determined. The mining activities have resulted in 64-98% decline in plant biomass and 67 to 73% in microbial nutrients in barren spoils. The decline in soil organic matter was 60-84% in these spoils. Revegetation of theses spoils resulted in 9-14 times increase in plant biomass and 1.5 to 5 times in soil nutrients. Also microbial nutrients increased 2.5 to 3 times in revegetated sports as compared to barren dumps.

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KEY WORDS : Coal Mining, Forest, Humid, Microbial Biomass, Nutrient Flux

Introduction

The region of Northern part of Chhattishgarh was once covered with dense forest. Rapid industrialization in this area has resulted in massive deforestation. The mining activities have caused extensive damage to the natural ecosystem. Open-cost mining remove surface earth, pilling it over unmined land and forming chains of external dumps. In such areas flora, fauna, hydrological relations and soil biological systems are drastically disturbed. Ecosystem degradation and loss of soil organic matter are the major adverse effect of open-cost mining which also results in development of a substrate which differs from the undisturbed soil in mycorrhizal association, biological activities and fertility status[1,2,7,10-12].

Soil microbial biomass, an active and living part of soil organic matter, is an agent of transformation of organic matter and is a reservoir of available natrients[3]. Post-mining ecology of soil and microbial nutrients is little studied in sub-humid tropical forest environment. In this study, effect of open-cost mining for coal on microbial C, N and P in forest of Chhattisgarh was examined. The effect of revegetation of these spoils was also explored.

Material and Methods

Study Sites

Two mine spoils from Bishrampur and Chirimiri area of Chhattishgarh and a native forest ($23^0$10'-$23^0$18' N lat., $81^0$38'-$83^0$04' E long and 240-346 meter above mean see level) were taken for study. The climate is sub-humid tropical monsoonal with distinct winter, summer and rainy seasons. Mean monthly temperature ranges from 10.9 to 42.8^{0}C. The average annual rainfall ranges from 1220 to 1603mm of which more than 85% occur in the rainy season.

The natural vegetation is tropical sub-humid forest, dominated by Sal (*Shorea robusta*) but also containing *Terminalia tomentosa*, *Diospyros melanoxylon*, *Woodfordia fruiticoza* and *Miliusa* spp. Both coal mine dumps were planted with teak (*Tectona grandis*), Sheesham (*Dulburgia sisso*) bamboo (*Dendrocalamus strictus*) and *Cassia fistula etc.*

The soils are residues from parent rocks comprising granites, biolites, chlorite and mica. The soils are sandy loom in texture, reddish to reddish brown in colour, slightly acidic in nature and with moderate water holding capacity. The spoils are unconsolidated mixed over burden materials derived from medwin to coarse grained sandstones. Certain physico-chemical properties of native forest and coalmine spoils are depicted (Table-1).

Soil Sampling and Biomass Analyses

Soil samples were collected randomly from 10-15 places (15cm depth), mixed thoroughly, sieved (<2mm) and divided into two parts. One part in fild-moist condition was used for determination of microbial nutrients. The

ACKNOWLEDGEMENT : Financial Support is gratefully acknowledged from Council of Scientific and Industrial Research, New Delhi as Senior Research Associateship to me.

TABLE-1 : Physico-chemical Properties of coal mine spoils and native forest soil

	Native Forest	Bishrampur		Chirimiri	
		Barren	Vegetated	Barren	Vegetated
Bulk density (g cm^{-3})	1.28	1.64	1.36	1.68	1.38
Sand (%)	74.6	88.2	84.4	89.2	84.9
Silt (%)	14.8	6.4	9.9	5.6	9.6
Clay (%)	10.6	5.4	5.7	5.0	5.2
WHC (%)	34.2	14.9	28.2	11.7	24.1
pH	5.1	6.9	6.4	6.7	6.5
Organic C (mg kg^{-1})	8226	1580	6480	1340	6620
Total N (mg kg^{-1})	875	133	526	110	566‘
Total P (mg kg^{-1})	380	150	200	140	210
C/N ratio	9.4	11.9	12.3	12.1	11.7

other part was air-derived for all other analyses. Soil organic carbon, total N and P were determined[6].

Microbial nutrients were estimated by chloroform furigation-extraction method. Microbial C and N were calculated by subtracting C and N content of K_2SO_4 extract of unfurigated soil from those of furigated soil by dividing these values by 0.33[4,5,9] and 0.54[3] respectively. Microbial P was calculated by dividing the flush of available P by 0.40[13]. All values are expressed on an oven-dry soil basis (105^0C, 24 h) and are means of three replications.

Plant Biomass

Above-ground plant biomass (litter in forest and canopy biomass in mine spoils) was measured by 5 1m x 1m quadrants place randomly on each site. Below ground biomass was estimated in 10x10x10cm. Five monoliths were sampled from each site and washed with a fine jet of water using 0.5mm mesh screen. Both the above and below ground materials were dried at 80^0C to constant weight.

Results and Discussion

The plant biomass was about 11-14 times lower in barren and 9-10 times in revegetated mine dumps (Table- 2). Root biomass provide a direct input of carbon and nutrients to the soil microbial population through organic secretion and upon mortality[12].

Soil Organic Matter and Microbial Biomass

The soil organic C total N and P for native forest were 8226, 875 and 380 mg kg^{-1}witha C/N ration of 9.4 (Table 1). These values for mine spoils ranged from1340-6620, 110-566 and 140-210 mg kg-1 respectively (C/N ratio 11.7-12.3). Microbial C, N and P ranged from 93-307, 10-31 and 4-15 mg kg^{-1}, respectively, being maximum in native forest and minimum is barren mine dumps (Table-2). The biomass C, N and P were about 3 times greater in forest soil than those in barren dumps.

Microbial C accounted for 3.7-6.9% of the soil organic C. Concentration of N in biomass, ranged from 4.8-5.4% (C/N ratio from 9.3-10.4) (Table 2). Concentration of P in the microbial biomass ranged from 2.0-2.4% (C/P ratio from 20.5-23.5). The narrow range of C/N and C/P ratio may indicate that the quality of biomass was similar across site. Similar ranges were also reported for Vindhyan hill regions[12].

TABLE-2 : Plant and microbial biomass (mg kg^{-1}) in mine spoils and native forest soil. Above ground biomass in forest is litter mass and in mine spoils is canopy biomass

	Native forest	Bishrampur barren	Bishrampur vegetated	Chirimiri barren	Chirimiri vegetated
Plant biomass (kg ha^{-1})					
Above ground	2600	60	820	80	740
Below ground (15cm)	5600	160	176	190	1980
Microbial biomass (mg kg^{-1})					
Carbon	307	100	282	93	260
Nitrogen	31	10	29	10	25
Phosphorus	15	4	12	4	12
C/N ratio	9.9	10.0	9.7	9.3	10.4
C/P ratio	20.5	22.5	23.5	23.3	21.7
% N in biomass	5.0	5.0	5.1	5.4	4.8
% P in biomass	2.4	2.0	2.1	2.2	2.3
as microbial C(%) organic C	3.7	6.3	4.4	6.9	3.9

Effect of Surface Mining on Microbial Biomass

Percent declines in selected soil properties, plant biomass and microbial C, N and P are presented in Table-3.

The open-cost mining for coal has resulted in 64-98% loss in vegetative mass, 40-87% in soil organic matters and 67-73% in microbial nutrients in barren dumps, as compared to the native forest (Table 3). The reduction in these nutrients in mine spoils are mainly due to the lack of top fertile soil layers, favourable nutrients, and active microbial system[11,12]. However, revegetation of mine dumps resulted in 2-3 times greater biomass. Vegetative spoils are reported to have larger population of bacteria such as ammonifiers and cellulose decomposers as compared to unvegetated spoils. Some workers have suggested that microbial biomass is a critical factor in the recovery of mine spoils as it aids in the re-establishment of nutrient cycling[12]. The level of microbial biomass C, N and P can be taken as functional indexes of soil redevelopment. Some workers have reported that growth of microbial biomass on residues enhances turnover of organic matter through concurrent immobilization, mineralization and stabilization reactions[14].

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TABLE-3 : Percent decline in organic matter and microbial biomass due to mixing values are compared with the native forest

	Bishrampur barren	Bishrampur vegetated	Chirimiri barren	Chirimiri vegetated
Above ground biomass	97.7	68.5	96.9	71.5
Below ground biomass	97.1	68.6	96.6	64.6
Microbial C	67.4	8.1	69.7	15.3
Microbial N	67.7	12.9	67.7	19.4
Microbial P	73.3	20.0	73.3	20.0
Organic C	80.8	21.2	83.7	19.5
Total N	84.8	40.0	87.4	35.3
Total P	60.5	47.3	63.2	44.7

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