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Soil Respiration and Microbial Biomass Carbon— the Potential Sensitive Biological indices of Soil Health

Abstract **: A total of 432 soil samples drawn from six plots from the rhizosphere and non-rhizosphere of the most dominant and the abundant plant species at monthly interval over a period of 2 consecutive years (Jan 2014-Dec 2015) made materialistic basis for faunistic survey and other analysis of this study. Of the six plots sampled, 3 were located in forest floor and 3 were located in coal mine fallow lands. Above-ground plant diversity and density markedly differed from one site to the other. Faunal and fungal population density varied considerably from month to month. Population of both the groups resulted in their maximum at monsoon months and minimum at summer months. Significant and positive correlation were found to exist between the population of Collembola - Acarina and fungal flora in both the sites;in coalmine fallow land, fungal population showed weakly negative relationship with Collembolan population. Soil microbial biomass carbon content and soil respiration were taken into consideration to correlate these factors with soil fungi and soil fauna. Soil microbial biomass-C and soil respiration found significantly correlated with soil fungal and faunal population. Contribution of soil fungi in the soil respiration found highly significant and correlated with the cumulative influence of different soil factors in relation to soil fertility.**

Keywords: **Soil fertility, Soil Microbial Biomass-C, Soil Respiration, Forest floor, coal mine fallow land, Acarine, collembolan and soil fungi**

Soil is considered to be a dynamic ecosystem which goes on changing continually. The vegetation growing in soil provides the organic material that remains closely associated with the mineral part of soil. The decomposition of organic matter (litter) is mainly influenced by the soil organisms[1]. Plants and organic debris provide habitats for soil organisms. Plants affect soil biota directly by generating inputs of organic matter above and below ground and indirectly by the physical effects of shading, soil protection and uptake of water and nutrients by roots. Energy and nutrients obtained by plants eventually become incorporated in detritus that provide the resource base of a complex soil food web. Soil fauna are often aggregated spatially which is probably indicative of the distribution of favoured resources, such as plant roots and organic debris[2,3].

Paul (1989)[4] acknowledged the soil as the 'best overall reflection of ecosystem process' due to its systemic internal organization, i.e. its control and indication of numerous ecological processes at varying temporal scales. The sustainability of forest resources depends on the continuation of essential biological processes. These biological processes, affecting the C, nutrient and hydrologic cycles, result from the activities of all forest organisms. Among the most important of these are invertebrates and micro-organisms inhabiting the soil and soil surface. With many thousands of named and unnamed species, they perform a vital role in decomposing litter by transforming dead organic material into complex web of new substances, resulting in the food chains that characterize much of the edaphic environment[5]. Soil organisms are essential to the productivity, high level of biodiversity, and homeostasis of undisturbed forests. Little is known about how the composition of the 'non-crop' flora affects microorganisms, invertebrates and other fauna, nor how it influences the healthy functioning of forest ecosystems. This may be particularly true in degraded lands. If there is a direct link between above ground biodiversity in the vegetation and below ground biodiversity then enhanced biodiversity above-ground will contribute to the reestablishment and multiplicity of soil organisms able to carry out essential biological functions. This will restore the resilience of the soil and thus buffer agro ecosystems against risk, and help to sustain productivity. Thus an assessment of soil properties which includes both soil biological and soil chemical assessments can provide valuable information for determining the ecological sustainability of alternative land uses. Soil biological parameters have the potential to be early sensitive indicators of stress on key populations or of productivity[6,7]. It is therefore essential to know the complete physiology,

ecology and behaviour of an indicator. In this respect soil Zoology is far beyond other disciplines such as hydrobiology[7]. In particular, most of our knowledge in the assessment and understanding of biotic and abiotic interactions, and their consequences on community structure, is still anecdotic. This has been identified as a major shortcoming in soil ecological research as the knowledge of mechanisms prevailing in biotic interactions is a prerequisite for a sound prediction of the fate of most ecosystems in an increasing changing world[8].

Biological indicators often recommended include: nitrogen mineralization, microbial biomass, microbial biomass to total carbon ratios, soil respiration, respiration to microbial biomass ratios, faunal populations and rates of litter decomposition[9,10]. In this study, particular emphasis was given in highlighting strong interactions between microbial biomass to total carbon ratios, soil respiration, respiration to microbial biomass ratios, faunal populations in relation to soil fertility.

Materials and Methods : The present study has been carried out by Innovation Hub of Burdwan science Centre, NCSM, Govt.of India at Dihika (Ward No-49)and Kalajharia(Ward No-37), Burnpur under Asansol Municipal Corporation of Burdwan district in West Bengal, India.It is situated at a distance of about 12 km (approx) in the south –west of Asansol Railway station. These area falls between $86^0$15'14"N latitude and $23^0$30'15"E longitude at an altitude of 100m above sea level. Dihika is a natural forest zone at the bank of River Damodar and Kalajharia is characterized by coal mine fallow land zone (considered as Site-I and Site-II respectively in the present study). The soil characteristics of the studied area are sandy loam to laterite with high porosity. In the present study soil samples were collected from non-rhizosphere and rhizosphere of most dominant plant species of study sites at monthly interval over a period of two years (January 2014 to December 2015)[11] described an apparatus for collection of soil samples, which was later, modified by[12] has been applied in this sampling process. In the present investigation Tullgren funnel as modified by[13] was used for extraction of the arthropods. The fungal population was assessed by inoculating the soil solution of 10^{-3} and 10^{-4} dilutions. The conventional dilution plate method was followed using potato dextrose agar (PDA) media. The fungal population was recorded after 3-4 days of incubation at 25ºC. From this, number of fungal colony forming unit (CFU) per gm of soil was calculated.

Estimation of Soil Microbial Biomass-C : Fumigated and non-fumigated soils were extracted with 0.5M K_2SO_4 for 30 min (1:5 Soil: Extractant ratio), filtered, and then an aliquot was analyzed for organic carbon by the acid dichromate oxidation method. The additional C and N obtained from the fumigated soils were taken to represent the microbial -C flush and converted to microbial biomass-C using the following relationship[10].

Biomass -C = C flush /0.35.

Fumigation of soil was made by ethanol-free Chloroform in the fumigation Chamber.

Measurement of Soil Respiration : 100 gm of soil sample was transferred into a sterile flask (1 litre capacity) and mixed with distilled water to adjust soil moisture to be 33% of water holding capacity. 10 ml of freshly prepared N/10 NaOH solution was taken into two test tubes and the mouth of test tubes were tied with a thread. Then the test tubes were hung into the two flasks (the second one devoid of soil acts as control) in such a way that the free end of thread remains out of the flask. The mouth of the flasks were closed with rubber stopper and sealed with molten wax to make them air-tight. The flasks were incubated at 30^0C. At weekly intervals test tubes were taken out from each flask.2-3 drops of Phenolphthalein indicator was added and the colour of NaOH solution turns to pink. Then it titrates against N/10 HCl solution pouring in a burette to measure the residual amount of NaOH unturned to Na_2CO_3. Volume of HCl was measured through end point when pink colour turns to colourless. The amount of CO_2 evolved was calculated following the formula of[14].

Statistical Analysis : All the statistical analysis was made using Windows Microsoft Excel and SPSS version 10.00

Results : The data presented here were based on a sample survey of 6 plots from two sampling sites (forest floor and coal mine fallow land) at Asansol, West Bengal, India. Altogether 432 samples (216 from non-rhizosphere and 216 from rhizosphere of the two sites) were collected at monthly interval over a period of 3 years (Jan 2014-Dec 2015). All the plots under study were in the Gangetic plain exposed to tropical climate with high humidity and high temperature, both of which were comparatively low in winter months.

Faunal Make up : It is evident from the Table1A that the total population of Acarina and Collembola in the forest floor on average showed a tendency to attain a maximum population (peak) during the month of July-Sept when the edaphic factors like moisture and organic carbon were appreciably high. During summer months the population were low and soil temperature were significantly

TABLE 1A: Showing monthly variation in population of Acarines,Collembola and Soil fungi in the non- rhizosphere and rhizosphere of Site-I(Mean values with ±S.Eof four samples from three replications in each month during January 2014- December 2015.)

MONTH	ACARINA (MEAN ± S.E)		COLLEMBOLA (MEAN±S.E)		FUNGAL COLONY (CFU/gm X10^3)	
	Non Rhizo	Rhizo	Non Rhizo	Rhizo	Non Rhizo	Rhizo
Jan	10 ± 0.94	26 ± 0.81	10 ± 0.81	14 ± 0.94	4 ± 0.47	4.5 ± 0.23
Feb	18 ± 0.47	20 ± 0.47	7 ± 0.47	10 ± 0.47	3.75 ± 1.22	4.5 ± 0.42
March	15 ± 0.47	38 ± 1.69	5 ± 0.94	9 ± 0.47	5 ± 0.81	5.5 ± 0.84
April	12 ± 0.47	43 ± 0.94	5 ± 0.47	8 ± 0.81	5.5 ± 0.23	12.5 ± 0.62
May	7 ± 0.94	10 ± 0.47	1 ± 0	3 ± 0.47	1.75 ± 0.11	3.25 ± 0.31
June	21 ± 1.24	26 ± 2.15	5 ± 0.47	7 ± 0.94	6 ± 1.69	9 ± 0.81
July	25 ± 2.93	70 ± 2.15	6 ± 0.47	10 ± 1.24	9 ± 0.81	9 ± 0.94
Aug	46 ± 4.7	75 ± 2.86	12 ± 0.81	21 ± 1.69	11.5 ± 1.92	18 ± 2.86
Sept.	31 ± 2.49	70 ± 0.94	8 ± 0.81	13 ± 0.88	7.25 ± 0.35	8 ± 0.81
Oct	28 ± 0.94	30 ± 2.04	7 ± 0.94	11 ± 0.47	6.5 ± 0.73	9 ± 1.24
Nov	23 ± 1.24	32 ± 0.81	8 ± 1.24	9 ± 0.81	5.5 ± 0.62	10 ± 1.24
Dec.	24 ± 0.46	27 ± 1.62	8 ± 0.81	8 ± 0.47	5.25 ± 0.35	6 ± 0.94

TABLE 1B: Showing monthly variation in population of Acarines,Collembola and Soil fungi in the non- rhizosphere and rhizosphere of Site-II\ (Mean values with ±S.E of four samples from three replications in each month during January 2014- December 2015.)

MONTH	ACARINA (MEAN ± S.E)		COLLEMBOLA (MEAN±S.E)		FUNGAL COLONY (CFU/gm X10^3)	
	Non Rhizo	Rhizo	Non Rhizo	Rhizo	Non Rhizo	Rhizo
Jan	12 ± 1.24	15 ± 0.47	3 ± 0.46	8 ± 0.47	2.5 ± 0.31	6.25 ± 0.51
Feb	15 ± 1.24	14 ± 0.81	2 ± 0.46	5 ± 0.47	2 ± 0.23	5.75 ± 0.73
March	10 ± 0.46	11 ± 0.81	1 ± 0.47	5 ± 0.81	1.5 ± 0.23	3.75 ± 0.40
April	12 ± 0.94	18 ± 1.24	1 ± 0.46	4 ± 0.94	1.5 ± 0.40	3.75 ± 0.25
May	5 ± 0.47	7±0.94	0.00	1 ± 0.46	0.25 ± 0.40	1.25 ± 0.51
June	12 ± 0.81	18 ± 1.24	1± 0.47	5±0.81	2.25 ± 0.51	4.25 ± 0.31
July	25 ± 2.49	42 ± 0.81	3 ± 0.81	9 ± 0.47	4.25 ± 0.31	8.75 ± 0.58
Aug	42 ± 1.69	50 ± 0.94	4 ± 0.85	17 ± 2.15	5.5 ± 0.42	12.5 ± 1.43
Sept.	17 ± 0.94	21 ± 1.24	10 ± 0.81	18 ± 0.47	5.5 ± 0.42	6.75 ± 0.20
Oct	14 ± 0.94	15 ± 0.81	4± 0.81	11 ± 0.94	4 ± 0.40	5.25 ± 1
Nov	13 ± 0.47	10 ± 0.47	2 ± 0.94	7 ± 0.47	3 ± 0.47	4 ± 0.40
Dec.	17 ± 0.94	7 ± 0.81	2 ± 0.47	7 ± 1.24	2 ± 0.47	3 ± 0.81

high. The collembolan population maintained a steady population from the month of July to December both in the non-rhizosphere and the rhizosphere of forest floor (Site-I).

The total population of Acarina and Collembola in the Coalmines fallow land did not follow a general tendency like the forest floor (Table 1B). The Acarina population reached its maximum during the month of July-August both in the rhizosphere and non-rhizosphere but collembola reached its maximum magnitude during the month of August-September. Collembola population remained absent during the month of May and showed a very low abundance in the non-rhizosphere of coalmine fallow land throughout the year.

Fungal Population : It is very evident from table 1A and table 1B that the fungal population in both the non-rhizosphere and rhizosphere of forest floor (Site I) and coalmine fallow land (Site II) showed a general tendency of being maximum in the month of May. Coalmine fallow land was found severely suffering from very poor fungal biomass content particularly in the non-rhizopheric region.

Soil Microbial Biomass –C and Soil Respiration : It is very evident from the table 2A that soil microbial biomass – C and soil respiration showed a general tendency of being maximum in the month of August and minimum in the month of May both in the rhizosphere and non- rhizosphere of the forest floor . However, coalmine fallow land showed a very irregular trend of soil microbial biomass – C both in the rhizosphere and non- rhizosphere zone.

Soil respiration also showed similar trend like the forest floor i.e being maximum in the month of August and minimum in the month of May (Table 2B). The soil microbial biomass –C showed a fluctuating mode

TABLE 2A: Showing monthly variation in Soil Microbial Biomass-C and Rate of Soil Respiration in the non-rhizosphere and rhizosphere of Site-I (Mean values with ±S.E. of four samples from three replications in each month during January 2014- December 2015.)

Month	Soil Microbial Biomass-C (mg C g Dw^{-1})		Soil Respiration (μg CO_2 Cg $Dw^{-1}h^{-1}$)	
	Non-rhizo	Rhizo	Non-rhizo	Rhizo
Jan	3.71± 0.85	3.99± 0.25	3.15 ± 0.25	4.49 ± 0.15
Feb	2.58 ± 0.25	3.92 ± 1.05	3.05 ± 0.5	5.05 ± 0.65
March	1.96 ± 0.50	4.19± 0.85	3.75 ± 0.5	5.25 ± 0.55
April	1.12 ± 0.75	4.86 ± 0.85	3.56 ± 0.25	5.75 ± 0.75
May	0.85 ± 0.25	1.98 ± 0.75	1.25 ± 0.15	2.15 ± 1.5
June	2.36 ± 1.00	6.12 ± 0.85	4.05 ± 0.85	6.15 ± 0.25
July	2.96 ± 1.00	6.79± 1.05	4.95 ± 1.25	6.00 ± 0.45
Aug	4.21 ± 1.25	9.18 ± 0.85	5.85 ± 1.00	9.15 ± 1.25
Sept	4.11 ± 1.05	7.86 ± 0.15	4.55 ± 1.00	6.75 ± 1.00
Oct	3.86 ± 0.85	5.11 ± 0.25	4.25 ± 0.95	7.15 ± 1.25
Nov	3.79 ± 0.85	4.85 ±1.05	3.86 ± 0.75	7.75 ± 0.95
Dec	3.70 ± 1.05	4.12 ± 0.68	3.20 ± 0.65	5.05 ±1.50

TABLE 2B: Showing monthly variation in Soil Microbial Biomass-C and Rate of Soil Respiration in the non-rhizosphere andrhizosphere of Site-II(Mean values with ±S.E. of four samples from three replications in each month duringJanuary 2014-December 2015.)

Month	Soil Microbial Biomass-C (mg C g Dw^{-1})		Soil Respiration (μg CO_2 Cg $Dw^{-1}h^{-1}$)	
	Non-rhizo	Rhizo	Non-rhizo	Rhizo
Jan	2.36± 0.25	2.15± 0.25	2.12 ± 0.75	2.5 ± 0.045
Feb	1.85 ± 0.85	1.75 ± 0.25	2.5 ± 0.25	3.15 ± 0.85
March	2.06 ± 1.00	1.25± 0.25	1.15 ± 0.45	1.65 ± 0.05
April	1.98 ± 0.25	2.15 ± 0.75	1.05 ± 0.15	1.49 ± 0.25
May	2.00 ± 0.05	2.16 ± 0.75	0.75 ± 0.15	1.00 ± 0.15
June	2.16 ± 0.75	4.12 ± 1.00	1.15 ± 0.25	2.10 ± 0.15
July	4.00 ± 1.00	5.16 ± 1.25	3.15 ± 0.15	3.75 ± 0.50
Aug	4.2 ± 1.00	5.10 ± 1.25	5.15 ± 0.50	6.51 ± 1.50
Sept	3.6 ± 0.75	4.25 ± 0.85	4.00 ± 0.45	4.25 ± 1.00
Oct	3.7 ± 0.525	4.00 ± 0.25	2.15 ± 0.75	3.15 ± 0.25
Nov	3.2 ± 0.05	3.00 ± 0.50	1.95 ± 0.45	3.00 ± 0.45
Dec	3.1 ± 0.25	3.15 ± 0.25	2.15 ± 1.25	2.75 ± 0 .50

throughout the period of sampling in the non-rhizosphere of coalmine fallow land.

Statistical Analysis **:** The data including soil fungi, soil microbial biomass –C, soil respiration and the mean number of microarthropod population (Acarina and Collembola) were subjected to statistical analysis separately for each site, in order to find out the simple correlation and simple regression coefficient. The dependence of soil microbial biomass-C (y) on Acarina, Collembola and fungi (Table 3A) and dependence of soil respiration(y) on soil microbial biomass –C, Acarina, Collembola and fungi (Table 3B) were studied.

Multiple correlation – coefficient between fungi, collembola, Acarina, microbial biomass-C and soil respiration (Table 4A) and multiple regression of soil respiration (y) on fungi, collembola, Acarina, microbial biomass-C were also studied (Table 4B).

The soil microbial biomass-C showed significant positive relation to fungi, Acarina and Collembolan population in all the sites under study.

Soil respiration showed highly significant positive correlation with fungi, Acarina and Collembolan population as well as with soil microbial biomass-C in all the sites under study except in the rhizosphere of forest floor where relation with Acarina was found weakly positive.

From the results of multiple correlation – coefficient (Table 4A) between different soil organisms (Fungi, Acarina and Collembola), soil microbial biomass-C and soil respiration it has been depicted that all these parameters were positively correlated in the rhizosphere and non-rhizosphere of all the sites under study.

Multiple Regression of soil respiration (y) on soil microbial biomass-C(β1), soil fungi(β2),Collembola(β3) and Acarina (β4) showed positive significant partial correlation with fungi population in the rhizosphere and non-rhizosphere of site-I and rhizosphere of site-II but in the non- rhizosphere of site-II it showed weak negative relationship .It showed highly significant positive relation with Collembola and Acarina population in the non- rhizosphere of site-II.

Discussion : In forest floor the surface soil in general contained good vegetational cover. According to[15] the surface soil vegetation exerts an indirect/ direct influence on the micro arthropod population through its

TABLE- 3A: Showing relationship between Soil Microbial Bio-mass C, Acarina, Collembola andFungi Population at different Study sites

Site	Parameters	r value	t value	Regression Equation y=a+bx
Site-I Rhizosphere	y= Soil Microbial Biomass C			
	Acarina	.8938	6.2983***	y=2.0686+0.08178x
	Collembola	.7435	3.5132***	y=1.8866+0.3298x
	Fungi	.7787	3.922***	y=2.1617+0.3731x
Site-I Non-Rhizosphere	y= Soil Microbial Biomass C			
	Acarina	.7234	3.3115***	y=1.2205+0.0791x
	Collembola	.8616	5.3645***	y=0.4847+0.3585x
	Fungi	.5583	2.126*	y=1.4156+0.2567x
Site-II Rhizosphere	y= Soil Microbial Biomass C			
	Acarina	.74087	3.485***	y=1.8+0.073x
	Collembola	.6901	3.013**	y=1.7357+0.1795x
	Fungi	.6641	2.8068***	y=1.5688+0.2975x
Site-II Non-Rhizosphere	y= Soil Microbial Biomass C			
	Acarina	.7376	3.4528***	y=1.7431+0.0685x
	Collembola	.60348	2.3916**	y=2.2915+0.2034x
	Fungi	.8771	5.7705***	y=1.5163+0.4676x

***Significant at 1 percent level
**Significant at 5 percent level
*Significant at 10 percent level

TABLE- 3B: Showing relationship between Soil respiration, Acarina, Collembola, Fungi Population and Soil Microbial Bio-mass C at different Study sites

Site	Parameters	r value	t value	Regression Equation y=a+bx
Site-I Rhizosphere	y= Soil Microbial			
	Acarina	.3880	1.3305	y=3.7906+0.054x
	Collembola	.7029	3.1227**	y=3.009+0.281x
	Fungi	.8343	4.7820***	y=2.9099+0.3604x
	Soil Microbial Biomass C	.8239	4.5938***	y=1.9926+0.742x
Site-I Non-Rhizosphere	y= Soil Microbial			
	Acarina	.8455	5.0026***	y=1.8251+0.0907x
	Collembola	.6499	2.7028**	y=1.997+0.2652x
	Fungi	.9576	10.503***	y=1.2349+0.4317x
	Soil Microbial Biomass C	.6156	2.4684*	y=2.0177+0.6037x
Site-II Rhizosphere	y= Soil Microbial			
	Acarina	.7187	3.2675***	y=1.3208+0.0853x
	Collembola	.8759	5.7363**	y=0.9007+0.2525x
	Fungi	.9104	6.9534***	y=0.4835+0.4521x
	Soil Microbial Biomass C	.7187	3.2662***	y=0.4032+0.7966x
Site-II Non-Rhizosphere	y= Soil Microbial			
	Acarina	.8814	5.8928***	y=0.3084+0.1215x
	Collembola	.7427	3.5055***	y=1.2885+0.3578x
	Fungi	.8948	6.332***	y=0.25281+0.7036x
	Soil Microbial Biomass C	.7836	3.9856***	y=-1.0425+1.1628x

***Significant at 1 percent level
**Significant at 5 percent level

effect on the porosity of soil, humus formation and soil moisture. In general there might be a moderate amount of interaction between plant and micro arthropod but there remain little evidence on the restriction of individual micro arthropod species to one species of plant.

In coal mine fallow land the soil surface in general contained very poor and patchy vegetational cover. This may in turn affect soil porosity, moisture content and organic matter accumulation in the surface soil. It has been found for the present investigation that coal mine fallow land has been suffering from poor species diversity along with irregular mode of distribution of plants. Plant species diversity and abundance as well as evenness of distribution, certainly was an indication of high above ground plant biodiversity. Thus above ground plant species diversity and abundance was markedly different between two sites under study. Plant communities govern the quality and quantity of plant litter produced within and ecosystem, which in turn influence the quality if the soil[16]. Thus it could be assumed from the differences in the faunal makeup of the plots under study that the vegetation being an integral part of ecological complex exerted certain impact on the arthropod population.

The Acarina and Collembolan fauna obtained in this study belonged to different genera. All the plots under study located in the same geographical sub-division (locality) and experienced more or less identical climatic condition but they differ

in faunal make up. Such a difference might be due to local differences in the composition of substrate and micro climate conditions prevailing there[12]. The acarines were numerically dominant over collembolans in both the sites under study (Table1 A and B). Acarines population range between 7±0.94 to 46±4.7 and 10±0.47 to 75±2.86 in the non-rhizosphere and rhizosphere of forest floor where as range between 5±0.47 to 42±1.69 and 7±0.94 to 50±0.94 in the non-rhizosphere and rhizosphere coal mine fallow land. The population of Acarines reached their maximum in the month of July-August when the edaphic factors like moisture and organic carbon were appreciably high. During summer the population decline with the sharp increase of temperature. The collembolan populations also showed the similar trend of distribution in the forest floor but in the coal mine fallow land their population found completely absent or present in negligible number in the summer month. The above mentioned variations in the faunal make-up might be due to the differences in the ecological condition. Some genera were wide spread occurring regularly in different sampling sites, they could tolerate wide variety of habitats and were aptly called 'ubiquists' or 'ecological generalists group', on the other hand some forms were localized i.e restricted to a particular habitat and they were accordingly termed as 'stenocious' or 'ecological specialists group'[17]. One genus of Acarina *Scheloribates albialatus* and one genus of collembola *Lepidocyrtus suborientalis* seemed to have wider tolerance for various habitats in the present study. Therefore, they were 'ubiquists' while other forms of acarines and collembola were restricted to single site as such they were 'stenocious'.

In the present study the micro-climatic condition of the two sites differ in the resource quality i.e leaf litter heterogeneity and complexity which were more heterogeneous and complex in the forest floor than that of coal mine fallow land. The litter quality acts as a guild for decomposer assemblage and microbial diversity. Thus forest floor harboured high below ground diversity than coal mine fallow land. Plant species composition, and therefore habitat has a significant, but as yet unquantified, control on below ground diversity[18].

Forest floor mycoflora showed wide species diversity and fungal biomass as well. The wide specious diversity may provide favourable and palatable flood for the fungivorous arthropods which serves as mixed diet of preferred fungi which in turn increase fitness and reproduction ability of collembola[19]. As the total population of fungi as well as species diversity obtained from all the sampling sites showed that coal mine fallow land generally suffers from poor fungal biomass as well as species diversity. This may in turn control the population of fungivorous collembola and acarines. The forest floor mycoflora may provide significant resource for these organisms and thereby maintained wide diversified fauna.

The total population of fungi obtained from sampling sites showed numerical variations with change of seasons. It was minimum in May and maximum in August i.e when moisture content was fairly high. Both the forest floor and coal mine fallow land experienced heavy rainfall in July-August resulting in rise of moisture level and there by leading to a vigorous growth of macro and micro flora. Thus an optimum condition was set for supporting a longer population of both flora and fauna. Contrary to this, durig summer month (particularly in May) just reverse condition was found[20].

From the Table 2A and 2B it has been revealed that soil microbial biomass-C and soil respiration also showed seasonal variation being maximum during July-August and minimum during May except in the non- rhizosphere of coal mine fallow land. It is evident from the regression analysis and scattered diagram that these two dependable variables showed positive significant relationship with soil fungi and micro arthropods. Soil respiration showed weakly negative relation with soil fungi and positive significant relationship with micro arthropod may be due to scanty distribution of favoured fungi population and higher predaceous micro arthropods (Table 3A, 3B and 4A, 4B).

TABLE 4A: Showing Multiple Correlation-Co-efficient between Fungi,Collembola,Acarina,Microbial biomassC and Soil respiration at different sites.

Site		Multiple R	R^2	F
Site-I	R	.90047	.81085	7.50171*
	NR	.96604	.93323	24.45967**
Site-II	R	.95959	.92081	20.34998**
	NR	.98288	.96605	49.79581**

Table value of F with k,(n-k-1) i.e. 4(12-4-1)=4,7 degree of Freedom at 1% and 5% levels are 14.98 and 6.09 respectively.

** Significant at 1% level

* Significant at 5% level.

Soil microbial biomass-C and soil respiration are the two important ecophysiological indicators[21]. Since microbial biomass is a potential source for plant nutrients a high level of microbial biomass is an indicator of a highly fertile

TABLE 4B: Multiple Regression of Soil respiration on Soil microbial biomass C, Fungi, Collembola and Acarina

Soil respiration(y) = β0 + β1 × Soil microbial Biomass + β2 × Fungi + β3 × Collembola + β4 × Acarina.

Site	Partial Correlation Coefficient				Constant
	β1	β2	β3	β4	β0
Site-I Rhizosphere	.600370 (1.443)	.196425 (2.824)**	.67204 (.681)	- 0.29585 (-0.976)	1.5782 (1.713)
Site-I Non-Rhizosphere	.183954 (.816)	.471615 (4.495)***	.001774 (.21)	-0.023679 (-.818)	.959943 (2.732)
Site-II Rhizosphere	.258093 (1.102)	.490781** (2.255)	.065142 (.943)	-0.48116 (- 1.078)	-0.161777 (-0.289)
Site-II Non-Rhizosphere	-.023050 (-0.098)	-0.137894 (-0.594)	.288528 (3.383)***	.112838 (5.834)***	.114136 (0.298)

Figures in bracket show (t) values

***Significant at 1 percent level

**Significant at 5 percent level

*Significant at 10 percent level

Table Value of t with (n-2) i.e. 10 degree of freedom at 1 percent, 5 percent, at 10 percent levels are 3.169, 2.228 and 1.812.

R- Rhizosphere
NR- Non-rhizosphere

soil[21]. Soil microbial activity enhance the soil organic matter turn over by decomposition which in turn related with the soil microbial biomass and the above ground phytomass[22]. The multiple regression (Table 6B) depicted that the soil respiration was significantly correlated with the fungal biomass particularly in the productive site i.e with above ground phytomass. But in the non –rhizosphere coal mine fallow land it showed weakly negative relationship with the fungal biomass may be due to weak fungus-fauna interactions. The positive significant relationships of soil respiration with soil micro arthropods (Acarines and Collembola) may be due to dominance of predaceous form prevail there in[23].

The results of this investigation mostly corroborated those of other workers, while in certain aspect they showed striking differences from those reported earlier. This might be due to the prevalence of local environmental factors which were like to exert profound influences in the pattern of population structure.

It might be inferred that factorial component evaluated herein conjunction with above ground vegetational characteristics and below ground biological diversity, biomass and activity may reflect the status of soil quality.

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