EFFECT OF FOREST FIRE ON THE CHEMICAL COMPOSITION OF THE SOIL OF MARGALLA HILLS OF PAKISTAN

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ABSTRACT

The current research was conducted to analyze the chemical properties of the soil of Margalla Hills of Pakistan affected by fire in comparison with un-burnt soil of the same area. Soil texture is affected by combustion but with the revival of nature plants, soil properties turn to pre-burn status. A study of fire affected soil revealed that soil properties were significantly improved on burnt soils than on the un-burnt site and the response was attributed changes in the host plant.

Keywords: Forest fire, Margalla Hills, Plant system.

Citation: Khan, J., B. Muhammad, M.A. Khan, Z. Hussain, S.U. Khattak, N. Bacha, F. Ullah, G. Lutfullah and R. Ali. 2014. Effect of forest fire on the chemical composition of the soil of Margalla hills of Pakistan. Pak. J. Weed Sci. Res. 20(2): 213-223.

INTRODUCTION

The friendship involving fire, people and environmental processes is very old. Especially, spring burning is known to improve below-ground biomass (Dhillon *et al.,* 1988). However, when nutrients were expressed in terms of plant nutrients per square meter, there was no significant difference, between burnt and unburntsoil. Spore count for soil collected from the different plant varied seasonally on the burnt and unburntsoil (Pattinson *et al.,* 1999). Burning of vegetation had serious effects on both the size and activities of plant population, especially as regards spore viability (Tommerup, 1985). The burnt sites had less viable amount than the control one. As far as root colonization was concern, in the burnt area ranged from 21% to

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37% as against 51% on the unburnt plots (Marion *et al.,* 1991). The severities of disturbance effect vary with soil from different vegetation types and are related to the incidence of infective propagules available for the re-establishment of colonization after soil disturbance (Vilarino and Arines, 1991). Many plants are sensitive to cultural and environmental stresses. Soil disturbance is perhaps the mostdrastic among cultural stress in its effects (Evan and miller, 1990). The population density of plant may also be reduced by soil erosion is not severe enough to cover. A significant effect of landscape position was reported for colonization. A positive correlation was also found between the increase in plant and the soil temperature as a result of fire (Klopatek*et al.,* 1988). Soil may be less affected by disturbances involving destruction of aerial biomass. A comparison of many types of little plants in burnt and unburnt sites indicated that burnt areas have high floristic composition. In an older study, annual plants which had very low infection levels, were common immediately after the fire but they were absent from older vegetation, while infection levels were high in older geophytes and shrubby perennials (Allsopp and Stock, 1994).The specific objective of the present study was to evaluate the effects of fire on chemical properties of soils-plant system Margalla Hills Pakistan, at burnt site and to compare it with those of control i.e. unburnt. The response of soil to fire may be attributed changes in the host plant and not due to any direct effect of fire. A study of fire effect on plant ecology revealed that colonization levels of little stem plants were significantly less on burnt site than on the control area during the first growing season post burn, but there were no significant differences between the two sites during the second year.

MATERIALS AND METHODS

Soil was collected from both sites i.e. burnt and unburnt. Soil texture was determined by boyoucos hydrometer method of Beverwijk 1967. Cleaning and staining of roots was carried out by modified Koske and Gemma (1989) method.Samples from all the sites from where data for vegetation was determined were taken and were kept separate and were brought to laboratory. Soil was air dried, gently crushed, sieved in 2mm mesh sieve to remove stone. The sample was carried out according to the following schedule, first sampling in May, second sampling in July, third sampling in August, fourth sampling in September and fifth sampling in December.

Soil analysis

Soil samples were prepared to collect the soil extracts of different samples.Soil pH was determined in soil saturation extracts (Aslam *et al.,* 1988). The concentration of potassium was directly determined from soil extracts by Atomic Absorption

Spectrophotometer Shimadzu AA-670 (Arienzoa *et al.,* 2009). The optical density was measured at 700 nm with the help of a new optical method for soil stress (Jarosaw and Krystyna, 2002). Bray *et al.* (1945) method was used to determine the concentration of organic matter and Phosphorus in soil extract. Cation exchange capacity was determine according to Carroll (1959). Nitrogen was determined by semi-micro Kjeldahl method as described by Neil (1936).The data was processed by F-test to determine whether there were significant (0.05) effects of fire on burnt soils (Timothy and Stuart, 2000).

RESULTS AND DISCUSSION

Soil texture

The relative extent of individual constituents in the soil of Margalla hills was determined. Table-1 shows the relative proportions of various mineral particles as resolute during various months. A comparison between soil texture of burnt and unburnt soils reveals that there was no significant difference in their texture.

Fire affected soil render the entire ecosystem ineffective resulting in ecological imbalances, loss of vegetation, forest floor and destruction of soil fauna. The results of this present study show some considerable effects of fire on soil texture (Table-1). Though, burnt soils have a little higher percentage of clay proportions as compared to unburnt sites. Soil texture appeared to be affected directly by fire (Fernandez *et al.,* 1991). At places where soil bums severely, a progressive difference in surface soil texture carried out. Burning of soil caused a distribution of particle-size due to fusion of clay into sand-sized particle. Fire is one of the environmental matters affecting the nutrient in the soil and content of organic substance. The effects of fire are influenced by vegetation, accumulation, soil type, fuel, geographical features especially precipitation. According to Fijita (1988), influence of fire on soil physiochemical properties will depend on the prevailing circumstances (Jasper *et al.,* 1991).

Table-1. Soil texture analysis (%) of collected soil samples

Sample Burnt	May	July	Aug	Sep	Dec
Sand	76.1	75.2	74.3	73.4	70.6
Silt	26.2	15.1	14.3	13.2	52.4
Clay	26.1	15.3	14.5	13.7	52.6
Unburnt					
Sand	76.3	75.2	74.3	73.4	72.6
Silt	16.1	15.1	14.5	13.3	42.6
Clay	26.4	15.2	14.3	13.4	42.6

Each reading is the mean of three replicated

Soil organic matter (SOM)

The assessment of soil organic matter (SOM) is reported in Table-2. A minor variation was proof among organic content of surface and subsoil of both the burnt and unburntsites. Subsoil of both fire affected and control soils were low in organic substance as evaluate to surface soils. Organic matter was much high (P ≤ 0.05) in burnt area in May to September in both surface and subsoil as compared to controlsite. Consequently, there was regular decline in organic substance in burnt soil. In September and December there was no considerable(P ≤ 0.05) feature in organic content of control and burnt sites.

Table-2. Soil organic matter (%) of the collected soil samples

Samples	May		July		Aug		Sep		Dec	
	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur
F1	3.1	2.8	2.8	2.6	2.7	2.6	2.6	1.3	2.4	2.1
F2	2.1	2.7	2.7	2.4	2.8	2.6	2.4	2.2	2.3	2.2
F3	3.1	2.7	2.8	2.5	2.5	2.5	2.5	1.4	2.5	2.0
F4	2.1	2.6	2.9	2.4	2.6	2.4	2.7	2.0	2.2	2.0
F5	3.1	2.8	2.7	2.6	2.7	2.3	2.4	2.1	2.3	2.1
C1	2.1	2.0	2.3	2.0	2.4	1.9	2.7	1.5	1.1	2.0
C2	2.1	1.9	2.8	1.9	2.0	1.7	2.3	1.0	1.6	2.7
C3	2.1	2.0	2.8	1.7	2.7	1.6	2.5	1.7	2.7	2.6
C4	2.5	1.8	2.5	1.8	2.8	2.0	2.5	1.8	2.4	2.9
C5	2.3	1.7	2.0	2.0	2.9	1.5	2.0	1.5	2.7	2.2
	AB	AB	AB	AB	AB	AB	AA	AA	AA	AA

Cation exchange capacity (CEC)

Cation exchange capacity (CEC) that a soil can adsorb was determined and has been presented in the Table-3. Table-3 show that cation exchange capacity in surface and Sub Soil was considerably (P≤0.05) higher in May as compared to control soil. There was a trend towards the reduction in cation exchange capacity in soil of burnt area and there was no considerably distinction among burnt and control area in December. The cation exchange capacity of subsoil of both burnt and unburnt area was slightly lower than surface soils.

It can be inferred from Table-3 that cation exchange capacity of burnt soil is better than that of control sites. Angela *et al.* (2000) have reported certain useful relationship between soil cation exchange capacity and pH. The cation exchange capacity of a reported area is determined by the fixed quantity of different colloids in that soil. It has been noticed that sandy soils have less cation exchange capacity than clay soils because the coarse soils have volatilization of NH_4 and an increase of pH in the control soil. Fernandez *et al.*(1991) reported that burning increased the nutrient level in the burnt area.

Table-3. Cation exchange capacity (in mg/100g of soil) in collectedsoil samples

Samples	May		July		Aug		Sep		Dec	
	Sur	Sub-Sur	Sur	Sub -Sur	Sur	Sub -Sur	Sur	Sub -Sur	Sur	Sub-Sur
F1	53	53	53	43	44	80	47	59	68	73
F2	53	44	43	43	43	70	41	50	46	33
F3	43	45	54	43	45	87	47	56	60	78
F4	53	48	44	44	46	70	48	47	36	33
F5	53	44	54	43	45	57	47	48	69	77
C1	43	54	33	31	78	37	37	56	64	73
C2	43	54	44	33	77	75	44	31	36	33
C3	44	54	34	32	75	37	47	53	66	71
C4	44	54	43	33	86	73	37	32	37	33
C5	44	54	34	42	88	37	47	40	38	75
	AB	AB	AB	AB	AB	AB	AA	AA	AA	AA

Hydrogen ion concentration (pH value)

Table-4 illustrates that pH values for collected soil form burnt area are somewhat high as compared to control sites. Significant ($P \leq 0.05$) distinction in pH value of burnt and control soils were reported in May at the time of fire hazard. Later on pH of burnt soils reduces regularly. Through August to September pH values of burnt area keep ($P \leq 0.05$) high as compared to control sites. There was no major($P \leq 0.05$) distinction between the values of burnt and control soil in December.

Soil pH increased directly after fire. Amount of potassium (K) initially increased in burnt soil, immediately after fire (Warren, 2004), but in July and August potassium amount of sub-soils were found considerably high in burnt sites. In December the amount of potassium in burnt soils returned close to those of control sites. At the site of burning, small differences encountered regarding the nutrient concentration after burning would be due to soil erosion by seedlings and plants. It has been noticed that the removal of vegetation from soil surface invited soil erosion i.e. combusted areas have greater potential for soil erosion (Gardner *et al.,* 1985).From the recent research, it is obvious that in future soil physiochemical properties of control sites will remain fixed. The results suggested that vegetation practice like restoration of flora etc. is the characteristic features of burnt sites. At the same time, fire significantly modifies surface soil character and erosion rates (Amaranthus, 1993).

Soil potassium content (K)

Potassium (K) content from surface as well as subsoils of fire-affected and control areas is presented in Table-5. Potassium concentrations were considerably ($P \leq 0.05$) higher in burnt soils of surface and sub-soils as compared to control sites directly after fire i.e. in May. In July to September there was no considerable ($P \leq 0.05$) difference between the potassium concentrations of surface soils of burnt and control area; whereas potassium concentrations were considerably higher ($P \leq 0.05$)in sub-soils of burnt area than the control area, in July to September.

Soil nitrogen content

Soil nitrogen % age for surface and subsoil both from fire-affected and control site are reported in Table-6. A little distinction was observed between nitrogen content of surface and subsoil of both fires affected and control site. It has been noticed show high ($P \leq 0.05$) difference between nitrogen content of fire affected and control area during the months from May to September. In December there was no major ($P \leq 0.05$) difference between soils nitrogen % ages of burnt and control sites. Small decrease in nitrogen % age of surface and subsoils of control area was also observed in December.

Soil phosphorus content

It is obvious from the results that there is comparable development in the amount of soil nitrogen (N) and phosphorus (P) in the surface and sub-soils of burnt and control sites. Table-7 illustrates major ($P \leq 0.05$) distinction in phosphorus amounts between burnt and control site directly after fire in May. The amount of phosphorus in burnt soils in surface and sub-soils remain ($P \leq 0.05$) increased as compare to control soils in the months of from July to December. The soil phosphorus content of burnt soils pursues a trend towards action in concentration. In December there was no significant ($P \leq 0.05$) difference in phosphorus concentrations of burnt and control sites.

Soil organic substance like nitrogen and phosphorus were increased after combustion (Tables-2, 5 and 6). After fire in December, there seems a decrease in concentrations of various nutrients where values were found close to the unburnt area. The increased nitrogen and organic substance directly after fire was mainlydue to combustion of woods in burnt soil. So, nitrogen and organic substances were high in fire-affected soils (Table-2 and 5). However, a later decrease in soil nitrogen and organic substance in fire-affected soil was due to the fact that loss of plant cover and herbaceous vegetation had prevented further addition of litter. Decomposition rate in burnt area surpassed as compared to small addition, which eventually decreased the nitrogen and organic matter contents of burnt soil (Table-2 and 5). In addition to that flora at burnt area had further exploited the nitrogen pool of burnt and organic matter substances of burnt soil. Balagopalan (1987) has also documented exchange capacity as compared to burnt ones. Moreover, soil pH of fire-affected burning are due to reduce in soil colloids and pH level (Table-3) than to control soils (Table-4).

Excessive loss of plants and rainfall has direct effect on the credibility of a particular soil. The present research reflects similar situations in which combustion was the root cause of disturbance. Changes in plant growth responses on burnt and unburnt sites also explain results. Soil analysis indicates that burning increased the nutrient level in soil (Eisele *et al.,* 1989) as well as plant growth is enhanced in burnt areas (Dhillion *et al.,* 1988; Dhillion and Anderson, 1993). The slope of site under study had greater potential of soil erosion especially at burnt plots where fire has resulted in the loss of plant cover from the soil surface, therefore, eroded soils have reduced number of mycrorrhizal propagules (Day *et al.,* 1987) and there is less chance of encountering infective VAM propagules to plant roots in order to develop infection.

CONCLUSION

It may be concluded that fire stresses on soil is strongly correlated with vegetation and soil. It proves that the burning of vegetation had serious effects on viability of propagules in soil. From the present study it is further concluded that soil levels have been affected by fire hazards. The comparison of fire-affected area and unburnt (control) revealed that various soil properties i.e. soil nitrogen, phosphorus, soil organic matter, potassium, pH and cation exchange capacity etc. are variously influenced by fire. The extent of alteration in soil properties of Margalla Hills status depends upon the burning of vegetation and fire intensity. Initially soil nutrients were increased in the burnt site after fire, but with the passage of time soil turned close to pre-burn conditions. Due to burning of vegetation, burnt site was exposed to severe nutrient loss by erosion and leaching. With the passage of time, along with revival of natural plant cover soil properties turned to pre-burn status. The revival of present conditions to normal ones could be facilitated if fire prevention measures are adopted in future at Margalla Hills.

Table-4 Hydrogen ion concentration in the collected soil samples

Samples	May		July		Aug		Sep		Dec	
	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur
F1	7.7	7.1	8.3	8.2	7.4	7.1	7.2	7.0	6.8	7.6
F2	7.7	8.0	8.2	8.1	7.4	7.2	8.3	8.1	6.9	8.2
F3	7.6	7.2	8.4	8.2	7.3	4.0	7.4	7.1	7.8	7.4
F4	8.7	8.1	8.5	8.2	7.2	7.9	8.2	7.0	6.9	8.5
F5	7.5	7.2	8.3	8.0	8.3	8.3	7.2	71	8.9	8.6
C1	7.5	7.3	7.5	5.3	7.6	7.2	5.4	5.1	5.6	5.3
C2	5.5	5.2	7.5	7.5	7.5	5.1	5.6	7.5	7.5	5.5
C3	5.5	7.1	7.4	5.5	7.5	7.3	7.3	5.1	5.5	7.2
C4	7.6	7.4	5.5	7.2	7.4	7.0	5.5	7.5	7.5	7.5
C5	7.5	5.2	7.5	5.5	7.5	5.5	7.4	5.1	5.5	5.2
	AB	AB	AB	AB	AB	AB	AA	AA	AA	AA

Table-5. Potassium content (ppm) in the soil samples collected from Margalla Hills

Samples	May		June		Aug		Sep		Dec	
	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub -
Fl	22.4	15.5	9.1	4.5	10.5	10.5	10.5	12.5	9.9	7.5
F2	23.2	15.5	8.3	2.6	20.4	8.8	60.3	12.8	10.0	9.2
F3	25.0	12.7	20.3	14.4	10.6	13.4	10.2	9.5	11.3	7.2
F4	23.8	3.5	20.2	23.8	5.8	9.1	6.3	12.9	7.7	8.5
F5	24.0	14.9	20.0	15.0	10.7	11.0	8.6	13.3	12.0	5.5
C1	26.2	7.6	9.6	8.6	6.6	8.6	11.6	10.6	8.6	7.6
C2	12.1	7.2	9.8	8.4	10.0	9.6	6.7	9.3	10.2	9.5
C3	21.5	6.9	10.5	14.0	70.5	8.0	9.6	10.2	8.5	8.1
C4	12.1	7.5	21.0	12.5	9.6	6.3	6.8	8.9	9.8	9.5
C5	21.2	7.7	20.7	20.2	50.1	9.8	8.9	9.1	9.3	9.0
	AB	AB	AA	AB	AA	AB	AA	AB	AA	AA

Table-6. Nitrogen concentration (%) in the collected soil samples

Samples	May		June		Aug		Sep		Dec	
	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur
Fl	0.2	0.1	0.2	0.2	0.3	0.2	0.1	0.2	0.1	0.2
F2	0.1	0.3	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2
F3	0.2	0.1	0.2	0.2	0.3	0.1	0.1	0.2	0.2	0.2
F4	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.2
F5	0.2	0.1	0.2	0.3	0.2	0.1	0.3	0.1	0.2	0.7
C1	0.1	0.9	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.1
C2	0.2	0.7	0.0	0.2	0.0	0.1	0.1	0.0	0.1	0.1
C3	0.0	0.7	0.1	0.0	0.5	0.1	0.1	0.1	0.1	0.1
C4	0.2	0.8	0.0	0.2	0.0	0.1	0.1	0.1	0.1	0.1
C5	0.2	0.5	0.2	0.0	0.3	0.1	0.1	0.1	0.1	0.1
	AB	AB	AB	AB	AB	AB	AB	AB	AA	AA

Table-7. Phosphorus content(ppm) in the collected soil samples

Samples	May		June		Aug		Sep		Dec	
	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur	Sur	Sub-Sur
F1	9.7	9.3	8.5	9.2	5.9	8.5	8.3	7.2	7.6	7.6
F2	4.6	7.2	9.5	9.1	8.7	7.5	8.2	8.1	6.6	6.2
F3	8.6	9.4	8.6	8.2	8.5	8.2	7.9	7.5	7.5 54	7.6
F4	9.6	4.2	9.4	9.1	8.8	7.4	8.7	5.6	7.3	5.0
F5	9.7	8.3	8.5	9.3	5.4	8.5	7.8	7.5	3.6	7.6
C1	9.1	6.8	7.3	8.8	7.1	8.6	7.3	7.5	7.1	8.8
C2	7.6	8.7	7.2	6.8	8.0	6.5	8.2	5.5	7.6	6.6
C3	9.2	9.9	8.1	8.9	6.9	8.5	7.0	6.7	6.9	8.6
C4	7.6	6.6	7.6	6.6	8.8	6.6	6.8	6.5	8.1	6.6
C5	7.1	6.8	6.9	6.6	7.0	6.6	7.1	6.7	7.0	6.7
	AB	AB	AB	AB	AB	AB	AB	AB	AA	AA

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