

Soil Fertility Status and Recovery in Abandoned Jhum Fallows of Nokrek Biosphere Reserve of Meghalaya

Vanlalhruaii Ralte*

Abstract

The study conducted in the Nokrek Biosphere Reserve of Meghalaya aimed at analyzing the impact of shifting agriculture ('jhum') on soil physico-chemical properties in relation to the undisturbed core zone and the recovery pattern of nutrients with the increase in fallow period. Changes in physical and chemical properties of soil of the BR as a result of shifting agriculture in the buffer zone were analyzed on the basis of several parameters such as bulk density and porosity, moisture content, texture, water holding capacity, water-stable aggregates, pH, cation exchange capacity, total organic C, total Kjeldahl N, available P and exchangeable K. Soil organic carbon content was highest (5.93 %) in the undisturbed core zone. Within the buffer zone, the 10-12-yr. old jhum fallow recorded a high value of 5.10 %, which gradually declined to 4.66 % in 6-8-yr. and 4.15 % in 1-yr. old fallow. The loss in total nitrogen, available phosphorus and exchangeable potassium were 35 %, 50 % and 6 % in the jhum fallows.

Keywords: *physico-chemical properties of soil, jhum fallows, recovery, Nokrek Biosphere Reserve, and soil fertility*

Introduction

The Nokrek Biosphere Reserve (BR) located in the western part of Meghalaya in the Garo Hills having an

*Ph.D; Assistant Professor, Department of Botany, Pachhunga University College, Aizawl, Mizoram; Email:apuii_r@yahoo.com

area of 820 sq. km has a core zone of 47.48 sq. km and a buffer zone of 772.52 sq. km. It lies between 90°13' E and 90°35' E longitudes and 25°20' N and 25°29' N latitudes. The vegetation in the core zone comprises of evergreen forest, semi-evergreen forest and a deciduous forest. About 85 % of the population extensively practices slash and burn agriculture (locally called 'jhum') in the entire buffer zone and the average area under jhum in each village is 243.70 ha. It is estimated that 31,473 ha or 38.47 % area on the hill slopes of the biosphere reserve is influenced by slash and burn agriculture.

Shifting cultivation affects the physico-chemical and biological characteristics of soil in different ways. In order to determine the effect of these activities, various physico-chemical properties of soil were studied in the undisturbed core zone (C) and jhum fallows of three different ages viz. 10-12-(J12), 6-8-(J6) and 1-year old (J1) in the buffer zone of the BR over a period of three years on seasonal basis. Changes in physical and chemical properties of soil of the BR as a result of shifting agriculture in the buffer zone were analyzed on the basis of several parameters such as bulk density and porosity, moisture content, texture, water holding capacity, water-stable aggregates, pH, cation exchange capacity, total organic C, total Kjeldahl N, available P and exchangeable K. The results of these analyses have been presented in this paper.

Materials and Methods

Soil samples were collected in January (winter) and August (rainy) for two consecutive years from the

selected sites. At each site, three to five replicate samples were collected. The replicated samples were mixed thoroughly to obtain one composite sample. Fresh samples were used for the analysis of soil moisture content and the rest were air-dried and sieved through 2 mm sieve and stored for further analysis. Soil analysis were carried out by using the method prescribed by Allen et al (1974), Elliot (1986), Piper (1942) and Anderson & Ingram (1992).

The data were analyzed using two-way and three-way analysis of variance (ANOVA) (fixed effect model) to test the effects of season, soil depth and/or site on various physico-chemical properties of the soil. Inter-relationship between different soil properties, and affect of climatic variables on soil properties were analyzed by computing linear regression models and coefficients of correlation (r) according to Zar (1974).

Results

Soil texture and bulk density (BD): The texture of the soil was sandy loam in the undisturbed core zone and jhum fallows of different ages. The clay content was generally higher at the lower depth (10-20 cm) except in the 10-12-yr. old jhum fallows (Table 1). Two-way ANOVA revealed a significant variation ($P<0.01$) in the proportion of fine particles (silt + clay) in soils of different sites. Bulk density of the soil showed a significant ($P<0.01$) variation due to site and soil depth.

Table 1: Texture and bulk density of soil at the study sites

Sites	Depth (cm)	Proportion of soil particles			Textural class	BD (g/cm ³)
		Sand (%)	Silt (%)	Clay (%)		
Core zone*	0-10	66.94	29.73	3.33	SL	1.2
	Oct-20	60.89	28.53	10.58	SL	1.79
Jhum fallows						
10-12-yr. old*	0-10	62.94	26.01	11.05	SL	1.14
	Oct-20	65.86	23.71	10.42	SL	1.18
6-8-yr. old*	0-10	75.05	19.37	5.58	SL	1.08
	Oct-20	61.78	26.14	12.08	SL	0.94
1-yr. old*	0-10	64.14	27.64	8.21	SL	1.09
	Oct-20	60.37	28.6	11.03	SL	1
Meant†	0-10	67.38	24.34	8.28	SL	1.1
	Oct-20	62.67	26.15	11.18	SL	1.04

SL=sandy loam

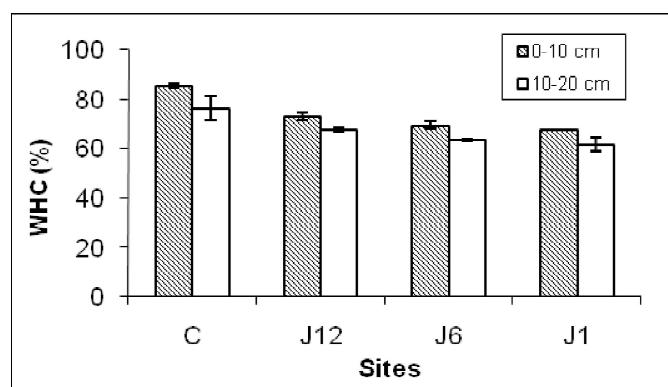
*Mean of the replicate sites; †Mean of the jhum fallows

It is minimum 0.94 g/cm³ in the subsurface layer of 6-8 yr old jhum fallows and maximum (1.79 g/cm³) in the core zone (Table 1). At all sites except the undisturbed core zone, the BD was high in the upper layer (0-10 cm).

Water holding capacity (WHC): Among the sites, WHC was highest in the core zone and lowest in 1-yr old fallow, and it declined significantly ($P<0.01$) from upper (0-10 cm) to lower (10-20 cm) soil depth (Figure 1).

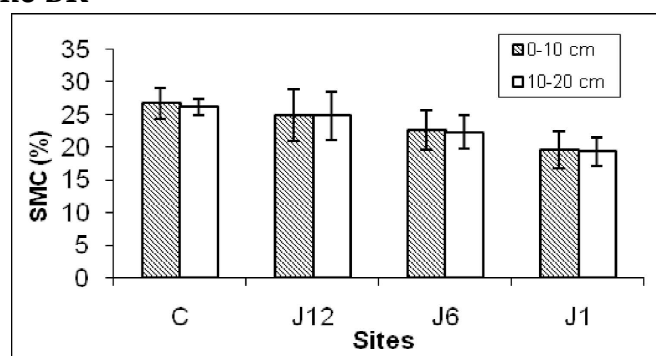
Two-way ANOVA revealed a significant ($P<0.01$) difference between the different sites. It also increased significantly ($P<0.01$) with vegetation regrowth on jhum fallows.

Figure 1: Mean water holding capacity (WHC, \pm SE) of surface (0-10 cm) and subsurface (10-20 cm) soil layers of the BR



Soil moisture content (SMC): Highest SMC was recorded in the undisturbed core zone followed by jhum fallows and lowest in the 1-yr. old fallow (Figure 2).

Figure 2: Mean soil moisture content (SMC, \pm SE) of surface (0-10 cm) and subsurface (10-20 cm) soil layers of the BR



Water-stable aggregates (WSA): Among different size classes of aggregates, the proportion of macroaggregates (0.3-2 mm) was maximum in all the stands (Table 2). The proportion of micro-aggregates (<0.3 mm) in soil was

more in the core zone than in the jhum fallows. On jhum fallows, it increased with the age of the fallow. At all sites, the proportion of micro-aggregates was more in the upper soil layer than the lower layer.

Table 2: Weight distribution (%) in different soil aggregate classes at different sites in the BR

Sites	Depth (cm)	Soil aggregate class (mm)				
		>4.75	2-4.75	0.3-2	0.063-0.3	<0.063
Core zone*	0-10	11.15	16.29	34.79	22.47	15.32
	Oct-20	11.81	16.04	42.75	17.27	12.14
Jhum fallows						
10-12- yr. old*	0-10	25	15.95	36.54	15.61	6.91
	Oct-20	23.84	16.61	41.93	13.87	3.76
6-8- yr. old*	0-10	18.07	12.94	45.37	16.8	6.83
	Oct-20	11.61	17.31	48.98	15.31	6.8
1- yr. old*	0-10	14.05	15.24	41.43	17.01	12.28
	Oct-20	13.15	10.11	49.22	20.08	7.46
Mean†	0-10	19.04	14.71	41.11	16.47	8.67
	Oct-20	16.2	14.67	46.71	16.42	6.01

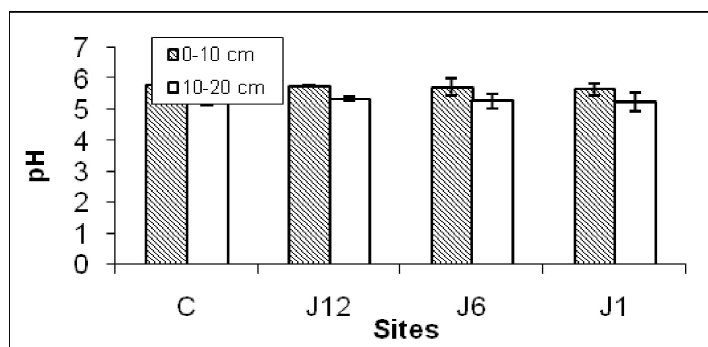
Micro-aggregates = <0.3 mm; macro-aggregates = >0.3 mm

*Mean of the replicate sites

†Mean of the jhum fallows

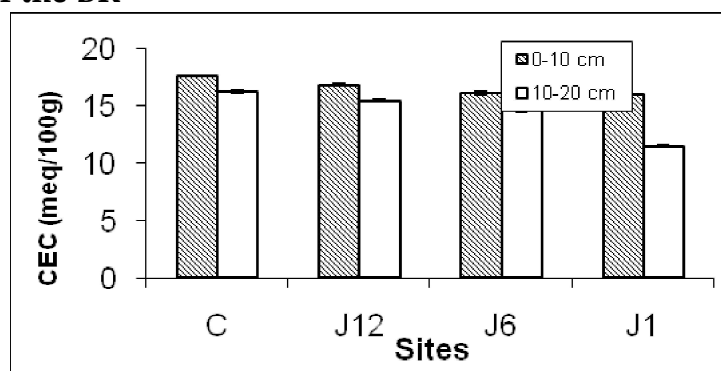
Soil pH: The soil was acidic (pH=3.50 - 6.14) at all sites. The acidity increased significantly ($P<0.01$) with the increase in soil depth and varied between different seasons; the values were high during winter and low during rainy season (Figure 3).

Figure 3: Soil pH (\pm SE) of surface (0-10 cm) and subsurface (10-20 cm) soil layers at different sites of the BR



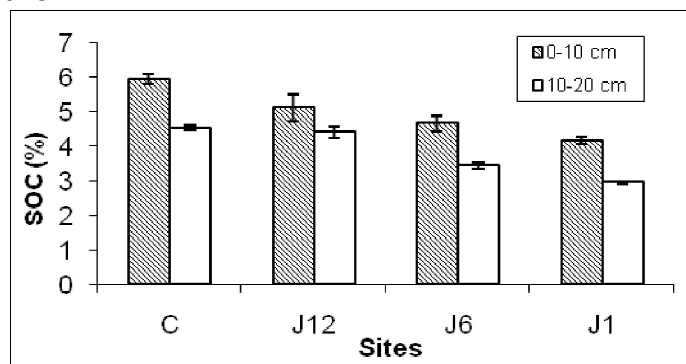
Cation exchange capacity (CEC): Two-way ANOVA revealed a significant variation ($P < 0.01$) in CEC between different sites. It increased significantly ($P < 0.01$) from young to old jhum fallow. The upper layer had significantly higher ($P < 0.01$) CEC than the lower layer (Figure 4).

Figure 4: Cation exchange capacity (CEC, \pm SE) of surface (0-10 cm) and subsurface (10-20 cm) soil layers of the BR



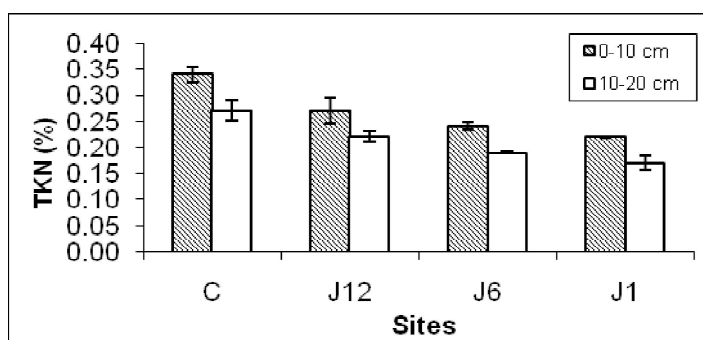
Total soil organic carbon (SOC): The SOC content was minimum during the winter season and maximum during the rainy season, and it declined significantly ($P<0.01$) with the increase in soil depth. Within the buffer zone, the 10-12-yr. old jhum fallow recorded a high value of 5.10 %, which gradually declined to 4.66 % in 6-8-yr. and 4.15 % in 1-yr. old fallow. The maximum value (5.78 %) was obtained in the core zone and minimum value (2.91 %) was recorded in 1-yr. old fallow (Figure 5). Three-way ANOVA revealed significant variation ($P<0.01$) in SOC content between sites and seasons.

Figure 5: Mean soil organic carbon (SOC, \pm SE) of surface (0-10 cm) and subsurface (10-20 cm) soil layers of the BR



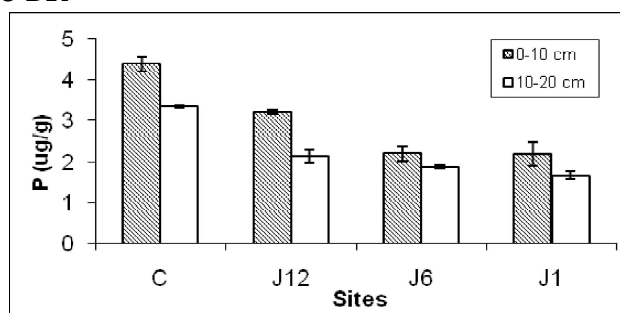
Total Kjeldahl nitrogen (TKN): TKN content showed a significant ($P<0.01$) variation between stands, year, season and soil depth. The concentration was minimum during winter season and maximum during rainy season, declining significantly ($P<0.01$) with the increase in soil depth. Core zone had the highest concentration of TKN (0.35 %) and 1-yr. old fallow recorded the lowest value (0.18 %) (Figure 6).

Figure 6: Mean total Kjeldahl nitrogen (TKN, \pm SE) of surface (0-10 cm) and subsurface (10-20 cm) soil layers of the BR



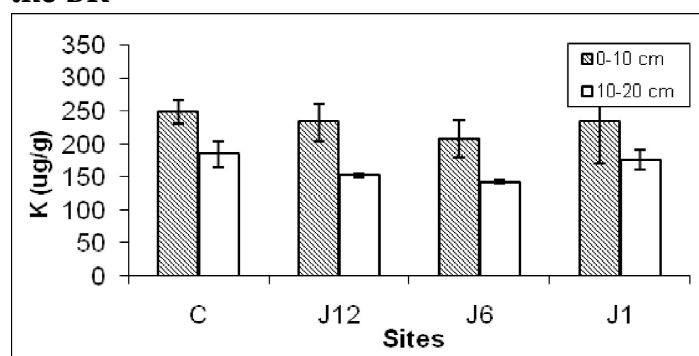
Available phosphorus (P): Available P showed a significant ($P < 0.01$) variation between stands and seasons. In the core zone and on jhum fallows, the maxima were recorded during winter and minima during the rainy season. The soil in the core zone had maximum concentration of available phosphorus ($4.56 \mu\text{g g}^{-1}$) while that of the mine 1-yr. old fallow had the minimum concentration ($1.58 \mu\text{g g}^{-1}$). The concentration also declined with the increase in soil depth (Figure 7).

Figure 7: Mean available phosphorus content (P, \pm SE) of surface (0-10 cm) and subsurface (10-20 cm) soil layers of the BR



Exchangeable potassium (K): The core zone had the highest concentration of exchangeable K ($230 \mu\text{g g}^{-1}$) followed by jhum fallows with minima in 6-8-yr old fallow ($140 \mu\text{g g}^{-1}$) (Figure 8). Among jhum fields, 1-yr. old fallow had a high concentration of K compared to the older fallows. At all sites, concentration was significantly ($P < 0.01$) higher in the surface soil layer than the subsurface layer. It was minimum during rainy season and maximum during the winter season.

Figure 8: Mean exchangeable potassium (K, \pm SE) of surface (0-10 cm) and subsurface (10-20 cm) soil layers of the BR



Discussion

Effect of shifting cultivation on physical properties of soil

The results presented in the foregoing pages clearly reveal that shifting agriculture in the buffer zone of the Nokrek Biosphere Reserve have led to changes in several physical and chemical characteristics of the soil system. The effect starts with the removal of vegetal cover from above the soil system. It has been reported that canopy harvesting in the forest results in erosion of the topsoil

due to extreme rainfall events (Scholes et al. 1994), and increase in bulk density (Hajabbasi et al. 1997). However, an examination of the mean values of BD reveals a marginal decrease from the core zone to jhum fallows.

A gradual decline in WHC from the core zone to jhum fallows was related to decrease in the proportion of silt particles in soil as is evident from the positive relation between WHC and proportion of silt particles ($r=0.68$, $P<0.05$).

Another important factor that contributed to decrease in WHC was soil organic matter, which also showed a positive relation with WHC ($r=0.83$, $P<0.05$). Ramesh et al. (2008) also reported similar findings.

Scholes et al. (1994) have reported a positive correlation between clay content and WHC. In the present study, however, the clay content was higher in the lower soil layer whereas WHC was more in the upper soil layer, which had greater accumulation of organic matter thereby indicating a stronger influence of SOM on WHC than the clay particles. Higher WHC has been reported from deodar forest soil in Uttar Pradesh, India (Yadav and Badolka 1973) and older forest regrowth in north-eastern India where SOM was as high as 11 % (Arunachalam & Pandey, 2003).

Similarly, greater moisture content in the surface soil layer may be ascribed to greater accumulation of litter on the forest floor that check evaporation losses and higher SOM that helps in retention of moisture. On the other hand, lower SMC in the surface soil layer during dry winter season could be the result of higher evapotranspiration from the soil and plant surfaces and percolation and infiltration of water to the lower depths.

Cai et al. (2017) reported that in contrast to surface soil moisture and precipitation consistency, deep soil moisture is less susceptible to real-time precipitation constraints. The lower SMC in the 1-yr. old jhum fallows as compared to the undisturbed core zone could be the result of greater loss of water as run off from the hill slopes and high evaporation from the exposed soil in the absence of tree cover.

Deleterious effects of cultivation on water-stable aggregates leading to decline in the macro-aggregates in soil have been reported by Spaccini et al. (2001). However, in the present study, higher values of macro-aggregates were recorded at the cultivation sites than the undisturbed core zone, where proportion of micro-aggregates was more than the macro-aggregates. Greater amount of microaggregates was responsible for higher concentration of organic carbon as well as higher C/N ratio in the core zone soil. They are more stable than macroaggregates because of binding by humus, iron and aluminium oxides and clay particles Wild (1996) and contain about 12 % more SOC than macroaggregates and have higher C / N ratios (Ashman *et al.* 2003).

Effect of shifting cultivation on chemical properties of soil

The soils of the undisturbed core zone and the jhum fallows were acidic in nature, but the jhum fallow soils were more acidic than the undisturbed core zone. Acidic nature of soils under shifting cultivation was recorded by Nayak and Srivastava (1995) in Arunachal Pradesh, where acidity increased with increasing soil depth. However, in some cases higher pH was recorded in younger jhum fallows than the undisturbed core zone.

Singh *et al.* (1995) recorded higher soil pH in jhum fallows than bamboo forest and natural forests of north-eastern India. Since acidic reaction of the soil is due to presence of exchangeable Al^{+3} and intensive leaching of bases, drop in the pH during rainy season could be the result of excessive leaching of basic cations by rainwater (Wild 1996).

CEC that did not vary markedly between the undisturbed core zone and the jhum fallows was negatively related ($r=0.86$, $P<0.05$) to the percentage of sand particles and positively correlated ($r=0.53$, $P<0.05$) with the clay content of the soil. This corroborates the findings of Scholes *et al.* (1994) who found a linear relationship between clay particles and CEC. However, a decline in CEC with the increase in soil depth where the proportion of clay was higher than the surface soil layer suggested that it was also influenced by organic colloids in the soil (Scholes *et al.* 1994). The significant positive relationship between CEC and pH ($r=0.68$, $P<0.05$) also explains the effect of pH on the exchangeable bases in soils of the BR.

Greater accumulation of organic carbon in the surface layer is ascribed to slow microbial decomposition of litter in acidic soils as reported by Nayak and Srivastava (1995) from humid sub-tropical soils under shifting cultivation in north-east India. In strongly seasonal climate where decomposition rate is fast, highly varied composition of litter protects the soil surface throughout the year and promotes organic matter accumulation (Brown *et al.* 1994). Higher nutrient status of the undisturbed core zone soil as compared to the jhum fallows is in confirmity with findings of Agbenin and Goladi (1997) who recorded 38 % reduction in

organic carbon, 41 % in TKN and 39 % in organic nitrogen, following continuous cultivation without fertilization. Garcia-Oliva *et al.* (1999) reported that slash and burn could result in significant disruption of soil carbon cycling in forest ecosystem and recorded 32 % decrease in organic carbon associated with macro-aggregates due to conversion of tropical deciduous forests into pastures by burning. Significant reduction in soil organic matter and organic carbon following conversion of tropical forests into pastures, agricultural fields, and shifting cultivation and tillage practices have been reported by Brown *et al.* (1994) and Henrot and Robertson (1994). Loss could even reach up to 50 % in organic matter and total nitrogen contents in comparison to the undisturbed natural forests sites (Saikh *et al.* 1998). Brand and Pfund (1998) noted a net loss of 20-22 % soil fixed carbon and nitrogen after burning in shifting cultivation systems. In the present study, a 30 % drop in SOC was recorded in 1-yr. old field compared to the core zone soil as a result of slash and burn agriculture.

Higher concentration of TKN in the surface layer of both the undisturbed core zone and jhum fallows of different ages could be due to the higher organic matter concentration in this layer. A sharp decline in TKN concentration from 0.35 % in the undisturbed core zone to 0.15 % in the 1-yr. old jhum fallow may also be due to runoff losses caused by heavy rainfall, besides low SOM content.

SOC was also positively correlated with available phosphorus ($r=0.93$, $P<0.0001$), therefore signifying the role of the organic matter in the availability of P, which is often present at low concentration in the soils of north-eastern region of the country. Though some workers

observed insignificant seasonal variation in total phosphorus and available phosphorus contents in regenerating jhum fallows, cultivated field, grassland and natural forests, the present findings are at variance with results obtained by these workers since available P showed a significant ($P < 0.01$) variation due to season, site and depth. Available phosphorus was higher during winter and lower during the rainy season. Greater input of phosphorus through litter during winter and spring seasons in the 7, 13 and 16 years old forest regrowth has been reported by Arunachalam and Pandey (2003) in humid subtropical region.

High potassium concentration ($450 \mu\text{g g}^{-1}$) observed in the 1-yr. old jhum fallow could be the result of ash content left in soil after burning of slash during preceding winter and its subsequent loss through rainwater. Potassium concentration further declined in the next rainy season in 1-yr. old fallow due to excessive leaching and run off losses. A greater fluctuation in the concentration of K than the other nutrients is because K cycles through vegetation and soil solely as an unbound ion, and is easily leached from living and decomposing plant tissues compared to other nutrients. The exchangeable K concentration in the core zone was higher than other sites in the buffer zone possibly because K is retained and cycled more dynamically in the forest ecosystem.

Changes in soil characteristics during vegetation regrowth on jhum fallows

Physical and chemical attributes and nutrient status of soil following abandonment of jhum field in the buffer zone showed a gradual recovery during regrowth

of vegetation. The recovery was differential in different attributes. For instance, SMC and WHC recorded 69-96 % and 80-86 % increase respectively from 1-yr. to 10-12-yr. old fallow; CEC, SOC, TKN and available P recorded 91-96 %, 70-86 %, 65-79 % and 50-73 % increase respectively during the same period (Fig. 12 a & b).

Figure 12a: Recovery of SMC, WHC and CEC in surface soil layer during secondary succession on jhum fallows

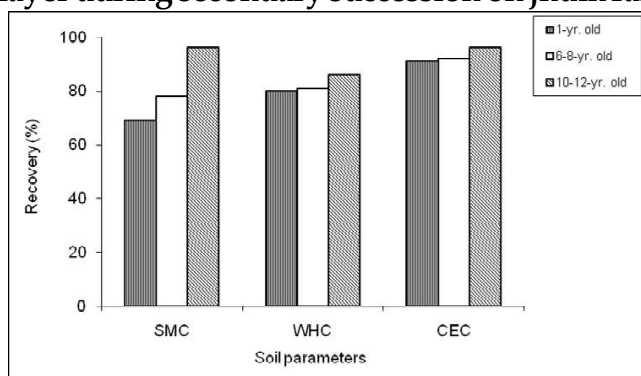
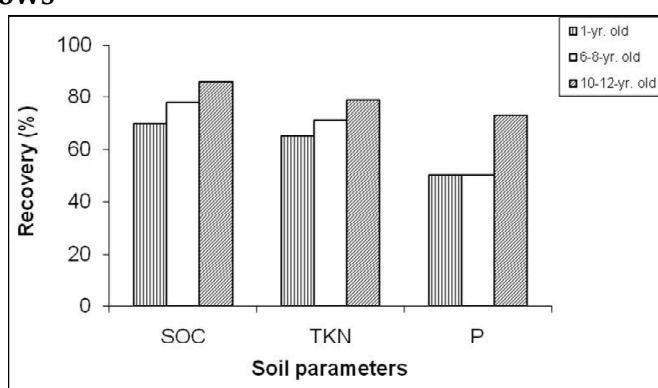


Figure 12b: Recovery of organic carbon, TKN and P in surface soil layer during secondary succession on jhum fallows



The increase in SMC during regrowth of vegetation on jhum fallows could be the result of greater infiltration and reduction in the losses due to run off and evaporation. Most of these changes were related to gradual build up of organic matter in soil (Arunachalam and Pandey, 2003). Tiessen *et al.* (1992) reported that organic matter in the topsoil approaches to the level of mature forest by the end of the tenth year of secondary succession in the forest ecosystem. In the present study, SOM, TKN and available P content in 10-12-yr. old jhum fallow was comparable to the mature forest in the core zone.

References

- Agbenin, J.O. & Goladi, J.T. (1997). Carbon, nitrogen and phosphorus dynamic under continuous cultivation as influenced by farm-yard manure and inorganic fertilizers in the savanna of northern Nigeria. *Agri. Eco. Environ*, 63, pp.17-24.
- Allen, S.C., Grimshaw, H.M., Parkinson, J.A. & Quarmby, C. (1974). *Chemical Analysis of Ecological Materials*, Blackwell Scientific Publications, Oxford.
- Anderson, J.M. & Ingram, J.S.I. (1993). *Tropical Soil Biology and Fertility – A Handbook of Methods*, 2nd edn., C.A.B. International, Wallingford, UK.
- Arunachalam, A. & Pandey, H.N. (2003). Ecosystem restoration of jhum fallows in northeast India: microbial C and N along altitudinal and successional gradient. *Rest. Ecol*, 11,168-173.

- Ashman, M.R., Hallett, P.D. & Brookes, P.C. (2003). Are the links between soil aggregate size class, soil organic matter and respiration rate artifacts of the fractionation procedure? *Soil Biol. Biochem*, 35, pp. 435-444.
- Brand, J. & Pfund, J.L. (1998). Site and watershed-level assessment of nutrient dynamics under shifting cultivation in eastern Madagascar. *Agri. Eco. Environ*, 71, pp.169-183.
- Brown, S., Anderson, J.M., Woome P.L. & Barrois E.C. (1994). Soil biological processes in tropical ecosystems. In: *Biological Management of Tropical Soil fertility (P.L. Woome and M.J. Swift Eds.)*, John Wiley & Sons, Chichester, U.K., pp. 15-46.
- Cai,J., Zhang, Y., Li, Y., Liang, X.S. & Jiang, T. (2017). Analyzing the characteristics of soil moisture using GLDAS Data: A case study in Eastern China Jingze, *Appl. Sci.*,7, pp. 2-13.
- Elliot,t E.T. (1986). Aggregate structure and carbon, nitrogen and phosphorus in native and cultivated soils, *Soil Sc. Soc. Am. J*, 50, pp. 627-633.
- Garcia-Oliva, F., Sansford, Jr. R.L. & Kelly, E. (1999). Effect of slash and burn management on soil aggregate organic C and N in a tropical deciduous forest. *Geoderma* 88, pp. 1-12.
- Hajabbasi, M.A., Jalalian, A. & Karimzadeh, H.R. (1997). Deforestation effect on soil physical and chemical properties Lordegan Iran. *Pl. Soil*, 190, pp.301-308.
- Henrot, J. & Robertson, G.P. (1994). Vegetation removal in two soils of the humid subtropics: Effect on microbial biomass. *Soil Biol. Biochem*, 26, pp. 111-116.

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- Nayak, D.C. & Srivastava, R. (1995). Soils of shifting cultivated areas in Arunachal Pradesh and their suitability for land use planning. *J. Ind. Soc. Soil Sc*, 43, pp.246-251.
- Piper, C.S. (1942). *Soil and Plant Analysis*. Hans Publishers, Bombay.
- Ramesh,V., Ballol,S.S., Sharma,K.L., Kausalya,R., Korwar,G.R. and Ramakrishna,Y.S.(2008). Characterization of soil for physical properties under different land use systems. *Indian J. Dryland Agric. Res. Dev.* 23(1), pp.102-109.
- Saikh, H., Varadachari, C. & Gosh, K. (1998). Changes in carbon, nitrogen and phosphorus levels due to deforestation and cultivation: A case study in Simlipal National Park, India. *Pl. Soil*, 198, pp.137-145.
- Scholes, R.J., Dalal, R. & Singer, S. (1994). Soil Physics and Fertility: The effects of water, temperature and texture. In: *The Biological Management of Tropical Soil Fertility (P.L. Woomer and M.J. Swift Eds.)*, John Wiley and Sons Publications, U. K., pp. 117-136.
- Singh, B., Singh, L. & Dhillon, N.S. (1995). A mathematical model for predicting urease activity in soils of Punjab. *J. Ind. Soc. Soil Sc*, 43, pp. 686-688.
- Spaccini, R., Zena, A, Igwe, C.A., Mbagwu, J.S.C. & Piccolo, A. (2001). Carbohydrates in water-stable aggregates and particle size fractions of forested and cultivated soils in two contrasting tropical ecosystems. *Biogeochem*, 53(1), pp.1-22.

- Tiessen, H., Salcedo, I.H. & Sampaio, E.V.S.B. (1992). Nutrient and soil organic matter dynamics under shifting cultivation in semi-arid Northeastern Brazil. *Agri. Eco. Environ*, 38, pp.139-151.
- Tiwari, S.C., Tiwari, B.K. & Mishra, R.R. (1992). Variation in some physico-chemical properties of pineapple orchard soils of north-eastern India. *J. Ind. Soc. Soil Sc*, 40, pp.204-208.
- Wild, A. (1996). *Soils and the environment: An introduction*, Cambridge University Press.
- Yadav, J.S.P. & Badolka, K.C. (1973). Soil characteristics of deodar forests in Western Himalayas of Uttar Pradesh. *Proc. Ind. Nat. Acad. Sc*, 43(A), pp.239-245.
- Zar, J.H. (1974). *Biostatistical Analysis*, 2nd edn. Prentice Hall, Englewood Cliffs, New Jersey.