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Evaluation of physico-chemical and biological properties of soil as affected by different land use system of Wokha district of Nagaland

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Abstract

A research was conducted on "Evaluation of physico-chemical and biological properties of soil as affected by different land use system of Wokha district of Nagaland" during 2019-2020 in the department of Agricultural Chemistry and Soil Science. Total 60 surface soil samples (15cm) were collected from 15 different villages of the 5 blocks of Wokha district from forest, horticulture, rubber, paddy land use system. The pH of the soils were strong to moderate acidic in reaction and normal in total soluble salts concentration. CEC on an average ranged from 12.32 to 15.34 cmol (p^+) kg^{-1}, bulk density and particle density on an average ranged from 1.01to 1.09g $cm^{-3}$and 2.38 to 2.54g cm^{-3}while porosity ranged from 53.62 to 59.72%, Organic carbon for forest, horticulture, rubber paddy land use system ranged from 1.77 %, 1.54%,1.62%, 1.38% respectively. The nutrient index for nitrogen for the four land use system ranged from 1.46,2, 2.06,respectively, phosphorus ranged from1.53,1.8,2, potassium ranged from 1.93,2.06,2.66, sulphur ranged from1.33, 1.86, 2, among the four land use system, forestland showed the highest nutrient index while paddy showed the least. Exchangeable acidity on an average ranged from1.69 to 2.68 cmol (p^+) kg^{-1}.On an average sand, silt and clay for forest ranged from 29.82%, 34.71%, 35.45%, for horticulture 29.33%, 32.89%, 37.7%, for rubber 31.48%, 32.92%, 35.53%, for paddy 36.6%, 31.06%, 32.27%.Soil respiration biomass and Soil microbial biomass carbon on average ranged from 49.53 to 50.26 mg CO_2/g soil/24 hours,150.97 to 269.94 µg/g. Available nitrogen, phosphorus, potassium, sulphur showed positive correlation with organic carbon while available phosphorus showed positive correlation with pH. Soil respiration biomass and soil microbial biomass carbon showed positive correlation with organic carbon. Soil respiration biomass showed negative correlation with EC.

Keywords: Soil respiration biomass, soil microbial biomass carbon, organic carbon, nutrient index, pH, correlation

Introduction

Soil fertility has been considered in the past in a restricted sense as a physico- chemical phenomenon or as an index of available nutrients for plants, but the modern usage of term connotes the capacity of the soil to produce crops of economic value to man and maintain the quality of soil for long term sustainable use, so any system of soil fertility management will ultimately consider all aspects of soil-plant relationships and pollution of the environment as well. Soil fertility evaluation may be considered as the soil system's nutrient supplying capacity. (Introductory soil science, D.K. Das; page no.767). Soil testing is an important tool for making fertilizer recommendations to crops. In case of soil testing, it will give a measure of the available nutrient status.

Materials and Methods

Altogether 60 soil samples was collected from 15 villages of Wokha district and these villages comes under the 5 blocks, Wokha town,Wozhuro, Ralan, Sanis and Bhandari, at a depth of 15 cm from randomly selected points with the help of khurpi and spade. From each village 4 soil samples of different land use system viz; forest, horticuture, rubber, paddy was collected for the investigation. The collected soil samples were analysed for pH in 1:2 soil water suspensions using glass electrode pH meter and EC using electrical conductivity meter.

bulk density determined by measuring the volume of a known mass of soil sample that may have been passed through a sieve into a graduated cylinder, particle density by pycnometer method, porosity by Porosity(%) =
(1-Bulk density/ Particle density) x 100, organic carbon by Walkley and Black method, CEC by ammonium acetate, available nitrogen was determined by ordinary distillation method using alkaline potassium permanganate method, available phosphorus by Bray& Kurtz No.1 method by using 0.03N NH_4F in 0.025N HCl, available potassium was extracted from the soil with neutral ammonium acetate and determined using flame photometer, available sulphur determined by turbidimetric measurement, exchangeable acidity measured by titration of soil extracts to a phenolphthalein endpoint at pH 8.3, mechanical analysis by international pipette method, soil respiration biomass by Kirita 1971, soil microbial biomass carbon determined by fumigation-extraction method, soil respiration measured by determining O_2 consumption and/or CO_2 release, statistical analysis correlation coefficient, nutrient index by using the formula suggested by Ravikumar *et al.* 2013 [17], nutrient index=1X No. of samples in low category+2X No. of samples in medium category+3X No. of samples in high category divided by total number of samples, nutrient index range below 1.67 indicate low nutrient, 1.67 to 2.33 medium, above 2.33 high for organic carbon.

Statistical analysis
Data was analysed using Correlation coefficient using the procedure suggested by Panse and Sukhatme (1961).

Results and Discussion: A research investigation entitled "Evaluation of physico-chemical and Biological properties of soil as affected by different land use system of Wokha District of Nagaland" was undertaken during 2019-2020 in the department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development (SASRD), Nagaland University Medziphema. The results obtained are discussed below.

pH
The soils of Wokha district under different land use system: forest, horticulture, rubber, paddy were found to be strongly to moderately acidic in reaction (Table 1), similar results was also reported by Patton (2015) [13] and Amenla *et al.* (2010) [2] for the soils of Nagaland. The highest acidity was found under paddy land use system as compared to other land use practice. Shau *et al.* (2016). Followed by horticulture> forest> rubber land use system. The acidic soil reaction maybe due of decomposition of soil organic matter which releases organic acids leading to leaching of bases from the exchange complex under prevailing heavy rainfall and hilly topography as reported by Petevino Chase, O.P. Singh (2014) [14].

EC (ds/m)
The Electrical Conductivity of Wokha district was found to have no deleterious effect on crops (Table 1)**.**Due to heavy rainfall in these areas most of the soluble salts from the soil profile produced during weathering are washed off due to leaching. Similar findings were also reported by Rajeswar and Khan (2007) [16], Sharma *et al*. (2012) [19]. It was also found that forest had higher EC due higher organic carbon content which enables the soil to retain the cation.
CEC [cmol p(+)/kg]
CEC of forest soils were higher for the soils of Nagaland (Table 1), Patton *et al*. (2005) [13] and Amenla *et al*. (2010) [2], this may be due to higher organic matter content in forest soils. Mishra *et al.* (2017) [10].

Organic carbon
Organic carbon of forest land use system showed highest organic carbon content with an average of 1.77% followed by rubber> horticulture> paddy with an average of 1.62%, 1,47%, 1.38% respectively (Table 1), the lowest content of organic carbon were found in paddy soil, this could be due to the rapid decomposition and mineralization of soil organic matter following the clearing of fields of the harvested crops as reported by Petevino Chase, O.P. Singh (2014) [14].

Available Nitrogen (kg/ha)
Available nitrogen was exhibited highest in forest land use practice. Higher availability of nitrogen in forest soil was also reported by Vishnu *et al*. (2017) [24], Tripathi *et al.* (2007) and Pankaj *et al.* (2011) [12]. Followed by horticulture> rubber> paddy (Table 1). Correlation studies (Table 2,3,4,5) show that available nitrogen had positive correlation with organic carbon under different land use practices which indicates that available nitrogen in soil is governed greatly by organic matter content of soil Singh and Bordoloi (2011).

Available Phosphorus (kg/ha)
Available phosphorus was found to be low to medium in acidic soil (Table 1) this maybe due to fixation of phosphorus with iron, manganese, aluminium. Leelavathi *et al*. (2009) [7] and Rudramurthy *et al*. (2007) [18]. Correlation studies (Table 2,3,4,5) shows that phosphorus had a positive correlation with pH under different land use practices. Similar type of correlation was reported by Amenla *et al.* (2010) [2].

Available Potassium (kg/ha)
Available potassium was found highest in forest soil (Table 2), this could be due to higher organic carbon content in forest soil. Singh *et al.* (1999) and Sharma *et al.* (2012) [19].
Correlation studies (Table 2,3,4,5) showed that available potassium had a positive correlation with soil organic carbon under different land use practices, similar type of correlation was reported by Mishra *et al.* (2007) [10].

Available Sulphur (kg/ha)
Available sulphur in soil under different land use system were found to be medium to low in sulphur content in the soil (Table 1) sluphur on an average ranged from of 26.92 kg ha^{-1} for forest, 23.53 kg ha^{-1} for horticulture, 24.78 kg ha^{-1} for rubber, 19.68 kg $ha^{-1}$for paddy.Similar findings were also reported by Kavita and Sujata (2015) [5] and Srikant *et al*. (2008). Correlation studies (Table 2, 3, 4, 5) revealed that available sulphur had a positive correlation with soil organic carbon. Singh *et al.* (2006).

Exchangeable acidity [cmol p(+)/kg]
Forest soil showed higher exchangeable acidity (Table 1), similar results reported by Laxminarayana (2010) [6]. Correlation studies (Table 2, 3, 4, 5) reveal that exchangeable acidity for all the four land use practices showed positive correlation with organic carbon. Bhandyopadhy and Chattopadhyay (1997).

Table 1: Villages surveyed under different land use system and surface soil (15cm) properties.

Land use systems	Name of Block	Villages surveyed	pH	EC (dSm^{-1})	CEC [cmol (P$^+$)Kg^{-1}]	OC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	Ex. Acidity [c mol (p+) kg^{-1}]	SRB (mg CO_2/g soil/24 hours)	BD (g cm^{-3})	PD (g cm^{-3})	Porosity (%)	SMBC (µg/g soil)
Forest	Wokha	Longsa	4.69	0.26	16.4	1.67	388.86	12.49	313.6	25.96	3	49.63	1.04	2.66	60.91	277.63
		Pongidong	4.83	0.27	13.78	1.16	454.48	11	313.6	25.42	2	49.76	1.03	2.85	63.85	229.73
		Tsungza	4.6	0.23	11.8	1.83	377.02	13.15	302.4	28.78	3.5	49.36	1.01	2.22	54.51	203.68
	Wozhuru	Sankiton	4.36	0.2	15.38	2.14	457.58	15	274	29.17	3	50.41	1.01	2.85	64.56	255.97
		Hanku	4.48	0.17	15.6	1.86	400.4	12.77	336	28	2.41	52.02	1.08	2.66	59.4	361.64
		Totsu yan	4.69	0.23	15.2	1.44	338.86	12.74	268.8	25.95	2.62	49.76	1.07	2.5	57.2	264.3
	Ralan	Ralan New	5	0.24	15.2	1.26	301.05	12.91	269.6	27.28	3	49.5	1.01	2.35	57.03	261.57
		Ralan Old	4.64	0.24	17.78	1.73	351.23	12.09	414.4	26.67	3.12	49.63	1.04	2.66	60.91	235.28
		L.Longchum	4.9	0.25	16.4	2.08	412.95	13.64	425.6	27.77	2.62	50.67	1.02	2.22	54.06	249.42
	Sanis	Sanis	4.7	0.25	15.3	1.72	325.14	14.97	302.4	25.8	2.25	49.84	1.02	2.85	64.21	319.05
		Baghty	4.71	0.25	16.4	2.57	527.4	12.85	312.8	25.9	2.12	49.36	1.03	2.22	53.61	230.83
		Meshangpen	5.1	0.2	15.2	1.52	373.23	14.59	235.2	25.2	1.87	50.41	1.01	2.85	64.56	213.75
	Bhandari	Bhandari	4.69	0.26	14.6	1.29	348.68	12.77	324	25.23	2.45	49.36	1.02	2.22	54.06	283.99
		Yimbang	5.2	0.25	15.4	2.73	377.02	14.89	257.6	28.7	3	52.76	0.8	2.66	69.93	297.97
		Yimza	4.78	0.23	15.8	1.67	343.77	12.77	380.8	28	3.37	52.02	1.01	2.35	57.03	364.3
		Average	4.75	0.23	15.34	1.77	385.17	13.24	315.38	26.92	2.68	50.26	1.01	2.54	59.72	269.94
Horticulture	Wokha	Longsa	5	0.21	15.1	1.34	326.14	10.14	134.4	22.37	2.3	50.41	1.05	2.5	58	207.9
		Pongidong	4.93	0.22	12.3	1.37	339.04	10.19	256	22.74	2.2	50.28	1.01	2.85	64.57	376.2
		Tsungza	4.64	0.26	11.53	1.52	413.95	12.27	234.4	20.56	2	50.15	1.19	2	40.5	219.05
	Wozhuru	Sankiton	4.51	0.2	14.68	1.73	401.4	10.29	256	25.9	2.54	50.02	1.12	2.85	60.71	271.71
		Hanku	4.12	0.16	13.78	1.32	388.51	12.85	100.8	23.09	2.66	50.62	1.11	2.5	55.6	210.78
		Totsu yan	4.72	0.14	12	1	388.68	9.77	112	27.28	2.37	49.63	1.1	2.6	57.15	191.24
	Ralan	Ralan New	4.64	0.23	13.78	1.9	488.51	10.66	278.4	30.09	2.54	50.41	1.09	2.35	53.62	373.6
		Ralan Old	4.7	0.26	12.3	1.72	288.51	10.17	280	24.73	2.66	50.62	1.06	2.5	57.6	253.9
		L.Longchum	4.8	0.23	15.1	1.96	351.23	13.99	234.4	29.16	2.37	50.41	1.03	2	48.5	213.75
	Sanis	Sanis	4.82	0.24	12.3	1.6	363.42	11.25	212.8	20.3	2.22	50.41	1.07	2.66	59.78	262.07
		Baghty	4.72	0.23	15.1	1.08	301.4	10.74	202.4	16.8	2.37	50.15	1.04	2	48	287.24
		Meshangpen	5.61	0.28	16.5	1.47	388.86	12.25	212.8	18.88	1.87	50.02	1.09	2.85	61.76	127.65
	Bhandari	Bhandari	4.54	0.21	10.8	1.26	313.6	8.89	212.8	21	2.5	50.67	1.01	2.85	64.57	219.05
		Yimbang	4.73	0.27	10.67	1.81	363.77	12.99	224	28.92	3	49.23	1.1	2.5	56	135.83
		Yimza	5.65	0.26	11.13	2.06	326.14	9.77	201.6	21.22	2.66	50.76	1.03	2.85	63.86	113.75
		Average	4.80	0.22	13.13	1.54	362.87	11.08	210.18	23.53	2.41	50.25	1.07	2.52	56.68	230.91
Rubber	Wokha	Longsa	5.27	0.2	11.55	1.17	288.86	8.25	235.2	20.22	2.45	49.63	1.02	2.66	61.66	277.63
		Pongidong	4.57	0.21	10.8	1.47	307.75	10	213.6	22.7	2.62	49.76	1.01	2.22	64.57	219.73
		Tsungza	4.55	0.16	11.13	1.5	304.05	12.74	257.6	28.77	2.42	49.36	1.0	2.5	62.4	203.68
	Wozhuru	Sankiton	5.51	0.17	15.3	1.61	340.68	11.65	212.8	24.73	3	50.41	1.02	2.22	54.06	255.97
		Hanku	5.25	0.15	13.78	1.77	325.79	12.6	257.6	23.72	3.12	52.02	1.2	2.22	45.95	331.64
		Totsu yan	4.68	0.13	16.5	1.19	326.49	10.36	259.6	22.85	1.78	49.76	1.03	2.35	56.18	264.3
	Ralan	Ralan New	4.74	0.17	13.78	1.71	350.6	12.64	190.4	27.9	2.66	49.5	1.08	2.22	51.36	261.57
		Ralan Old	4.74	0.19	12.78	1.62	363.42	10.03	256	21.33	2.41	49.63	1.03	2.66	61.28	233.28
		L.Longchum	5.74	0.18	15.3	1.72	374.32	11.77	280	25.2	1.78	50.67	1.07	2.5	57.2	249.42
	Sanis	Sanis	4.68	0.21	11.2	1.74	326.14	11.06	245.6	25.95	2.62	49.84	1.08	2.35	54.05	219.05
		Baghty	4.71	0.22	13.78	1.76	390.6	9.82	244.8	24.86	1.78	49.36	1.03	2.22	53.61	230.83

		Meshangpen	4.79	0.2	14.68	1.72	315.95	12.14	300.8	25.42	2.5	50.41	1.04	2.66	60.91	213.75
	Bhandari	Bhandari	4.42	0.17	10.66	1.83	362.96	9.44	235.2	29.36	2.24	49.36	1.07	2.22	51.81	283.99
		Yimbang	4.83	0.21	10.13	1.73	374.02	12.48	233.6	27.72	1.83	49.76	1.04	2.35	60	297.97
		Yimza	4.51	0.16	11.53	1.77	355.77	13	224	21	2.16	50.02	1.02	2.66	61.66	264.3
		Average	4.86	0.18	12.85	1.6	340.49	11.19	243.12	24.78	2.35	49.96	1.0	2.4	57.11	253.80
Paddy	Wokha	Longsa	4.46	0.15	10.4	1.27	255.32	9.31	167.2	18.5	1.5	49.76	1.07	2.66	59.78	121.97
		Pongidong	4.3	0.12	12.8	1.09	200	10.76	122.4	17.8	0.37	50.54	1.09	2.35	53.62	142.1
		Tsungza	4.6	0.11	10.6	1.31	253.77	10.82	189.6	16.08	1.5	49.1	1.06	2	47	132.03
	Wozhuru	Sankiton	4.38	0.13	14.8	1.27	238.68	8.25	154	23.09	2.25	50.02	1.14	2.35	51.49	153.9
		Hanku	4.67	0.12	12.8	1.09	288.51	8.53	168.4	16.8	2.5	50.15	0.92	2.5	63.2	107.76
		Totsu yan	4.45	0.13	12.1	1.09	303.6	9.39	100.8	23.8	1.5	48.71	1.18	2.5	52.8	130.83
	Ralan	Ralan New	4.3	0.12	12.8	1.45	250.88	10.15	213.6	25.2	2.25	50.15	1.14	2	43	156.31
		Ralan Old	4.5	0.12	11.13	1.02	251.23	10.39	234	16.08	2.5	48.71	1.2	2.35	48.94	161.64
		L.Longchum	5.37	0.12	12.8	1.47	351.05	10.29	291.2	28	1.5	49.76	1.16	2.35	50.64	158.97
	Sanis	Sanis	5.85	0.2	14.8	1.95	238.33	10.2	179	16.08	2	50.15	1.12	2.66	57.9	203.68
		Baghty	4.64	0.2	12.8	1.58	318.86	10	156	14.7	0.87	49.1	1.15	2.35	51.07	164.3
		Meshangpen	4.67	0.15	12.1	1.07	301.05	8.06	212.8	18.2	0.87	48.71	1.07	2.5	57.2	158.97
	Bhandari	Bhandari	4.35	0.15	10.4	1.1	288.51	10	144.8	14.7	2.25	48.71	1.0	2.5	58.4	132.03
		Yimbang	4.48	0.12	14	1.6	213.95	9.03	123.2	26.6	1.5	50.28	0.92	2	54	191.24
		Yimza	4.6	0.11	10.6	2.3	338.33	9.06	177	19.6	2.12	49.1	1.19	2.66	55.27	148.92
		Average	4.64	0.13	12.32	1.38	272.80	9.61	175.6	19.68	1.69	49.53	1.09	2.38	53.62	150.97

Table 2: Correlation coefficient between different soil properties under forest land use system

	pH	**EC**	**CEC**	**BD**	**PD**	**Porosity**	**OC**	**N**	**P**	**K**	**S**	**Ex-A**	**SRB**	**SMBC**
pH	1													
EC	0.333	1												
CEC	0.027	-0.0006	1											
BD	-0.620**	-0.234	0.08	1										
PD	-0.026	-0.251	0.117	-0.068	1									
Porosity	0.280	-0.105	0.078	-0.542*	0.873**	1								
OC	0.044	-0.096	0.267	-0.547*	-0.092	0.181	1							
N	-0.249	-0.003	0.053	0.050	0.020	-0.033	0.500*	1						
P	0.169	-0.315	0.011	-0.491	0.255	0.436	0.498*	-0.092	1					
K	-0.246	0.182	0.434	0.301	-0.351	-0.434	0.024	0.039	-0.408	1				
S	-0.169	-0.398	-0.132	-0.377	-0.136	0.078	0.515*	0.042	0.340	0.106	1			
Ex-A	-0.182	-0.006	-0.057	-0.255	-0.321	-0.134	0.148	-0.342	-0.001	0.24	0.700**	1		
SRB	0.277	-0.411	0.138	-0.571*	0.309	0.549*	0.531*	0.055	0.430	-0.113	0.486	-0.017	1	
SMBC	-0.131	-0.240	0.243	-0.041	0.067	0.101	0.048	-0.316	0.100	0.184	0.210	0.137	0.436	1

*Significance at 5% level: 0.49; **significance at 1% level: 0.62.

Ex-Exchangeable acidity, SRB-Soil Respiration Biomass, SMBC-Soil Microbial Biomass Carbon.

Table 3: Correlation coefficient between different soil properties under horticulture land use system

	pH	EC	CEC	BD	PD	Porosity	OC	N	P	K	S	Ex-A	SRB	SMBC
pH	1													
EC	0.499*	1												
CEC	0.414	-0.044	1											
BD	-0.166	-0.135	-0.046	1										
PD	0.173	-0.110	-0.202	-0.223	1									
Porosity	0.187	-0.089	-0.145	-0.497*	0.948**	1								
OC	0.040	0.383	0.153	0.116	-0.260	-0.236	1							
N	-0.078	-0.133	0.139	0.643**	-0.084	-0.259	0.375	1						
P	0.063	0.243	0.286	0.301	-0.523*	-0.542*	0.515*	0.274	1					
K	0.166	0.640**	-0.079	-0.170	-0.06	-0.033	0.634**	0.080	-0.022	1				
S	-0.248	-0.212	-0.119	0.169	-0.091	-0.074	0.602*	0.437	0.224	0.179	1			
Ex-A	-0.614*	-0.112	-0.419	-0.132	0.068	0.160	0.161	-0.137	-0.043	0.006	0.516*	1		
SRB	0.0331	-0.010	0.052	-0.484	0.052	0.175	0.168	-0.258	-0.277	0.064	-0.306	-0.077	1	
SMBC	-0.188	-0.207	0.110	-0.164	-0.151	-0.079	0.236	0.212	-0.256	0.434	0.128	-0.113	0.48	1

*Significance at 5% level: 0.49; **significance at 1% level: 0.62.
Ex-Exchangeable acidity, SRB-Soil Respiration Biomass, SMBC-Soil Microbial Biomass Carbon

Table 4: Correlation coefficient between different soil properties under rubber land use system

	pH	EC	CEC	BD	PD	Porosity	OC	N	P	K	S	Ex-A	SRB	SMBC
pH	1													
EC	-0.041	1												
CEC	0.497*	-0.415	1											
BD	0.239	-0.310	0.110	1										
PD	0.034	0.050	-0.055	-0.342	1									
Porosity	-0.223	0.319	-0.342	-0.767**	0.645**	1								
OC	-0.105	0.173	-0.173	0.407	-0.215	-0.389	1							
N	0.017	0.140	0.104	0.014	-0.214	-0.289	0.610*	1						
P	0.049	-0.329	0.108	0.337	0.006	-0.126	0.508*	0.122	1					
K	0.177	-0.015	0.329	0.159	0.478	0.113	0.029	-0.064	0.040	1				
S	-0.208	-0.001	-0.179	0.232	-0.454	-0.326	0.506**	0.238	0.346	-0.032	1			
Ex-A	0.160	-0.110	-0.039	0.410	-0.190	-0.280	0.077	-0.520*	0.166	-0.267	-0.053	1		
SRB	0.600*	-0.295	0.393	0.703**	-0.065	-0.430	0.220	-0.099	0.409	0.330	-0.207	0.436	1	
SMBC	0.297	-0.361	0.001	0.554*	-0.263	-0.536*	0.05	0.172	0.067	-0.206	-0.062	0.085	0.473	1

*Significance at 5% level: 0.49; **significance at 1% level: 0.62.
Ex-Exchangeable acidity, SRB-Soil Respiration Biomass, SMBC-Soil Microbial Biomass Carbon

Table 5: Correlation coefficient between different soil properties under paddy land use system

	pH	EC	CEC	BD	PD	porosity	OC	N	P	K	S	Ex-A	SRB	SMBC
pH	1													
EC	0.464	1												
CEC	0.382	0.281	1											
BD	0.119	0.100	-0.118	1										
PD	0.319	0.399	-0.167	0.218	1									
Porosity	0.193	0.279	-0.042	-0.504*	0.727**	1								
OC	0.450	0.200	0.153	0.212	0.157	-0.019	1							
N	-0.042	-0.295	-0.354	0.282	0.140	-0.114	0.149	1						
P	0.127	0.067	-0.081	0.378	-0.355	-0.584*	0.119	-0.329	1					
K	0.433	-0.125	-0.109	0.310	-0.079	-0.307	0.068	0.353	0.253	1				
S	-0.004	-0.443	0.374	0.057	-0.376	-0.357	0.116	0.279	-0.133	0.158	1			
Ex-A	0.043	-0.211	-0.036	0.012	0.076	0.030	0.122	0.396	-0.145	0.210	0.020	1		
SRB	0.153	-0.08	0.637**	-0.378	-0.220	0.058	0.162	-0.350	0.097	-0.104	0.346	-0.048	1	
SMBC	0.516*	0.406	0.596*	0.162	-0.171	-0.242	0.504*	-0.295	0.286	0.155	0.212	-0.083	0.199	1

*Significance at 5% level: 0.49; **significance at 1% level: 0.62.
Ex-Exchangeable acidity, SRB-Soil Respiration Biomass, SMBC-Soil Microbial Biomass Carbon.

BD (g/cm^3)

Paddy land use systemhad the highest bulk density (Table 1), this may be due to continuous tillage operation, low organic matter content in paddy soil and forest had the lowest bulk density it might be due to higher organic matter content in forest soil. Similar findings were reported by Mathan and Kannan (1993) [9].

PD (g/cm^3): It was found that particle density in different land use system followed forest> horticulture> rubber> paddy with an average values of 2.54, 2.52, 2.40, 2.38 g cm^3. Similar findings was reported by Amenla *et al.* (2007) [1].

Porosity (%)

The porosity under different land use system (Table no. 1) on an average ranged from 59.72% for forest, 56.68% for horticulture, 57.11% for rubber, 53.62% for paddy. Similar findings was reported by Debnath and Pattanaaik (2014) [3].

Soil Texture: Soils of Wokha district, Nagaland under different land use system varied in soil texture from clay to clay loam to loam to sandy clay loam. Soil texture varied under different land use system. Similar observation was reported by Sitanggang *et al.* (2006) [20], as shown in (Table 6).

Table 6: Particle size distribution under different land use system

Land use system	Name of block	Name of village	Sand (%)	Silt (%)	Clay (%)	Textural class
Forest	Wokha	Longsa	33.33	34.36	32.33	L-CL
		Pongidong	30.8	38.2	31	L-CL
		Tsungza	31	34.8	34.2	CL-C
	Wozhuru	Sankiton	30.36	28.26	41.36	CL-C
		Hanku	27.6	30	42.4	CL-C
		Totsu yan	36.87	24.27	38.86	CL-C
	Ralan	Ralan New	24.53	38.8	36.66	CL
		Ralan Old	30.23	29.6	40.16	CL-C
		L.Longchum	30.27	32.13	37.6	CL
	Sanis	Sanis	28.96	39.97	31.06	CL
		Baghty	28.96	39.97	31.06	CL
		Meshangpen	24.53	38.8	36.66	CL
	Bhandari	Bhandari	30.86	35.87	33.27	L-CL
		Yimbang	28.96	39.97	31.06	CL
		Yimza	30.1	35.7	34.2	CL
		Average	29.82	34.71	35.45	
Horticulture	Wokha	Longsa	29.13	37.73	33.13	CL
		Pongidong	33.26	32.2	34.53	CL
		Tsungza	27.6	30	42.4	CL
	Wozhuru	Sankiton	26.23	29.93	43.83	CL-C
		Hanku	20.86	35.46	43.67	CL-C
		Totsu yan	29.6	29.73	40.67	CL-C
	Ralan	Ralan New	21.73	37.8	40.46	CL-C
		Ralan Old	28.03	31.3	40.66	CL-C
		L.Longchum	28.8	33.86	37.33	CL
	Sanis	Sanis	30.1	35.7	34.2	CL
		Baghty	30.36	28.26	41.36	CL-C
		Meshangpen	44.3	32.43	23.27	L
	Bhandari	Bhandari	27.26	40.2	32.53	CL
		Yimbang	31.87	29.4	38.73	CL
		Yimza	31.87	29.4	38.73	CL
		Average	29.33%	32.89%	37.69%	
Rubber	Wokha	Longsa	30.5	38.5	30.9	CL
		Pongidong	30.4	32.8	36.7	CL
		Tsungza	36.87	24.27	38.86	CL
	Wozhuru	Sankiton	30.27	32.13	37.6	CL
		Hanku	23.8	33.6	42.5	CL-C
		Totsu yan	31.1	29.4	39.4	CL
	Ralan	Ralan New	24.4	36.7	38.8	CL
		Ralan Old	32	29.9	38	CL
		L.Longchum	29.93	38.23	31.83	CL
	Sanis	Sanis	30.27	32.13	37.6	CL
		Baghty	30.1	35.7	34.2	CL
		Meshangpen	39.4	31.3	29.2	CL
	Bhandari	Bhandari	30	35.3	34.6	CL
		Yimbang	28	37.4	34.5	CL
		Yimza	45.2	26.5	28.3	SCL-CL
		Avergae	31.48	32.92	35.53	
Paddy	Wokha	Longsa	27.7	40.2	32	L-CL
		Pongidong	23	35	42	L
		Tsungza	52.6	21.13	26.27	SCL-CL
	Wozhuru	Sankiton	45.4	25.7	28.8	SCL-CL
		Hanku	23.7	33.5	42.7	CL
		Totsu yan	45	26.7	28.2	SCL-CL
	Ralan	Ralan New	43.4	29.3	27.2	SCL-CL
		Ralan Old	30.6	33.5	35.8	CL
		L.Longchum	28.4	38.4	33.2	CL
	Sanis	Sanis	43.2	28.5	28.3	CL
		Baghty	38	27.2	34.7	CL

		Meshangpen	45	28	27	SCL-L
	Bhandari	Bhandari	27.7	38.4	33.8	CL
		Yimbang	30	33	37	CL
		Yimza	45.3	27.4	27.2	SCL-CL
		Average	36.56%	31.06%	32.27%	

CL-Clay loam, L-Loam, C-Clay, SCL- sandy clay loam

Soil Respiration Biomass (mg CO_2/g soil/24 hours)

Soil respiration biomass was found highest in forest soil, this may be due to higher organic carbon because it can supply substrates to microbial substrates. Similar findings were reported by Liming Lai *et al*. (2012) [8].

Correlation studies (Table 2, 3, 4, 5)showed that soil respiration biomass had positive correlation with organic carbon under all the land use system. Brooks *et al.* (2004), while soil respiration showed negative correlation with EC and positive correlation with pH. Liming Lai *et al.* (2012) [8].

Soil Microbial Biomass Carbon ((**µg/g soil**)

Forest soil showed higher soil microbial biomass carbon (SMBC) (Table 1). This may be due to higher organic matter in the forest soil which allows higher microbial activity as reported by Powlson *et al.* (1987) [15].

Correlation studies (Table 2, 3, 4, 5) revealed that soil microbial biomass carbon was positively correlated with organic carbon. Similar correlation was reported by M. Ali Tabatabai *et al.* (2000) [22].

Nutrient Index

The nutrient index for available Nitrogen was calculated to be 2.06 under forest soil 2 under horticulture soil and rubber soil, 1.46 under paddy soil. Forest, rubber, horticulture soils, showed medium available nitrogen nutrient index while paddy soil showed low nutrient index. Similar result was reported by Amenla *et al*. (2010) [2].

The nutrient index for available phosphorus was calculated to be 2 under forest soil, 1.8 under horticulture soil, rubber soil, 1.53 under paddy soil. Thus, forest soil had medium nutrient index for phosphorus. Similar findings was reported by Motsara (2002) [11], while rubber, horticulture, paddy soil show low phosphorus nutrient index.

The nutrient index for available potassium was calculated to be 2.66 under forest soil, 1.93 under horticulture and paddy soil, 2.06 under rubber soil. Thus, forest had higher fertility status,Petevino Chase and O.P. Singh (2014) [14], while horticulture, rubber and paddy had medium nutrient index.

The nutrient index for available sulphur was calculated to be 2 under forest, rubber soil, 1.86 under horticulture soil and 1.33 under paddy soil. This indicates that forest, horticulture, rubber soils were found to have medium nutrient index for available sulphur while paddy was found to have low nutrient index for sulphur.

Conclusion

This study shows that due to continuous cultivation practices in paddy fields it led to depletion of nutrients. Due to conversion of forest to rubber cultivation there was a major decrease in diversity of soil micro- and meso fauna, decrease in soil carbon which provides a source for many microorganisms, long years of plantation under rubber cultivation led to the depletion of the fertility status as well as the biological properties of soil. The correlation studies also reveal that the macronutrients as well as the biological properties of soil had positive correlation with organic carbon. Thus for enhancing biological properties of soil, for improving fertility status of soil, proper management of rubber plantation, proper management of organic matter is advisable.

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