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Impact of Long-Term Tea Crop Cultivation on Soil Nutrients of Tea Gardens in Southern Assam

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Abstract—*Intensive conventional farming practice and long term tea crop cultivation cause a lot of negative impact such as organic matter depletion, soil pH, soil conductivity, impairment of environmental quality. Therefore need of the hour is to achieve substantially higher crop yield from limited land resources on a sustainable basis. Extensive use of fertilizers, lack of proper waste management practice in tea gardens also results in loss of plant nutrients and productivity. A long term (2012-2014) field experiment was conducted in three different tea agroecosystem of Silcoorie, Rosekandy and Borokai tea estate in Cachar district located in the state of Assam to assess the impact on soil nutrients. Soil samples were collected from the tea gardens and analyzed for different physico-chemical properties i.e., soil texture, water holding capacity, moisture content, bulk density, soil pH, soil conductivity, organic carbon, total nitrogen, total phosphorous and total potassium. Though very little changes were observed in the soil texture and bulk density of tea estate's soil, the electric conductivity, organic carbon and pH were altered significantly during the study period. Wide variations were also noted for nitrogen, phosphorus and potassium levels. Organic carbon, total N and total P showed positive correlation with soil conductivity. The extent of soil nutrient showed a decreasing trend with depth. This calls for proper planning and management of soil through a balanced use of mineral fertilizers combined with organic and biological sources of plant nutrients for sustainable production of tea.*

Keywords: *Agroecosystem, conventional farming, nutrient status, fertilizer North East India, sustainable.*

1. INTRODUCTION

Tea (*Camellia sinensis* L.O. kuntze) is the major plantation crop of northeast India and forms the back bone of the economy of this region. It grows in a wide range of soil types derived from diverse parent material in tropical, subtropical and temperate climate [5]. Intensive conventional farming practice and long term tea crop cultivation leads to organic matter depletion, soil pH, soil conductivity, impairment of environmental quality [1]. A comprehensive assessment of soil quality requires a systematic approach for measuring and interpreting soil properties that would serve as suitable soil quality indicators [2].To achieve relatively higher crop yield from the existing limited land resources is a sustainable goal. Nutrient requirements for commercial tea production are particularly high because the harvestable portions of tea are succulent shoots, which contain the largest percentage of nutrients in the plant [3]. Thus, nutrient recycling and mineral balance are important factors affecting nutrient budgets in tea soil. Fertilization is an important approach to balancing nutrient cycling. Applications of fertilizer to improve plant growth and crop yield have long been a common practice for tea cultivation in India. However, extensive use of fertilizers, lack of proper waste management practice in tea gardens also result in loss of in turn economic loss for the farmer. The low pH value of the soil of the tea cultivation sites are due to the intensive application of nitrogen fertilizers [4]. This article addresses the long term impact of tea cultivation on soil of tea gardens in southern Assam.

2. MATERIALS AND METHODS

Study area

The study was conducted in three different tea estates, i.e., Silcoorie Tea Estate (STE), Rosekandy Tea Estate (RTE) and Borokai Tea Estate (BTE) in Cachar district of Assam, North East India. The district lies between 92° 24' E and 93° 15' E longitude and 24°22' N and 25° 8' N latitude and situated at 36.5 (MSL). The geographical area covered by Cachar district is 3,786 Sq. Km. The area of Cachar district experiences subtropical, warm and humid during summer where humidity ranges from 53.67 to 94.59 % in winter and 64.04 to 94.60 % in summer and received about 3200-3500 mm rainfall during the year. The geographical location of the study sites (Table 1)

Table 1: Geographical location of the study sites

Sl No	Parameter	Silcoorie Tea Estate	Rosekandy Tea estate	Borokai Tea Estate
1	GPS coordinates	24º42´N 092º46´E	24º41´N 092º42´E	24º37´N 092º40´E
2	Altitude (meter)	29.6	19.7	9.6

3. SELECTION OF SAMPLING SITES

The selection of sampling sites was based on similar ecological situation without taking into consideration the minor differences in environmental conditions of the sites [6]. This method is suitable in comparing soil properties under the same type of land use in a continuous manner for a number of years (the land use periods are not necessarily the same) such that the degree of soil degradation or improvement can be found. In general, the tea estates have very similar cultivation history although records have not been kept meticulously and systematically. Tillage was not often applied when the tea crop matures because tea rows were covered by plant canopy. Criteria for the field site selection were absence of recent application of organic fertilizers.

4. SOIL SAMPLING

Soil samples were collected, in the months of February, because no fertilization or compost was applied during these months in the all the tea estates. Three sets of soil samples were collected from each site at three different depths, 0-20 cm (surface soil), 20-40 cm (subsurface soil I) and 40-60 cm (subsurface soil II) for three consecutive years (2012-2014).

5. LABORATORY METHODS FOR SOIL SAMPLE ANALYSIS

The soil samples were collected from midway between two tea plants, after removal of the surface debris. At each site, a hand-operated auger was used to dig out the soil cores from appropriate depth. Several such cores were collected from a single site from a (7 x 10) m grid for each depth, put in a polythene pack and brought to the laboratory. The cores from a particular site were visually inspected for the presence of plant debris, pebbles, etc.

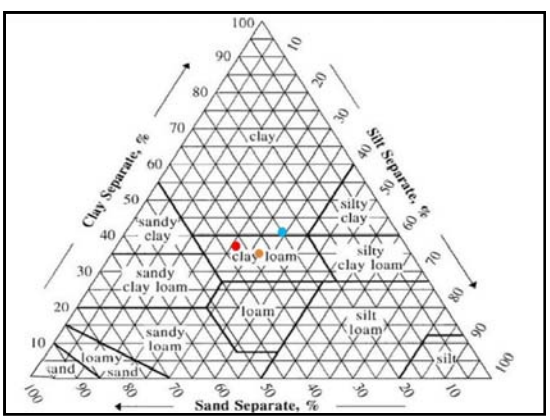

Figure 1a.: Textureal classification of soil of Silcoorie tea estate

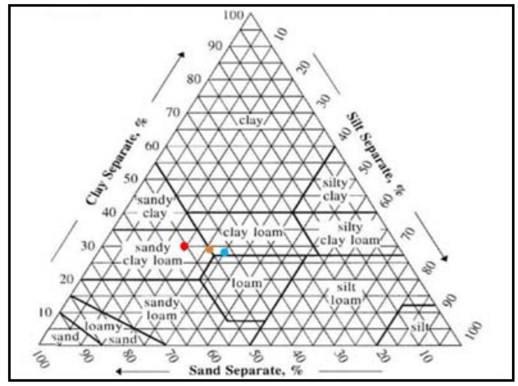

Figure 1b: Textureal classification of soil of Rosekandy tea estate

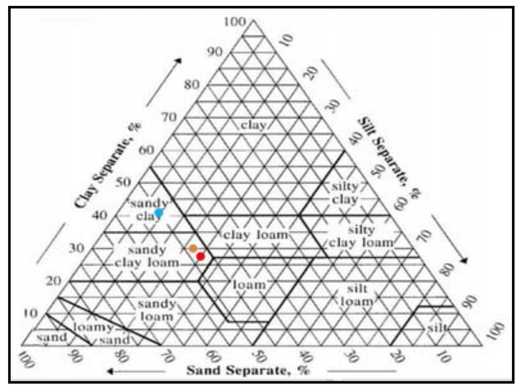

Figure 1c: Textureal classification of soil of Borokai tea estate

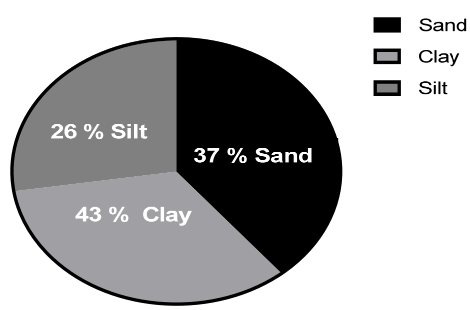

Figure.2a : Pie diagram showing average percentage of clay, sand and silt of Silcoorie tea garden

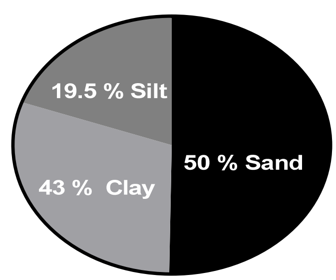

Figure.2b: Pie diagram showing average percentage of clay, sand and silt of Rosekandy tea garden

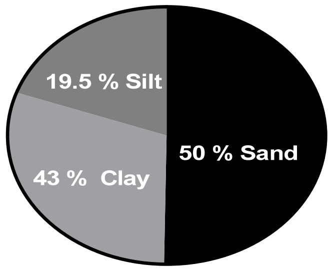

Figure.2b: Pie diagram showing average percentage of clay, sand and silt of Rosekandy tea garden

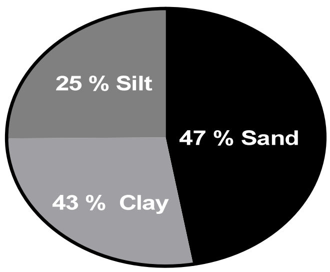

Figure.2c: Pie diagram showing average percentage of clay,sand and silt of Borokai tea garden

which were separated and removed, and the cores were spread out over a stout paper for drying in air in a shade. Entry of dust particles from air was prevented by covering the soil samples with superfine wire net. The big lumps were broken down and plant roots, pebbles and undesirable matter, still remaining, were removed. The dried samples were ground into powder, sieved through 2 mm sieve and preserved in clean polythene bags for analysis [9].

6. LABORATORY METHODS FOR SOIL SAMPLE ANALYSIS

Physico-chemical properties were analysed using the different standard methods as explained in the following sections. Soil texture was analysed by Hydrometer method [6]. The moisture content of the soil samples was determined by using standard methods given by Anderson and Ingram [7]. Electrical conductivity of soil was determined in the soil: water suspension (1:2.5) [8] Soil pH was determined at 1:2.5 soil-water suspensions using a digital pH meter (Ge Nei pH meter).Soil organic carbon, total nitrogen, total phosphorus and total potassium were determined following standard protocol by Okalebo et al., [9] Total nitrogen, total phosphorus and total potassium were determined following standard protocol by Okalebo *et al*. [9]

7. STATISTICAL ANALYSIS

All the calculations including statistical analysis and graph plotting were computed using Microsoft Excel 2010, SPSS 21 and Graph Pad prism.

8. RESULTS AND DISCUSSION

Very little change was observed in the texture of the tea estate soil during the study period (2012-2014). Five different kinds of soil were found in the tea estates viz., clay loam, clay, sandy clay loam, sandy clay and sandy clay loam. The average percentage of clay, silt and sand as well as the textural classification of the soil is shown in Figure (1a-1c) and (2a-2c). The results show that sand dominates over clay and silt except STE soil, and the values could be arranged in the ranges of Clay: 43 % Silt: 19.5 to 26 % and Sand: 37 to 50 %. Usually clay loam soil is considered as more preferable for agricultural crops [10] but it seems that good tea production can also take place in other types of soil. Soil texture is considered an important parameter. It influences the other properties like bulk density, water holding capacity and hydraulic conductivity that control the flow dynamics of water, nutrients and salts in the soil.

Table 2: Bulk density (BD) of soil samples with different depth (Each value is the mean of the values obtained for three sampling sites of each of the tea estates)

Site	Depth(cm)	2012 (gcm^{-3})	2013 (gcm^{-3})	2014 (gcm^{-3})
STE	0-20	1.34±0.69	1.32±0.63	1.29±0.1
	20-40	1.35±0.59	1.33±0.63	1.3±0.32
	40-60	1.37±0.41	1.35±0.47	1.32±0.6
RTE	0-20	1.32±0.26	1.3±0.61	1.27±0.1
	20-40	1.33±2.22	1.31±0.78	1.28±0.6
	40-60	1.34±0.34	1.32±0.80	1.29±0.3
BTE	0-20	1.31±0.67	1.29±0.66	1.26±0.1
	20-40	1.32±0.15	1.3±0.36	1.27±0.4
	40-60	1.33±0.54	1.31±0.72	1.28±0.0

The bulk density of soils of the tea estates soil was given in Table 2. The values for the tea estate soil vary

Table 3: Water holding capacity (WHC) of soil samples with different depth (each value is the mean of the values obtained for three sampling sites of each of the tea estates)

Site	Depth(cm)	2012 (%)	2013 (%)	2014 (%)
STE	0-20	59.43±0.1	57.35±0.63	55.15±0.69
	20-40	62.84±0.3	58.65±0.63	56.32±0.59
	40-60	65.21±0.6	61.26±0.47	59.65±0.41
RTE	0-20	57.54±0.1	55.65±0.61	53.21±0.26
	20-40	59.32±0.6	56.32±0.78	54.25±2.22
	40-60	61.02±0.3	59.32±0.80	54.88±0.34
BTE	0-20	60.01±0.1	57.26±0.66	56.23±0.67
	20-40	64.08±0.4	61.45±0.36	59.32±0.15
	40-60	65.69±0.0	64.23±0.72	62.26±0.54

Table 4: Moisture content of soil samples with different depth (Each value is the mean of the values obtained for three sampling sites of each of the tea estates)

Site	Depth(cm)	2012	2013	2014
STE	0-20	29.11±2.0	29.31±1.63	28.65±1.79
	20-40	27.15±0.7	27.60±2.74	25.65±1.44
	40-60	25.41±1.3	28.64±0.48	24.52±0.41
RTE	0-20	26.43±1.2	27.58±1.67	28.64±1.19
	20-40	25.14±0.5	25.65±0.37	25.65±1.36
	40-60	24.56±1.9	24.61±1.27	24.55±0.27
BTE	0-20	26.81±1.2	26.51±1.19	27.01±2.59
	20-40	24.32±0.6	24.35±1.55	25.64±1.09
	40-60	23.17±0.7	23.11±1.77	24.91±1.73

from 1.26 to 1.37 g cm^{-3}. The soil of the STE soil is heavy with maximum bulk density while the bulk density is minimum for the soil of the BTE indicating presence of light organic fractions. Under the same considerations, the soil of STE must have contained heavier inorganic fractions. A decrease in the values of bulk densities was also observed from the year 2012 to 2014. The tea estate soil had widely varying water holding capacities as seen from Table 3. The water holding capacity values varies from 53.21 to 65.69 % reflecting considerable differences in soil composition from one tea estate to another. The result reveals that there is a tendency for the water holding capacity to decrease from year to year (2012 to 2014). Whether such tendencies existed earlier could not be ensured in absence of earlier data, but for the three year measurement period, the trend is quite clear. The decrease was uniform and the relative decrease was also very much similar. The soil loses some amount of its WHC, if the relative content of hydrophobic organic matter increases over the time. It has been found by other workers that if there is a slow accumulation of hydrophobic organic substances in the soil that forms a coating over the soil, the water holding capacity decreases [13].The soil moisture content of different tea estate soil are presented in Table 4. The values vary from 24.52 to 29.11. The soil pH from each tea estate is presented in Table 5. The values vary from 4.5 to 5.18. In the present work, the soil pH is found to be less than 7.0 in the tea estate areas, which is close to the natural pH of the Assam soil (around 5.5). Tea grows well on high land and well drained soils having a good depth with an acidic pH in the range of 4.5 to 5.5.

Table 5 pH of soil samples with different depth (Each value is the mean of the values obtained for three sampling sites of each of the tea estates)

Site	Depth(cm)	2012	2013	2014
STE	0-20	4.51±0.2	4.55±0.4	4.56±0.32
	20-40	4.56±0.2	4.57±0.1	4.67±0.01
	40-60	4.67±0.1	4.59±0.2	4.69±0.35
RTE	0-20	4.99±0.2	5.10±0.1	5.10±0.24
	20-40	5.13±0.2	5.14±0.3	5.15±0.06
	40-60	5.16±0.1	5.17±0.3	5.18±0.30
BTE	0-20	4.77±0.2	4.82±0.1	4.86±0.25
	20-40	4.81±0.1	4.89±1.8	4.97±0.27
	40-60	4.87±0.1	4.96±0.1	4.99±0.12

Table 6 Electrical conductivity (mS/cm) of soil samples with different depth (Each value is the mean of the values obtained for three sampling sites of each of the tea estates)

Site	Depth(cm)	2012	2013	2014
STE	0-20	0.48±0.03	0.64±0.06	0.80±0.09
	20-40	0.47±0.05	0.53±0.08	0.69±0.02
	40-60	0.41±0.09	0.52±0.07	0.52±0.03
RTE	0-20	0.76±0.03	0.80±0.20	0.90±0.05
	20-40	0.72±0.03	0.75±0.07	0.88±0.07
	40-60	0.69±0.06	0.74±0.09	0.69±0.09
BTE	0-20	0.69±0.12	0.77±0.17	0.96±0.16
	20-40	0.54±0.18	0.55±0.03	0.89±0.18
	40-60	0.50±0.02	0.42±0.09	0.71±0.13

Table 7 Organic carbon % (OC) of soil samples with different depth (Each value is the mean of the values obtained for three sampling sites of each of the tea estates)

Site	Depth(cm)	2012	2013	2014
STE	0-20	1.33±0.18	1.34±0.19	1.36±0.18
	20-40	1.23±0.17	1.26±0.08	1.27±0.14
	40-60	1.10±0.11	1.13±0.07	1.15±0.13
RTE	0-20	1.36±0.21	1.39±0.15	1.40±0.19
	20-40	1.33±0.17	1.35±0.09	1.38±0.17
	40-60	1.29±0.14	1.30±0.05	1.37±0.08
BTE	0-20	1.32±0.15	1.32±0.02	1.34±0.15
	20-40	1.26±0.14	1.26±0.10	1.25±0.08
	40-60	1.18±0.22	1.21±0.07	1.23±0.10

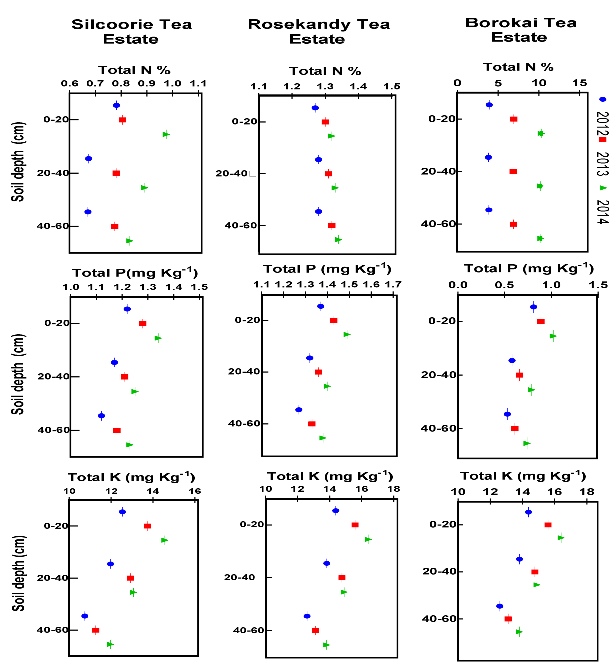

Figure: 3 Variation of (3A) Total Nitrogen, (3B) Total phosphorus and (3C) Total potassium of different soil profile of differnt tea estate during 2012-2014

It is observed that in most cases that the pH of the soil has a tendency to increase slowly from one year to another indicating that the soil may lose its acidic character over a long period of time. The electrical conductivity values of surface tea estate soil are given in Table 6. The mean values are in the range of 0.41 to 0.96 mS cm-1. The values are generally high having a tendency to rise further from 2012 to 2014.The organic carbon % contents of the tea estate soil samples were given in Tables 7. If the organic carbon content is < 0.50%, the soil is considered as low in carbon and if the same is > 0.75%, the soil is considered very rich in carbon [14]. In the present study, the values of organic matter are in the ranges of 1.10 to 1.40 %. The highest values of organic carbon were recorded for the RTE soil followed by BTE soil. The total organic matter of the tea estate soil has an increasing trend from 2012 to 2014. Such increase may be due to the addition of tea leaves and branches into the soil every year. The total nitrogen, total phosphorous and total potassium contents of the soil samples shown in Figure 3 (a), (b) and (c). The total N value ranges from (0.31 -0.98) %. A value of total nitrogen content < 0.03 % is considered as 'low' while values > 0.06% are termed as 'high' in the present work, soil from all the tea estates. The soil loses some amount of its WHC, if the relative content of hydrophobic organic matter increases over the time. The average value of total phosphorus in the tea estate soil ranges from 0.53-1.49 mg/kg. The surface soil has higher value than those of the subsurface soil. With time, there appears to be a gradual accumulation of Total P in the soil. The tea estates regularly apply large amounts of superphosphate to improve growth of tea bushes and hence to increase yield. This also is believed to be the reason for accumulation of phosphorous in the soil. The Total potassium contents of the soil samples ranged from 6.24 to 16.41 mg/kg. With respect to depth, K-content decreases vertically downward indicating that the natural K-content of the soil gets enriched at the surface through application of chemicals fertilizers. Organic carbon, total N and total P showed positive correlation with soil conductivity at a significant level of 0.785, 0.728 and 0.880, respectively.

9. CONCLUSION

The soil nutrient levels over the period under study revealed a decreasing trend with depth as is also expected since the fertilizer applied to the surface soil and nutrients remaining unutilized by the plants gradually moved downward. This observation would provide a baseline data for proper planning and management of soil through a balanced use of mineral fertilizers combined with organic and biological sources of plant nutrients for sustainable production of tea.

Table 8. Correlation coefficient analysis of physico-chemical properties of STE soil

	pH	Cond	MC	BD	OC	N	P	K
pH	1							
Cond	.018	1						
MC	.351	-.037	1					
BD	-.203	.170	.408	1				
OC	-.181	.785*	-.062	.495	1			
N	.073	.472	-.235	-.338	.117	1		
P	-.144	.381	-.226	.488	.515	.403	1	
K	.279	.289	-.365	-.185	.109	.712*	.719*	1

Table 9. Correlation coefficient analysis of physico-chemical properties of RTE soil

	pH	Cond	MC	BD	OC	N	P	K
pH	1							
Cond	.074	1						
MC	.819**	.164	1					
BD	-.355	.106	-.403	1				
OC	.179	-.092	.495	-.240	1			
N	.087	.728*	.245	.107	.021	1		
P	.022	.880**	.101	.071	.011	.844**	1	
K	.563	.621	.651	.190	.275	.537	.424	1

Table 10. Correlation coefficient analysis of physico-chemical properties of BTE soil

	pH	Cond	MC	BD	OC	N	P	K
pH	1							
Cond	.027	1						
MC	-.344	-.098	1					
BD	-.590	-.288	.165	1				
OC	-.151	.818**	-.265	.023	1			
N	-.019	.413	.578	.261	.422	1		
P	-.026	-.522	.591	.303	-.496	.345	1	
K	-.451	.283	.005	.508	.286	.202	.106	1

10. ACKNOWLEDGEMENTS

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REFERENCE

[1] Dang VM, Anderson DW (2000). Application of soil taxonomy classification into Northern Vietnam. *Vietnamese Soil Sci*. 13, pp 15-23.

[2] Anon, Tocklai Experimental Station 1911-1991, TRA Pub. Tocklai, p 232. (1992)

[3] Do, N.Q., Vo, T.T.N., Vi, K.T., (1980). Results of experiment: chemical fertilizers (NPK) on tea crop in Phu Ho. In: Agricultural Research. *Agricultural Publishing House,* Hanoi, pp. 127–146.

[4] Amir, B., I. Emododin, M.R. Atashi and H.R. Bork. 2010. Land-Use Change and Soil. Degradation: A case study, North of Iran. *Agric. Biol. J. N. Am*., 1(4): 600-605

[5] Eden, I. 1976. Tea 3rd (Eds.).Longman, London, , pp 816.

[6] Dyck, W.J., Cole, D.W. (1994). Strategies for determining consequence of harvesting and associated practices on long-term productivity. Impacts of Forest Harvesting on Long-Term Site Productivity. Chapman and Flail, London, pp. 13-35.

[7] Black, C.A. (Ed.). 1965. Methods of soil analysis. Part I and II. American society of Agronomy, Inc., Publishers, Madison, Wincosin USA.

[8] Anderson , J.M. and Ingram , J.S.I. (1993) Tropical Soil Biology and Fertility : A Handbook of Mehtods. *CAB International*, Wallingford, U.K.

[9] Trivedy, R.K. and Goel, P.K. (1984). In: Chemical and biological methods for pollution studies. Environmental Publication, Karad (India).

[10] White. R.E. (1987). In: Introduction to the Principles and Practice of Soil Science English Language Book Society/ Blackwell Scientific Publication. London

[11] Jackson, M. L. (1958). `Soil Chemical Analysis.' (*Prentice Hall: Englewood Cliff, NJ.*)

[12] Okalebo, J.R., Gathua, K.W. Woomer, P.L. (1993). Laboratory methods of soil and plant analysis: A working manual – Technical Bulletin no.1, Soil Science Society, East Africa.

[13] Bosset, M. and Berth, R. (1985). The fate of Petroleum in Soil Ecosystem. In: Petroleum Microbiology. (Ed. Atlas R.M). Macmillan, New York, pp 436-472.

[14] Baruah, T.C. and Borthakur, H.P. (1997). In: A textbook of soil chemical analysis, Vikash Publishing, New Delhi.