Integrated Forest Management Systems: Evaluation of forest soil properties for Environmental Quality and Agricultural Productivity

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Abstract: Soil physical and chemical properties do affect forests (plant) growth and soil management systems. Some key and important physical and chemical properties of soil are mineral content, texture, cation exchange capacity, bulk density, structure, porosity, organic matter content, carbon-to-ni- trogen ratio, color, depth, fertility, and pH. Sustainable forest management and soil quality parameters may include such terrestrial functions as carbon sequestration, land use management, erosion control, plant productivity and a soil's capacity to produce biomass. Sustainable forest management consistently requires enhancement of both the chemical and physical properties of forest soil quality. Land use and change in land use as well as forest management systems, are main indicators that may determine which soil properties induce changes in any forest site. Forest management and crop yield are key issues of environmental/productivity quality in addressing carbon mitigation and absorption in plant species and agricultural productivity. Five distinct forest soils under major physical properties and chemical properties were evaluated at the forest ecology laboratory. The results were determined while considering regional forest management regimes. Correlation analysis in Deqing forest soil showed that higher correlation of NMC at 25-50cm depth, BD at 0-25cm as well as 25-50cm while EC was high on 0-40 and 0.60 At the Guangzhou site, acidic levels (pH 0-25cm) indicated minor correlation and soil salinity (EC 25-50cm) also showed minor correlation. The trend was same the at the Changtan forest site where soil salinity showed only minor significant relationship (0-25cm). A percentage assessment of SOC (g/kg) among the forest sites by plot observation showed that Deqing forest site, Changtan and Nanling were well distributed which confers best forest management regimes that yield to good forest soil chemical and physical properties. This study gave scientific insight and boast plant functional nutrient interaction as well as stability towards better agricultural productivity and forest management systems. This is in agreement that good management and less disturbance in forest soils are major component of physical and chemical properties interaction, thereby for effective integrated forest and agricultural management systems.

Keywords: Integrated Forest management Systems, Soil Physical Properties, Soil Chemical Properties, Environmental Quality, Agricultural Productivity and Correlation analysis of forest soil properties.

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1 Introduction

Forest Inventory System (FIS) is known as to store and process forestry information and produces estimates of current and projected volume and value estimates of timber and non-timber products. The Forest Inventory System is a component of Integrated Forestry Management Systems and has been developed to provide managers with up-to-date information about their forest resources based upon forest surveys. It is a Strategic Planning Module formulated for the optimum long-term forest management strategy and reports the optimum combination as well as the schedule of activities, while considering constraints, which includes wood flows, capital, manpower, and environmental considerations. It is based on the environmental and ecological factors that this study was designed to evaluate the basic soil physical and chemical factors at a regional scale. Over the years, the forestry discipline as a natural science has witnessed a paradigm shift in the approach of forest management (sustainable utilization of timber) to environmental stability, biodiversity monitoring and management, protecting ecosystem services rendered by forests and sustained delivery of socio-economic benefits. These goals are enshrined in the scientific knowledge for the management of forests towards the provisioning of multiple ecosystem services which includes biodiversity conservation, water resource management and conservation, and carbon sequestration, adaptation, soil quality and agricultural systems. This paper considered some technological, scientific and laboratory evaluation as well as analytical advances in forest data collection and utilization. Forest management and crop yield are key issues of environmental/productivity quality in addressing carbon mitigation and absorption in plant species and agricultural productivity. This evaluation was based on seeking an advanced scientific knowledge to understand the various parameters of Integrated Forest Management System (IFMS) and Agricultural Systems (AS) in which soil physical and chemical properties are of critical importance. This issue at recent times have been considered a global challenge in forest soil, environmental management and agricultural productivity. Soil constituents are of varying amounts of silt, sand and clay and the proportion of components determines a particular classification. Soil texture constitutes its implication for management towards ability to cultivation and compaction. Soils physical and chemical properties do affect forests (plant) growth and soil management systems. The key and important physical and chemical properties of soil are mineral content, texture, cation exchange capacity, bulk density, structure, porosity, organic matter content, carbon-to-ni- trogen ratio, color, depth, fertility, and pH. In forest management, actual applications of an integrated approach in forest management do not occur often but Integrated forest management generally involves taking into account the totality of interactions of various sub-systems-social, economic, and ecological-within the biosphere, together with integration of goals set for such management. The main thrust of this paper is to successfully integrate field and laboratory evaluation of forest soil chemical and physical properties as a sub-system of forestry and agricultural systems. The lack of scientific knowledge regarding the effect of physical and chemical soil properties as a sub-system on the other, as well as lack of information on integrated forest management and agricultural systems and their goals, are some of the major obstacles.

Forest and land are natural resources that have been attracting increasing utilization within the tropical regions, thereby resulting in degradation of soil and forest resources (Greenland, 1981; Larson, 1986; El-Swaify, 1991; Lal, 1995; Eden, 1996, and Eswaran et al., 1992). Using a protected forest and cropland, carbon and nitrogen are considered very vital in managing forest ecosystems and soil nutrient availability for soil fertility which physical and chemical properties are strong influencing factors. The evaluation of soil physical and chemical properties as a forest management parameter in different forest management systems as in table 1 of various forest regimes becomes a strategic study at this time of global change ecology and climate change. These two important soil factors constitute major requirement that gives insight to forest soil environmental quality and plant yield/ productivity. Soil properties are critical determinant to fertility of agricultural soils, it provides the knowledge and scientific ability to predict and manage forest soil nutrient dynamics and time versus space intensity which tends to facilitate the transition to provide sustainable model in integrated forest management and agricultural systems.

Soil chemical and physical properties in forest and agricultural soils

Soil scientists and foresters in recent times are faced with the challenge of protecting soil health. To meet this challenge, they must gain a better understanding of which chemical and physical properties of soil are important to fostering good management of terrestrial ecosystems and sustainability. In forest sites, soil quality is relative to forest ecosystems functions and plant productivity. Forest soils and forest regimes are management and ecosystem-dependent, thus they are an interesting aspect of investigations. The evaluation of soil organic carbon and chemical and physical soil environment properties have become an important concepts. S.H. Schoenholtz et. al., (2000) asserted that the concepts of soil quality involves evaluation of soil properties and the relationship of their functions as a component of a forest/soil healthy ecosystem. In the same document, soil quality has been defined as the capacity of a soil to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity and maintain or enhance water and air quality. Sustainable forest management and soil quality parameters may include such terrestrial functions as carbon sequestration, land use management, erosion control, plant productivity and a soil's capacity to produce biomass. Sustainable forest management consistently requires enhancement of both the chemical and physical properties of forest soil quality. Land use and change in land use as well as forest management systems, are main indicators that may determine which soil properties induce changes in any forest site. Soils in various forest management and stand types in South China is in line with documented studies, that soil is considered topmost as a major component in sustainable land management (Bouma, 1994, Scholes et al., 1994, Swift and Sanchez, 1984). Managing soil organic carbon in relation to soil nutrients is a recognized challenge in this era of climate change (Ewel, 1986; Okigbo, 1990; Ragland and Lal, 1993; Greenland and Szabolcs, 1994; Eger et al., 1996), and has been characterized by problems of spatial and temporal borders (Fresco and Kroonenberg, 1992; Heilig, 1997). This study was designed to evaluate soil properties in different forest management regimes as selected field indicators for forest management and in relation to SOC concentrat0ion. This aspect is in conformity that soil quality can be determined by soil chemical and physical properties. This has posed a challenge that can be an opportunity to advance the knowledge of integrated sustainable forest management and agricultural systems.

2. Methodology

Study area: This study was conducted among five forest management regimes and stand types in Guangdong province of Southern China. Guangdong Province is located in the Southeast Asian mainland and surrounded by Fujian province to the east, by Jiangxi and Hunan to the north, and Guangxi province to the West. Guangdong Province has a long coastline on the South China Sea and the covers an area of 179,766 km^2.

Sampling design and selection of materials

Five forest management regimes in Guangdong Province, China were selected for this evaluation. The forest management sites as defined in table 1 includes; Changtan Nature Reserve (secondary forest), Deqing Nature Reserve (pine and broad mixed forest), Dongguan Forest Park (young plantation for non-commercial purpose), Guangzhou Nature Reserve (Non-commercial ecological forest) and Nanling National Nature Reserve (Secondary forest). The soil samples evaluated were taken from these forest sites while being mindful also of each site's forest stand type and management systems that might have influenced organic carbon and soil properties.

Regional geographical distribution of vegetation regime in Guangdong province, China

Table 1 Geographical distribution of the individual forest regimes and stand types

Forest Regime	*Geographic Location*	*Stand type*
Nature Reserve	Changtan 116º03'-16º08'E,24º41' - 24º49'N	Secondary forest, protected and less disturbance
Nature Reserve	Deqing 112º01E,- 23º26'N	Pine and broadleaved mixed forest
Forest Park	Dongguan 22º 57' N, 113º 47' E	Public forest park and formally a tree farm, non commercial purposes
Nature Reserve	Guangzhou 113º21'E, - 23º09'N	Non – commercial ecological forest
Nature Reserve	Nangling 24 º 37 '- 24 º 57' N, 112 º 30 '- 113 º 04' E	Secondary forest and protected

Regional geographical location design of forest/vegetation regimes of Guangdong province: Guangzhou – North, Changtan – East, Deqing – West, Dongguan – North and Nanling – South

3. Determination of soil physical and chemical properties

After establishing forest soil sites according to stand type classification and forest management regimes in the region, soil samples were collected. Soil samples were taken in all the five forest sites. A 20 x 20 m plot was marked out at each forest site and ten 5 x 5 m (0.025) quadrants were used, of which five were randomly selected for sampling. Surface (mineral) soil level was categorized under soil below O horizon and deep soil was adopted for sampling at designated depths of 0 - 25 cm (surface level) and 25 - 50 cm (deep level) using a standard 2-cm diameter stainless steel sampling probe. A total of 10 cores were composite for each quadrant. Two 5 x 5 cm cores (strata) designated for surface and inner depth were taken per plot (forest site) sample to determine bulk density. Soil samples at both depth samples were separately finely mixed, air dried, grounded, and sieved as recommended by Nelson and Sommers (1996). The collected soil samples were finely mixed up, bagged in transparent bags, labeled and transported to the laboratory for analysis. The samples were air-dried for 48 hours, crushed with pestle and mortar then sieved to separate whole soil (< 2mm). Ground floor soil aggregates, plant/biomass materials (tree) components (live vegetation/roots) and stones were sieved out and removed. Soil bulk density (P_b) was determined by the core method (Blake and Hartge, 1986).

Soil chemical data

In reference to the laboratory method referenced in table 2, major chemical factors were determined according to the soil properties analyzed. Chemical properties include organic matter (external heating of potassium dichromate volumetric method), Total soil carbon content was measured using the H_2SO_4 -K_2 CrO, oxidation method (Nelson and Sommers, 1982), we regarded total soil carbon as SOC; and semi-micro Kjeldhal method was applied for the determination of total nitrogen. Other factors were total phosphorous where the method of bulk soil of 0.05 mol L^{-1} HCl - 0.025 mol -1 H_2SO_4 digestion - ammonium paramolybdate calorimetric phosphorous with $HClO_4$ - H_2SO_4 digestion was applied (Olson and Sommers 1982- NaOH Fusion-flame spectrophotometry), alkali nitrogen was determined using Alkaline hydrolysis diffusion method, available phosphorous was determined using 0.5 M $NaHCO_3$ extraction- Molybdenum blue colorimetry method, available potassium was by NH_4OAc extraction-flame spectrophotometry.

Table 2 Laboratory methods reference in determination of soil chemical parameters

Chemical properties	*Method applied*	*Reference*
SOM determination	Soil Survey laboratory staff.	1992 manual
SOC concentrations and SOC density	Heating potassium dichromate volumetric & Walkley-Black (Cwb) method	Nelson/Sommer 1982 Metson, 1956
Total Nitrogen (Tot.N)	Semi-micro Kjeldhal	Pella. E 1990
Available Nitrogen (Av.N)	Semi-micro Kjeldhal	Pella. E 1990
Total Phosphorous (Tot.P)	Calorimetric method	Olsen & Summer
Available phosphorous (Av.P)	Calorimetric method	Olsen & Summer 1982
Available potassium (Av.K)	0.5 M $NaHCO_3$ extraction	1992 manual

Table 3 Laboratory methods applied in determination of soil physical parameters

Physical properties	*Method applied*	*Reference*
Natural moisture content	Gravimetric method	Gardner 1986
Electrical conductivity	Conductivity method	1992 manual
pH values	$Cacl_2$ solution by electrode/meter	McLean 1982
Bulk Density	Measured by method described	Mclean 1982

Soil physical data

Major physical properties of the forest soil derived from all soil samples for laboratory and field determination included pH, soil moisture content, bulk density and electrical conductivity. Table 3 shows the determination reference background. Acidity level was determined in 1: 5 (W/V) soil/water and 0.01 mol L^{-1} $Cacl_2$ solution using a glass electrode (McLean, 1982)- (pH meter method), electricity conductivity (conductivity method), bulk density and soil moisture was further determined by the method described by McLean (1982).

4 Calculations

The dried sieved samples across the forest sites were used to measure various soil properties, of which organic matter (SOC) content and concentration was determined by loss on ignition (450 °C for 4 h). Soil Organic Carbon was estimated by multiplying organic matter content by 0.58 (Soil Survey Staff, 1992). Organic C concentration/amounts (kg C m^{-2}) were calculated as the same in all the forest sites within two specific depth strata. The analysis was presented for soil organic C data for each site in respect to forest stand type and management regimes.

Soil Organic carbon was calculated using the basic formula:

$$SOC\ (t\ ha^{-1}) = a \times D \times B \times C \times S.$$

Where a was the constant to adjust for area,
D the soil depth in cm,
B the soil bulk density in g cc^{-1},
C the organic carbon content (%) and
S the proportion of soil mass <2 mm in the sample which do not include stone particles.

Soil density values were calculated according to the equation (Post et al., 1982) of D = 100 x c B (1 - § 2mm): Where:
D indicates Soil Organic Carbon density (kg C m $^{-3}$)
C indicates SOC content (g kg $^{-1}$) for a certain soil depth
B indicates Soil Bulk density (g cm $^{-3}$)
§ 2mm indicates the content (%) of soil particles with > 2 mm diameter.
We considered Bulk Density calculation of the mineral soil core and was calculated by

$$P_b = \frac{ODW}{CV - (RF/PD)}$$

Where
P_b - Bulk density of the < 2mm fraction (g/cm^3)
ODW - Oven-dry mass of fine fraction (> 2mm) in g
CV - Core volume (cm^3)
RF - Mass of course fragments (> 2mm) in g
PD - Density of rock fragments (g/cm3) often expressed as 2.65g/cm^3
The mineral soil, the amounts of carbon per unit area are calculated by; C (t/ha) = [(soil bulk density, (g/cm3) x soil depth (cm) x % C)] x 100, whereby in the equation above, % C is expressed as a decimal. In summary, Bulk density is a measure of the weight of the soil per unit volume (g/cc), usually given on an oven-dry (110° C) basis, that is bulk density is calculated by weight over the volume, while soil porosity (%) is calculated by 1 - bulk density divided by particle density multiplied by 100.

Data analysis

The data analysis primarily involved and was concentrated on the various forest soils ranging from 0-25cm and 25-50cm. Descriptive statistics parameters were calculated with Microsoft Excel and STASTICA software 6.0 versions (2001) and SPSS software (2006). SOC concentration and density were subjected to tests of significance as analysis of variance (ANOVA). The Kruskal-Wallis median test was used at 5% probability level to evaluate and determine differences between SOC variations among forest sites and locations as shown as least significant difference (LSD). Soil Organic Carbon including bulk density, and effects between soil depths among forest soils were reported. Multivariate and correlation analysis was performed with SPSS software to evaluate the SOC concentration, SOC by stand types and management regimes. The physical soil data, standard error of the differences in mean infiltration rates and soil bulk density were calculated for the various forest regimes. Further descriptive statistics such as means and coefficients of variation (standard deviation/mean) and comparative (ANOVA, and Turkey's multiple comparison) analyses were also performed with the SPSS version (1999).

Results

Evaluation of soil bulk density

Individual soil bulk densities were evaluated at 0-50cm correspondingly. The Dongguan site (1.43±0.02), Deqing site (1.39±0.02), and Guangzhou site (1.29±0.03) as shown in table 4 were assessed in relation to forest management system and vegetation stand type.

Table 4 Soil bulk density (Mg m-3) among forest management regimes (0-50cm)

Site	*BD Mean*	*BD Sdv*
Deqing	1.39±0.02	0.14
Guangzhou	1.29±0.03	0.18
Changtan	1.03±0.03	0.19
Dongguan	1.43±0.02	0.11
Nanling	1.28±0.02	0.17

Soil physical properties by multivariate analyses

Physical soil properties at the five regional forest sites show that natural moisture content (NMC) in figure 5 was higher in Changtan Nature Reserve, which is a secondary forest. Natural moisture content is evaluated in relationship with soil and forest management practices and in Changtan was 400.00g*kg^{-} at a depth of 25-50cm. The site showed a statistical difference from other forest depths, though with a minor correlation to moisture content at the Dongguan site. Deqing, Guangzhou and Nanling showed slight correlations and there was no correlation to the Dongguan site. Moisture content at the Dongguan site showed a unique result and strongly correlated to both depths at the site. The result in figure 5 therefore indicated that the higher natural moisture content in Changtan, Dongguan, and Guangzhou forest sites at 25-50cm is a prove that soil organisms and plant stands may show higher respiration and photosynthetic chemical processes. Bulk densities under various forest management systems were not similar in all forest soil depths as in figure 6 though at the Deqing site all depths showed the same trend and were correlated. The bulk densities in the secondary forest, protected (non-commercial), young plantation as well as pine and broad mixed leaved forest were however, significantly higher, especially in Deqing (1.40g*cm^{3-}) and Guangzhou (1.42 g*cm^{3-}).

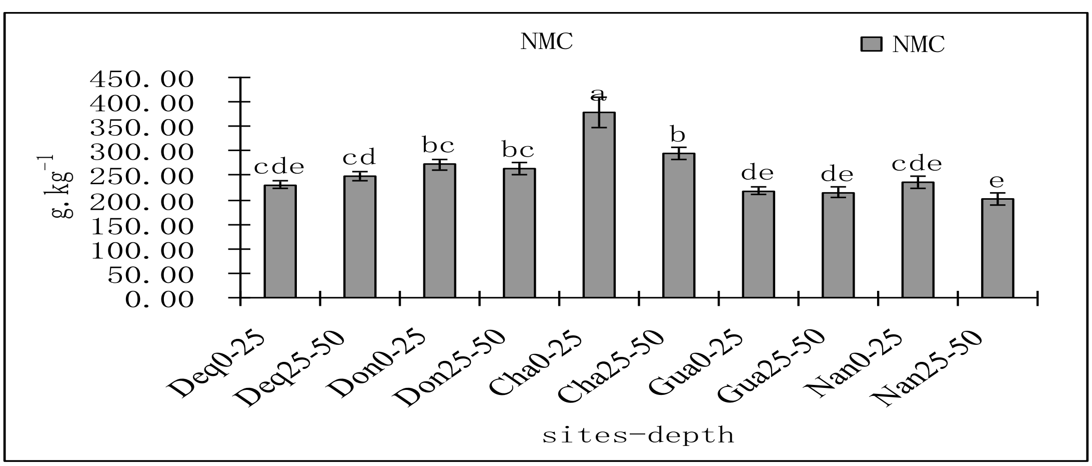


Figure 5: Natural moisture evaluations in forest soils

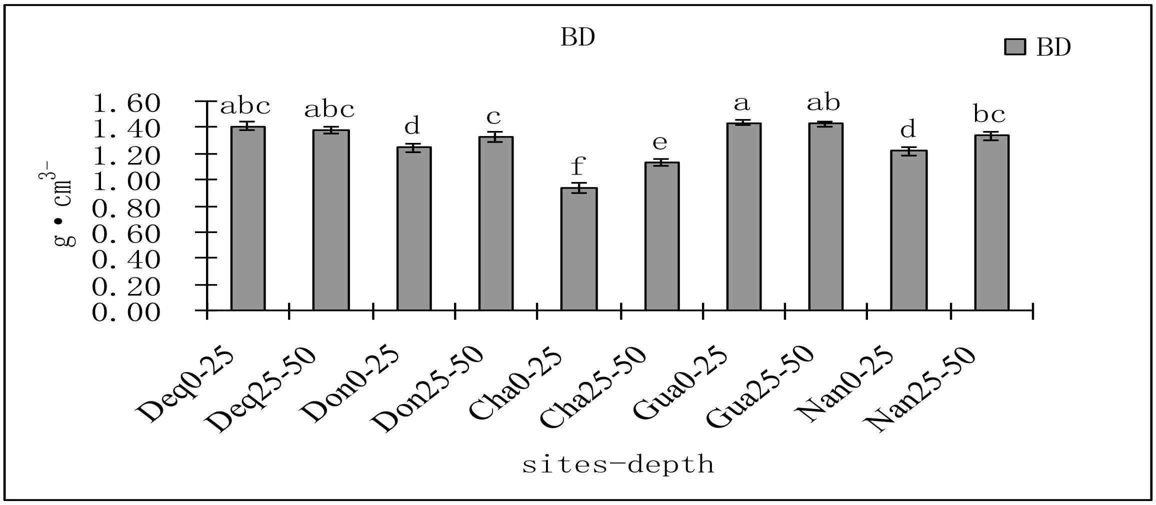


Figure 6: Bulk Density evaluations among forest sites

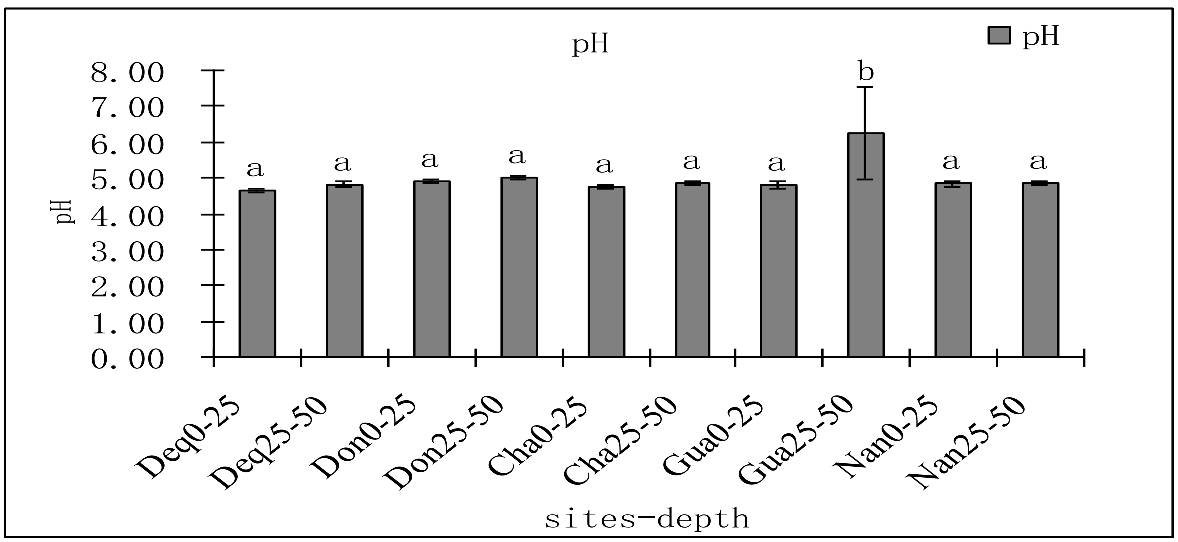


Figure 7 pH evaluations in the forest sites

Bulk density is a measure of the total mass of a moist soil per unit volume. Topsoil and medium depth from all the forest sites showed a unique and classical inference of the region's soil acidic level irrespective of the management practices. Figure 6 confirms this information but from a different level in the Guangzhou Nature Reserve (a non-commercial site) at 25-50cm depth (6.0) showing a significant decline in pH. pH levels of soil acidity or alkalinity were found in the topsoil but no changes were found in the lower horizons of all sites (fig.7), where all were less than 7.

Electrical conductivity level in all the sites were high as shown in figure 8. Soil salinity is conventionally expressed in terms of EC and is among the most useful and easily obtained spatial properties of soil that influences crop productivity and forest health. Deqing and Changtan forest sites showed highest and significantly different at surface level (0-25cm). However, the EC evaluation in Changtan site indicated highest in both soil levels (0-25cm and 25-50cm).

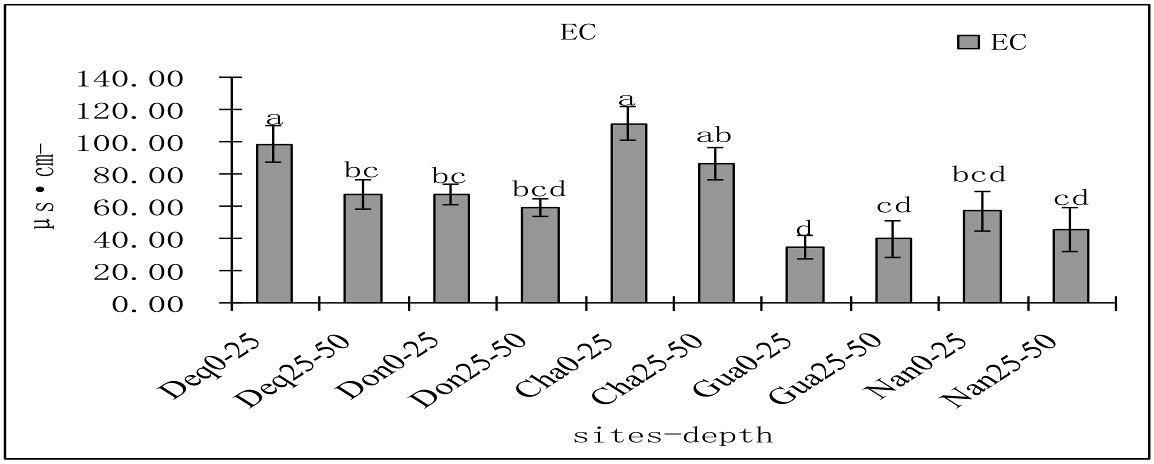


Figure 8: Electrical conductivity evaluations among the forest sites

Table 5: Correlation analysis of major physical properties in Deqing site

SOC	*NMC*		*BD*		*pH*		EC	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Deqing0-25	0.06	-0.20	-0.03	0.27	0.02	-0.01	-0.40*	0.60**
Deqing25-50	-0.48*	0.03	0.25	-0.39	-0.02	-0.06	0.10	0.22

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed).

Based on these evaluations, further correlation analyses for basic physical soil properties in individual sites for the determination of critical values was conducted as shown in table 5. There was minor correlation in most sites though there was significant differences at the Deqing site (25-50cm) on NMC and EC (-0.48 and -0.40), with critical and significant difference at the same site for which NMC at 25-50cm was 0.60. At the Guangzhou site, acidic level (pH) 0-25cm indicated minor correlation and soil salinity (EC) 25-50cm also showed minor correlation in table 6. The trend was the same at the Changtan forest site shown in table 7, where soil salinity showed only minor significant relationship at 0-25cm.

Table 6: Correlation analysis of major physical properties in Guangzhou site

SOC	*NMC*		*BD*		*pH*		EC	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Guang0-25	-0.14	-0.09	-0.23	0.04	0.37	-0.37	-0.27	-0.42*
Guang25-50	-0.03	0.02	-0.09	-0.01	-0.42*	-0.39	0.34	-0.44*

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed).

Table 7: Correlation analysis of major physical properties in Changtan site

SOC	*NMC*		*BD*		*pH*		EC	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Chang0-25	-0.12	-0.10	-0.14	-0.10	-0.18	-0.04	-0.03*	-0.05
Chang25-5	-0.14	0.03	-0.07	-0.33	-0.22	-0.22	-0.45*	-0.19

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed).

The fact remains that a combination of factors influences EC measurements to varying degrees across the region, which may be attributed to regional forest management practices. These factors include soil salinity, bulk density, pH and moisture content that has been evaluated among the forest regimes and where EC dominated the soil factors though the forest sites measurements and interpretations showed no correlation, as shown in table 8 (Dongguan site) and table 9 (Nanling site) that NMC, BD and EC were indicated as strongly correlated especially at the deeper depth (25-50cm). To use spatial measurements, these soil properties are significantly influential factors for vegetation stand type and considered in management regimes.

Table 8: Correlation analysis of major physical properties in Dongguan site

SOC	*NMC*		*BD*		*pH*		EC	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Dong0-25	-0.09	0.19	-0.32	-0.05	-0.10	-0.05	-0.11	-0.07
Dong25-5	-0.08	0.56**	-0.24	-0.52**	-0.20	-0.12	-0.46*	-0.02

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed).

Table 9: Correlation analysis of major physical properties in Nanling site

SOC	*NMC*		*BD*		*pH*		EC	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Nang0-25	-0.01	0.18	-0.22	-0.12	-0.02	-0.02	-0.18	-0.15
Nang25-5	-0.07	0.15	-0.26	-0.44**	-0.09	-0.07	-0.16	-0.10

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed).

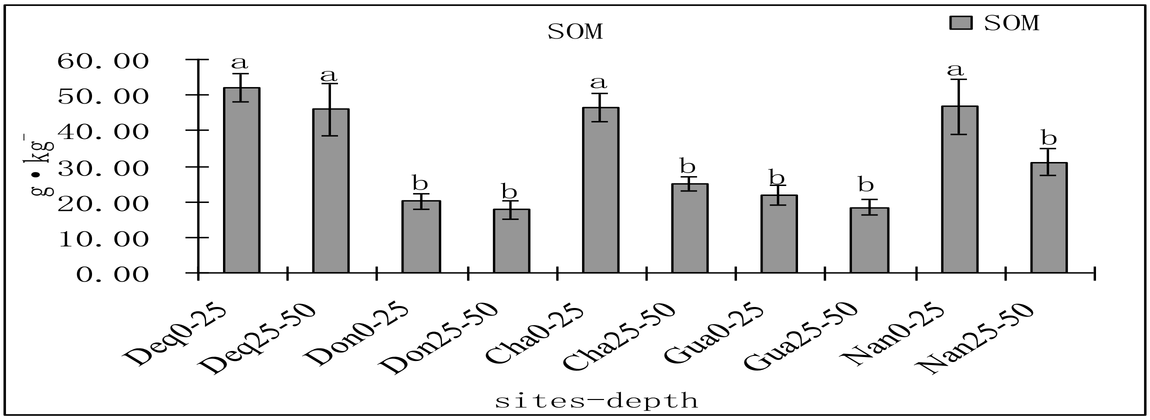


Figure 9: SOM evaluations among forest soils
(Deq- Deqing, Don-Dongguan, Cha- Changtan, Gua-Guangzhou and Nan-Nanling forest sites)

Soil chemical properties by multivariate analysis

SOM and SOC evaluation in all the forest sites in fig. 9 and fig. 10 showed that the density and concentration found in these properties reflect as a strong indicator's relationship with soil properties and forest ecosystem function. SOM in fig. 9 showed highest at the Deqing (Deq) forest site (51g∗kg$^-$ and 49g∗kg$^-$) at both designated depths; Changtan (Cha) and Nanling (Nan) sites (0-25cm) were very high (49g∗kg$^-$). High concentration of SOC was further observed at the Deqing forest site (30g∗kg$^-$ and 27g∗kg$^-$), exhibiting same pattern in Changtan and Nanling at surface level (29g∗kg$^-$), respectively, in each sites (fig 10). Dongguan (Don) and Guangzhou (Gua) were comparably low in all the forest soil depths indicating no significant differences.

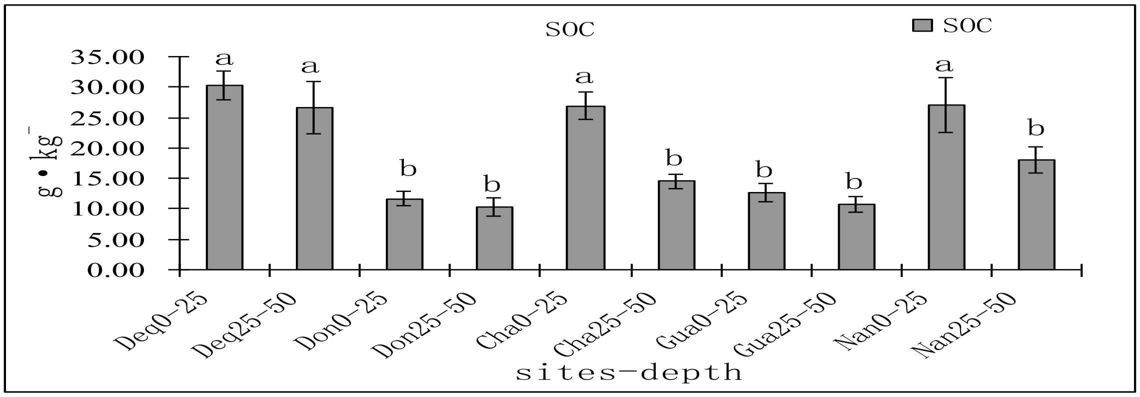


Figure 10: SOC concentration among forest soils
(Deq- Deqing, Don-Dongguan, Cha- Changtan, Gua-Guangzhou and Nan-Nanling forest sites)

This skewed distribution may be as a result of forest soil management systems and nutrient interactions. Available nitrogen was highest at the Deqing and the Changtan site, available potassium was evenly distributed at almost all the sites, though highest in Deqing, Guangzhou, and Nanling, as shown in fig. 11. Furthermore, available phosphorous showed very low distribution in all the forest sites and highest in Changtan and Deqing (fig.11).

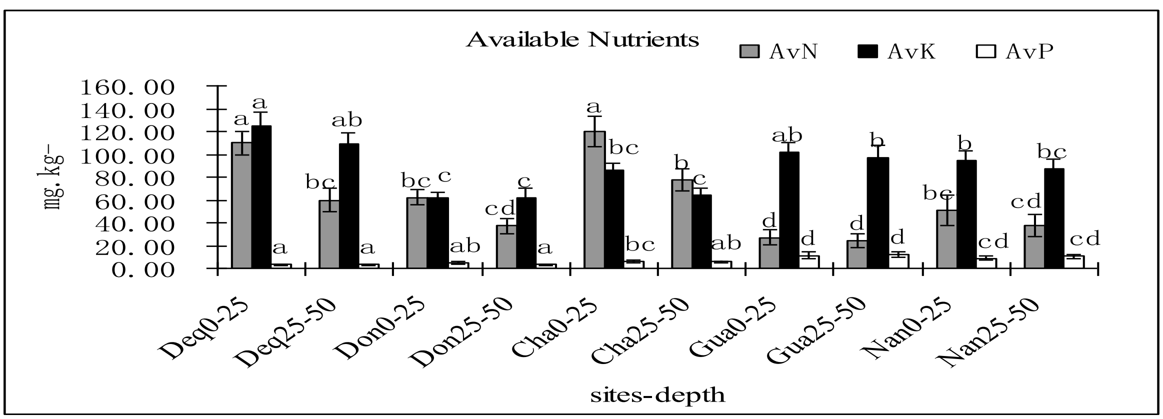


Figure 11: Available nutrients evaluation among the forest soils (available nitrogen, available potassium and available phosphorous
(Deq- Deqing, Don-Dongguan, Cha- Changtan, Gua-Guangzhou and Nan-Nanling forest sites)

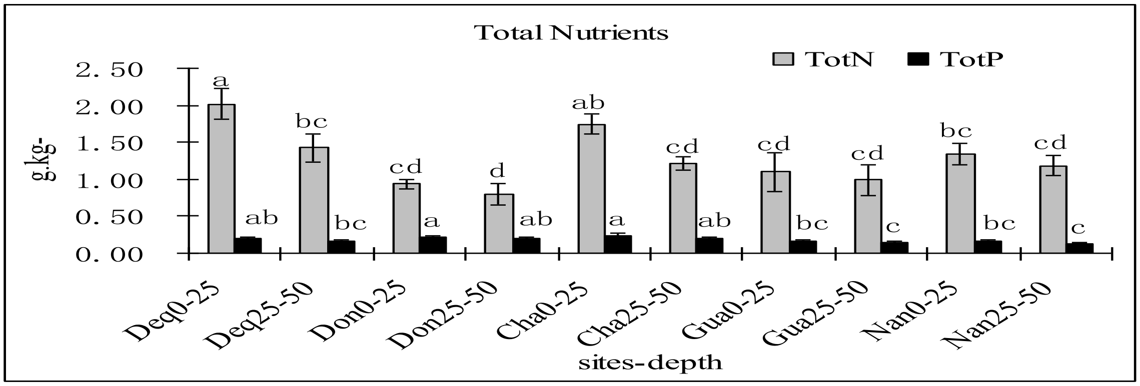


Figure 12: Total nutrients evaluated among forest soils (total nitrogen and total Phosphorous (Deq- Deqing, Don-Dongguan, Cha- Changtan, Gua-Guangzhou and Nan-Nanling forest sites)

Spatial distribution of total nitrogen was normally distributed and high in all sites as shown in figure 12, while total phosphorous was comparably low at all sites. These results seem to be in complete agreement to the fact that overall of Soil Quality (SQ) reflects the effects of management practices on soil function. Correlation analyses of the major chemical parameters to SOC concentration further indicated at the Deqing site (table 10) has critical correlation at surface level (0-25cm) in total nitrogen, available potassium, and phosphorous, but has a minor correlation in total phosphorous.

Table 10: correlation evaluation of chemical properties in Deqing site

SOC	*Vann*		*TotN*		*AvK*		*AvP*		*TotP*	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Deq0-25	0.14	0.38	0.63**	-0.17	0.57**	-0.16	-0.12	-0.43*	0.14	0.50*
Deq25-50	-0.11	-0.03	0.04	0.39	-0.12	0.34	-0.03	-0.38	-0.07	0.09

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed). Deq - Deqing forest site

The Guangzhou site as in table 11 was significant and critically correlated as compared to other sites, where total nitrogen, available P, K and total P were critically correlated virtually at all depths against SOC concentration. This was attributed to the management practices from the University forest authority and restrictive policies. Table 12 indicated that at the Changtan site, total N and available P in correlation to organic carbon concentration were significantly higher at all depths.

Table 13 and 14 showed the correlation results in Dongguan and Nanling forest sites where available K (25-50cm) at the Dongguan site showed critical correlation to SOC concentration, while at the same site, as well in Nanling (25-50cm), available P, N and K were minor in relation to SOC.

Table 11: Correlation evaluation of chemical properties in Guangzhou site

SOC	*AvN*		*TotN*		*AvK*		*AvP*		*TotP*	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Guang0-25	0.17	0.09	0.69**	0.81**	0.55**	0.47*	0.73**	0.71**	0.05	0.41*
Guang25-50	0.12	0.08	0.74**	0.81**	0.51**	0.40*	0.83**	0.77**	0.06	0.44*

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed). Guang - Guangzhou forest site

Table 12: Correlation evaluation of chemical properties in Changtan site

SOC	*AvN*		*TotN*		*AvK*		*AvP*		*TotP*	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Chang0-25	0.32	0.09	0.83**	0.27	0.24	-0.36	0.30	0.19	0.24	-0.14
Chang25-50	-0.06	0.00	0.39	0.57**	0.15	0.33	0.78**	0.73**	-0.07	0.19

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed). Chang - Changtan forest site

Table 13: Correlation evaluation of chemical properties in Dongguan site

SOC	*AvN*		*TotN*		*AvK*		*AvP*		*TotP*	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Dong0-25	-0.13	-0.02	0.05	-0.14	0.14	0.08	0.08	0.01	-0.13	-0.07
Dong25-50	0.20	-0.22	-0.16	0.38	0.08	0.55**	-0.13	0.41*	0.14	0.32

* Correlation is significant at the 0.05 level ** Correlation is significant at the 0.01 level (2-tailed). Dong-Dongguan forest site

Table 14: Correlation evaluation of chemical properties in Nanling site

SOC	*AvN*		*TotN*		*AvK*		*AvP*		*TotP*	
	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50	0-25	25-50
Nang0-25	-0.24	-0.19	0.15	0.19	0.22	0.34	0.15	0.21	0.00	-0.41*
Nang25-50	-.40*	-0.08	0.11	0.16	0.32	0.48*	0.24	0.11	0.05	-0.23

* Correlation is significant at the 0.05 level (2-tailed) ** Correlation is significant at the 0.01 level (2-tailed). Nang- Nanling forest site

5 Discussion

Forest soil physical properties

The assessment of soil chemical and physical properties which is classified as indicators for sustainable forest management. Forest sites and soil quality is relative to forest ecosystems functions and plant productivity. Forest soils and forest regimes are management and ecosystem-dependent thus becoming an interesting aspect of investigations. It also focuses on the influences of soil environment factors in the concentration and density of organic carbon in forest soils. This study aspect is in conformity that land use and land-use change are major culprit in soil nutrients negative impacts. Forest management systems and forest soils health should be maintained through less exploitation of soil and forest resources. This current study has further proved that physical and chemical forest soil parameters are influential to soil organic carbon concentration and density in forest regimes.

The higher moisture content in soils depicted the plant potential to engage in biogeochemical processes for organic matter density and concentration. We attributed this evidence to the fact that the Changtan and Nanling sites are secondary forests with protected management practices. The situation at the Dongguan site may be attributed to the indirect influence of urban and industrial activities (Oke, 1995, Mount et al., 1999, Lee and Longhorns' 1992, De Miguel et al., 1977 and Meilke 1999). However, land use and vegetation cover may serve as an indicator of disturbance, site history, management, and the urban environment—factors that should disproportionately affect surface rather than subsurface soil properties that greatly influence moisture content. Forests site may be associated with lower moisture content and correspondingly will result in differences in organic matter composition. We observed that in some pits roots were absent in some parts which is commonly found in compacted soils, and it has been found that soil compaction is an attribute of land use and change in land use, as well as forest management practices that may arise, as reported by Juang and Uehara (1971) in sugarcane harvesting and other field operations. The pH factor becomes important because some plant stand types grow better in either acidic or alkaline conditions. pH can influence the availability of soil nutrients in different forest types. Acidification thus increases the concentration of potassium (K), magnesium (Mg), and calcium (Ca) in soil solution. Smith, C. J et. al., (1994) documented that nutrient cations such as zinc (Zn^{2+}), aluminium (Al^{3+}), iron (Fe^{2+}), copper (Cu^{2+}), cobalt (Co^{2+}), and manganese (Mn^{2+}) are soluble and available for uptake by plants below pH 5. pH levels also affect the complex interactions among soil chemicals.

Furthermore, Wikipedia organization (http://en.wikipedia.org/wiki/Soil_pH) extensively reported that soil acidification may also occur by addition of hydrogen, due to decomposition of organic matter, acid-forming fertilizers, and exchange of basic cations for H^+ by the roots. Certain factors influence pH values of a soil, such as the kinds of parent materials used for soil formation and rainfall. Anthropogenic pollutants do influence soil pH; this was attributed to the Guangzhou and Dongguan forest sites that have attracted heavy traffic across these urban sites. Also the application of fertilizers containing ammonium or urea speeds up the rate at which acidity develops. The decomposition of organic matter also adds to soil acidity. pH and EC are associated with the effects of salinity and acidity that may be manifested in loss of stand, reduced rates of plant growth, reduced yields, and in severe cases, total crop failure (Rhoades and Loveday, 1990). Salinity limits water uptake by plants by reducing the osmotic potential and thus the total soil water potential. In the studied forest sites, there exists strong correlation between the amount of salinity in the Deqing and Changtan secondary and protected forests measured at 0-25cm surface depth. The site-specific relationship with all the forest sites in South China therefore shows that sustainable forest and land management are based on distributive soil chemical and physical factors. These factors also exhibit corresponding influence on soil organic carbon density and concentration (Smyth and Dumanski, 1995).

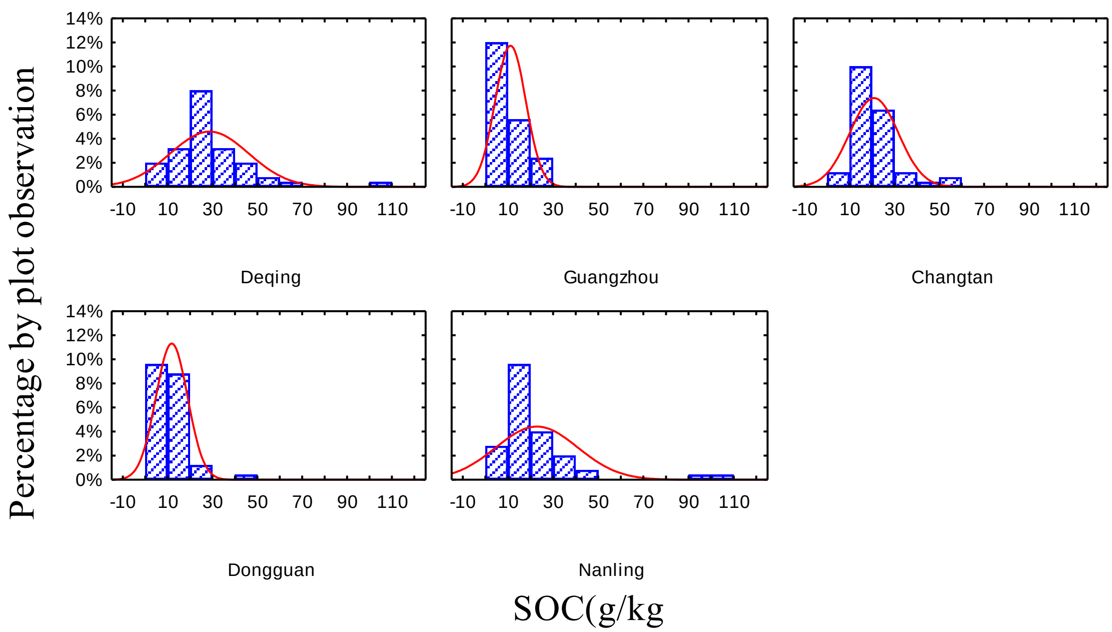
Forest soil chemical properties

This study results suggests that soil chemical properties may be spatially dependent and that the dependence in this example represents and reflect the soil-forming processes and perhaps forest soil management. Soil properties may strongly suggest that soil management and forest regimes are strong indicators for soil and forest health. The major chemical parameters evaluated in South China showed that there was normal distribution in most of the variables. This inference is related to the specific forest management history and effect of stand types in the region. This investigation in situ therefore shows that protected, fewer disturbances, secondary stand types and management practices that is classified in the Deqing, Changtan and Nanling forest soils were positively correlated to SOC concentration. This has been considered also proved by the correlation analysis in most chemical factors in the sites. The Guangzhou forest soil and SOC concentrations were strong and showed positive relationship between the parameters. This is an attribute of best forest soil management control from the University forest authority. Other physical and chemical factors across the region supports enhanced microbial dynamics, including respiration rates (Bohlen et al., 2001; Chen et al., 2003; Hannam and Prescott, 2003);

Changes in soil properties may continue to change as long as the current management strategies remain unchanged though it may not be possible to predict at what pace such will happen. In as much as the use of fertilizers, encroachment to forested lands, high emission of greenhouse gases and other anthropogenic activities are likely to be steadily into play in the region. These may result to influences on organic carbon and soil properties. Some important and general references are such example as documented by Hartemink, (1998), on pH buffering capacity may increase reducing the acidifying effects of sulphate of ammonia which may also reduce the compatibility of the soil by increasing resistance to deformation (Soane, 1990). Based on the current study, which is in conformity that physical and chemical forest soil parameters are influential to soil organic carbon concentration and density in forest regimes. This may have accounted to the various site soil organic carbon distribution and patterns in South China.

Correlation of forest soil properties and SOC

Correlation analyses of the major chemical parameters to SOC concentration further indicated at the Deqing site (table 8) has critical correlation at surface level (0-25cm) in total nitrogen, available potassium, and phosphorous, but has a minor correlation in total phosphorous. The Guangzhou site (fig.9) was significant and critically correlated as compared to other sites, where total nitrogen, available P, K and total P were critically correlated virtually at all depths against SOC concentration. This was attributed to the management practices from the University forest authority and restrictive policies. Table 10 indicated that at the Changtan site total N and available P in correlation to organic carbon concentration were significantly higher at all depths. Table 11 and 12 showed the correlation results in Dongguan and Nanling forest sites where available K (25-50cm) at the Dongguan site showed critical correlation to SOC concentration, while at the same site, as well in Nanling (25-50cm), available P, N and K were minor in relation to SOC. A percentage assessment of SOC (g/kg) among the forest sites by plot observation showed that Deqing forest site, Changtan and Nanling were well distributed which confers best forest management regimes that yield to good forest soil chemical and physical properties.



6. Conclusions

The long and short term improved natural management systems and regimes adapted have significant effects on soil physical and chemical properties in Guangdong region of China. Soil chemical and physical properties in both systems of management appear to be in line with management regimes and overtime. The dynamics of soil physical and chemical indicators do change significantly in both systems of management as compared to secondary natural forest (SF). It is observed that assessment and depth of soil have significant effects on physical indicators such as bulk density, porosity, field capacity and wilting point. It is anticipated that in both systems of management and regimes the SOM content at various soil depths increased with time (periodic), however increase of SOM, extractable P, K, and Mg, and exchangeable.

Future research is needed to explore the spatial impact of different vegetation stand type and influence of climate change, soil microbes and socio-economic services. This study identifies the following findings:
a. Soil structure is influenced by its physical, chemical and biological characteristics. Good soil structure is vital, as it can affect the availability of air, water and nutrients for plant growth.
b. Forestry and Agricultural practices can significantly alter soil structure.
c. Management systems significantly influenced total soil C and N concentrations at the 0- to 25- cm profile in forest soil and associated with both chemical and physical properties.
c. Forest soil properties 0- to 25-cm soil profile are influenced and correlations with different
d. Relationship of forest soil (chemical and physical) properties are influenced by management systems and regimes at regional and time scales.
The field and laboratory evaluation reveals that forest soils and management systems are key factors of managing SOC and N in forestry and agricultural systems. This study recommends the appropriate application of Soil Conditioning Index (SDI) in the effective forest soil and agricultural management systems. SCI can be used to predict a positive or negative trend in soil organic matter on agricultural land, predict how modifications of a management system will affect the level of soil organic matter and evaluate conservation management systems, when used along with other assessment methods. The periodic evaluation and SDI knowledge of forest/vegetation soils, forest and agricultural management systems will proffer solutions to problems of integrated forest/agricultural management system in this era of global change ecology.

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