IJRCE

International Journal of
Research in Chemistry and Environment
Available online at: www.ijrce.org

ISSN 2248-9649

Research Paper

Physicochemical Properties of Soils under Different Tea Growing Regions of North Bengal: A study from 2006 to 2010

Tarun Kumar Misra[1], Ashis Kumar Nanda[2], Palash Mandal[3] and Aniruddha Saha[4*]
[1, 3, 4] Department of Botany, University of North Bengal, Raja Rammohunpur, Siliguri, Darjeeling, W.B., INDIA
[2]Department of Chemistry, University of North Bengal, Raja Rammohunpur, Siliguri, Darjeeling, W.B., INDIA

(Received 15th August 2017, Accepted 27th December 2017)

Abstract: *The physicochemical properties of tea soil (0-45cm) were analysed to evaluate the characteristics of tea growing soils under three different locations of West Bengal (India), considering the age of tea plantation during the period from 2006 to 2010. The soil samples of Hills, Dooars and Terai region of West Bengal were collected on the basis of age (young, medium and old) of the tea plants, although Darjeeling region as organic and non-organic tea growing soils. The soils of the Dooars region were clay to sandy loam in texture whereas; soils of Terai and Darjeeling was sandy loam in texture. The selected TG soils were strong to moderately acidic in reaction with low electrical conductivity (EC) and Chloride (Cl^-). The organic carbon/organic matter/available nitrogen content of different regions was found medium to high, but very little variation was obtained with organic tea growing regions of Darjeeling. The soil available P content were low to medium in all the regions but higher available K content were found with the soils of Hills, Dooars and Terai regions. The correlation study indicated that available N and K were influenced by soil organic carbon content, while the available P content by the soil pH. The available N, K and EC were negatively influenced by sand content of the soils.*

Keywords: *Camellia sinensis*, Terai, Dooars, Darjeeling Hill, soil physico-chemical properties.

Introduction

Tea growing area of North Bengal (Figure 1)mostly in the Terai and Hill region of Darjeeling district and Dooars region of Jalpaiguri district. The Tista, Torsha, Jaldhaka, Kaljani, Rydak and mainly Sankosh river basin under North Bengal have large catchment area in the hills where the rivers cut down the ridge and mountain to come down to the plains of *Terai* and *Dooars* area[1] of the lower foothills of Terai and Dooars are very susceptible to disposition of dolomite loam and sand. In Darjeeling district, tea is mainly grown in regions of Terai and mountain slopes at an altitude of 100-2,000 m msl and in Jalpaiguri district, it is grown mainly in *Dooars* regions. These Sub-Himalayan mountainous tracts are characterized by deep steep sided valley, separated by terraced high lands, immediately to the south of the Himalayas. Tea naturally grows in tropical to subtropical conditions, where the annual rainfall[2] is more than 200 cm. Tea thrives well under acid, well drained sloping ground, sandy loam, heterogeneous soil and climatic conditions. It is well known fact that for the plant growth i.e. optimizing the yield of tea and its quality-quantity of secondary metabolites highly influences by the soil physicochemical characters[3]. Henceforth, evaluations of soil fertility status of soils are necessary to make a proper management and sound fertilizer recommendation.

Material and Methods

All chemicals used were analytical grade and were bought from Sigma (USA).

Soil sampling and determination of physicochemical properties

Soil samples from 18 tea garden in Terai, Dooars and Hills were collected from three different cultivated plots of four plants (top and sub soil with 0-22.5 cm and 22.5-45 cm depth respectively) and composite soil were prepared as per the standard method[3].The samples were processed for physicochemical analysis[4] viz. pH, electrical conductivity, moisture contents, texture, organic carbon, available form of nitrogen, potash as K_2O, phosphorus as P_2O_5 and sulphur as SO_4^-.

Statistical analysis
The data were pooled in triplicate and subjected to analysis of correlation co-efficient matrix using SPSS (Version 12.00) for drawing the relation among soil physicochemical properties.

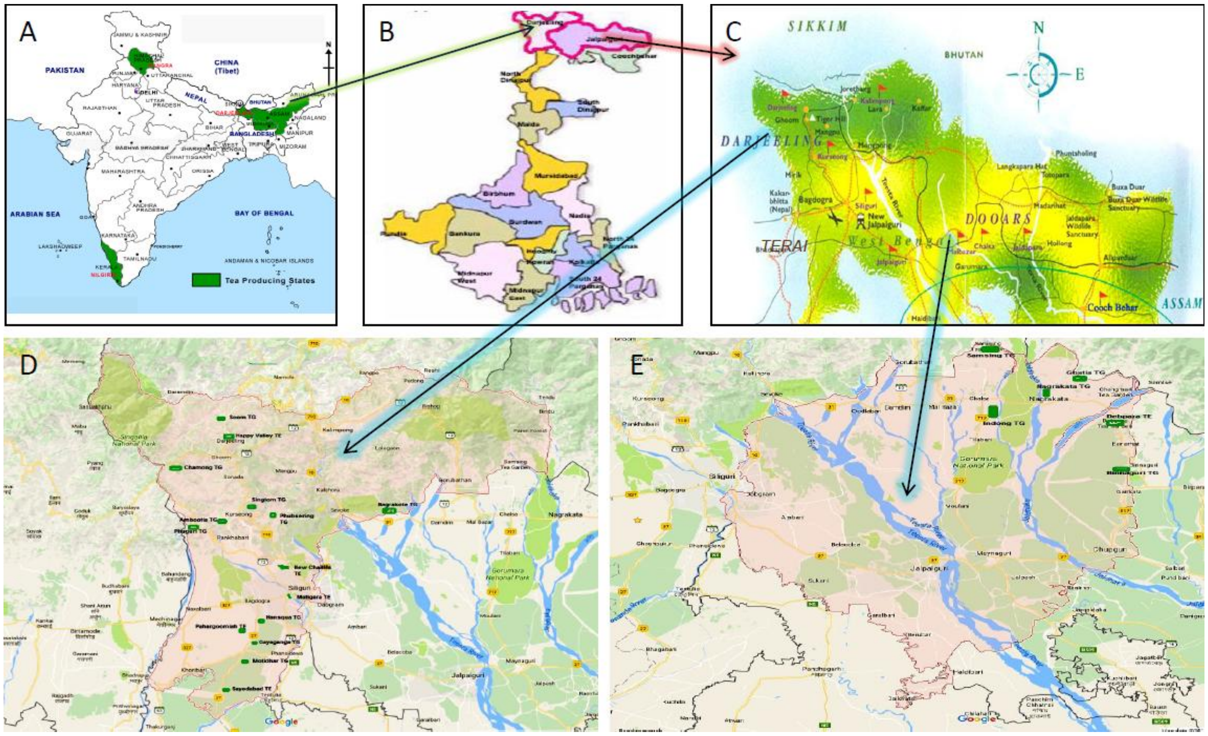

Figure 1: Map of study area under Darjeeling Hills, Terai and Dooars regions of North Bengal. [A: Map of India, green colour showing tea cultivating area. B: Map of West Bengal, pink colour border showing tea cultivated area. C: Map showing Darjeeling, Terai and Dooars regions. D & E: Experimental Tea garden/ Estate(Green colour spot with name) of Darjeeling and Terai and Dooars.(*Source : Google map modified*)]

Results and Discussion
The soils (0-45 cm) of six tea garden in Dooars region *viz.* Debpara, Binnaguri, Nagrakata, Ghatia, Samsing and Indong were recorded to be strong to moderately acidic in reaction [4.15 to 5.5]. The soils varied from sandy loam to clay laom in texture. Among the six tea gardens of Dooars regions, the soils of Debpara and Binnaguri tea garden were predominantly sandy loam to clay loam in texture; whereas, the soils of Nagrakata and Ghatia were clay loam to clay in texture. Samsing and Indong were Sandy clay loam to clay loam. The organic carbon, organic matter and available nitrogen percent varied from 0.69 to 1.75, 1.2 to 3.03 and 0.1 to 0.24% respectively in young, 0.45 to 1.80, 0.78 to 3.12 and 0.06 to 0.25% respectively in medium and 0.41 to 0.78, 0.71 to 1.35 and 0.06 to 0.11% respectively in old aged soils of Dooars region. The organic carbon, organic matter and available nitrogen was found relatively higher in young aged section of Ghatia and Samsing and medium aged section of Debpara, Binnaguri, Nagrakata tea garden and aged section of Indong tea garden. The available nitrogen status of all the soils were generally low to medium and this variation might be due to leaching loss, emission of nitrous oxide of Nitrogen from the surface soil and less moisture content. Available Phosphorus content varied between 20.30 to 95.00 ppm in young, 13.8 to 58.20 ppm in medium and 22.90 to 32.5 ppm in old aged soils of Dooars. Higher P content was found with medium aged section of Debpara, Binnaguri and Samsing and the lowest was with medium aged sections of Indong. The available Potassium content was found low to medium.

Maximum potassium content was found with young section of Samsing and the lowest was with aged sections of Indong tea soil. Available Sulphur were below recommended levels of all section and Chloride, Electrical conductivity were within limits of all section. Moisture content were highest in medium aged section of Debpara, Samsing and Nagrakata tea garden, this is because of using mulching in dry spell and comparatively satisfactory levels of organic matter. Soil were compared with virgin and multicrops system of very closest area from respective tea garden, it was found that pH lies in between 4.56 to 5.50, EC were within limits and all nutrients were maintained at a certain limits of all tea garden in Dooars region. Tea is monoculture crops and planters used more nutrient supplements that's why widely varied in tea gardens' soil.

The soil pH was positively correlated (Table 1) with sand content, available nitrogen(N), phosphorus(P) and moisture content(MC) were negatively correlated with clay, silt and available potassium(K), sulphur (S) and chloride(Cl) and electrical conducitvity(EC). The EC had a negative correlation with silt, pH, and available nitrogen. The EC had significant positive correlation with potassium, phosphorous, sulphur, chloride and moisture. Soil organic carbon, organic matter, available nitrogen, phosphorus, potassium, sulphur, moisture content and chloride had a positive correlation with nutrient and physical parameter, suggesting that soil organic carbon increased the availability of nutrients under tea growing soil. Strong and positive correlation was observed between EC and available sulphur ($r = 0.813$), moisture and available phosphorus ($r = 0.808$) which indicated that the cation adsorption at the exchange sites of the clay.

The soils (0-45 cm) of six tea garden in Terai region; viz. New Chumta, Sayedabad, Hansqua, Gayaganga, Motidhar and Paharghumia were recorded. Physicochemical properties of soils were strong to moderately acidic (4.10 to 5.34) with low EC. Soils were sandy loam in texture. The clay content varied from 6.6 to 20.4%. The organic carbon, organic matter and available nitrogen content varied from 0.98 to 1.60%, 1.54 to 2.77 % and 0.14 to 0.22 % respectively in young, 0.95 to 1.80, 1.65 to 2.94, 0.13 to 0.24% in medium and 0.85 to 1.90, 1.47 to 3.28, 0.12 to 0.26% in old aged soils. The highest available nitrogen was obtained with Motidhar TG and the lowest in Gayaganga TG. Available phosphorus content varied between 8.92 to 32.55 ppm in young, 9.22 to 25.96 ppm in medium and 3.91 to 41.08 ppm in old aged soils and wide variation of soil available P might be due to the fixation of phosphorus in soil as insoluble aluminium and iron phosphate, higher acidity and poor application of rock phosphate. Available K content varied from the medium to high. Higher potassium content was found in both medium and young aged sections of all tea soils respectively. Available Sulphur was below recommended levels of all section and Chloride was within limits of all section. Moisture content were highest in medium aged section of Motidhar tea garden, this is because of using mulching in dry spell and comparatively satisfactory levels of organic matter. Soil were compared with virgin and multicrops system of very closest area from respective tea garden, it was found that pH lies in between 4.1 to 5.50, EC were within limits and all nutrients were satisfactory levels in Terai region.

The pH had a significant positive correlation (Table 2) with available nitrogen ($r = 0.642^{**}$), Phosphorus ($r = 0.567^{**}$) which indicated that availability of P were dependent on soil acidity. Available K had positive correlation with available N ($r= 0.439^{**}$), S($r= 0.391^{**}$), MC($r=0.456^{**}$).

The soils (0-45 cm) of six tea garden in Hills of Darjeeling region viz: Phubsering, Singtom, Ambootia, Happy Valley, Soom and Chamong were recorded for three times in a year for five years. Soils pH were found to be strong to moderately acidic in nature (4.11 to 5.50), with low electrical conductivity (EC), might be due to leaching of soluble salts by heavy rainfall. Soils under study were sandy loam to sandy clay loom in texture and the clay content varied from 8.5 to 41.20. The organic carbon, organic matter and available nitrogen content were high in all section and these variations might be due to the effect of management practices of these locations. The availability of soil P varied from 10.65 to 78.96 under low, medium and high elevations respectively. The higher availability of phosphorus under lower elevation was observed. The available soil K content varied from 86.94 to 445.57 ppm.

Soil pH had a positive correlation (Table 3) with all nutrients. The P had a significant correlation with EC, organic carbon and available potassium. The K had a significant positive correlation with nitrogen, P, S. Soil were compared with virgin and multicrops system of very closest area from respective tea garden, it was found that pH lies in between 4.26 to 5.40 and all nutrients were satisfactory levels in Hills region.

Conclusion

The results have undoubtedly shown that the antioxidant quality of tea is best, preferable sandy-loam soil having the soil pH is in between 4.50-5.00, electrical conductivity less than 0.5 mmho, available form of nitrogen status 0.13%, phosphorous as P_2O_5 is in between 15-45 ppm, potassium as K_2O is in between 80-100ppm, sulphur is 30-45ppm, chloride 0.1ppm and moisture content at 15-20% level. Soil agronomic practices greatly influence the antioxidant and phytochemical attributes of tea. Further studies were undertaken for the characterization of individual components of bioactive fractions of tea extracts to elucidate the mechanisms for restoring high antioxidant activity.

Table 1: Correlation matrix analysis among physicochemical properties of soil, Dooars region

Variables	Clay%	Silt%	sand%	pH	EC (mmho)	OC%	OM%	Av N%	Av P (ppm)	Av K(PPM)	Av S(ppm)	MC%	Cl^-(ppm)
Clay%	**1**	0.339	-0.887	-0.238	0.098	0.021	0.021	0.021	-0.176	0.345	0.003	-0.135	0.011
Silt%	0.339	**1**	-0.735	-0.407	-0.155	-0.305	-0.305	-0.305	-0.238	0.217	-0.189	-0.258	-0.119
sand%	-0.887	-0.735	**1**	0.373	0.003	0.135	0.135	0.135	0.244	-0.355	0.088	0.221	0.048
pH	-0.238	-0.407	0.373	**1**	-0.324	0.152	0.152	0.152	0.071	-0.432	-0.368	0.061	-0.284
EC (mmho)	0.098	-0.155	0.003	-0.324	**1**	-0.188	-0.188	-0.188	0.498	0.239	0.813**	0.551**	0.394
OC%	0.021	-0.305	0.135	0.152	-0.188	**1**	1.000	1.000	0.051	0.122	-0.017	0.060	0.223
OM%	0.021	-0.305	0.135	0.152	-0.188	1.000	**1**	1.000	0.051	0.122	-0.017	0.060	0.223
Av N%	0.021	-0.305	0.135	0.152	-0.188	1.000	1.000	**1**	0.051	0.122	-0.017	0.060	0.223
Av P (ppm)	-0.176	-0.238	0.244	0.071	0.498	0.051	0.051	0.051	**1**	0.193	0.589**	0.808**	0.399
Av K(PPM)	0.345	0.217	-0.355	-0.432	0.239	0.122	0.122	0.122	0.193	**1**	0.390	0.176	0.303
Av S(ppm)	0.003	-0.189	0.088	-0.368	0.813**	-0.017	-0.017	-0.017	0.589	0.390	**1**	0.585	0.446
MC%	-0.135	-0.258	0.221	0.061	0.551	0.060	0.060	0.060	0.808**	0.176	0.585	**1**	0.469
Cl^-(ppm)	0.011	-0.119	0.048	-0.284	0.394	0.223	0.223	0.223	0.399	0.303	0.446	0.469	**1**

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

Table 2: Correlation matrix analysis among physicochemical properties of soil, Terai region

Variables	clay%	Silt%	sand%	pH	EC (mmho)	OC%	OM%	Av N%	Av P (ppm)	Av K(PPM)	Av S(ppm)	MC%	Cl^-(ppm)
clay%	1	-0.139	-0.778	0.056	-0.047	-0.199	-0.199	-0.200	0.076	0.188	0.175	-0.106	0.125
Silt%	-0.139	1	-0.514	-0.051	0.156	-0.329	-0.329	-0.366	-0.142	-0.173	0.126	-0.135	-0.047
sand%	-0.778	-0.514	1	-0.017	-0.058	0.383	0.383	0.406	0.023	-0.053	-0.234	0.177	-0.077
pH	0.056	-0.051	-0.017	1	-0.108	0.615**	0.715**	0.642**	0.567**	-0.266	-0.154	-0.486	-0.519
EC (mmho)	-0.047	0.156	-0.058	-0.108	1	0.406**	0.407**	0.377	0.010	0.044	-0.030	0.219	-0.013
OC%	-0.199	-0.329	0.383	-0.215	0.406	1	1.000	0.972**	0.065	0.423	0.146	0.441	0.306
OM%	-0.199	-0.329	0.383	-0.215	0.407	1.000	1	0.972**	0.064	0.424	0.146	0.441	0.305
Av N%	-0.200	-0.366	0.406	-0.242	0.377	0.972**	0.972**	1	0.104	0.439	0.189	0.475	0.318
Av P (ppm)	0.076	-0.142	0.023	0.031	0.010	0.065	0.064	0.104	1	-0.017	0.054	0.045	0.284
Av K(PPM)	0.188	-0.173	-0.053	-0.266	0.044	0.423	0.424	0.439	-0.017	1	0.391**	0.456	0.322
Av S(ppm)	0.175	0.126	-0.234	-0.154	-0.030	0.146	0.146	0.189	0.054	0.391	1	0.298	0.357
MC%	-0.106	-0.135	0.177	-0.486	0.219	0.441	0.441	0.475	0.045	0.456	0.298	1	0.468
Cl^-(ppm)	0.125	-0.047	-0.077	-0.519	-0.013	0.306	0.305	0.318	0.284	0.322	0.357	0.468	1

Table 3: Correlation matrix analysis among physicochemical properties of soil, Hills region

Variables	Clay%	Silt%	sand%	pH	EC (mmho)	OC%	OM%	Av N%	Av P (ppm)	Av K(PPM)	Av S(ppm)	MC%	Cl^-(ppm)
Clay%	**1**	0.553	-0.916	-0.214	0.100	-0.010	-0.010	-0.010	-0.018	-0.042	0.175	-0.272	-0.090
Silt%	0.553	**1**	-0.841	-0.434	0.224	-0.156	-0.156	-0.156	0.247	0.000	0.305	-0.115	-0.005
sand%	-0.916	-0.841	**1**	0.348	-0.173	0.082	0.082	0.082	-0.107	0.028	-0.261	0.232	0.061
pH	-0.214	-0.434	0.348	**1**	-0.116	0.531**	0.631	0.631	0.461**	0.515**	0.359	0.137	-0.126
EC (mmho)	0.100	0.224	-0.173	-0.116	**1**	0.409	0.409	0.409	0.583	-0.018	0.072	0.320	0.466
OC%	-0.010	-0.156	0.082	-0.031	0.409	**1**	1.000	1.000	0.594	0.503	0.104	0.374	0.126
OM%	-0.010	-0.156	0.082	-0.031	0.409	1.000	**1**	1.000	0.594	0.503	0.104	0.374	0.126
Av N%	-0.010	-0.156	0.082	-0.031	0.409	1.000	1.000	**1**	0.594	0.503	0.104	0.374	0.126
Av P (ppm)	-0.018	0.247	-0.107	-0.161	0.583**	0.594	0.594	0.594**	**1**	0.216	0.074	0.179	0.237
Av K(PPM)	-0.042	0.000	0.028	-0.015	-0.018	0.503	0.503	0.503	0.216	**1**	0.234	0.248	-0.154
Av S(ppm)	0.175	0.305	-0.261	-0.359	0.072	0.104	0.104	0.104	0.074	0.234	**1**	-0.192	0.204
MC%	-0.272	-0.115	0.232	0.137	0.320	0.374	0.374	0.374	0.179	0.248	-0.192	**1**	0.187
Cl^-(ppm)	-0.090	-0.005	0.061	-0.126	0.466	0.126	0.126	0.126	0.237	-0.154	0.204	0.187	**1**

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

References

1. Roy S. and Majumdar S., Antioxidative properties of the leaves of *Daphniphyllum chartaceum* Rosenthal, *Journal of Medicinal Plants Research*., **7(18):**1239-1243**(2012)**

2. Jana M.M., Workshop of River Behaviour in the North Bengal Rivers, North Bengal University, India, **(1994)**

3. Misra T.K., Saha A., Nanda A.K., Biswas R. and Mandal P., Shade trees in tea plantations in different soil conditions of North Bengal. *Pleione*, **3(2):** 219-223**(2009)**

4. Jackson M.L., Soil chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi**(1973)**