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Variation of Soil Fertility with Diverse Hill Soils of Chittagong Hill Tracts, Bangladesh

Masud Hassan[1*], Rakib Hassan[1], Husna Israt Pia[1], Md. Arafat Hassan[2], Suriya Jesmine Ratna[2] and Marufa Aktar[1]

[1]Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, Bangladesh.
[2]Department of Geography and Environment, University of Dhaka, Dhaka-1000, Bangladesh.

Authors' contributions

This work was carried out in collaboration between all authors. Authors MH and RH designed the study, performed the statistical analysis and wrote the protocol. Authors HIP and RH wrote the first draft of the manuscript. Authors MAH and MA managed the analyses of the study. Authors SJR and MA managed the literature searches and editing of the paper. All authors read and approved the final manuscript.

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ABSTRACT

This study was carried out to evaluate chemical and nutritional properties in high, medium and low hill soils of three hilly district of Chittagong Hill Tracts, Bangladesh. There were 30 hill sites and every hill site was a different hill with changeable slopes. A total number of 90 soil samples were collected from surface from three position of each hill for analysis. Results showed that chemical and nutritional properties varied for different hills. Mean values of soil pH, organic matter, total N, total P, Ca, Mg, K, S, B, Cu, Fe, Mn and Zn of three different hill soils ranged from 5.00 to 5.35, 1.82 to 2.19 %, 0.09 to 0.17 %, 3.44 to 5.24 mg kg^{-1}, 2.19 to 2.82 mg $100g^{-1}$, 1.39 to 1.62 mg 100 g^{-1}, 0.29 to 0.49 mg 100 g^{-1}, 5.97 to 10.85 mg kg^{-1}, 0.23 to 0.25 mg kg^{-1}, 0.24 to 0.67 mg kg^{-1}, 44.48 to 67.63 mg kg^{-1}, 16.28 to 20.84 mg kg^{-1}, and 0.44 to 0.71 mg kg^{-1}. Individually high, medium and low hill soils showed variation in chemical and nutritional properties for different sites. From this result it is assessed that the soils are generally poor in organic matter and nutrients as well as poor in fertility status.

**Corresponding author: E-mail: jibonswe@gmail.com, masudhassanswe1112@gmail.com;*

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1. INTRODUCTION

Bangladesh is consisted of a total land area of 147,570 km^2 with hilly areas of 17,342 km^2 (8.5 % of total area of Bangladesh). Chittagong Hill Tracts is the wide ranging hilly area in the southeastern part of the country which is situated in between 21°25' N and 23°25' N latitude and 91°54' E to 92°50' E longitude [1]. Rangamati, Bandarban and Khagrachari are three unique geographical and cultural landscape administrative districts in this region [2].

The area of the Chittagong Hill Tracts consists of 92% is highland, 2% medium highland, 1% medium lowland and 5% homestead and water bodies. It is estimated that the agricultural potential of hill soils is mainly suitable for low for field crops, though it ranges between low and high for tree crops including transplanted aman-cowpea, aubergin, broadcast aush, bitter gourd, sweet potato, cotton ,okra, cucumber, sweet gourd, sugarcane, maize, pineapple, coriander leaf, and some other summer and winter vegetables. The weather of this region is tropical monsoon climate. The mean annual rainfall here is about 2540 mm to 3810 mm in the south and west and 2540 mm in the north. November to March is the dry and cool season; pre-monsoon season is April to May which is very hot and sunny and June to October is the monsoon season in this area, which is warm, cloudy and wet. Most of the people here live on agriculture which is the main source of livelihood. The water quality of hill areas is less toxic than treated waste water & river water quality of the capital of the country [3,4]. Generally, there is lacking of Non-farm income opportunities and in some areas it doesn't even exist. On the other hand, other floodplain areas like Tista floodplain soil of Bangladesh is comparatively fertile and well managed due to over conscious and proper management [5]. Besides, fertility status changed over time in a positive direction [6]. The tribal populations here are deprived of many facilities and they are the most disadvantaged group of populations in Bangladesh. Shifting agriculture, which is also known as Jhum is the main cultivation systems in this region. There is only a little impact on agricultural land use patterns of different government plans and programs to promote the agricultural system. So eventually the shifting agriculture led to indiscriminate destruction of forest and the tribal populations are suffering from food insecurity which is ultimately resulting ecological degradation in this hill tract regions. Environmentally compatible and economically viable agricultural system policies and program should be provided to remove poverty caused by traditional agriculture and environmental degradation in the Chittagong Hill Tracts of Bangladesh [7]. It is a mandatory fact that there should be understanding in local condition for making any effective plans and programs for agricultural development which led to classification and characterization of farming/agricultural systems [8].

Some decades ago, humid tropical rainforests and diverse flora and fauna covered this region. Now-a-days, this area is largely been deforested because of the pressure of increased human population. Shifting cultivation in hilly areas is also considered as one of the main factors of forest degradation [9]. The physical, geomorphic and soil characteristics of the Chittagong region differs to the rest of Bangladesh. It consists of high land and medium hills and there is also a small area which is consisted of lowland valleys and plain lands [10].

The soils of hilly areas are graded into broken shale and mottled sand at a depth with the color of yellowish brown to reddish brown loams. This natural resource is not infinite in nature. The source is important and not possible for within time span of a human life [11]. While there is an agricultural operations, soil should be the utmost importance because it is the cradle for all crops and plants. The depth of top soil is about 15–30 cm on which plants grow. The farming activities also flourishes here. Hence, to increase agriculture production, it is important to keep healthy and productive soil with appropriate soil amendment and crop management practices so - that the function of the soil can be continued optimally [12]. To increase the fertility status of soil of this region, a wide variation in the parent materials, topography and vegetation should be brought in this soil. At present, the most common phenomenon in the hill tract and undulated areas of Bangladesh is land degradation. There occurs a high intensity rainfall (>3000 mm in some areas) which causes extremely soil erosion in most of the areas of Chittagong Hill Tracts by run-off over steep and very steep slopes [13] Deforestation, soil erosion and soil fertility depletion are considered as land degradation which take place at a massive scale in the Chittagong areas. Water storage and supply schemes of sedimentation and flooding resulting in the increased negative downstream effects which is caused by the hydrological regime (E.g. the Kaptai reservoir, [14].

Though it is a satisfactory matter that alternative land uses in some areas are gradually evolving day by day. Agro-forestry is getting popular in some tribal communities. Horticulture is also considered to be environmentally and economically suitable; others are also having their agriculture by integrating trees and livestock with annual crops. It is helpful to improve the economic benefits as well as reduce possible risks of food scarcity and low income in many ways [15,16]. The Government of Bangladesh has taken some steps to generate scientific information alternative land-use practices while facing the development challenge in the Chittagong, In addition, there are many reports elsewhere about the short-term soil nutrient dynamics which are studied in detailed associated with the slash and burn practice [17]. Therefore, a comprehensive knowledge proved that geo-statistical analysis methods are very useful for obtaining for the understanding of characteristics, distribution and variability of soil fertility in timely and proper manner for agricultural farming. For the site-specific management, that is a management practice which increases productivity of agriculture [18].

Several scholars (Feder, Onchan, & Chalamwong) have laid emphasis on tenurial security of fertility status as important factor influencing land use decision which can make a better agroforestry management. Thapa and Rasul [7] classified agricultural systems in the mountain regions of Bandarban in the Chittagong Hill Tracts of Bangladesh. This systems were classified into three major groups and they are extensive, semi-extensive and intensive - using cluster analysis. There was conducted a study on the three districts of Chittagong hill tract in khagrachari, Rangamati and Bandarban to evaluate and analysis the fertility status on each sites having individual slopes, elevation and forest type.

As a developing country, soil nutrient status is the main constrain to agricultural productivity. So the knowledge of nutrient status in the various region of the country led to proper management of land patterns. As Chittagong Hill Tracts region cover a huge land area, so sustainable agricultural managements and systems should be applied in this area to increase soil productivity and crop yield. The objective of this present study is to draw a general picture of fertility status of hilly soils in this area to strengthen the national and local soil quality database so that goal-oriented soil evaluations and predictions can be made and to show the changes of chemical and nutritional properties in high, medium and low hill soils. This research work also conducted to give some suggestion on improving chemical and nutritional properties of soil for the maintenance of soil health quality and to increase agricultural productivity. This information also will help to apply revised soil management and effective strategy on organic and fertilizer inputs as well as suitable agricultural technique and cropping patterns.

2. MATERIALS AND METHODS

This study area covered mainly three hilly districts, Rangamati, Khagrachari and Bandarban of Chittagong Hill Tracts. Ten high hill, ten medium hill and ten low hill sites were randomly selected from these locations for collecting soil samples. Soil samples were collected from three surface position in each sampling hill site. Three samples were obtained from the hill top, mid-slope and foot hill of each hill site and then a composite sample is made for each hill. Total 90 soil samples are collected and 30 composite soil samples are made for three different type hills. Soil samples are taken in polythene bags, marked well and carried to the laboratory to assess chemical and nutritional properties.

Total Nitrogen content was determined following micro-kjeldal method as described by Jackson [19]. Soil sample was digested with H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4. $CuSO_4$. $5H_2O$: Se = 10:1:O.1) Nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 [20] The determination of total P content was made colorimetrically by the vanadomolybdate procedure based on the yellow color of the unreduced vanadomolybdo-phosphoric heteropoly complex in HNO_3-$HClO_4$ digest medium [21]. Total sulfur was estimated by the turbid metric method using HNO_3-$HClO_4$ acid digest [19].

The pH in a solution can be measured by the use of glass electrode associated with a millivolt meter. The pH measured in a soil suspension made using 0.01M $CaCl_2$ and the pH varies less with changes in soil: solution ratio [22]. The organic matter of the soil sample was determined by Walkley and Black's (1934) wet oxidation method. Here Oxidation was done with potassium dichromate associated with sulfuric acid conc. Total potassium in HNO_3-$HClO_4$ acid digest was determined by using Flame Photometer. Total Calcium and Magnesium content was determined titrimetric ally [22] from HNO_3-$HClO_4$ acid digest [19]. Total Iron content was determined using colorimetric method (Olson 1965) from HNO_3 acid digest [19]. Total Manganese content was determined using colorimetric method (Adams 1965) from HNO_3 acid digest [19]. Total Zinc was determined by Atomic Absorption Spectrometer (Model: VARIAN 220) from HNO_3 acid digest [19]. Total Copper was determined by Atomic Absorption Spectrometer (Model: VARIAN 220) from HNO_3 acid digest [19]. Total Boron was determined by Curcumin method using a suspension associated with 1N $CaCl_2$ [22].

3. RESULTS AND DISCUSSION

3.1 Chemical Properties

Soil pH varied between 4.5 (sample A_4) to 5.8 (sample A_7) among high hill soils (Table-1), 4.5 (sample B_4) to 6.0 (sample B_9 and B_{10}) among medium hill soils (Table-2) and 4.3 (sample C_5, C_7 and C_{10}) to 5.8 (sample C_8) among low hill soils (Table-3). According to the USDA classification [23], mean pH of the presently studied high hill soils and medium hill soils fall in strongly acid category and mean pH of low hill soils fall in very strongly acid category.

Organic matter content varied from 1.42% (sample A_5) to 2.87% (sample A_8) among high hill soils, 0.57% (sample B_4) to 3.09% (sample B_6) among medium hill soils and 0.99% (sample C_1) to 2.76% (sample C_9) among low hill soils. Bangladesh soils normally contain low organic matter content; most soils having less than 1.5% organic matter in 0-15 cm surface soil [24]. On the basis of organic matter content, agricultural soils of Bangladesh classified into very low (<1.0%), low (1.0-1.7%), medium (1.7-3.4%), high (3.4-5.5%) and very high (>5.5%). Hill soils contain higher organic matter than agricultural soils [25]. According to this scheme, mean organic matter content of high, medium and low hill soils fall in medium category.

3.2 Nutritional Properties

The hill soils in most under developed countries are not fertilized and nutrient demands of trees are mainly met by nutrient recycling [26]. Most terrestrial ecosystems are considered nitrogen (N) and phosphorus (P) limited [27]. Total nitrogen contents ranged from 0.08% (sample A_1) to 0.70% (sample A_5) among high hill soils, 0.03% (sample B_4) to 0.15% (sample B_6) among medium hill soils and 0.05% (sample C_1) to 0.16% (sample C_9) among low hill soils. Normally soils with low organic matter contain low nitrogen. Mean values of total nitrogen content of all three types of hill soils seem very low.

Total P in the presently studied soils varied between 1.24 mg kg^{-1} (sample A_{10}) to 6.68 mg kg^{-1} (sample A_3) among high hill soils, 1.50 mg kg^{-1} (sample B_4) to 10.38 mg kg^{-1} (sample B_1) among medium hill soils and 1.95 mg kg^{-1} (sample C_6) to 10.31 mg kg^{-1} (sample C_{10}) among low hill soils. Mean value of total P content of high and medium hill soils fall in medium (between 2.66 to 4.22 mg kg^{-1}) and low hill soils fall in high (>4.22 mg kg^{-1}) category.

Total calcium content in this present study ranged from 1.00 mg 100 g^{-1} (sample A_5 and A_6) to 5.50 mg 100 g^{-1} (sample A_1 and A_4) among high hill soils, 0.43 mg 100g^{-1} (sample B_4) to 3.50 mg 100 g^{-1} (sample B_2 and B_3) among medium hill soils and 0.10 mg 100 g^{-1} (sample C_1) to 6.01 mg 100 g^{-1} (sample C_3) among low hill soils. Mean values of total calcium content was low (<42.0 mg 100 g^{-1}) for all three types of hill soils.

Total magnesium content varied between 0.80 mg 100 g^{-1} (sample A_6) to 2.50 mg 100 g^{-1} (sample A_2, A_3 and A_4) among high hill soils, 50 mg 100 g^{-1} (sample B_4) to 2.50 mg 100 g^{-1} (sample B_2 and B_3) among medium hill soils and 0.52 mg 100 g^{-1} (sample C_5) to 3.50 mg 100 g^{-1} (sample C_3) among low hill soils. Mean total magnesium content for high and medium hill soils fall in medium (between 14.1 to 21.9 mg 100 g^{-1}) and low hill soils fall in low (<14.1 mg 100 g^{-1}) category.

Total potassium ranged from 0.11 mg 100 g^{-1} (sample A_6) to 0.70 mg 100 g^{-1} (sample A_5) among high hill soils, 0.15 mg 100g^{-1} (sample B_4) to 0.47 mg 100 g^{-1} (sample B_5) among medium hill soils and 0.11 mg 100 g^{-1} (sample C_5) to 2.10 mg 100 g^{-1} (sample C_2) among low hill soils. There were low mean values of K (<9.4 mg 100 g^{-1}) in all the three types of hill soils.

Table 1. Chemical and nutritional properties of high hill soils

Sample	pH	Organic Matter (%)	Total N (%)	Total P (mg kg^{-1})	Ca (mg 100 g^{-1})	Mg (mg 100 g^{-1})	K (mg 100 g^{-1})	S (mg kg^{-1})	B (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})
A_1	5.3	1.53	0.08	4.28	5.50	1.00	0.16	6.35	0.17	0.36	11.80	12.00	1.72
A_2	5.6	2.27	0.11	1.95	4.00	2.50	0.16	5.44	0.17	0.26	28.20	6.00	0.22
A_3	5.2	2.73	0.14	6.68	2.50	2.50	0.40	7.60	0.26	0.86	34.20	46.20	0.36
A_4	4.5	2.20	0.11	6.50	5.50	2.50	0.53	12.47	0.38	0.92	42.60	25.60	0.36
A_5	5.6	1.42	0.70	3.69	1.00	1.00	0.70	10.64	0.17	0.86	10.60	11.00	0.08
A_6	5.6	1.91	0.09	2.59	1.00	0.80	0.11	1.00	0.32	0.04	54.60	5.80	0.30
A_7	5.8	1.47	0.09	2.74	2.00	1.45	0.20	8.00	0.20	0.62	71.80	5.00	0.62
A_8	5.3	2.87	0.15	2.53	1.83	0.96	0.39	4.66	0.25	0.24	54.40	22.80	0.28
A_9	5.5	2.59	0.12	2.24	1.85	1.31	0.27	4.50	0.25	1.47	73.95	11.54	0.20
A_{10}	5.7	2.69	0.13	1.24	3.00	2.18	0.21	8.00	0.21	1.06	62.65	16.90	0.23
Mean	5.35	2.17	0.17	3.44	2.82	1.62	0.31	6.87	0.24	0.67	44.48	16.28	0.44

Table 2. Chemical and nutritional properties of medium hill soils

Sample	pH	Organic matter (%)	Total N (%)	Total P (mg kg^{-1})	Ca (mg 100 g^{-1})	Mg (mg 100 g^{-1})	K (mg 100 g^{-1})	S (mg kg^{-1})	B (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})
B_1	5.3	2.42	0.12	10.38	1.50	1.50	0.36	2.98	0.36	0.14	50.10	23.60	1.92
B_2	5.2	1.12	0.05	3.20	3.50	2.50	0.17	7.55	0.21	0.14	12.60	6.60	0.08
B_3	5.0	2.83	0.14	4.92	3.50	2.50	0.25	2.40	0.19	0.12	76.80	37.80	0.56
B_4	4.5	0.57	0.03	1.50	0.43	0.50	0.15	3.78	0.12	0.04	5.00	31.40	0.10
B_5	5.0	2.27	0.11	3.20	2.50	1.50	0.47	5.31	0.35	0.10	34.40	25.80	0.42
B_6	5.8	3.09	0.15	2.11	2.30	1.76	0.29	8.00	0.27	0.75	63.10	16.15	0.31
B_7	5.5	2.64	0.11	5.92	2.00	1.15	0.37	1.00	0.29	0.03	36.20	13.20	0.24
B_8	5.8	2.50	0.12	3.05	2.10	1.36	0.36	8.20	0.28	0.38	64.30	13.70	0.65
B_9	6.0	2.46	0.11	2.87	2.50	1.30	0.36	5.33	0.22	0.16	117.40	28.20	0.31
B_{10}	6.0	2.03	0.10	3.68	1.60	0.98	0.19	15.15	0.25	0.51	62.18	11.92	0.35
Mean	5.41	2.19	0.10	4.08	2.19	1.50	0.29	5.97	0.25	0.24	52.21	20.84	0.49

Table 3. Chemical and nutritional properties of low hill soils

Sample	pH	Organic matter (%)	Total N (%)	Total P (mg kg^{-1})	Ca (mg 100 g^{-1})	Mg (mg 100 g^{-1})	K (mg 100 g^{-1})	S (mg kg^{-1})	B (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})
C_1	4.8	0.99	0.05	2.82	0.10	0.22	0.18	8.20	0.41	0.26	8.00	11.00	1.02
C_2	5.1	1.70	0.08	7.92	3.07	2.80	2.10	20.36	0.36	0.62	28.60	25.20	0.62
C_3	5.0	1.90	0.09	__	6.01	3.50	0.28	9.24	0.20	1.36	44.60	26.80	0.64
C_4	5.2	1.68	0.08	8.03	2.43	0.92	0.60	2.16	0.15	0.10	8.60	9.60	0.78
C_5	4.3	1.95	0.09	2.80	0.73	0.52	0.11	16.27	0.14	0.08	20.40	11.80	0.38
C_6	5.6	2.04	0.10	1.95	2.26	1.06	0.14	11.88	0.18	0.18	27.80	19.60	0.40
C_7	4.3	1.85	0.09	9.16	1.93	1.29	0.43	18.20	0.05	0.22	25.80	22.60	0.86
C_8	5.8	2.16	0.10	2.12	2.00	1.35	0.31	14.62	0.22	0.43	54.85	17.30	0.53
C_9	5.5	2.76	0.16	2.09	2.00	1.45	0.29	1.00	0.29	1.30	336.80	4.20	1.40
C_{10}	4.3	1.18	0.06	10.31	1.28	0.78	0.53	6.60	0.33	0.24	120.80	16.40	0.50
Mean	5.0	1.82	0.09	5.24	2.19	1.39	0.49	10.85	0.23	0.48	67.63	16.45	0.71

Total Sulfur content varied between 1.00 mg kg^{-1} (sample A_6) to 12.47 mg kg^{-1} (sample A_4) in high hill soils, 1.00 mg kg^{-1} (sample B_7) to 15.15 mg kg^{-1} (sample B_{10}) in medium hill soils and 1.00 mg kg^{-1} (sample C_9) to 20.36 mg kg^{-1} (sample C_2) in low hill soils. It is observed that mean values of sulfur content is low (4 – 7 mg kg^{-1}) in high and medium hill soils and medium (8 - 12 mg kg^{-1}) in low hill soils.

Total Boron content ranged from 0.17 mg kg^{-1} (sample A_1, A_2 and A_5) to 0.38 mg kg^{-1} (sample A_4) in high hill soils, 0.12 mg kg^{-1} (sample B_4) to 0.36 mg kg^{-1} (sample B_1) in medium hill soils and 0.05 mg kg^{-1} (sample C_7) to 0.41 mg kg^{-1} (sample C_1) in low hill soils. Mean value of boron content seems very low (0 – 0.3 mg kg^{-1}) for all the three types of hill soils.

Total Copper content of this studied soils ranged from 0.04 mg kg^{-1} (sample A_6) to 1.47 mg kg^{-1} (sample A_9) in high hill soils, 0.04 mg kg^{-1} (sample B_4) to 0.75 mg kg^{-1} (sample B_6) in medium hill soils and 0.08 mg kg^{-1} (sample C_5) to 1.36 mg kg^{-1} (sample C_3) in low hill soils. It is observed that mean copper content in high and low hill soils is low (0.3 – 0.8 mg kg^{-1}) but very low (0 – 0.3 mg kg^{-1}) in medium hill soils.

Total Iron content of this studied soils varied between 10.60 mg kg^{-1} (sample A_5) to 73.95 mg kg^{-1} (sample A_9) in high hill soils, 5.00 mg kg^{-1} (sample B_4) to 117.40 mg kg^{-1} (sample B_9) in medium hill soils and 8.00 mg kg^{-1} (sample C_1) to 336.80 mg kg^{-1} (sample C_8) in low hill soils. It seems that mean value of iron content is very high (>30.00 mg kg^{-1}) for all the three types of hill soils.

Total Manganese content ranged from 5.00 mg kg^{-1} (sample A_7) to 46.20 mg kg^{-1} (sample A_3) in high hill soils, 6.60 mg kg^{-1} (sample B_2) to 37.80 mg kg^{-1} (sample B_3) in medium hill soils and 4.20 mg kg^{-1} (sample C_9) to 26.80 mg kg^{-1} (sample C_3) in low hill soils. It is observed that mean values of manganese content is very high (>1.0 mg kg^{-1}) in high, medium and low hill soils.

Total Zinc content in this study varied between 0.08 mg kg^{-1} (sample A_5) to 1.72 mg kg^{-1} (sample A_1) in high hill soils, 0.08 mg kg^{-1} (sample B_2) to 1.92 mg kg^{-1} (sample B_1) in medium hill soils and 0.38 mg kg^{-1} (sample C_5) to 1.40 mg kg^{-1} (sample C_9) in low hill soils. It seems that mean values of zinc content is very low (0 – 0.5 mg kg^{-1}) for high and medium hill soils and low (0.5 – 1.0 mg kg^{-1}) for low hill soils [28].

From above results it seems that chemical and nutritional status of hill soils increase with decreasing heights except manganese (Mg). So we can say that soils of low hilly area is more fertile than soils of medium and high hilly areas. The reasons are drainage conditions, steepness, shift cultivation, varieties in vegetation, erosion, land slide, shifting cultivation (Jhum cultivation) etc. Soil pH of this area is strongly acid to very strongly acidic which is not suitable for plants. Organic matter content is moderate which is normally good for vegetation and agro-forestry. Deficiency in total N, total Ca, total Mg, total K, total S, total B, total Cu and total Zn content seemed for all type of hills which should be increased by long term fertility management program. Total phosphorus content is medium to high which is quite good for agriculture. Total Iron and Manganese content is very high. So no further step is needed for total P, total Fe and total Mn.

4. CONCLUSION

In this study the outcome revealed differences in chemical and nutritional properties among different soil samples of three type hill soils of three districts of Chittagong Hill Tracts. The general fertility of the three hill soils was low, although some samples showed adequate levels of organic matter. Soils of high hill areas are less fertile than soils of low hill area. Land degradation is one of the major concerns in this area, so management of soil chemical and nutritional properties are important. The data from this study suggest that new research initiatives should be taken on the use of organic materials to ameliorate high acidity and enhance N, Ca, Mg, K, S, Cu and Zn supply in this hilly areas. Applications of nutrients should be in recommended dose. Therefore, researchers must continue to face the challenge to provide a base for bridge building between farmer's and scientist's knowledge. Without this, a satisfactory level of crop production and the maintenance of soil quality cannot be achieved. A long term fertility management program, integrated inorganic-organic soil fertilization program and monitoring are urgently needed for sustainability. Establishment of new agricultural technologies and information of resource management in this areas would be effective in meeting the ecological needs and in fulfilling the high food demands of the increasing population in future. Horticulture cultivation might be one of the alternative way to protect land degraded area, instead of shifting cultivation (Jhum cultivation).

Conservation tillage and cover crop management will be crucial for eroded soil surface. The observations of the present work may give a sign of the future planning and program in the management of soils of Chittagong Hill Tracts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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