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Morpho-physical and Chemical Characteristics of Strongly Weathered Soils in Silago, Southern Leyte, Philippines

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ABSTRACT

The study evaluated the morpho-physical and chemical characteristics of strongly weathered soils in Silago, Southern Leyte, one of the biodiversity hotspots in the Philippines. Examination of seven soil profiles revealed that the soils have colors ranging from yellowish brown to yellowish red, have high clay content (37.04 to 62.15%), and moderate to high porosity values (38.49 to 52.83%). They are deep (>3 m) and friable when moist but very plastic and very sticky when wet. In terms of soil chemistry, most of the soils have acidic pH values (<6.75), have low to moderate potential CEC (11.31 to 38.13 $cmol_c$/kg), low to high base saturation (0.76 to 69.62%), and extremely low to medium organic matter content (0.07 to 2.59%). The soils contain low to medium N (0.01 to 0.28%), and extremely low available P (< 5 mg/kg). However, most of the soils contain sufficient amounts of exchangeable Mg (0.12 to 9.28 $cmol_c$/kg), and Na (0.05 to 1.70 $cmol_c$/kg) except profile 5, but are deficient in Ca (0.07 to 0.27 $cmol_c$/kg) and exchangeable K (0.02 to 0.37 $cmol_c$/kg) since the soils are acidic. Most of the soils are classified as Hapludults (USDA Soil Taxonomy) or Haplic Alisols (WRB) except the one in the toeslope which is a Hapludalf or Haplic Luvisol. The study revealed that the soils have closely related properties probably due to their similar parent material, original forest vegetation and climate. The differences in some soil properties appear to be the effect of topography.

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INTRODUCTION

Many soils of the humid tropics are deeply or strongly weathered and are generally nutrient-poor, acidic, and rich in sesquioxides. The high rainfall coupled with high temperature, good drainage, and geomorphologically stable land surfaces favor leaching of nutrients (Sanchez, 1976; Eswaran et al., 1992). Despite deep weathering, the effective root zone is limited by high mechanical strength, Al toxicity, P deficiency, and elemental imbalances in the subsoil.

In the Philippines, strongly weathered soils are common and are often degraded due to the long history of cultivation (Asio, 1996; Navarrete et al., 2009 & 2010). Many of the potential expansion sites for agriculture have strongly weathered soils, which are generally characterized by low nutrient status. Likewise, large areas of land, which have been the subject of large-scale reforestation programs in the past, have such kind of soils developed mostly from sedimentary and volcanic parent materials. The low crop yield and the failure of many of these reforestation projects in such areas can largely be attributed to improper soil management due to poor understanding of the soils.

Blum (1983) noted that the lack of a basic understanding about the ecological relationship in the ecosystem results in trial and error method of land use leading to soil degradation and ecological problems. This is partly attributed to the fact that research prioritization in the past focused more on applied research particularly on crop production and fertilization. Until now, the reports of the reconnaissance soil surveys done in the early part of the 1990s such as those by Barrera et al. (1954) and Simon et al. (1975) for the islands of Leyte and Samar, respectively, which classified Philippine soils into soil series and soil types, are still the major source of soil information.

Southern Leyte is a province located in the Eastern Visayas region of the Philippines. It occupies the southern one-fourth of the island of Leyte. The province, which has a total land area of 1,734.8 sq. km, is characterized by relatively flat lands along the coastal areas, where population centers are concentrated, but is rugged and mountainous toward the interior. The town of Silago has large mountainous areas which are considered as biodiversity hotspots.

The study was conducted to evaluate the morphological, physical, and chemical characteristics of the strongly weathered soils in Silago, Southern Leyte, Philippines.

MATERIALS AND METHODS

Selection of Sampling Sites

The study was conducted in the mountainous area of Silago, Southern Leyte, Philippines along the newly-constructed Silago-Abuyog highway (Figure 1). Seven sampling sites at various elevations and physiographic positions were selected.

Field Soil Description and Sampling

Fresh road cuts and landslide surfaces in the study sites were used for characterization. Boundaries between soil horizons were marked for proper soil morphological description following the FAO Guidelines for Soil Description (FAO, 2006).Since this is a pedological field study, the soil profile was used as the basic sampling unit. Thus, 1 kg soil was collected from each genetic horizon of every profile for physical and chemical analyses. Sampling was done following the quantitative method of Schlichting et al. (1995) wherein three continuous and uniform slices of soil are taken from the uppermost horizon down to the lowest. Samples were placed separately in properly-labeled plastic bags and were brought to the laboratory for air-drying and analysis. Undisturbed clods were collected for bulk density determination; the clods were placed in properly labeled plastic bags and were transported carefully to the laboratory.

Laboratory Analyses

The bulk soil samples collected (excluding the samples for bulk density determination) were pounded with a wooden mallet to pass a 2-mm sieve (fine earth sample). In addition, enough amounts of each sample were further ground to pass 0.425-mm sieve for the analysis of soil organic matter and total nitrogen. Thereafter, the soil samples were analyzed for the following parameters:

Soil Physical Properties

Soil texture was determined by the pipette method (ISRIC, 1995),bulk density by the paraffin clod method (Blake and Hartge, 1986), and porosity was calculated from the determined bulk density value and a constant particle density of 2.65 g/cm^3. Liquid Limit and Plastic Index were estimated using the following pedotransfer equations (NSSC, 1995):

LL (Liquid limit) = 0.9 clay% + 10
PI (Plastic index) = clay- 21 (35-55% clay)
PI (Plastic index) = clay- 15 (>55% clay)

Soil Chemical Properties

Soil pH was analyzed potentiometrically using water and 1 N KCl at a soil: solution ratio of 1:2.5 (ISRIC, 1995). Delta pH (ΔpH) was determined by subtracting pH determined using H_2O from pH determined using KCl (pH_{KCl}–pH_{H2O}) (Mekaru and Uehara, 1972).

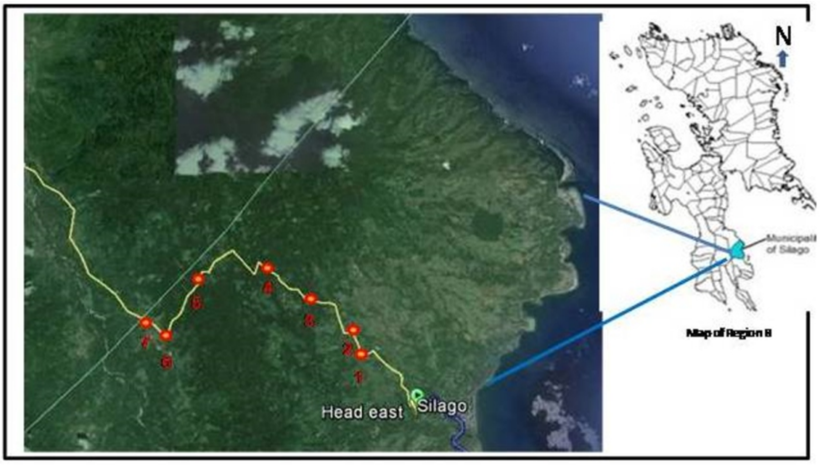

Figure 1. Map of Silago, Southern Leyte showing the sampling sites (Source: Google)

Soil organic matter (OM) was analyzed following the Modified Walkley-Black method (Nelson and Sommers, 1982), Available Phosphorus (mg/kg) by the Bray #2 method (Bray and Kurtz, 1945), and Total Nitrogen (%) by the micro-Kjeldahl method (ISRIC, 1995). Exchangeable Bases (Ca, Mg, Na, and K) ($cmol_c$/kg) were extracted by 1N NH_4OAc (pH 7.0) according to ISRIC (1995) and quantified using an atomic absorption spectrophotometer (Varian Spectra 220 FS). Exchangeable Acidity (Al^{3+} and H^+) ($cmol_c$/kg) was analyzed using 1 N KCl extraction (Thomas, 1982). Cation Exchange Capacity (potential) ($cmol_c$/kg) was determined using the ammonium acetate (NH_4OAc) method at pH 7.0

(ISRIC, 1995). Base Saturation (%) was calculated by dividing the sum of K, Mg, Ca, and Na (bases) in $cmol_c$/kg soil by the potential CEC (CEC_{pot}) and multiplying the result by 100. Effective Cation Exchange Capacity (CEC_{eff}) ($cmol_c$/kg) was calculated by summing up the amounts of exchangeable bases (K, Mg, Ca, and Na) and total acidity (Al^{3+} and H^+) (ISRIC, 1995).

RESULTS AND DISCUSSION

Location and Environmental Characteristics of Study Sites

Southern Leyte is one of the six provinces of Eastern Visayas or Region VIII. It is bounded by the province of Leyte to the north, by Surigao Strait to the east, Bohol Sea to the south, and Canigao Channel, across from Bohol, to the west.It covers about one-fourth of the island of Leyte. The province is characterized by relatively flat lands along the coastal areas where population centers lie but rugged and mountainous toward the interior. The province lies within the Philippine Fault System. The major fault lines traverse the municipalities of Sogod, Libagon, St. Bernard, and San Juan to Panaon Island.

In the mountainous portion of Southern Leyte, strongly weathered soils (Ultisols) that developed from andesite, basalt, and other igneous rocks are widespread. They probably belong to the Luisiana clay that was mapped in parts of Southern Leyte, Northern Leyte, and Biliran in the 1930s (Barrera et al., 1954). Ultisols are acidic, clayey, and have generally low nutrient status. They are the most widespread soils in the Philippines.

Silago area is composed of central highland volcanic rock formation of Miocene age consisting of andesite and basalt (Figure 2) with pyroclastic materials, and Pangasugan formation consisting of conglomerates, sandstone, and shale with pyroclastic materials (JICA, 1990). The geology of an area has a profound effect on many things, from the likelihood of landslides to the availability of groundwater in wells, from the amount of shaking suffered in an earthquake to the presence of desirable minerals, from the way the landscape is shaped to the kinds of plants that grow best in the area (USGS, 2000).

Information on land use is important because it gives an idea of the nature of soil disturbances as a result of management practices as well as it influences the direction and rate of soil formation (FAO, 2006). As in most parts of Leyte, the original vegetation of the study area was tropical rainforest of the Dipterocarp forest type (Figure 3) of which an estimated

10 percent only remains (Asio and Bande, 2005). Logging and shifting cultivations have replaced the original forest with a mosaic of agricultural land uses particularly pasture, upland crops, and patches of trees and shrubs (as discussed above). Consequently, local inhabitants do intensive cultivation and farming, triggering changes to the natural vegetation and leading to soil resource degradation. In addition, the combination of heavy rainfall, high temperature, and steep slope gradients further escalate the degradation (erosion of the topsoil, leaching leading to low soil fertility, high rate of weathering, and extensive development of residual soils problems (Hart et al., 2002). Most of the study sites in Silago show evidences of recent conversion from the original forest vegetation. This can be expected since the Abuyog-Silago highway has been completed recently.

Southern Leyte has two types of climate according to the Coronas Classification (Coronas, 1920). These are Type II and Type IV. Type II is characterized by the absence of dry season with a very pronounced maximum rain period occurring in the months of November to January. This type prevails in the eastern half of the province that includes the municipality of Sogod, Libagon, Liloan,

Figure 2.The basaltic-andesitic volcanic rock which is the dominant parent material of the soils in Silago, Southern Leyte (left - fresh rock; right – partly weathered rock or saprolite)

San Francisco, Pintuyan, San Ricardo, St. Bernard, San Juan, Anahawan, Hinundayan, Hinunangan, and Silago (study site). The annual mean precipitation in Southern Leyte is 1,700 mm and an average annual temperature of 27°C.

Table 1 presents the environmental characteristics of the seven sampling sites.

Site 1 (Figure 4) is on the upper backslope with an elevation of 98 m above sea level (asl) in Tubod, Silago. The site is poorly drained and the soil is derived from basaltic-andesitic volcanic rocks. Vegetation includes ferns and grasses such as cogon (*Imperata cylindrica*).

Figure 3. Photograph showing the forest vegetation of the study site in Silago, Southern Leyte

Site 2 (Figure 5) is located in Sitio Lemon, Tubod, Silago. The area is positioned in the shoulder of a volcanic mountain with an elevation of 170 masl. The area is well drained and is also dominated by ferns and cogon (*Imperata cylindrica*).

Site 3 (Figure 6) is an upper backslope situated in SitioLagtik of Tubod, Silago, and has an elevation of 251 m asl. The area is well drained, and the dominant vegetation includes ferns, cogon (*Imperata cylindrica*), makahiya (*Mimosa pudica*), agricultural crops such as coconut (*Cocos nucifera*), and trees such as gmelina (*Gmelina arborea*).

Site 4 (Figure 7) is positioned on a backslope in Tubod, Silago, with an elevation of 387 m asl. The site also belongs to secondary forest, and vegetation includes trees such as kakawate (*Gliricidia sepium*), and ipil-ipil (*Leucaena leucocephala*), ferns, cogon, and goatweed (*Ageratum conyzoides*). The area is poorly drained.

Site 5 (Figure 8) is located in Imelda, Silago. The area sampled is in a summit which is nearly level and has an elevation of 369 m asl. The site is well drained and considered as secondary forest, which is dominated with trees, grasses such cogon, ferns, taro (*Colocasia esculenta*), and goatweed.

Site 6 (Figure 9) is positioned on a footslope in Katipunan, Silago with an elevation of 194 m asl. The area is an abandoned agricultural farm with

Table 1. Site characteristics of the strongly weathered soils in Silago, Southern Leyte

Site Characteristics	Site						
	1	2	3	4	5	6	7
Location	Tubod, Silago, So. Leyte	Sitio Lemon, Tubod, Silago	SitioLagtik, Tubod, Silago	Tubod 4, Silago	Imelda, Silago	Katipunan, Silago	Katipunan, Silago
Coordinates	N10°31'54.4"	N10°32'19.5"	N10°32'59"	N10°33'49"	N10°33'44"	N10°33'0.7"	N10°33'17.4"
	E125° 09'4.1"	E125° 08'47.1"	E125° 07'57.8"	E125° 06'58"	E125° 05'48.3"	E125° 05'12.2"	E125° 04'42.7"
Elevation	98m asl	170m asl	251m asl	387m asl	369m asl	194m asl	166m asl
Landform	Volcanic mountain	Volcanic mountain	Volcanic mountain	Volcanic mountain	Volcanic mountain	Volcanic mountain	Alluvial plain
Slope Position	Upper backslope	Shoulder	Upper backslope	Backslope	Summit	Footslope	Toeslope
Slope Gradient	Sloping	Gently sloping	Sloping	Sloping	Nearly level	Nearly level	Nearly level
Exposition	North-facing	East-facing	West-facing	North-facing	North-facing	North-facing	West-facing
Parent Material	Basaltic-andesitic volcanics	Basaltic-andesitic volcanics	Basaltic-andesitic volcanics	Basaltic-andesitic volcanics	Basaltic-andesitic volcanics	Basaltic-andesitic volcanics	Alluvium of volcanic origin
Soil Moisture Regime	Udic	Udic	Udic	Udic	Udic	Udic	Udic
Soil Temperature	Isohyperthermic	Isohyperthermic	Isohyperthermic	Isohyperthermic	Isohyperthermic	Isohyperthermic	Isohyperthermic
Erosion	No evidence	No evidence	No evidence	Slight	No evidence	No evidence	No evidence
Rock outcrops/stoniness	Very few	Few	Few	Common	Very few	Few	Few
Drainage	Poorly-drained	Well-drained	Well-drained	Poorly-drained	Well-drained	Poorly-drained	Well-drained
Land-use	Agricultural	Agricultural	Agricultural	Secondary Forest	Secondary Forest	Abandoned Agricultural Farm	Secondary forest
Vegetation	ferns, cogon	ferns, cogon	ferns, cogon, makahiya, coconut, Gmelina	kakawati, ferns, cogon, goat weed	ferns, cogon, taro, goatweed	ferns, banana, cogon, coconut, jackfruit, goatweed	rice, banana, palm, sambong, ferns, morning glory

Scientific names of plant species:

Imperata cylindrica	cogon	*Ipomoea triloba*	morning glory
Mimosa pudica	makahiya	*Leucaena leucocephala*	ipil-ipil
Oryza sativa	rice	*Cocosnucifera*	coconut
Colocasia esculenta	taro	*Blumea balsamifera*	sambong
Gmelina arborea	gmelina	*Ageratum conyzoides*	goatweed
Gliricidia sepium	kakawati	*Musa spp.*	Banana

vegetation that includes banana (*Musa spp.*), coconut (*Cocos nucifera*), jackfruit (*Artocarpus heterophyllus*), ferns, cogon (*Imperata cylindrica*), and goatweed (*Ageratum conyzoides*). The area is poorly-drained.

Site 7 (Figure 10) is located in the toeslope of an alluvial plain in Katipunan, Silago with an elevation of 166 m asl. The area is well-drained and considered as a secondary forest with rice field on the side of the sampled soil profile and mixed natural vegetation which includes banana (*Musa spp.*), palm, sambong (*Blumea balsamifera*), rice (*Oryza sativa*), ferns, and morning glory (*Ipomoea triloba*).

Soil Morpho-Physical Properties

Figures 4 to 10 show the sites and soil profiles while Table 2 presents the morphological characteristics of the soils studied.

Generally the soil profiles possess Ah-Bw-Bt-C sequence of horizons. Elevation of the sampling sites appears to have no effect on the horizonation of the profiles studied. However, the physiographic positions of the soils are related to the thickness of the horizons. Presence of B horizon indicates that the soil is well-developed. Thick sola were observed in almost all of the soil profiles, which may be due to deeper weathering caused by vertical water movement at the start, and deposition of eroded soil materials in the later stage of soil development. Results in solum thickness also generally agree with the literature that the thickness of solum, clay, and moisture contents increase downslope with obvious alluvial stratification at the footslope and toeslope due to constant depositional process (Butler et al., 1982).

Data show that the soil color ranges from yellowish brown to yellowish red. The yellowish red color is due to the abundance of iron oxides primarily hematite and goethite, which are important weathering products in the soil. This is especially true for soils derived from parent materials containing high amounts of iron such as the basaltic-andesitic rock in the study area. Although caution should be given in interpreting color of tropical soils (Young, 1976), it is nevertheless a useful soil property in soil genetic and classification investigations.

Soil structure is mostly subangular blocky except soil profile 2. The consistence in most soils is very friable to very firm but generally sticky and plastic when wet. Landon (1991) stated that consistence is the property commonly used to describe the "feel" of the soil and includes soil properties such as plasticity, stickiness, and resistance to compression and shear, which have obvious importance for cultivation.

Fine to coarse roots can be found on the surface horizons but can no longer be observed in the lower portion particularly in the BC and C horizons of the soil profiles as roots of most crops reach only up to B horizon or 50 cm depth; although in profiles 3, 4, 5, and 7, there were very fine to fine roots on the lower portion of the profile. Rock fragments are very few and common in the lower horizons since BC and C horizons are close to the bedrock and consist chiefly of weathered partially decomposed rock; although some occurrences of small rock fragments can be observed in the upper parts of the profile. Most of the horizons also show a clear smooth boundary.

Figure 4. Photographs showing site (left) and profile characteristics (right) of soil profile 1 located at the upper backslope position at 98 m asl in Tubod, Silago, Southern Leyte

Figure 5. Photographs showing site (left) and profile characteristics (right) of soil profile 2 located at the shoulder position at 170 m asl in Sitio Lemon, Tubod, Silago, Southern Leyte

Figure 6. Photographs showing site (left) and profile characteristics (right) of soil profile 3 located at the upper backslope position at 251 m asl in Sitio Lagtik, Tubod, Silago, Southern Leyte

Figure 7. Photographs showing site (left) and profile characteristics (right) of soil profile 4 located at the backslope position at 387 m asl in Tubod 4, Silago, Southern Leyte

Figure 8. Photographs showing site (left) and profile characteristics (right) of soil profile 5 located at the summit position at 369 m asl in Imelda, Silago, Southern Leyte

Figure 9. Photographs showing site (left) and profile characteristics (right) of soil profile 6 located at the footslope position at 194 m asl in Katipunan, Silago, Southern Leyte

Figure 10. Photographs showing site (left) and profile characteristics (right) of soil profile 7 located at the toeslope position at 166 m asl in Katipunan, Silago, Southern Leyte

Table 2. Morphological characteristics of the strongly weathered soils in Silago, Southern Leyte

Soil Profile/ Horizon	Depth (cm)	Soil Color (Munsell Color-dry)	Texture	Structure	Consistence		Roots	Pores	Boundary	Rock Fragments
					Moist	Wet				
Profile 1 (Tubod)										
Ah	0–18	10YR 3/4 (dark yellowish brown)	CL	1fsbk	fr	st&pl	mm	cvf	as	n
Bw	18–46	10YR 5/8 (yellowish brown)	C	1fsbk	fi	st&pl	cf	fvf	as	n
Bt1	46–72	5YR 5/8 (yellowish red)	C	2fsbk	vfi	vst&vpl	fc	fvf	gs	n
Bt2	72–104	5YR 5/8 (yellowish red)	C	2fsbk	vfi	vst&vpl	vfvf	fvf	gs	n
Bt3	104–135	5YR 5/8 (yellowish red)	C	2fsbk	vfi	vst&vpl	n	fvf	gs	n
Bt4	135–172	5YR 5/8 (yellowish red)	C	2fsbk	vfi	vst&vpl	n	fvf	gs	n
BC	172–206	5YR 5/8 (yellowish red)	C	2fsbk	vfi	vst&vpl	n	fvf	gs	c
Profile 2 (Sitio Lemon)										
Ah	0–21	5YR 4/4 (reddish brown)	SiCL	1mg	fr	vst&pl	mf	mf	cs	c
Bw	21–44	5YR 4/6 (yellowish red)	C	1mg	fr	vst&pl	cf	cf	cs	v
Bt1	44–75	5YR 4/6 (yellowish red)	C	1fsbk	fr	vst&pl	vff	vfvf	cs	v
Bt2	75–113	5YR 5/8 (yellowish red)	C	1fsbk	fr	vst&pl	vfvf	vfvf	cs	v
Bt3	113–276	5YR 5/8 (yellowish red)	C	1fsbk	fr	vst&pl	n	vfvf	cs	v
C	276 below	5YR 5/8 (yellowish red)	C	1fsbk	fr	vst&pl	n	vfvf	cs	a
Profile 3 (SitioLagtik)										
Ah	0–20	10YR 4/3 (dark brown)	CL	1fsbk	fr	st&spl	mf	cf	cs	v
Bw	20–39	10YR 5/6 (yellowish brown)	CL	1fsbk	fr	st&spl	cf	cf	cs	v
Bt1	39–73	10YR 5/8 (yellowish brown)	C	2msbk	fr	st&spl	vff	vfvf	gs	n
Bt2	73–98	10YR 5/8 (yellowish brown)	C	2msbk	fr	st&spl	vfvf	vfvf	gw	n
Bt3	98–142	10YR 5/8 (yellowish brown)	C	2msbk	fr	vst&vpl	vfvf	vfvf	[illegible]	■
[illegible]	142–180	5YR 5/8 (yellowish red)	C	2msbk	fr	vst&vpl	vfvf	vfvf	gw	n
BC	180 below	5YR 5/8 (yellowish red)	C	2msbk	fr	vst&vpl	vfvf	vfvf	cs	c
Profile 4 (Tubod 4)										
Ah	0–18	10YR 5/6 (yellowish brown)	SiC	1fsbk	fr	st&pl	mf	mf	cs	c
Bt1	18–45	5YR 5/8 (yellowish red)	C	2msbk	vfi	vst&vpl	cf	cvf	gs	v
Bt2	45–77	5YR 5/8 (yellowish red)	C	2msbk	vfi	vst&vpl	ff	cvf	gw	v
Bt3	77–106	5YR 5/8 (yellowish red)	C	2msbk	vfi	vst&vpl	ff	cvf	gw	v
Bt4	106–145	5YR 5/8 (yellowish red)	C	2msbk	vfi	vst&vpl	ff	cvf	gw	v
C	145 below	5YR 5/8 (yellowish red)	C	1fsbk	vfi	vst&vpl	ff	vfvf	cs	c

Table 2 Continuation

Soil Profile Horizon	Depth (cm)	Soil Color (Munsell Color-dry)	Texture	Structure	Consistence		Roots	Pores	Boundary	Rock Fragments
					Moist	Wet				
Profile 5 (Imelda)										
Ah	0–26	5YR 4/6 (yellowish red)	CL	1fsbk	fr	sst&spl	mc	cf	cs	n
Bw	26–51	5YR 4/6 (yellowish red)	CL	1fsbk	fr	sst&spl	mc	cf	gs	n
Bt1	51–80	5YR 4/6 (yellowish red)	C	2msbk	fi	st&pl	cc	cvf	gw	n
Bt2	80–95	5YR 5/6 (yellowish red)	C	1fsbk	fr	vst&vpl	fc	vfvf	gw	n
Bt3	95–135	5YR 4/6 (yellowish red)	C	1fsbk	fr	vst&vpl	fc	vfvf	gw	n
BC	135 below	5YR 4/6 (yellowish red)	C	1fsbk	fr	vst&vpl	ff	vfvf	cs	c
Profile 6 (Katipunan 1)										
Ap	0–23	7.5YR 3/4 (dark brown)	CL	1fg	vfr	st&pl	ff	cf	cs	v
Bt1	23–52	2.5Y 5/6 (light olive brown)	CL	1fsbk	fr	st&pl	vff	fvf	gs	n
Bt2	52–86	7.5YR 6/8 (reddish yellow)	C	2msbk	fi	vst&vpl	vfvf	vfvf	gs	n
BC1	86–127	7.5YR 6/8 (reddish yellow)	C	2msbk	fi	vst&vpl	n	vfvf	as	n
BC2	127 below	2.5Y 5/6 (light olive brown)	C	2msbk	fi	vst&vpl	n	vfvf	aw	n
Profile 7 (Katipunan 2)										
Ah1	0–25	7.5YR 3/4 (dark brown)	SiC	1fsbk	fr	sst&spl	mf	mf	cs	v
Ah2	25–46	7.5YR 3/4 (dark brown)	SiC	1fsbk	fr	sst&spl	mf	mf	cs	v
Bw	46–72	7.5YR 3/4 (dark brown)	C	1fsbk	fr	vst&pl	mf	cf	cs	v
Bt1	72–113	10YR 4/4 (dark yellowish brown)	C	1fsbk	fr	vst&pl	cc	cf	cs	v
Bt2	113–143	10YR 5/8 (yellowish brown)	C	2fsbk	fr	vst&pl	cc	cf	cs	v
Bt3	143 below	10YR 4/4 (dark yellowish brown)	C	2fsbk	fr	vst&pl	cc	cf	cs	v

Symbols
(Key to Abbreviations in Table 2)

a. Soil texture
SiC- Silty clay
C- Clay
SiCL-Silty Clay Loam

b. Soil structure

Grade	Size	Type
1-weak	f-fine	g-granular
2-moderate	m-medium	sbk-subangular blocky
3-strong		

c. Soil consistency-moist
fr- friable; vfr- very friable;
fi- firm; vfi- very firm

Soil consistency-wet
st- sticky; sst- slightly sticky;
vst- very sticky;
pl- plastic; spl- slightly plastic;
vpl- very plastic

d. Roots

Abundance
n-none; f-few; vf- very few;
c-common; m-many
Size: vf-very fine; f- fine; — medium;
c- coarse

e. Soil pores

Abundance
vf- very few; f-few; c-common; m-many
Size: vf-very fine; f-fine; m-medium; c-coarse

f. Horizon boundary
Distinctness: a-abrupt; c-clear; g-gradual
Topography: s- smooth; w- wavy

g. Rock Fragments
n-none; v -very few; c-common

Particle size distribution expresses the relative sizes of particles comprising a given soil in terms of percentage by weight of the individual sizes. Most of the soils in each site are clayey with clay content ranging from 37.04 to 62.15 percent (Figure 11). Results also show that all soil profiles have increasing clay content with depth, indicating the presence of an argic (or argillic) horizon (Figure 12). The high clay content of the soils is probably from formation of clay during the weathering of the basaltic-andesitic parent material. This suggests the important role of parent material in the development of strongly weathered soils such as the soils studied. Also, through time soils undergo several processes and developments which would result to clay accumulation. Bulk density (Db), expressed in g/cm^3, is used as an index of compaction and porosity and directly affects root development and gas movement in the soil. Figure 13 shows that bulk density values are lower in upper horizons but tend to increase in subsurface horizons, ranging from 1.25 to 1.63 g/cm^3 (Table 3).

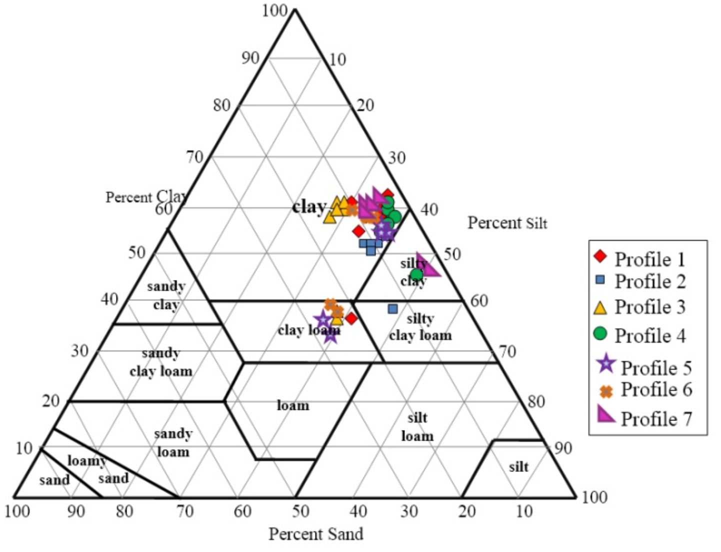

Figure 11.Textural classes of strongly weathered soils in Silago, Southern Leyte based on the USDA textural triangle

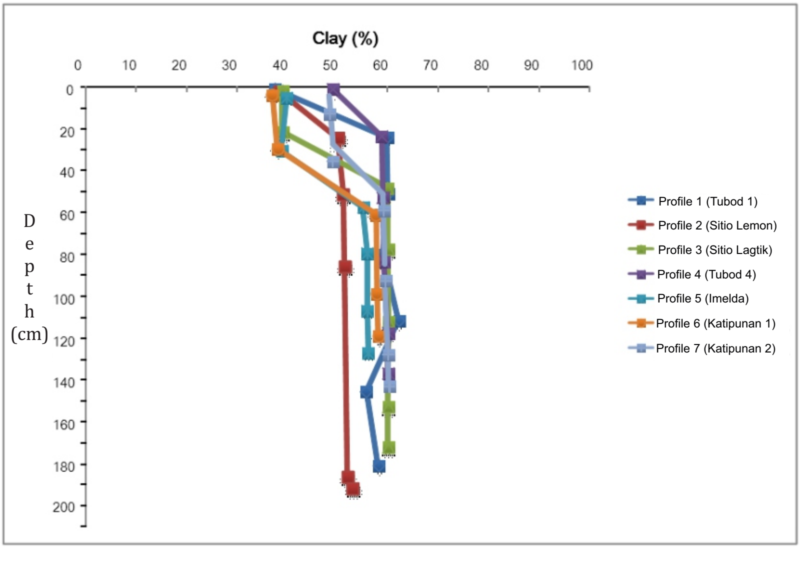

Figure 12. Depth function of clay content of the strongly weathered soils in Silago, Southern Leyte

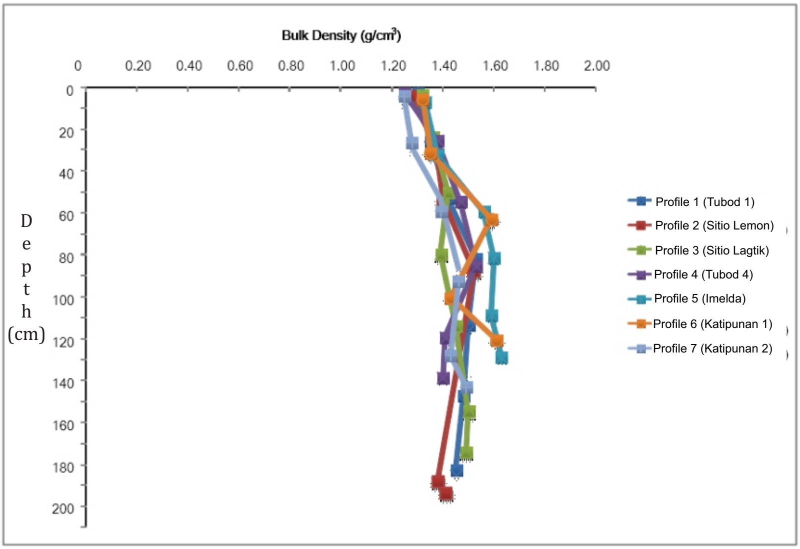

Figure 13. Depth function of bulk density of the strongly weathered soils in Silago, Southern Leyte

The lower bulk density values can be attributed to the higher porosity values on the surface horizon brought about by good soil aggregation. The increasing bulk density values with depth can be attributed to the higher clay content of the subsoil and to the lower biological activity. Lower bulk density values suggest better aeration on the surface horizon compared to the subsurface horizon.

Liquid limit is the percent water content of a soil at the arbitrarily defined boundary between the liquid and plastic states; while plastic index is the range of water content over which a soil behaves plastically. Results show that all soils have high liquid limit ranging from 43.34 to 65.94 and plastic index with values ranging from 16.60 to 47.15 (Table 3). The data suggest that the soils exhibit liquid states at water content above 50%. This means that the soils are prone to liquid movement at this indicated water content, which can happen during heavy storms or typhoons.

Soil Chemical Properties

Soil reaction (pH) expresses the activity of the hydrogen ions in the soil solution. It affects the availability of mineral nutrients to plants as well as many soil formation processes (Jahn et al., 2002). Figure 14 and Table 4 show that all soils have low pH-H_2O values ranging from 4.52 to 6.75. The

Table 3. Physical characteristics of the strongly weathered soils in Silago, Southern Leyte

Soil Profile/ Horizon	Depth (cm)	PSA (%)			Textural Class	Bulk Density (g/cm^3)	Porosity (%)	Liquid Limit*	Plastic Index**
		Sand	Silt	Clay					
Profile 1 (Tubod)									
Ah	0–18	21.31	41.09	37.60	Clay loam	1.30	50.94	43.84	16.60
Bw	18–46	5.20	35.00	59.80	Clay	1.35	49.06	63.82	44.80
Bt1	46–72	9.78	30.20	60.02	Clay	1.42	46.42	64.02	45.02
Bt2	72–104	6.05	35.00	58.95	Clay	1.53	42.26	63.06	43.95
Bt3	104–135	4.65	33.20	62.15	Clay	1.50	43.40	65.94	47.15
Bt4	135–172	10.22	34.02	55.76	Clay	1.48	44.15	60.18	40.76
BC	172–206	8.42	33.45	58.13	Clay	1.45	45.28	62.32	43.13
Profile 2 (Sitio Lemon)									
Ah	0–21	12.5	49	38.50	Silty clay loam	1.27	52.08	44.65	17.50
Bw	21–44	11.07	38.88	50.05	Clay	1.37	48.30	55.05	29.05
Bt1	44–75	10.90	37.98	51.12	Clay	1.40	47.17	56.01	30.12
Bt2	75–113	10.54	38.01	51.45	Clay	1.52	42.64	56.31	30.45
Bt3	113–276	9.85	38.15	52.00	Clay	1.38	47.92	56.80	31.00
C	276 below	8.01	39.00	52.99	Clay	1.41	46.79	57.69	31.99
Profile 3 (SitioLagtik)									
Ah	0–20	21.88	39.10	39.02	Clay loam	1.32	50.19	45.12	18.02
Bw	20–39	21.51	39.50	38.99	Clay loam	1.36	48.68	45.09	17.99
Bt1	39–73	11.26	28.85	59.89	Clay	1.42	46.42	63.90	44.89
Bt2	73–98	11.33	28.65	60.02	Clay	1.39	47.55	64.02	45.02
Bt3	98–142	10.88	29.00	60.12	Clay	1.45	45.28	64.11	45.12
Bt4	142–180	11.08	28.95	59.97	Clay	1.50	43.40	63.97	44.97
BC	180 below	11.96	27.99	60.05	Clay	1.49	43.77	64.05	45.05
Profile 4 (Tubod 4)									
Ah	0–18	5.50	45.50	49.00	Silty clay	1.25	52.83	54.10	28.00
Bt1	18–45	6.13	35.12	58.75	Clay	1.38	47.92	62.88	43.75
Bt2	45–77	5.50	35.50	59.00	Clay	1.47	44.53	63.10	44.00
Bt3	77–106	4.87	36.00	59.13	Clay	1.53	42.26	63.22	44.13
Bt4	106–145	4.01	35.99	60.00	Clay	1.41	46.79	64.00	45.00
C	145 below	5.14	34.87	59.99	Clay	1.40	47.17	63.99	44.99

Table 3 Continuation

Soil Profile/ Horizon	Depth (cm)	PSA (%)			Textural Class	Bulk Density (g/cm^3)	Posority (%)	Liquid Limit*	Plastic Index**
		Sand	Silt	Clay					
Profile 5 (Imelda)	0–26	24.37	35.75	39.88	Clay loam	1.33	49.81	45.89	18.88
Bw	26–51	26.00	35.15	38.85	Clay loam	1.38	47.92	44.97	17.85
Bt1	51–80	8.82	36.18	55.00	Clay	1.56	41.13	59.50	34.00
Bt2	80–95	7.39	36.74	55.87	Clay	1.60	39.62	60.28	40.87
Bt3	95–135	8.12	35.98	55.90	Clay	1.59	40.00	60.31	40.90
BC	135 below	6.87	37.00	56.13	Clay	1.63	38.49	60.52	41.13
Profile 6 (Katipunan 1)									
Ap	0–23	24.57	38.39	37.04	Clay loam	1.32	50.19	43.34	16.04
Bt1	23–52	23.75	38.15	38.10	Clay loam	1.35	49.06	44.29	17.10
Bt2	52–86	9.23	33.12	57.65	Clay	1.59	40.00	61.89	42.65
BC1	86–127	8.24	33.98	57.78	Clay	1.43	46.04	62.00	42.78
BC2	127 below	10.75	31.13	58.12	Clay	1.61	39.25	62.31	43.12
Profile 7 (Katipunan 2)									
Ah1	0–25	5.16	46.50	48.34	Silty clay	1.25	52.83	53.51	27.34
Ah2	25–46	4.01	46.99	49.00	Silty clay	1.28	51.70	54.10	28.00
Bw	46–72	9.65	31.32	59.03	Clay	1.39	47.55	63.13	44.03
Bt1	72–113	8.55	32.00	59.45	Clay	1.46	44.91	63.51	44.45
Bt2	113–143	8.12	31.87	60.01	Clay	1.43	46.04	64.01	45.01
Bt3	143 below	7.80	32.01	60.19	Clay	1.49	43.77	64.17	45.19

pH-H_2O values tend to slightly decrease with depth. The low pH-H_2O values can be attributed to the parent material, and the soils are weathered so they are expected to be acidic. On the other hand, pH values in KCl ranging from 3.74 to 6.04 are lower than pH values in H_2O as expected and tend to slightly decrease with depth. The use of 1 M KCl is based on the premise that K-ions can replace weakly adsorbed H- and Al-ions, which is not possible with H_2O (Schlichting et al., 1995). The pH-KCl is more stable than the pH-H_2O because it limits suspension and stirring effects (Bache, 1988 as cited by Asio et al., 1992). Results also show that all soils have negative ΔpH (Table 4) indicating that the soil colloids have net negative charge and they possess cation exchange capacity.

Soil OM includes all the organic materials derived from plants and animals incorporated into the soil or lying on its surface, which is either living or in various stages of decomposition. Results revealed that OM and total N are high in the upper horizons and then decrease considerably with depth (Figures 15 and Table 4). The decrease in OM with depth can be attributed to the accumulation of leaf litter as well as to the higher amount of roots of grasses concentrated in the surface horizon (Navarrete et al., 2000). Profile 7 has the highest OM and total N content that is probably due to the prolonged fallow and the site is in a toeslope position suggesting the influence of deposition processes.

Phosphorus is a critical element in natural and agricultural ecosystems (Brady and Weil, 1999). Tropical soils are generally P deficient; and in many cases, P is the limiting nutrient in agriculture (Sanchez and Logan, 1992).

Available P refers to the P that is readily available to plant. Available P contents are low in all soils in the seven profiles and slightly decrease with soil depth (Table 4). This may be due to the acidic condition of the soils, which causes precipitation of the element. Phosphorus occurs in the soil solution as the negatively-charged phosphate ion $H_2PO_4^-$ in acid soils. These ions react readily with iron, aluminium, and manganese compounds in acid soils. They become strongly attached to the surfaces of these compounds or form insoluble phosphate precipitates. These reactions remove immediately available phosphate ions from the soil solution. The upper layer of the soil usually retains almost all of the phosphorus so this means that very little phosphorus moves into or through the subsoil (Brady and Weil, 1999).

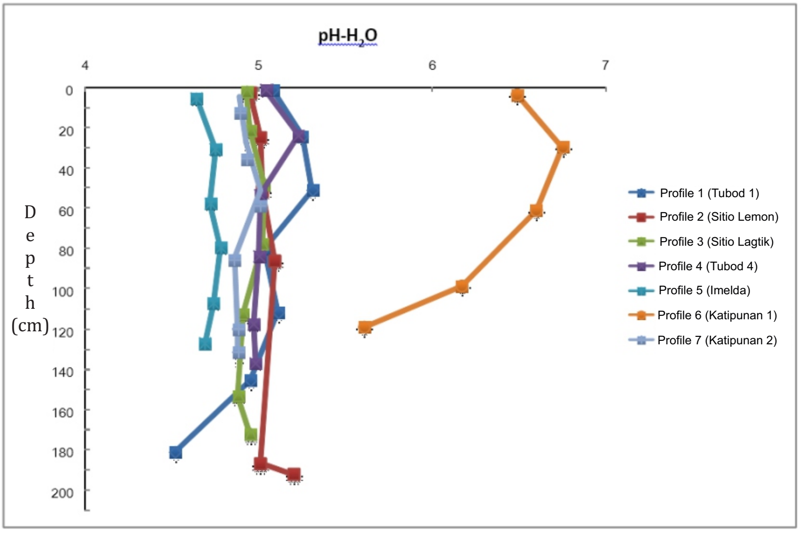

Figure 14. Depth function of pH-H_2O of the strongly weathered soils in Silago, Southern Leyte

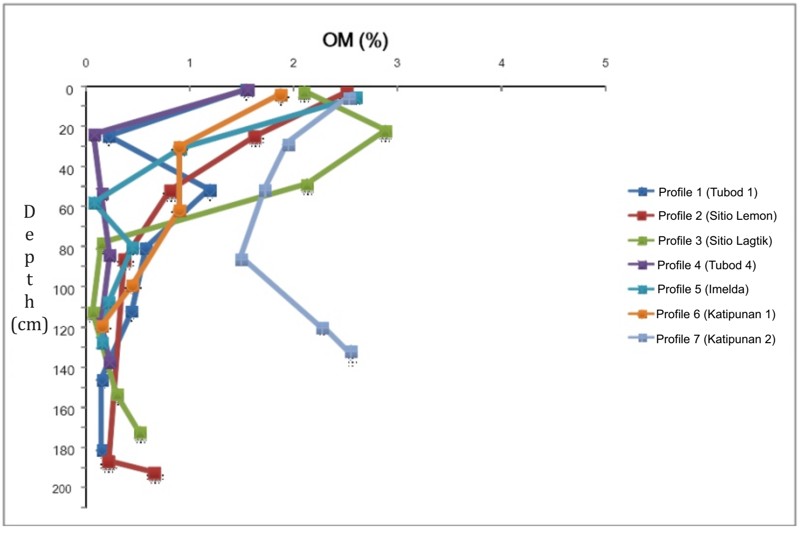

Figure 15. Depth function of OM contents of the strongly weathered soils in Silago, Southern Leyte

Table 4. Chemical characteristics of the strongly weathered soils in Silago, Southern Leyte

Soil Profile/ Horizon	Depth (cm)	pH (1:2.5)		ΔpH	OM	Total N	Available P	Exchangeable Bases ($cmol_c$/kg)			
		KCl	H_2O		(%)	(%)	(mg/kg)	K	Ca	Mg	Na
Profile 1 (Tubod)											
Ah	0–18	4.03	5.08	-1.05	1.54	0.20	0.25	0.18	0.15	0.44	0.45
Bw	18–46	4.21	5.25	-1.04	1.19	0.06	0.44	0.02	0.10	0.12	0.10
Bt1	46–72	4.28	5.31	-1.03	0.58	0.03	0.06	0.12	0.14	0.44	0.15
Bt2	72–104	4.34	5.03	-0.z	0.44	0.02	0.06	0.04	0.11	0.1	0.13
Bt3	104–135	4.12	5.11	-0.99	0.22	0.01	0.06	n.d	n.d	n.d	n.d
Bt4	135–172	3.95	4.95	-1.00	0.15	0.01	0.03	n.d	n.d	n.d	n.d
BC	172–206	3.74	4.52	-0.78	0.15	0.01	0.03	0.03	0.27	0.3	0.08
Profile 2 (Sitio Lemon)											
Ah	0–21	3.96	4.95	-0.99	2.51	0.18	0.59	0.13	0.12	0.34	0.51
Bw	21–44	4.05	5.01	-0.96	1.62	0.06	0.06	0.06	0.15	0.14	0.22
Bt1	44–75	4.08	5.02	-0.94	0.81	0.04	0.03	0.03	0.09	0.17	0.15
Bt2	75–113	4.08	5.09	-1.01	0.66	0.02	0.00	0.02	0.07	0.23	0.16
Bt3	113–276	4.06	5.01	-0.95	0.37	0.02	0.03	n.d	n.d	n.d	n.d
C	276 below	3.99	5.20	-1.21	0.22	0.01	0.00	n.d	n.d	n.d	n.d
Profile 3 (Sitio Lagtik)											
Ah	0–20	3.99	4.93	-0.94	2.88	0.19	0.19	0.17	0.19	0.61	0.65
Bw	20–39	4.05	4.95	-0.90	2.13	0.08	0.07	0.09	0.22	0.35	0.20
Bt1	39–73	4.13	5.03	-0.90	2.10	0.04	0.07	0.04	0.16	0.22	0.11
Bt2	73–98	4.14	5.02	-0.88	0.52	0.03	0.03	0.02	0.15	0.15	0.05
Bt3	98–142	4.07	4.91	-0.84	0.30	0.02	0.03	n.d	n.d	n.d	n.d
Bt4	142–180	4.01	4.88	-0.87	0.15	0.01	0.00	n.d	n.d	n.d	n.d
BC	180 below	3.94	4.95	-1.01	0.07	0.02	0.00	0.04	0.20	0.52	0.17
Profile 4 (Tubod 4)											
Ah	0–18	4.02	5.04	-1.02	1.56	0.10	0.35	0.14	0.18	0.77	0.51
Bt1	18–45	4.08	5.23	-1.15	0.23	0.02	0.19	0.04	0.22	0.78	0.25
Bt2	45–77	4.00	5.01	-1.01	0.23	0.02	0.07	n.d	n.d	n.d	n.d
Bt3	77–106	3.96	5.00	-1.04	0.15	0.02	0.03	0.04	0.19	0.30	0.10
Bt4	106–145	3.94	4.97	-1.03	0.15	0.01	0.03	n.d	n.d	n.d	n.d
C	145 below	3.86	4.98	-1.12	0.08	0.02	0.00	n.d	n.d	n.d	n.d

Table 4 continuation

Soil Profile/ Horizon	Depth (cm)	pH (1:2.5)		ΔpH	OM	Total N	Available P	Exchangeable Bases ($cmol_c$/kg)			
		KCl	H_2O		(%)	(%)	(mg/kg)	K	Ca	Mg	Na
Profile 5 (Imelda 1)											
Ah	0–26	3.86	4.64	-0.78	2.59	0.14	0.51	0.11	0.17	0.21	0.11
Bw	26–51	3.90	4.75	-0.85	0.91	0.06	0.19	0.06	0.15	0.21	0.08
Bt1	51–80	3.92	4.72	-0.80	0.45	0.04	0.16	0.03	0.16	0.21	0.09
Bt2	80–95	3.91	4.78	-0.87	0.22	0.03	0.12	n.d	n.d	n.d	n.d
Bt3	95–135	3.85	4.74	-0.89	0.15	0.04	0.03	n.d	n.d	n.d	n.d
BC	135 below	3.78	4.69	-0.91	0.08	0.02	0.00	0.04	0.19	0.41	0.12
Profile 6 (Katipunan 1)											
Ap	0–23	5.43	6.49	-1.06	1.87	0.22	0.47	0.35	0.11	9.28	0.46
Bt1	23–52	6.04	6.75	-0.71	0.90	0.06	0.00	0.37	0.19	4.07	0.13
Bt2	52–86	5.96	6.60	-0.64	0.90	0.04	0.00	0.30	0.19	4.16	0.15
BC1	86–127	5.44	6.17	-0.73	0.45	0.03	0.03	0.18	0.25	3.72	0.14
BC2	127 below	4.63	5.61	-0.98	0.15	0.02	0.00	n.d	n.d	n.d	n.d
Profile 7 (Katipunan 2)											
Ah1	0–25	3.98	4.89	-0.91	2.55	0.28	0.80	0.25	0.14	3.78	1.70
Ah2	25–46	3.98	4.93	-0.95	2.53	0.25	0.67	0.17	0.16	3.41	1.52
Bw	46–72	3.95	5.01	-1.06	2.27	0.24	0.42	0.16	0.15	3.70	1.66
Bt1	72–113	3.83	4.86	-1.03	1.94	0.23	0.35	0.11	0.11	2.36	1.14
Bt2	113–143	3.79	4.88	-1.09	1.72	0.20	0.16	0.12	0.15	2.31	1.06
Bt3	143 below	3.86	4.88	-1.02	1.49	0.16	0.03	n.d	n.d	n.d	n.d

Table 4 continuation

Soil Profile/ Horizon	Depth (cm)	Exchangeable ($cmol_c/kg$)		Exchangeable Acidity ($cmol_c/kg$)	CEC ($cmol_c/kg$)		CEC Clay ($cmol_c/kg$)	Base Saturation (%)
		Al^{+3}	H^+		Pot	Eff		
Profile 1 (Tubod)								
Ah	0–18	1.00	0.34	1.34	16.70	2.56	44.41	7.31
Bw	18–46	0.90	0.7	1.60	34.48	1.94	57.66	0.99
Bt1	46–72	0.57	0.20	0.76	29.83	1.61	49.70	2.85
Bt2	72–104	0.39	0.36	0.75	50.05	1.13	84.90	0.76
Bt3	104–135	0.84	0.40	1.24	38.13	n.d	61.35	n.d
Bt4	135–172	1.47	1.58	3.06	23.48	n.d	42.11	n.d
BC	172–206	2.38	0.75	3.13	17.68	3.81	30.41	3.85
Profile 2 (Sitio Lemon)								
Ah	0–21	1.52	0.49	2.01	25.36	3.11	65.87	4.34
Bw	21–44	1.23	0.49	1.72	25.57	2.29	51.09	2.23
Bt1	44–75	1.54	0.18	1.72	30.67	2.16	60.00	1.43
Bt2	75–113	1.28	0.38	1.67	36.73	2.15	71.39	1.31
Bt3	113–276	1.33	0.43	1.77	32.95	n.d	63.37	n.d
C	276 below	1.56	0.53	2.09	41.08	n.d	77.52	n.d
Profile 3 (Sitio Lagtik)								
Ah	0–20	1.20	0.62	1.81	25.07	3.43	64.25	6.46
Bw	20–39	1.18	0.61	1.79	32.95	2.65	84.51	2.61
Bt1	39–73	1.01	0.34	1.35	18.94	1.88	31.62	2.80
Bt2	73–98	0.96	0.24	1.19	14.80	1.56	24.66	2.50
Bt3	98–142	1.29	0.17	1.46	22.15	n.d	36.84	n.d
Bt4	142–180	1.36	0.22	1.58	26.62	n.d	44.39	n.d
BC	180 below	1.60	0.33	1.92	16.70	2.85	27.81	5.57
Profile 4 (Tubod 4)								
Ah	0–18	1.02	1.09	2.12	23.57	3.72	48.10	6.79
Bt1	18–45	0.92	0.69	1.61	28.71	2.90	48.87	4.49
Bt2	45–77	1.88	0.48	2.36	26.95	n.d	45.68	n.d
Bt3	77–106	1.89	0.26	2.16	23.33	2.79	39.46	2.70
Bt4	106–145	1.03	0.90	1.94	26.77	n.d	44.62	n.d
C	145 below	2.20	0.64	2.85	15.42	n.d	25.70	n.d

Table 4 continuation

Soil Profile/ Horizon	Depth (cm)	Exchangeable ($cmol_c/kg$) Al^{3+}	H^+	Exchangeable Acidity ($cmol_c/kg$)	CEC ($cmol_c/kg$) Pot	Eff	CEC Clay	Base Saturation (%)
Profile 5 (Imelda)								
Ah	0–26	1.86	1.00	2.86	20.59	3.46	51.63	2.91
Bw	26–51	2.14	0.48	2.62	35.07	3.12	90.27	1.43
Bt1	51–80	2.17	0.42	2.59	17.94	3.08	32.62	2.73
Bt2	80–95	2.04	1.07	3.11	31.18	n.d	55.81	n.d
Bt3	95–135	2.57	0.45	3.02	20.74	n.d	37.10	n.d
BC	135 below	2.69	0.62	3.31	20.25	4.07	36.08	3.75
Profile 6 (Katipunan 1)								
Ap	0–23	0.06	0.22	0.27	14.65	10.47	39.55	69.62
Bt1	23–52	0.06	0.44	0.49	32.69	5.25	85.80	14.56
Bt2	52–86	0.11	0.30	0.41	23.58	5.21	40.90	20.36
BC1	86–127	0.06	0.36	0.41	31.23	4.70	54.05	13.74
BC2	127 below	0.11	0.33	0.44	18.66	n.d	32.11	n.d
Profile 7 (Katipunan 2)								
Ah1	0–25	1.40	0.00	1.41	11.31	7.28	23.40	51.90
Ah2	25–46	1.36	0.86	2.22	14.90	7.48	30.41	35.30
Bw	46–72	1.37	0.52	1.89	12.03	7.56	20.38	47.13
Bt1	72–113	2.56	0.59	3.16	13.68	6.88	23.01	27.19
Bt2	113–143	2.98	1.33	4.31	17.94	7.95	29.90	20.29
Bt3	143 below	1.76	0.52	2.28	21.87	n.d	36.33	n.d

Base saturation refers to the proportion of the cation exchange sites in the soil that are occupied by the various cations such as K, Ca, Mg, and Na. Table 4 shows that profiles 6 and 7 have the highest values due to their higher exchangeable bases content compared to the other soil profiles. Base saturation is positively related to soil pH because a high base saturation value indicates that the exchange sites on a soil particle are dominated by non-acidic ions.

Exchangeable bases are the exchangeable basic cations that are adsorbed on the exchange sites of soil colloids. These include calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na). Results show that generally the four (4) exchangeable bases are low in all soils and tend to decrease with depth which may be attributed to low inherent content from the parent material as well as to the low pH values of the soils (Table 4).

The capacity of the soil to adsorb or to hold cations and to exchange species of ions is termed as cation exchange capacity or CEC. The conventional CEC method (by 1 N NH_4OAc at pH 7.0) measures the potential CEC of the soil (CEC_{pot}) while the "alternative method," which involves the summation of basic cations (extracted by 1 N NH_4OAc at pH 7.0) plus the 1M KCl exchangeable acidity, measures the effective CEC of the soil (CEC_{eff}) (ISRIC, 1995). The effective CEC is probably a more meaningful value as far as plant growth, fertilizer additions, and liming are concerned than the potential CEC determined with the buffered solutions at high pH values (Tisdale and Nelson, 1975). Results show that $CEC_{pot}$and CEC_{eff} are both higher in the upper two (2) horizons in all profiles compared to the lower horizons, and the two also decrease with depth (Figures 16 and Table 4). Higher CEC in the upper horizons could be attributed to the organic matter, which is higher in the upper horizons. Results suggest that the surface soil contains high amounts of variable charge than the subsoil. The low CEC in the subsoil or deeper part of the soil profile may also be attributed to the clay mineral types and to the low organic matter content.

It can be observed also that CEC_{pot} values are higher than CEC_{eff}values. The high potential CEC values indicate that considerable amount of negative charge was produced with the raising of pH to 7.0 during soil analysis (Scheffer and Schachtschabel, 1992). Tisdale and Nelson (1975) also pointed out that the use of ammonium acetate method will result in a high CEC value if the soil is acid simply because of the adsorption of NH_4^+ ions in the so-called pH-dependent exchange sites.

Exchangeable acidity is the amount of H^+ and Al^{3+} in the exchange complex of the soil extracted by 1 M KCl. Results show that exchangeable

Al^{3+} is the major component of exchangeable acidity in all soils (Table 4). The increase in Al^{3+} with depth corresponds to the decrease of pH-H_2O and pH KCl. The result indicates that under acid condition, Al^{3+} is the major cation in the soil (Kamprath, 1980).

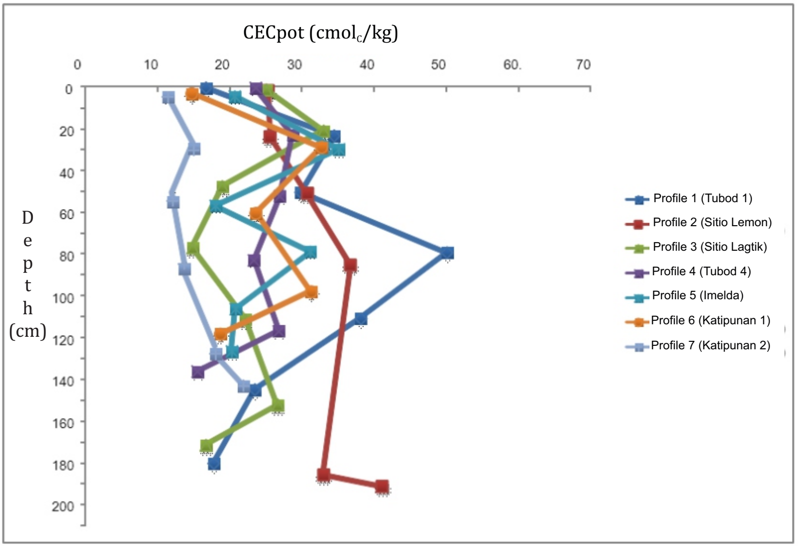

Figure 16. Depth function of potential CEC of the strongly weathered soils in Silago, Southern Leyte

Clay Mineralogy and Classification

Due to the unavailability of an X-ray diffraction (XRD) apparatus for identifying low- (<24 $cmol_c$ / kg clay) and high-activity clay (≥24 $cmol_c$ / kg clay, WRB 2014) the following formula was used (compare with ISRIC, 1995).

$$CEC_{clay} = \frac{CEC_{pot} - CEC_{org} \ x \ 3.5}{\%clay} \ x \ 100$$

Where:

CEC_{pot} is the CEC determined by ammonium acetate method at pH 7.0 ($cmol_c$/kg)
% clay is the amount of clay of the sample
C_{org} = Organic matter / 1.724

Results show that most of the soils have high activity clay with either montmorillonite or mixed mineralogy. Only the Bt2 of profile 3 and most horizons of profile 7 have low-activity clay but do not fit the requirements of a kandic horizon (<16cmol$_c$ / kg clay; (USDA, 1996). Earlier pedological studies in Leyte have shown that the strongly weathered volcanic soils are dominated by kaolinite and halloysite clay minerals (Asio, 1996; Navarrete et al., 2009). Thus, it appears that the pedotransfer equation is not applicable to the soils studied.

According to Soil Taxonomy (USDA, 1999), soil profiles 1 to 6 are classified as Typic Hapludults. The reason is that they belong to the order Ultisol that have an argillic horizon and percent base saturation of less than 35. They also have an udic moisture regime (Udults) and possess characteristics that do not qualify under the criteria of other groups of Udults (Hapludults). On the other hand, soil profile 7 is classified as Typic Hapludalf. This soil belongs to the order Alfisols. Like Ultisols, it possesses an argillic horizon but it has more than 35 percent base saturation which means it is more fertile than the Ultisols. Soil profile 7 also appears younger than the soils in the upper physiographic position probably because of periodic deposition of soil materials and elements.

In the WRB (2014), soil profiles 1 to 6 are classified as Alisol which indicate soils having an argic horizon with a cation exchange capacity (by 1 M NH_4OAc) equal to or more than 24 cmol$_c$ kg^{-1} clay throughout the profile. Soil profile 7 can be classified as a Luvisol.

CONCLUSION

Based on the results of the study, it may be concluded that:

1. The soils studied have colors ranging from yellowish brown to yellowish red, have subangular blocky structure, clay in texture, deep (>3 m), friable when moist but very plastic and very sticky when wet, and have moderate to high porosity values. For the chemical properties, the soils have low pH-H_2O values ranging from 4.52 to 6.75 with profile 6 as the highest, potential CEC of 11.31 to 38.13 cmol$_c$/kg, base saturation of 0.76 to 69.62 %, organic matter content of 0.07 to 2.59%,total N of 0.01 to 0.28%, and available P of less than 5 mg/kg.
2. The soils have closely related properties probably due to by their similar parent material, original vegetation (rainforest) and climate. The differences in some soil properties appear to be largely the effect of topography.

3. Most of the soils are classified as Typic Hapludults in the USDA Soil Taxonomy or Haplic Alisols in the WRB, which reflect their strongly weathered characteristics while the soil in the lowest part of the landscape (toeslope) is classified as Typic Hapludalf or Haplic Luvisol which indicates that it is slightly younger than the other soils.

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