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Properties and Utilisation of Andisols in Indonesia

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Abstract

Soils formed on volcanic ash parent materials and classified as Andisols are widespread in the Indonesian archipelago, covering an area about 3 million hectares. Soils are developed from mostly andesitic to basaltic rocks on Upper Pleistocene to Holocene surfaces. Weathering gradually increases downslope and with the prevailing high precipitation and high temperature produces deep soils. The Indonesian Andisols mostly have dark epipedons with high content of organic carbon and low bulk densities (< 0.9 Mg m^{-3}). soil reaction is slightly acid with negative A pH values with CEC ranges from 22 to 30 cmol(+) kg^{-1}. Major minerals in the sand fraction are quartz, plagioclase, hornblende, augite, hypersthene, olivine and volcanic glass. Short–range–order minerals like allophane, imogolite and/or ferrihydrite dominate the clay fraction, whilst halloysite, gibbsite, cristobalite are also detected in lesser amount. The surface charge of Indonesian Andisols containing allophane and imogolite is pH dependent (variable charge) resulting high phosphate fixation. The Langmuir phosphorus sorption maxima ranged from 300 to 2,500 mg P kg^{-1}.

Most of the Indonesian Andisols are among the most productive soils. These soils are intensively cultivated with both annual and perennial of upland crops like tea, coffee, cocoa with quite high productivity. The areas in the vicinity of volcanoes are also well–known as the horticultural centre and support more than 50% of the Indonesian people. The tea and Arabica coffee plantations occupied hundreds hectares of land from lower to medium slopes of volcanoes both in Sutmatra and Java islands while secondary and primary forests formed in the upper slopes of volcano.

Introduction

The Indonesian archipelago consists of a chain of volcanoes, which are relatively young and mostly still active. Volcanoes emit a variety of substances such as lava, pyroclastic materials, ash and gases. These volcanic products are very important parent materials of soils in the vicinity of the volcanoes that rejuvenate mineral contents in the soils. The effect of volcanic ash on soil properties varies according to the age and depth of the ash deposit, land form and lithology.

Information on the nature, genesis and properties of volcanic ash soils in Japan, Hawaii and New Zealand is available. This information has been used to maximize land productivity in those countries. The same cannot be said for the volcanic ash soils of Sumatra and Java, Indonesia. It is clearly shown that our knowledge on the soils of West Sumatra regions and Java is limited. Many issues are unclear with problems unresolved. It is clearly shown that our knowledge on the soils of West Sumatra regions and Java is limited. For instance, it may be possible to describe the fertility of the soil in terms of charge property and/or P–fixation behavior. Accurate and extensive information on these properties are necessary for improving productivity, sustainable utilization and conservation of the soils.

Soils formed on volcanic materials are classified as Andisols regarding these soils meet the andic properties' requirement. Tan (1965) reported that die Parent material from which the Indonesian Andisols developed changes from basic to acid types when moving from east to west in Java and from north west to south east in Sumatra island. Andisols in Indonesia occur within a wide range of altitudes from 100 m above sea level in West Sumatra (Fiantis et al., 2002) to above 900 m upwards in Java island (Subagyo and Buurman, 19$0; Van Ranst, et al., 2002). Nevertheless, the Indonesian Andisols is

Table 1. Selected chemical properties of the soils at Mt. Marapi and Mt. Pasaman, West Sumatra.

Horizon	Depth	pH(H2O)	Org C	clay	Ca	Mg	K
	(cm)	----------------	-%-------		--cmol(+) kg^{-1} soil-----		
		Profile I	Mt. Marapi				
Alp	0-25	5.7	3.32	20	1.16	0.60	0. 12
A12	25-39	5.8	2.73	13	0.80	0.34	0.06
B	39-68	5.9	1.88	16	0.10	0.42	0.04
BC	68-100	6.1	1.63	28	1.00	0.50	0.02
		Profile II	Mt. Marapi				
Alp	0-26	5.0	3.91	31	1.18	0.32	0.06
A12	26-39	5.7	2.14	29	1.38	0.38	0.02
B	39-63	6.1	1.34	16	1.62	0.46	0.02
BC	63-85	6.0	1.61	20	2.10	0.68	0.06
		Profile III	Mt. Pasaman				
Alp	0-14	5.7	8.74	50	1.86	0.66	0.28
B21	14-33	6.2	5.67	41	1.90	0.50	0.04
B22	33-46	6.3	3.17	51	1.48	0.66	0.04
C	46-85	6.3	0.52	20	1.16	0.68	0.04
		Prone IV	Mt. Pasaman				
Alp	0-11	6.0	5.1	59	2.06	1.74	0.16
B21	11-46	5.7	3.64	54	0.28	0.30	0.06
B22	46-68	5.8	1.87	34	0.46	0.52	0.24
C	68-95	6.0	0.23	47	0.66	0.78	0.04

covering an area of approximately 3.831.000 ha (Sukarman, et al., 1997).

Most of the Andisols in Indonesia are utilized for food and industrial estate crop production and support some of the highest population densities in the country especially in central and east Java. They are often considered the most important factor for a successful horticultural and food crop operation and are favored for growing potatoes, cabbages, carrots, onions, maize, green pepper, tomatoes and cut flowers. The best tea and coffee plantations are also found on these soils and the upper part of the volcano slopes are covered with primary and secondary forests of pine trees.

Indonesian Andisols are thought be very productive soils, but many of them are not utilized to their full capacity. These soils have unique and distinct properties; low bulk density, high water retention, high permeability, Stable structure, high amount of 'active Al and/or Fe', variable charge and high phosphate fixation (Shoji et al., 1993). Chemical, physical and morphological properties of these soils ate closely related to the nature and behavior of non-crystalline and para-crystalline clay minerals, such as allophane, ferrihydrite and imogolite (Wada, 1 980).

Allophanes are the most reactive components in volcanic ash soil because of their high specific surface area. They strongly retain phosphate and organic matter (Bear, 1967; Wada, 1985; Famer et al., 1991). The availability to plants of soluble phosphorus, applied as fertilizer, is quickly decreased and only 10 % of the applied phosphorus is utilized by most crops (Egawa, 1977). The loss of applied phosphorus and the availability of native phosphates for crops are very important problems related to agricultural practices on these soils.

Chemical md mineralogical properties influence the productivity of Andisols in various ways. Accurate and extensive information on these properties are necessary for improving their productivity, sustainable utilization and conservation. In the tropical regions where low input farming is common and weathering of soil materials is rapid, Andisols are generally evaluated as the most productive soils (Shoji et al., 1993). The high productivity of these Soils is largely due to their rapid release of nutrients. But leaching may occur severely in Andisols,

Table 2. Different forms of iron in the soils from Mt. Marapi and Mt. Pasaman

Horizons	Fed	Feo	Fep	Fet	Ferryhydrite	Feo–Fop	Fed–Feo	Feo/Fed
				%				
			Profile I, Tanjtmg Karang, Mt. Marapi					
Alp	0.80	1.05	0.39	2.24	2	0.60	-	1.31
A12	0.84	1.18	0.15	2.17	2	1.03	-	1.40
B	0.92	1.22	0.08	2.22	2	1.14	-	1.33
C	1.45	1.37	0.05	2.87	2	1.32	0.08	0.94
			Profile II, Guguk Batu, Mt. Marapi					
Alp	1.38	1.27	0.21	2.86	2	1.06	0.11	0.92
A12	1.41	1.15	0.08	2.64	2	1.07	0.26	0.82
B	1.18	1.14	0.03	2.35	2	1.11	0.04	0.97
C	1.32	1.45	0.03	2.80	2	1.42	-	1.10
			Proflle Ill, Banjar Kubu, Mt. Pa3iaman					
Alp	1.59	1.24	0.45	3.28	2	0.79	0.35	0.78
A12	1.89	1.29	0.30	3.63	2	0.99	0.60	0.68
B	2.50	1.97	0.11	4.58	3	1.86	0.53	0.79
C	1.85	I.48	0.02	3.35	3	1.46	0.37	0.80
			Profile IV, Pasar Pinagar, Mt. Pasaman					
Alp	1.89	0.71	0.28	2.88	1	0.43	1.10	0.38
B21	2.64	0.99	0.23	3.86	2	0.76	1.65	0.38
B22	2.31	1.50	0.09	4.00	3	1.51	0.71	0.69
C	2.58	1.04	0.03	3.65	2	1.01	1.54	0.40

Fed = Fe is extracted with DCB
Feo = Fe is extracted with amonitm oxalate
Fep = Fe is extracted with pyrophosphate

resulting in a rapid depletion of the weatherable mineral reserves in the soil (Van Wambeke, 1 992).

Surface charge characteristics are of fundamental importance in Soil management. It is because the majority of the reactions that control nutrient availability, along with many of the soil physical properties, are dependent upon the physico–chemical processes that occur at the soil particle surface (Uehara and Gillman, 1981). Andisols display typical variable charge contributing from active Al, Si and Fe complexes such as allophane, imogolite, ferrihydrite and metal humus complexes (Uehara and Gillman, 1981; Shoji et al., 1993).

Despite of the extensively use of these soils, highland Andisols both in Java Nan Ranst et al., 2002) and Sumatra Fiantis et al., 2002) have significant fertility problems that are accentuated by agricultural intensification. Furthermore Van Ranst et al. (2002) stated that an understanding of the factors governing soil fertility is prerequisite to determining the feasibility of ameliorating they constrains and increasing soil productivity. The main objective of this paper is to characterize the physico–chemical, mineralogical properties and utilization of Andisols from Sumatra and Java, Indonesia.

2. Physical Environment

As recorded by Van Bemmelen (1970), there are about 177 volcanoes spread over different islands in Indonesia. On the island of Sumatra alone, 52 volcanoes are found along a great volcanic motmtain chain known as the BariSan Mountains–Range. Whilst in Java Island there about 35 volcanoes are spread from east to west and the rest of volcanoes are scattered in lesser Sunda islands, Celebes and Moluccas or Banda Arcs.

The main physiographic trendlines of Sumatra are rather simple. Its backbone is formed by the Barisan Range along its western side. The slope towards the Indian Ocean in the western part is generally steep and consequently the West Coast belt is mostly mountainous. The Barisan range is the prominent orographic element of the island and measures about 1,650 km long and about 100 km wide with several summit altitudes above 3,000 m (Van Bemmelen, 1970; Hamilton, 1979).

This mountainous region consists of pre-Tertiary rocks and is topped by Quaternary volcanic rocks. The areas Of the Quaternary are separated in a general way from areas of older volcanic rocks. The pre-Holocene rocks are andesite and dacite and mostly concentrated in the Northwest-central part of Sumatra. Along the Southwest coast, old rocks are surmounted by recent volcanic rocks of the active magma arc (Hamilton, 1 979).

Van Ranst et al. (2002) reported that Java island is characterized by distinct wet and dry seasons. This seasonality is somewhat more pronounced in the east, and locally in the central part, compared with the western part of the island. The Java's Andisols were developed in finely comminuted Quarternary volcanic ash, ranging from basic (calc-alkaline basaltic ash) in East Java to more acid types (basalt-andesitic ash) in Central and andesitic tuffaceous in West Java.

The distribution of volcanoes both in Sumatra and Java is closely related to the tectonic structure of the region. Based on dated eruptions, the active volcanoes can be grouped into three different types as follows (Van Bemmelen, 1970) :

- type A volcanoes ; volcanoes with eruptions or with periods of increased activity later than 1600 AD (Amo Domini);
- type B volcanoes with fumarole or solfatara stages; no magma eruptions after 1600 AD.,
- type C volcanoes; no dated eruptions, but with actual fumarole activity.

3. The Indonesian Andisols Properties

3.1. Sumatra's Andisols

3.1.1. Physico-Chemical properties

The bulk density values of the soils are less than 0.9 Mg m^{-3}, satisfying the andic soil properties requirement. The BD of the A horizons of the southern slope soils of Mt. Marapi ranges from 0.73 to 0.89 Mg m^{-3}, while for the northern slope soils it ranges from o.63 to 0.88 Mg m^{-3}. The bulk density value of the B horizons is slightly lower than those of the surface horizons; the values are 0.58 - 0.86 Mg m^{-3}. Allophane is responsible for the lower bulk density in the B horizons as it is more abundant in B horizons than in the topsoils. Bulk density tends to be lowered also by organic matter.

Total porosity varies from 59 to 74% (w/w). These values are comparable with those of the Andisols from Japan. Young volcanic ash soils have porosity of about 60 %, while the matured soils have porosity up to 80 percent (Shoji and Ono, 1978; Nanzyo et al., 1993a). There is a negative relationship between total porosity add organic carbon. However, total porosity is linearly correlated with allophane content. The high porosity in Andisols is attributable to the allophane structure. Allophanes have hollow spherical aluminosilicates sheets, which create macro, meso and micropores Nanzyo et al., 1993a).

Soil water storage is commonly measured at different moisture tensions, namely pF (potential Force) 1, 2, 2.54 and 4.2. Water storage of soils from Mt. Marapi measured at pF 1 ranges between 54 to 74% w/w or between 25 to 209 mm while soils of Mt. Pasaman have water storage between 53 to 72% w/w or 53 to 162 mm. Statistical analysis indicates that there is no influence of both allophane and organic carbon on gravitational water.

In the A horizons, the available water held between pF 2 and 4.2 varies from 8 to 60 mm (39% w/w) for soils of Mt. Marapi. For the soils from Mt. Pasaman it is 15-48 mm (38% w/w). In the B horizons the variation is narrower and ranges from 20 to 60 mm. Compared to other soils in the tropics sdch as Oxisols, these figures are high (Van Wambeke, 1992) but they are similar to those obtained from Andisols in Japan, Hawaii, Chile, Equador and New Zealand (Wada, 1985).

Selected chemical properties were presented in Table 1. The carbon contents ape quite high in the upper horizons with values increasing with increase elevation in both volcanoes. Available phosphorus contents are quite low as compared to total P. Phosphate retention is very high (> 95 %) in both toposequences; these satisfy the requirements for andic properties. Lower P retention values were observed with decreasing altitude (Fiantis et al., 1998). The high P retention capacity is related to large specific surface areas of these soils (Wada, 1980; Sanyal aLld Datta, 1991). CEC ranges from 22 to 28 cmol(+) kg^{-1} soil in the soils of Mt. Marapi and from 19 to 30 cmol(+) kg^{-1} soil on those of Mt. Pasaman. The pH_0 values of the topsoils are lower than those of the subsoils, attributed to higher amount of organic matter in the topsoils.

Comparable results were also found earlier by Tan (1965) for Andisols in North Sumatra and West Java. These soils have a low permanent charge then variable charge soils that have medium to high variable charge show low anion-exchange capacity (AEC) whereas soils with low variable charge tends to have high AEC.

Humus composition in Andisols from North Sumatra dominated by the fulvic acid (up to $l%) whereas humic acid only count l8%. Comparable results were also obtained by Puteri et al. (2003) for Andisols from West Sumatra which have more fulvic acid than humic acid also but with lesser amount of humic acid (<1%).

DCB solution extracted more Fe than acid ammonium oxalate or Na-pyrophosphate (Table 2). The Fe_o/Fe_d ratios of the surface horizons of soils from Mt. Pasaman are lower compared to those of the Mt. Marapi, indicating that iron oxides in soils from Mt. Pasaman are of higher crystal1inity. The higher crystallinity and the larger amounts of Fe_d indicate that soils from Mt. Pasaman are more weathered than soils from Mt_ Marapi. This is in agreement with Mizota and Van Reeuwijk (1989) who believed that the Fe_o/Fe_d ratio can be used as an index for the crystallinity or 'age' of iron oxides. Values for young Andisols are > 0.75, whereas the older soils have values<0.75.

The soils from Mt. Maqapi show lower Al_p/Al_o ratios than the soils from Mt. Pasaman (Table 2). This indicates that the soils from Mt. Pasaman are more weathered than the soils from Mt. Marapi. The ratio of Al_p over Al_o also gives some indications about the occurrence of allophane and imogolite. A lower ratio (close to zero) indicates the presence of allophane and imogolite Mizota and Van Reeuwijk, 1989). The allophane content is lower in the topsoil than in the subsoil (Table 2). The lower content of allophane in the topsoil is probably due to the higher content of organic matter in the A horizonn than the underlyihg B and C horizons. The al1ophane content of soils from Mt. Pasaman is lower than that of Mt. Marapi. Moisture content also plays an important role in the formation of allophane. Low amounts of annual precipitation that reduce the loss of Si from the soils favor the formation of allophane and imogolite rather than ferrihydrite and/or gibbsite (Parfitt et al., 1988).

3.1.2. Mineralogical Properties

Andisols from Mt. Pasaman have more clay content than Andisols from Mt. Marapi as reported by Fiantis et al. (1998). The clay fraction of soil at Mt. Marapi is largely amorbhous to x-rays (diffused spectrum) as compared to that of Mt. Pasaman which is largely crystalline. The mineralogical composition of the clay fraction of the two soils does not change with depth. The soils are characterized by the presence of cristobalite (0.405 nm), feldspars (0.377, 0.321, 0.315 nm) and halloysite (1.01, 0.405 nm). Opaline silica, which gives a diffuse, broad X-ray spectrum centers at about 0.41 nm, is only observed in profile 1 from Mt. Marapi. This findings is in agreement with the results obtained by Diakite (1992) who found opaline silica accumulating in the surface horizons of Andisols from Mexico. High amounts of opaline silica are also reported present in the Andisols of Japan. A review of literature shows that opaline silica is found more abundantly in younger Andisols (< 500 years) than in older ones (4000-7000 years), also in humus-rich A horizon than in uhderlying B and C-horizons. Therefore, opaline silica is a product of the early stages of weathering of volcanic ash.

Gibbsite (0.485 nm) is detected in the clay fraction of the soils at Mt. Pasaman, but absent in the soils from Mt. Marapi. Formation of gibbsite in the clay hction of Mt. Pasaman soil is presumably due to high precipitation. Under high precipitation, Si and basic cations are leached out of the profiles, leaving aluminum behind to precipitate as aluminum oxide (Parfitt et a1., 1 988). Weathering of Al-silicates directly to gibbsite or through a 1 : 1 layer is governed by the intensity of leaching which, in turn, is affected by minLal1, temperature, topography, ground water table and time (Hsu, 1989).

Disappearance of the 0.715 and 0.357-nm reflection peaks after heating at 550^0 C is indicative of the occurrence of 1 : 1 layer minerals in the samples. This phenomenon occurred in all the samples. The 1 : 1 layer silicate is found to be halloysite. The presence of halloysite in the samples is confirmed by the strong reflection at 0.445 nm and the collapse of the 1.01 nm reflection to 0.72 nm after heating at 350^0 C (Dixon, 1989). The intensity of the halloysite XRD reflections increases with decreasing altitude of the soil profiles and also with increasing soil depth. This suggests that silica is subjected to leaching from the upper topographic areas and accumulates in the lower zones. This is supported by the study of Mizota and Chapelle (1988) who found that high amounts of halloysite accumulated in the lower parts of Andisols in Rwanda. Silicium with its intermediate solubility can partly be leached out and precipitate in the lower subsoils (Van Ranst, 1995).

Interstratified 1 : 1− 2 : 1 phyllosilicates are observed in the fine and medium clay fraction of the surface horizons (Figure 1C). The presence of shoulder at the low angle side of 0.715 nm after heating at 350^0 C and 550^0 C and shift of this peak towards low angle side after glycolation indicates the presence of interstratified 1 : 1−2 : 1 layers and swelling properties. Dehydroxylation of the interstratified 1 : 1 layers gives a broad diffraction band between 0.99−1.4 nm (Herbillon et al., 1981). This result is in

agreement with the study of Wada et al. (1987) and Delvaux et al. (1990). Wada et al. (1987) named this mineral as a 'embryomic halloysite', but Parfitt et al. (1988) disagreed and call it as 'a mixed layer of kaolidte/smectite' instead.

3.2. Java's Andiols

3.2.1. Physico−chemical Properties

Utami (1 998) reported that Andisols of Java island are characterized by relatively good physical properties as shown by low bulk density (< 0.90 Mg m^{-3}) and high total porosity indicate that a lwge mount of water can be stored in the soil profiles. Bulk density decreases with decreasing organic matter content but the effect of organic matter on bulk density is less important than that of allophane, DCB−extractable Al and Fe. The amount of available water for plant grow is considered to be equal to the difference between water content at field capacity (0.033 MPa) and at wilting point (1.5MPa). Allophane, DCB and pyrophosphate extractable Al and Fe, ferrihydrite and organic matter content are highly correlated to the water content held at these two suction values.

Van Ranst et al. (2002) summarized that soil acidity (pH) and sum of exchangeable basic cations, sepecially Ca^{2+} of Andisols in Java generally decreased from East to West Java. This trend is attributed to the combined effect of the parent ash, becoming more acid from east to west and the more pronounced seasonality in East Java. The Andisols from East Java are capable of holding far great amount of exchangeable basic cations then the other soils from Central and West Java at natural pH. On the other hand, Andisols in West Java have far greater capacity to retain anions such as NO_3^- and SO_4^{2-} in subsoils (at 50 cm). Thus, these soils are capable of holding a large store of such nutrients in the subsoil. Andisols in West Java showed different behavior which has more humic acid than fulvic acid with the values of 57% and 43%, respectively (Tan, 1965).

Subagjo and Buurmm (1980) investigated soil catenas on the west and north−east slopes of the Lawu volcano in East Java and found that base saturation in those soils gradually increased dowhill with the lowest value obtain in Andisols compared to Inceptisols or Alfisols. The same trend was also observed for CEC, permanent charge and effective CEC. Whils variable charge of Andisols of Mt. Lawu was the highest one compared to other soils and highly correlated with one or both of organic matter and non−crystalline substances and/or sesquioxides.

3.2.2. Mineralogical Properties

The mineralogical composition of Andisols in Java consist of long−range order crystalline minerals as well as short−order or non−crystalline minerals as it was reported by Utami (1998). Feldspar, cristobalite and pyrophillite are commonly found in all soils. She further grouped Andisols in Java into four types such as smectitic, halloysitic, gibbsitic and mixed mineralogies groups. The content of the long−order minerals are in inverse relation with the non−crystalline minerals. In the allophanic Andisols, allophane, imogolite and ferrihydrite constitute 30 − 50% of the clay fraction in A horizons, and 30 − 65% in B horizons.

Van Ranst et al. (2002) reported that the weight average contents of Si_o, Al_o, Fe_o.,allophane and ferrihydrite in the fine earth of the upper 100 cm showed clear increase in the pedons from East to West sides of Java. Differences in the amounts of Si_o, Al_o, Fe_o are less marked between the A and B horizons in the pedons of East and Central Java, but clearly increased with depth in pedons of West Java. This indicates that the development of active forms of Al and Fe in weathering of volcanic ash is favored by strongly leaching conditions (Mizota et al., 1 988).

3.3. Utilization of Andisols

Highland Andisols both in North and West Sumatra are utilized for industrial estate and horticulture crop productions. The area of north Sumatra is famous for its Deli-tobacco wrappers and tea plantations and the quality of the tobacco and tea are considered as the best ones in the country (Tan, 1965).

Fiantis et al. (2003) found that Andisols in surrounding Mt. Talang in West Sumatra have Climatic Rating Index of 80 wd high Land Production Potential for horticulture crops such as potato and cabbage. Those areas ate considered as the most productive horticultural region in West Sumatra. Furthermore, they reported that in the lower middle to upper slope of Mt. Talang laid huge tea plantations, cinnamomum trees, robusta and arabica coffee. The production of these estate crops are considered quite high in the province and the quality of this highland tea and coffee are more favored than lowland estate crops.

Similar soil utilization were also reported for Andisols ih Java. In West Java, best horticultural and tea plantation sites are located in the slopes of Mt. Gede and Mt. Pangrango. Andisols in foot slopes of Mt. Merapi and Mt. Merbabu in Central Java are classified also as the most productive region. These two volcanoes are type-A volcano which from time to time intermittently ejected volcanic materials from their caldera into surrounding slopes. Shoji et al. (1993) summarized that the high productivity of Andisols in Central Java related to cumulative deposits of basaltic to andesitic volcanic parent materials, soils have a deep and unrestricted rooting zones, thick humus horizons with large amounts of organic N, relatively abundant of apatite in the parent material and the high content of available water.

Conclusions

Andisols from West Sumatra have lower allophane content in the topsoil than in the subsoil. This is related to higher amount of organic matter in the topsoil. Due to higher rainfall, the soils at Mt. Pasaman are more weathered than those at the Mt.Marapi. This is reflected by lower allophane and higher ferrihydrite contents in the soils at Mt. Pasaman. The clay fraction of West Sumatra's Andisols is composed mainly of halloysite, cristobalite and feldspars. The intensity of halloysite reflections in the B horizons iS more pronounced with decreasing altitude of the soil profile, indicating a downward leaching of Si. Gibbsite is only present in the clay of the soils at Mt. Pasaman, ale opaline silica is only present in the clay of Mt. Marapi soils. Interstratified 1/1-2/1 phyllosilicates are identified in the deferrated clay fraction. In all the soils, the surface horizons have lower pH_o value than the underlying B horizons. The negative variable charge of the soils varies from 6 to 10 cmol kg^{-1} soil, while the negative permanent charge varies from 0.42 to 7.4 cmol(+) kg^{-1} soil. The AEC is higher in the subsoil than in the topsoil, having values ranging from 0.3 to 1. 1 cmol(+) kg^{-1} soil.

Andisols in highlands of Java island, Indonesia have varying chemical compositions. The development of these soils is affected by the parent ash composition and climatic conditions. From East to West Java, pH and exchangeable Ca decrease, whereas allophane and ferrihydrite contents, PZNC, and pH_o, increase. Some of the soils tend to develop a net positive variable charge at $pH < pH_o$; this may affect the soils's productivity. Managing the soils for sustainable crop production should consider the CEC at the natural soil pH, the PZNC, and the pH_o.

Andisols both in in Sumatra and Java high Land Production Potential for horticulture crops such as potato and cabbage, rice, and tea plantation. Those areas are considered as the most productive horticultural region, rice, and tea plantation in country.

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