**Characteristics of Inceptisols Derived from Basaltic Andesite**

**from Several Locations in Volcanic Landform**

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Abstract

The widespread of Inceptisols in Indonesia especially in volcanic landform has the characteristics potentially to be used as agricultural land. The aim of this research is to identify the characteristics of Inceptisols found in volcanic landform developed from basaltic andesite parent materials. Soil samples were collected in 6 locations. A total of 24 samples were taken from each horizon from 6 pedons for physical, chemical, and mineral analysis. Result of this research showed Inceptisols have yellowish brown to very dark brown colors with hue 7,5 YR to 10 YR, color value varies from 2,5 to 4, and croma value from 1 to 6. Base saturation varies from low to high, cation exchages capacity low to moderate. Soil textures dominated by clay, clay loam, and sandy loam. Two pedons (P4, P5) dominated by weatherable minerals while the others dominated by unweatherable minerals such as opaque and quartz. Inceptisols from this pedons were Udepts and Aquepts sub ordo, in Dystrudepts, Humudepts, Endoaquepts, and Eutrudepts great group, and 5 sub group namely *Typic Eutrudepts*, *Andic Dystrudepts, Typic Humudepts, Typic Epiaquepts*, and *Eutrik Humudepts*.

Keywords: parent materials, basaltic andesite, Inceptisols

1. **Introduction**

Inceptisols is a relatively young soil which is characterized by the presence of cambic horizon, a horizon formed as a result of physical alteration processes. Cambic horizon is characterized by the development of structure or color, chemistry transformation, material transfer, or combination of two/more of these processes (Soil Survey Staff, 2014). Some of Inceptisols are also eluvial soils, which lose its elements by leaching but do not have a large amount of iluvization horizon, such as the argillic horizon (Smith, 1965).

Inceptisols are widely distributed in Indonesia, with area of 70 million hectares (Subagyo et al, 2000). The widest distribution is on Sumatra with area of 17.6 million hectares. The widespread distribution of Inceptisols was caused by the effects of erosion due to high rainfall on sloping land, alluvium and koluvium sediments, and the age of quarter volcanic materials.

Soil characteristics can be catagorised into different soil types eventhough they came from the same parent material. The formation of soils was not only influenced by parent material, but also by other factors, such as climate, topography, organisms, and time. In older geological formations, Inceptisols can be formed from the result of slow weathering process due to rainfall or low temperatures. Besides, resistant parent materials, high erosion rates due to topographic factor, ground water or acidic rocks also caused slower soil weathering process (Lopulisa, 2004).

The aim of this research was to determine the characteristics of Inceptisols formed from basaltic andesite parent materials from several locations. In particular, this research studied several physical and morphological properties, chemical properties, sand mineral composition associated with soil nutrient reserves, and soil classification based on the properties described.

1. **Materials and methods**
   1. **Materials**

The materials used in the study were six pedons taken from several locations with same parent material, Basaltic Andesite. Pedons were found in the volcanic landform group, like old volcanic plains, foot of a mountain, volcanic slopes, and volcanic cone. Detailed information about pedons was presented in Table 1.

Table 1. Information of pedons observed

|  |  |  |  |
| --- | --- | --- | --- |
| **Pedon** | **Parent material** | ***Landform*** | **Location** |
| P1 | Basaltic Andesite (rock) | Old volcanic plain | Seluma Regency, Bengkulu Province |
| P2 | Basaltic Andesite (tuff) | Foot of a mountain | Rejang Lebong Regency, Bengkulu Province |
| P3 | Basaltic Andesite (tuff) | Lower volcanic slope | Purwakarta Regency, West Java Province |
| P4 | Basaltic Andesite (tuff) | Upper volcanic slope | Pekalongan Regency, Central Java Province |
| P5 | Basaltic Andesite (tuff) | Volcanic cone | Lumajang Regency, East Java Province |
| P6 | Basaltic Andesite (tuff) | Old volcanic plain | Ogan Komering Ulu Selatan Regency, South Sumatera Province |

* 1. **Methods**

A total of 24 soil samples were taken from each horizon on the six pedons for physical, chemical, and mineral analysis. Physical and chemical analysis included texture, organic carbon, pH (H2O and KCl), potential P and K (25% HCl), available P (Olsen), cation exchange capacity and base saturation (NH4OAc, pH 7). Analysis procedures were done according to Soil Survey Investigation Report No. 1 (Soil Survey Laboratory Staff, 1991) and Petunjuk Teknis Analisis Kimia, Air, Tanaman, dan Pupuk (Eviati dan Sulaeman, 2012). The composition of the sand fraction mineral was determined by line counting method, which is counting up to 100 grains of mineral using polarization microscope.

1. **Result and Discussion**

***Morphological and Physical Attribute***

The depth, color, and texture of each pedons can be seen in Table 2. All pedons observed have a deep solum (80-150 cm). Bw horizon showed that Inceptisols have undergone color or structural development (Soil Survey Staff, 2014) while the Bg horizon on pedon P5 showed strong glealization which indicated that the soil condition was in inundation or water saturation state for a long time. Land use of P5 was rice fields so that soil was in the water saturated conditions.

Tabel 2. Morphological and physical attribute of pedons observed

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pedon** | **Horizon** | **Depth (cm)** | **Matrix color** | **Texture, consistency** |
| P1 | A | 0-19 | db (7,5YR 3/4) | CL |
|  | Bw | 19->120 | ydb (10YR 4/4) | CL |
| P2 | A | 0-19 | ydb (10YR 3/4) | SiC, ss sp |
|  | Bw | 19->120 | ydb (10YR 3/6) | C, s p |
| P3 | A | 0-15 | db (7,5YR 3/2) | C, s p |
|  | Bw | 15-120 | db (7,5YR 3/4) | C, s p |
| P4 | A | 0-30 | vdb (7,5YR 2,5/2 | C, s p |
|  | Bw | 30-150 | db (7,5YR 3/3) | C s p |
| P5 | A | 0-15 | vdg (7,5YR 2,5/2) | SiL, so po |
|  | Bg | 15-80 | db (7,5YR 3/2) | SL, ss sp |
| P6 | A | 0-23 | vdg (2,5Y 3/1) | C, s p |
|  | Bw | 23-120 | db (7,5YR 3/3) | C, s p |

Notes : Matrix color = db (dark brown), ydb (yellowish dark brown), vdb (very dark brown), vdg (very dark gray); Texture = CL (clay loam), SiC (Silty Clay), C (clay), SiL (Silty Loam), SL (Sandy Loam); Consistency = ss (slightly sticky), s (sticky), so (non-sticky), sp (slightly plastic), p (plastic), po (non-plastic)

The topsoil color is generally darker than the lower layer because of abundant organic matter (Rajamudin and Sanusi 2014). The soil will be brighter in the lower layers due to decreasing of organic matters as the soil gets closer to the parent materials or C horizon (Pairunan et al 1987).

The texture of the soil was dominated by clay (clay content of 40% to 59%), but in certain pedons (P1 and P5) the texture were clay and sandy clay. This fine to slightly fine texture showed one of the cambic characteristics of Inceptisols (Soil Survey Staff, 2014).

**Mineral Sand Fraction**

Pramuji and Bastaman (2009) in Khusrizal et al. (2012) reported that easily weathered minerals are minerals that altered and released their constituent elements in the process of soil formation. While hard weathered minerals are minerals that are hard to decay in the soil formation process caused of strong Si-O bonds.

The results of mineral sand fraction analysis showed that two pedons (P4, P5) were dominated by easily weathered minerals, such as augite, hiperstin, labradorite, rock fragments, and volcanic glass. The easily weathered mineral content in the parent rock materials described nutrient reserves in the soil (Bali et al. 2018) and indicated that the Inceptisols has not experienced advanced weathering so that can be classified as young soils (Aini and Mulyono 2004).

The remaining four pedons contained fewer easily weathered minerals but more hard weathered minerals, such as opaque and quartz. Some minerals were found sporadically, such as zircon, hydragilite, volcanic glass, andesine, bitownite, anortite, orthoclasts, sanidin, and hornlende. The mineral composition of the sand fraction was presented in Table 3.

Table 3. Composition of sand fraction mineral

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Pedon** | **Depth (cm)** | **Mineral** | | | | | | | | | | | | | | | | | | | | | | |
| **Op** | **Zi** | **Kk** | **Kg** | **Kb** | **Li** | **Ze** | **Hi** | **Lm** | **Fb** | **Gv** | **An** | **Lb** | **Bi** | **An** | **Or** | **Sa** | **Hh** | **Au** | **Hi** | **Ga** | **Tu** | **Ad** |
| P1 | 0-19 | 7 | 1 | 39 | 21 | sp |  |  | sp | 1 | 6 | 1 | sp | 2 |  |  | 3 | 1 | 3 | 4 | 6 | - | 5 | sp |
|  | 46-74 | 9 | 1 | 34 | 17 | - | - | - | sp | 2 | 5 | sp | 1 | 1 | - | - | 2 | 2 | 6 | 5 | 9 | - | 6 | - |
| P2 | 0-19 | 52 | 1 | 4 | 8 | sp | - | - | sp | 8 | 8 | 4 | 1 | 2 | sp | - | - | 1 | 1 | 4 | 6 | - | - | - |
|  | 42-90 | 42 | sp | 6 | 16 | - | - | - | sp | 11 | 11 | 3 | sp | 1 | - | - | sp | sp | 2 | 3 | 5 | - | - | - |
| P3 | 0–15 | 65 | 5 | 14 | 12 | - | 1 | - | - | - | 1 | sp | sp | - | - | - | sp | - | sp | - | 1 | - | 1 | - |
|  | 15–50 | 76 | 2 | 12 | 8 | sp | sp | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  | 50–80 | 54 | sp | 15 | 18 | 1 | 3 | - | - | 5 | 4 | sp | - | sp | - | - | sp | - | sp | - | sp | - | - | - |
|  | 80–120 | 71 | 1 | 10 | 11 | sp | 1 | - | - | 2 | 3 | - | - | sp | - | - | sp | - | sp | - | 1 | - | sp | - |
| P4 | 0–30 | 20 | - | - | - | - | - | - | - | 3 | 9 | sp | - | 2 | 5 | - | - | - | sp | 36 | 20 | 4 | 1 |  |
|  | 30-55 | 21 | - | - | - | - | - | - | - | 2 | 11 | sp | - | 1 | 3 | - | - | - | 1 | 38 | 18 | 4 | 1 |  |
|  | 55-85 | 15 | - | - | - | sp | - | - | - | 2 | 17 | sp | - | 2 | 3 | - | - | - | sp | 42 | 16 | 3 | sp |  |
|  | 85-120 | 14 | - | - | - | - | - | - | - | 2 | 20 | sp | - | 1 | 2 | - | - | - | sp | 43 | 15 | 3 | sp |  |
| P5 | 0-15 | 17 | - | - | - | - | - | - | - | 3 | 16 | 11 | 1 | 29 | 7 | 2 | - | - | 2 | 9 | 3 | sp | - | - |
|  | 15-45 | 14 | - | - | - | - | - | - | - | 2 | 18 | 14 | sp | 31 | 5 | 2 | - | - | 1 | 8 | 4 | 1 | - | - |
|  | 45-80 | 17 | - | - | - | - | - | - | - | 3 | 14 | 16 | 1 | 25 | 4 | 3 | - | - | 2 | 9 | 6 | sp | - | - |
|  | 80-120 | 16 | - | - | - | - | - | - | - | 2 | 16 | 9 | sp | 36 | 2 | 1 | - | - | 2 | 8 | 8 | sp | - | - |
| P6 | 0-23 | 12 | 1 | 49 | 25 | 1 | - | - | - | 8 | 1 | sp | - | sp | - | - | 1 | 1 | sp | sp | sp | - | sp | 1 |
|  | 53-120 | 37 | sp | 25 | 12 | 3 | - | - | - | 13 | 3 | 1 | - | 2 | - | - | sp | sp | 2 | 1 | 1 | - | - | sp |

Note: Op=Opaque, Zi=Zirkon, Kk=Turbid quartz, Kg=Clear quartz, Kb=Iron concretion, Li=Limonit, SiO= Organic SiO2, Ze=Zeolit, Hi=Hidragilit, Lm=Weathered mineral, Fb=Rock fragmen, Gv=Vulkanic glass, Al=Albit, An=Andesin, Lb=labradorit, Bi=Bitownit, Or=Ortoklas, Sa=Sanidin, Hh=Green horblende, Au=Augit, Hi=Hiperstin, Tu=Turmalin, Ad=Andalusit, sp=sporadic.

Table 4. Result of chemical analysis

| Pedon | Depth (cm) | pH | Organic carbon | HCl 25% | | Cation Exchange Rate (NH4-Acetat 1N, pH7) | | | | | | | | KCl 1N | | Saturation | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| H2O | P2O5 | K2O | Ca | Mg | K | Na | Total | CEC of soil | CEC of clay | Effective CEC | Al 3+ | H + | Base | Al |
|  | % | mg/100g | | cmolc/kg | | | | |  |  |  | cmolc/kg | | % | |
| P1 | 0-19 | 5,4 | 1,65 | 61 | 5 | 6,82 | 5,57 | 0,09 | 0,24 | 12,72 | 23,18 | - | 13,33 | 0,61 | 0,17 | 54,87 | 4,58 |
|  | 19-46 | 5,5 | 0,55 | 50 | 4 | 6,84 | 6,17 | 0,07 | 0,30 | 13,38 | 23,32 | - | 13,47 | 0,09 | 0,17 | 57,38 | 0,67 |
|  | 46-74 | 6,0 | 0,36 | 78 | 2 | 3,95 | 2,33 | 0,03 | 0,08 | 6,39 | 8,70 | - |  | - | 0,06 | 73,45 | - |
|  | 74-120 | 6,2 | 0,18 | 79 | 3 | 3,85 | 2,22 | 0,04 | 0,05 | 6,16 | 7,49 | - |  | - | 0,04 | 82,24 | - |
| P2 | 0-19 | 4,7 | 2,66 | 28 | 10 | 3,18 | 1,06 | 0,20 | 0,11 | 4,55 | 17,93 | - | 7,31 | 2,76 | 0,37 | 25 | 37,76 |
|  | 19-42 | 4,5 | 1,22 | 20 | 7 | 2,44 | 1,58 | 0,13 | 0,05 | 4,2 | 15,75 | - | 7,58 | 3,38 | 0,33 | 27 | 44,59 |
|  | 42-90 | 4,7 | 0,57 | 15 | 10 | 2,16 | 1,42 | 0,19 | 0,08 | 3,85 | 15,29 | - | 7,48 | 3,63 | 0,36 | 25 | 48,53 |
|  | 90-120 | 4,6 | 0,51 | 19 | 6 | 2,82 | 1,32 | 0,11 | 0,05 | 4,3 | 15,88 | - | 7,97 | 3,67 | 0,45 | 27 | 46,05 |
| P3 | 0–15 | 4,4 | 2,45 | 226 | 7 | 2,04 | 0,57 | 0,13 | 0,03 | 2,77 | 19 | 39 | 4,17 | 1,40 | 0,18 | 14 | 33,58 |
|  | 15–50 | 4,5 | 1,74 | 135 | 5 | 1,85 | 0,43 | 0,10 | 0,10 | 2,48 | 17 | 39 | 3,57 | 1,09 | 0,20 | 15 | 30,48 |
|  | 50–80 | 5,1 | 1,41 | 117 | 7 | 2,36 | 0,67 | 0,14 | 0,06 | 3,23 | 18 | 32 | 3,61 | 0,38 | 0,17 | 18 | 10,65 |
|  | 80–120 | 5,3 | 1,07 | 97 | 10 | 3,20 | 0,75 | 0,19 | 0,07 | 4,21 | 18 | 31 | 4,39 | 0,18 | 0,18 | 24 | 4,13 |
| P4 | 0 –30 | 4,3 | 5,32 | 151 | 5 | 0,76 | 0,33 | 0,08 | 0,06 | 1,23 | 22,22 | 46 | 2,17 | 0,94 | 0,18 | 6 | 43,19 |
|  | 30-55 | 4,7 | 4,40 | 131 | 4 | 0,68 | 0,26 | 0,05 | 0,03 | 1,02 | 19,06 | 43 | 1,07 | 0,05 | 0,19 | 5 | 4,34 |
|  | 55-85 | 4,9 | 4,12 | 111 | 5 | 0,62 | 0,27 | 0,06 | 0,04 | 0,99 | 18,11 | 45 | 1,08 | 0,09 | 0,18 | 5 | 8,20 |
|  | 85-120 | 4,9 | 3,46 | 124 | 3 | 0,67 | 0,26 | 0,03 | 0,04 | 1,00 | 22,15 | 54 | 1,04 | 0,04 | 0,14 | 5 | 4,28 |
|  | 120-150 | 4,9 | 3,23 | 146 | 5 | 1,05 | 0,41 | 0,06 | 0,22 | 1,74 | 24,24 | 121 | 1,79 | 0,05 | 0,12 | 7 | 2,79 |
| P5 | 0-15 | 6 | 0,65 | 146 | 29 | 7,03 | 1,36 | 0,58 | 0,19 | 9,26 | 16,71 | - |  | - | - | 55 | - |
|  | 15-45 | 5,9 | 0,42 | 161 | 9 | 4,21 | 1,78 | 0,18 | 0,07 | 4,29 | 9,7 | - |  | - | - | 44 | - |
|  | 45-80 | 5,8 | 0,18 | 123 | 15 | 3,15 | 1,51 | 0,29 | 0,1 | 4,11 | 10,37 | - |  | - | - | 40 | - |
|  | 80-120 | 5,7 | 0,92 | 170 | 18 | 4,23 | 1,9 | 0,35 | 0,06 | 5,64 | 11,03 | - |  | - | - | 51 | - |
| P6 | 0-23 | 5,2 | 1,64 | 42 | 5 | 5,3 | 1,31 | 0,09 | 0,18 | 6,88 | 17,03 | - | 6,93 | 0,05 | 0,05 | 40 | 0,72 |
|  | 23-53 | 5,3 | 0,78 | 25 | 8 | 6,75 | 2,7 | 0,14 | 0,26 | 9,85 | 16,25 | - | 9,89 | 0,04 | 0,09 | 61 | 0,40 |
|  | 53-120 | 5,1 | 0,38 | 19 | 14 | 3,86 | 1,29 | 0,26 | 0,29 | 5,7 | 13,78 | - | 6,10 | 0,4 | 0,17 | 41 | 6,56 |

**Soil Chemical Characteristics**

The content of organic matter is indicator of soil fertility (Susanto, 2005). C-organic soil is generally high at the depth of 0-30 cm and decreases at the depth of >30 cm. In P5, C-organic at the depth of 80-120 cm was higher than the surface. The irregular decline was suspected due to post eruption sedimentation (Hikmatullah, 2010).

Cation exchange rate (Ca, Mg, K, Na) varied in all pedons. The content of Mg in P3 and P4 were very low to low (0.41-0.75 mg/100 gr), while in P1, P2, P5, and P6 were moderate to high (1.06-6.17 mg/100 gr). The high content of Mg was suspected to be obtained from plagioclase and pyroxene (Hikmatullah, 2010).

Cation exchange capacity (CEC) of all pedons were moderate (16,71-24,24 cmolc/kg). The CEC value were generally decreased in the lower layer, as in P1 and P5 the underlying layer had low CEC (7.49-9.7 cmolc/kg). Soils with moderate to high organic matter have higher CEC than soil with low organic matter (Suriadiakarta et al. 2002, Sufardi et al 2017). Therefore the low CEC value in the underlying layer was because the content of organic matter decreased along with the depth of the soil.

***Soil Classification***

Soil classification was based on morphological, physical, and chemical analysis of soil. The epipedone of the soil observed was Ochric and Umbric. Soil categorized as Ochric because it has bright colors, value and croma ≥3 (P1 and P2) and depth of <18 cm (P3 and P5), so that they do not fulfill the criteria of epipedon mollic and umbric. While P4 and P6 were categorized as umbric because they have values ​​and croma <3 and base saturation <50% so that they do not fulfill the criteria of epipedon mollic. The subsurface horizons in all pedons were Cambic because they have undergone structural development without clay illuviation process. All pedon orders were included in Inceptisols.

At the level of suborders all pedons were included in the udepts suborders, except P5 was included in aquepts. The aquepts regime in P5 due to land use in the form of rice fields. P1 belonged to the great groups of eutrudepts because it has base saturation of ≥60% at depth of 25-75 cm. P2 and P3 belonged to dytrudepts due to their soil features do not fulfill other udepts. Humudepts were udepts that have umbric epipedones so that P4 and P5 belonged to the humudepts. Epiaquepts showed that P5 have episaturation.

At the level of subgroups, typic subgroups shows pedon characteristics do not meet criteria on other subgroups. Andic subgroups shows the presence of an 18 cm thickness in 75 cm mineral soil surface. Eutric signify humudepts which have base saturation of 50% or more in half/more than the total thickness between 25-75 cm from the soil surface.

1. **Conclusion**

From the overall characteristics, it expressed that all pedons were still in the development stage.

**References**

Bali, I., Ahmad A., Lopulisa C. 2018. Identifikasi Mineral Pembawa Hara untuk Menilai Potensi Kesuburan Tanah. Jurnal Ecosolum 1 (2), 81-100.

Hilmatullah. 2010. Sifat-Sifat Tanah yang Berkembang dari Bahan Volkan di Halmahera Barat, Maluku Utara. Jurnl Ilmu-Ilmu Pertanian Indonesia 12 (1), 40-48.

Khusrizal, Basyaruddin, Mulyanto, B., Rauf, A. 2012. Karakteristik Mineralogi Tanah Pesisir Pantai Aceh Utara yang Terpengaruh Tsunami. Bionatura-Jurnal Ilmu-ilmu Hayati dan Fisik 14 (1), 12-21.

Lopulisa, C. 2004. Tanah-Tanah Utama Dunia. Ciri, Genesa dan Klasifikasinya.nLembaga Penerbitan Universitas Nasanuddin. Makassar.

Pairunan, A. K., Nanere J.L., Arifin, Samosir S.S.R., Tangkaisari R., Lalopua J.R., Ibrahim B., Asmadi H., 1987. Dasar-Dasar Ilmu Tanah. Badan Kerjasama Perguruan Tinggi Indonesia Bagian Timur.

Rahayu, A., Utami S.R., Rayes M.L. 2014. Karakteristik dan Klasifikasi Tanah pada Lahan Kering yang Disawahkan di Kecamatan Perak, Kabupaten Jombang. Jurnal Tanah dan Summberdaya Lahan 1 (2), 79-87.

Rajamuddin, U.A. dan Sanusi I. 2014. Karakteristik Morfologi dan Klasifikasi Tanah Inceptisol pada Beberapa Sistem Lahan di Kabupaten Jeneponto Sulawesi Selatan. Jurnal Agroland 21 (2), 81-85.

Soil Survey Staff. 2014. Keys to Soil Taxonomy. 12th edition. United States Departement of Agriculture. New York.

Subagyo, H., Suharta N., Siswanto A.B. 2000. Tanah-tanah Pertanian di Indonesia dalam Buku Sumber Daya Lahan Indonesia dan Pengelolaannya. Pusat Penelitian dan Agroklimat. ISBN:979-9474-04-3. Halaman 21-65.

Sufardi, Martunis L., Muyassir. 2017. Pertukaran Kation pada Beberapa Jenis Tanah di Lahan Kering Kabupaten Aceh Besar Provinsi Aceh (Indonesia). Prosiding Seminar Nasional Pascasarjana Unsyiah 13 April 2017. Banda Aceh, Indonesia.

Suharta, N. 2007. Sifat dan Karakteristik Tanah dari Batuan Sedimen Masam di Provinsi Kalimantan Barat serta Implikasinya terhadap Pengelolaan Lahan. Jurnal Tanah dan Iklim 25, 11-26.