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Morphological characteristics and classification of inceptisol in Mamuju reGENCY, West Sulawesi

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Abstract. Soil morphology provide overview the evolution in the soil body through description and interpretation of soil profile properties as initial information in classifying soil. The research purpose is to determine the morphological characteristics and soil classification of Inceptisols in four study profiles: Kalonding, Batu Papan, Pepalang and Batu Ampat, in Mamuju reGENCY, West Sulawesi. The research method used is descriptive qualitative exploration by survey in the field and soil analysis in the laboratory. The results showed that the dominant texture was clay in all soil profiles with a low silt / clay ratio. This was related to the high intensity of weathering due to high rainfall and easily weathered host rock and relatively high content of resistant minerals. Other chemical properties such as pH, N-total, cation exchange capacity, base saturation, exchangeable bases (Ca, Mg, K, Na) and P-available are generally low with a relatively constant distribution pattern with increasing depth. Soils are classified into the order of inceptisols in all soil profiles because they have a cambic sub-horizon resulting from physical alteration, chemical transformation or a combination of these processes. The hicks humidity regime so that the sub-order category is named udepts. The temperature regime includes Isohiphthermic so that it is categorized into the Great Group Dystrudepts and the Typic Dystrudepts sub-group for the Study Profile of Batu Papan, Pepalang and Batu Ampat, while for the Profile of the Kalonding study is Lithic Dystrudepts.

1. Introduction

Soil is formed and developed from natural processes, the differentiation of the soil profile forms horizons and there are striking differences between the characteristics of the parent material and the formed soil horizons, especially in terms of morphology, chemistry, physics and biology. Soil is formed from materials in the form of mineral and organic materials, water and air are arranged in the room which forms the body of the soil.

Soil morphology is soil properties that can be observed and studied directly in the field [1]. Soil morphology can provide an overview of changes or evolution that occur in the soil body through descriptions and interpretations of soil properties that can be used as initial information in classifying soil.

Soil taxonomy by USDA is used to classify soils based on the similarity and similarity of soil properties from the Order category to the important family for agriculture in detail. Inceptisol is a young



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soil and is starting to develop. Horizon formation in the profile is rather slow as a result of alteration of the parent material. The horizons did not show the results of extreme destruction. Utilization of Inceptisol in Indonesia can still be developed with appropriate cultivation techniques to obtain maximum productivity [2].

2. Materials and methods

The research was conducted in Papalang District, Mamuju Regency, West Sulawesi Province. The research location was conducted in 4 villages with different toposequen, namely Kalonding village (S: 02° 20' 27.3"; E: 119° 15' 32.8 "), Batu Papan village (S: 02° 25' 55"; E: 119° 09' 37.8"), Pepalang village (S: 02° 25' 54.3"; E: 119° 10' 18") and Batu Ampat village (S: 02° 26' 2.2"; E: 119° 11' 1.5").

The materials used are (1) intact and disturbed soil samples taken from each layer for analysis of soil physical and chemical properties (2) Primary data and secondary data. Primary data obtained from field observations include information around the research location in the form of soil and soil profile descriptions, while secondary data is data related to the object of research from related agencies, in the form of satellite imagery of Mamuju Regency at a scale of 1: 175,000, land cover maps at a scale of 1: 500,000, Indonesian earth map sheet Mamuju Regency scale 1: 500,000, Land system map scale 1: 250,000, Slope map scale 1: 500,000, Land cover map scale 1: 500,000, Mamuju Regency land map scale 1: 500,000, District Forest Area Map Mamuju scale 1: 500,000.

The research method is descriptive qualitative exploratory carried out by surveying in the field and describing the soil profile and conducting field and laboratory analysis, so that the existing data will be analyzed and interpreted to find relationships and describe the conditions that are the research objectives.

Soil profiling at each research location is based on the similarity of dominant soil properties in each land system. Soil observations are carried out by making a cross section of the soil profile measuring 2 m x 1.5 m or to obtain the ground water level or parent material. Morphological observations on each profile include solum thickness, layer boundaries, color, texture, structure, effective depth, consistency and so on for each layer. Analysis of physical properties includes texture, bulk density, porosity, permeability, silt and clay ratio. Analysis of soil chemical properties includes cation exchange capacity, soil reaction (pH), organic matter, base saturation, exchangeable bases (Ca, Mg, K and Na), N-Total and P₂O₅. Soil classification using the soil taxonomy system by the USDA in 2010 from the Order category to the Sub Group.

3. Results and discussion

3.1. General description of research location

Papalang District is located at the position of 02° 25' 21" South Latitude and 119° 09' 73" East Longitude with an elevation of 0-100 masl and has an area of 160.43 km² and about 2% of the total area of Mamuju Regency.

The dominant rock or mineral types found in the study area are Andesite and Basalt. The main mineral that forms Andesite rocks is plagioclase, which produces rich and fertile soil, because it is composed of alkaline elements that are easily weathered. Several types of minerals and Andesite rocks, namely, pyroxin, biotite and amphibole biotite. Basalt is a base rock, with mainly plagioclase and augite minerals and additional minerals hornblende, olivine and biotite. Basalt is a rock that is rich in elements of Ca, Fe, and Mg [3]. The forms of land cover in Papalang District include secondary forest, plantations, dry land agriculture, mixed dry land farming, swamps, rice fields and ponds. The forms of land cover in Papalang district include secondary forest, plantations, dryland agriculture, mixed dryland farming, swamps, rice fields and ponds (figure 1).

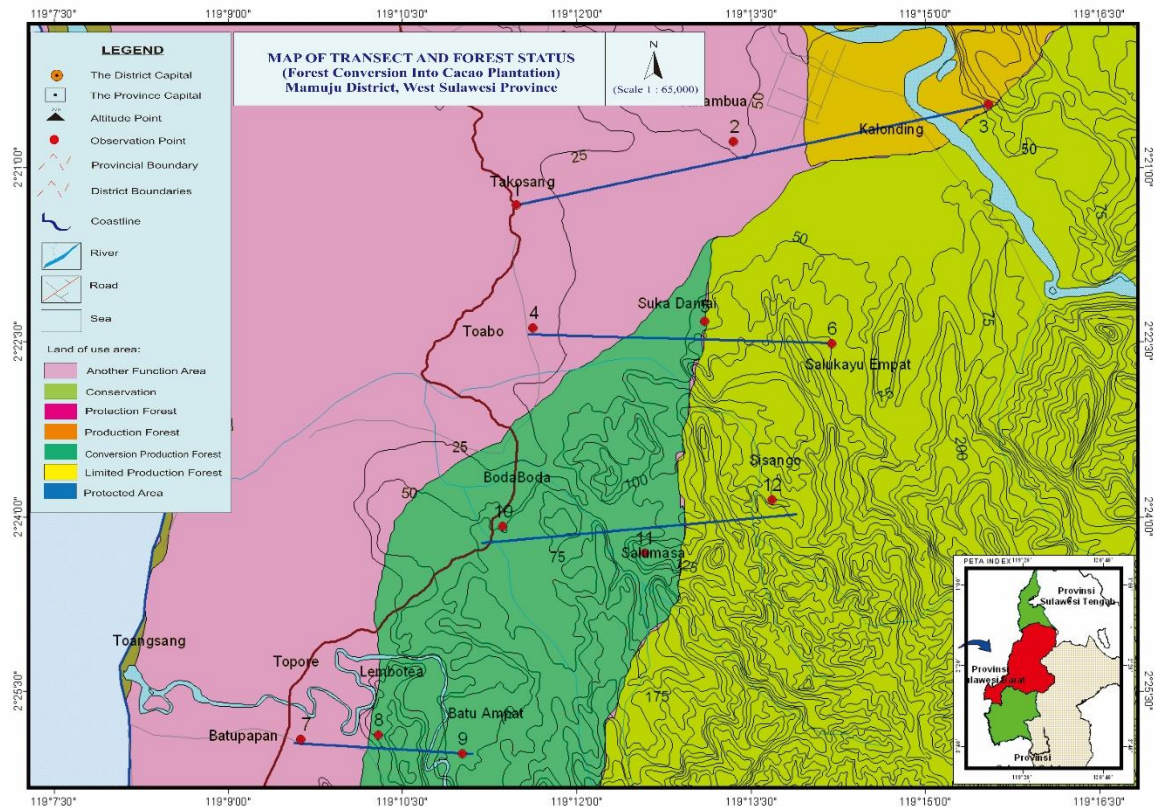


Figure 1. The map of transect and forest status.

3.2. Morphological description of the research profile

3.2.1. Profile of Batu papan village. The Batu Papan profile is located at an elevation of 7 masl with a slope of 3% with an East-West exposition at the foot of the slope. The dominant vegetation is grass, cocoa, banana, rambutan, langsung, durian, coconut and mango. Surface drainage is good and inside is bad. Effective depth of 93 cm with medium-large micro pores in all soil layers (table 1).

Table 1. Description of soil morphology in Batu Papan village.

Layer of soil	Depth (cm)	Description
1	0-12.5	Clay texture; angular lump structure; slightly sticky consistency; color 10 YR 7/6 (brown); diffuse horizon boundary.
2	12.5-37.5	Clay texture; angular lump structure; slightly sticky consistency; color 10 YR 4/3 (brown); clear horizon boundary.
3	37.5-50	Clay texture; angular lump structure; slightly sticky consistency; color 10YR 4/4 (brown); diffuse horizon boundary.
4	50-62.5	Clay texture; angular lump structure; sticky consistency with color 10 YR 4/4 (brown); diffuse horizon boundary.
5	62.5-87.5	Clay texture; angular lump structure; sticky consistency; color 2.5 Y 5/4 (yellow); diffuse horizon boundary.

6	87.5-112.5	Clay texture; angular lump structure; sticky consistency; color 10 YR 5/4 (brown); diffuse horizon boundary.
7	>112.5	Clay texture; angular lump structure; slightly sticky consistency; color 10YR 5/4 (brown); diffuse horizon boundary.

3.2.2. Profile of Pepalang village. Pepalang profile is located about 17 masl with a slope of 15% and a North-South exposition in the middle of the slope. The dominant vegetation is grass, cocoa, banana, rambutan, langsung, durian, coconut and mango. Surface drainage is good and inside is bad. Effective depth 95 cm with medium-large number of micro pores in all soil layers (table 2).

Table 2. Description of soil morphology in Pepalang village.

Layer of soil	Depth (cm)	Description
1	0-12.5	Clay texture; angular lump structure; slightly sticky consistency; color 10 YR 4/4 (brown); diffuse horizon boundary.
2	12.5-37.5	Clay texture; angular lump structure; slightly sticky consistency; color 10 YR 5/3 (brown); diffuse horizon boundary.
3	37.5-50	Clay texture; angular lump structure; slightly sticky consistency; color 10YR 4/2 (brown); clear horizon boundary.
4	50-62.5	Clay texture; angular lump structure; sticky consistency; color 10 YR 5/4 (brown); diffuse horizon boundary.
5	62.5-87.5	Clay texture; angular lump structure; sticky consistency; color 2.5 Y 4/3 (yellow); diffuse horizon boundary.
6	87.5-112.5	Clay texture; angular lump structure; sticky consistency; color 10 YR 5/4 (brown); diffuse horizon boundary.
7	>112.5	Clay texture; angular lump structure; slightly sticky consistency; color 10YR 4/6 (brown); diffuse horizon boundary.

3.2.3. Profile of Batu ampat village. The Batu Ampat profile is located about 36 masl with a slope of 40% and a West - East exposition. Located on the upper slope slopes. The dominant vegetation is grass, cacao, banana, rambutan, palm sugar and corn. Generally good surface and inside drainage. Effective depth 135 cm with a moderate number of micro pores - a lot in all soil layers (table 3).

Table 3. Description of soil morphology in Batu ampat village.

Layer of soil	Depth (cm)	Description
1	0-12.5	Clay texture; angular lump structure; slightly sticky consistency; color 10 YR 3/2 (brown); diffuse horizon boundary
2	12.5-37.5	Clay texture; angular lump structure; slightly sticky consistency; color 2.5 YR 4/2 (brown); horizon boundary incrementally
3	37.5-50	Clay texture; angular lump structure; slightly sticky consistency; color 2.5 YR 6/4 (brown) ;, diffuse horizon boundaries
4	50-62.5	Clay texture; angular lump structure; sticky consistency; color 10 YR 5/4 (brown); diffuse horizon boundary

5	62.5-87.5	Clay texture; angular lump structure; sticky consistency; color 2.5 YR 5/4 (brown); diffuse horizon boundary
6	87.5-112.5	Clay texture; angular lump structure; sticky consistency with color 10 YR 5/3 (brown); diffuse horizon boundary
7	>112.5	Clay texture; angular lump structure; slightly sticky consistency; color 10YR 5/3 (brown); diffuse horizon boundary

3.2.4. Profile of Kalonding village. Kalonding forest profile is located about 75 masl with a slope of 15% with a North-South exposition at the top of the slope. The dominant vegetation is secondary forest, specifically palapi wood, banana, rattan, blue tree and durian. Drainage on the surface and inside is generally good and inside is bad. Effective depth of 40 cm with medium-large micro pores in all soil layers (table 4).

Table 4. Description of soil morphology in Kalonding village.

Layer of soil	Depth (cm)	Description
1	0-12.5	Clay texture; angular lump structure; slightly sticky consistency; color 10 YR 3/4 (brown); diffuse horizon boundary.
2	12.5-35	Clay texture; angular lump structure; slightly sticky consistency; color 10 YR 3/4 (brown); diffuse horizon boundary.
3	>35	Clay texture, angular lump structure; slightly sticky consistency; color 10YR 4/4 (brown); diffuse horizon boundary.

3.3. Soil physical properties

Data from the analysis of soil physical properties can be seen in table 5.

Table 5. Analysis of soil physical properties at the research location.

No	Profil code	Villages	Bulk density (gr/cm ₃)	Porosity (%)	permeability (cm/jam)	Clay (%)	Silt (%)	Sand (%)	Texture	Silt/clay ratio
1	P1T3	Batu papan (0 cm)	1.22	53.61	1.34	63	26	11	Clay	0.41
2	P1T3	Batu Papan (12.5cm)	1.24	52.67	1.35	43	21	36	Clay	0.49
3	P1T3	Batu papan (37.5 cm)	1.28	51.33	1.33	44	22	34	Clay	0.50
4	P1T3	Batu Papan (50 cm)	1.3	50.19	1.32	52	35	13	Clay	0.67
5	P1T3	Batu Papan (62.5 cm)	1.33	49.24	1.33	51	36	13	Clay	0.71
6	P1T3	Batu Papan (87.5 cm)	1.43	45.42	1.32	46	16	38	Clay	0.35
7	P1T3	Batu Papan (112.5 cm)	1.5	42.96	1.32	45	17	38	Clay	0.38
8	P2T3	Pepalang (0 cm)	1.25	52.65	1.31	49	19	32	Clay	0.39
9	P2T3	Pepalang (12.5 cm)	1.27	51.71	1.23	50	19	31	Clay	0.38
10	P2T3	Pepalang (37.5 cm)	1.25	52.47	1.24	48	20	32	Clay	0.42
11	P2T3	Pepalang (50 cm)	1.25	52.47	1.25	52	29	19	Clay	0.56
12	P2T3	Pepalang (62.5 cm)	1.27	51.53	1.24	45	49	6	silt clay	1.09
13	P2T3	Pepalang (87.5 cm)	1.25	52.65	1.23	52	39	9	Clay	0.75
14	P2T3	Pepalang (112.5 cm)	1.21	54.51	1.24	50	39	11	Clay	0.78

15	P3T3	Batuampat (0 cm)	1.35	48.30	1.23	62	26	12	Clay	0.42
16	P3T3	Batuampat (12.5 cm)	1.37	48.30	1.24	60	25	15	Clay	0.42
17	P3T3	Batuampat (37.5 cm)	1.35	48.67	1.21	52	28	20	Clay	0.54
18	P3T3	Batuampat(50 cm)	1.45	44.65	1.22	45	32	23	Clay	0.71
19	P3T3	Batuampat (62.5 cm)	1.5	42.53	1.23	42	28	30	Clay	0.67
20	P3T3	Batuampat (87.5 cm)	1.46	44.06	1.24	43	26	31	Clay	0.60
21	P3T3	Batuampat (112.5 cm)	1.47	43.89	1.24	24	32	44	Loam	1.33
22	P3T1	Kalonding (0 cm)	1.40	50.00	1.77	62	20	18	Clay	0.32
23	P3T1	Kalonding (12.5 cm)	1.40	50.00	1.76	60	21	19	Clay	0.35
24	P3T1	Kalonding (35 cm)	1.43	45.00	0.80	56	19	25	Clay	0.34

Based on the table above, it can be seen that the texture in the research profile is dominated by clay and a low silt / clay ratio. This is related to the high intensity of weathering due to high rainfall and easily weathered source rock and the relatively high content of resistant minerals. The pattern of distribution of clay with a depth that is generally relatively constant or slightly reduced is basically related to the loss of all or part of the A horizon from the study profile. Naturally, horizon A generally has a clay content that is relatively lower than horizon B. The pore distribution pattern according to depth which is in line with the clay distribution indicates no clay accumulation in horizon B due to the absence of a clear dry period in the study area.

3.4. Soil chemical properties

Data from the analysis of soil physical properties can be seen in table 6.

Table 6. Analysis of soil chemical properties at the research location.

No	Profiles code	Villages	pH H ₂ O	pH KCl	C-Organic (%)	N (%)	P ₂ O ₅ (ppm)	Cation exchange capacity (cmol/kg)	exchangeable bases (cmol/kg)				Base saturation (%)
									Ca	Mg	K	Na	
1	P1T3	Batu Papan (0 cm)	4.91	3.36	2.10	0.22	15.42(B)	22.65	2.71	2.16	0.28	0.16	23.44
2	P1T3	Batu Papan (12.5)cm	4.71	3.22	1.46	0.17	15.28(B)	21.15	2.58	1.69	0.13	0.13	21.42
3	P1T3	Batu Papan (37.5 cm)	4.65	3.23	1.45	0.17	15.25(B)	21.1	2.56	1.67	0.13	0.13	21.28
4	P1T3	Batu Papan (50 cm)	4.52	3.22	1.38	0.21	15.12(B)	21.85	1.95	1.40	0.28	0.13	17.21
5	P1T3	Batu Papan (62.5 cm)	4.51	3.21	1.37	0.20	15.10(B)	21.75	1.94	1.40	0.27	0.13	17.19
6	P1T3	Batu Papan (87.5 cm)	4.54	3.04	1.98	0.15	15.70(B)	21.69	2.64	0.96	0.09	0.13	17.61
7	P1T3	B. Papan (112.5 cm)	4.52	3.02	1.96	0.14	15/65(B)	21.65	2.60	0.85	0.05	0.11	16.67
8	P2T3	Pepalang (0 cm)	4.64	3.59	1.52	0.20	15.42(B)	23.65	2.60	2.05	0.32	0.11	21.47
9	P2T3	Pepalang (12.5 cm)	4.64	3.56	1.51	0.20	15.40(B)	23.64	2.59	2.04	0.32	0.11	21.4
10	P2T3	Pepalang (37.5 cm)	4.59	3.53	1.50	0.19	15.39(B)	23.6	2.58	2.03	0.3	0.1	21.23
11	P2T3	Pepalang (50 cm)	4.61	3.56	0.78	0.11	15.24(B)	22.65	2.04	1.49	0.25	0.11	17.17

12	P2T3	Pepalang (62.5 cm)	4.70	3.22	2.07	0.20	14.00(B)	19.36	2.58	0.98	0.16	0.13	19.89
13	P2T3	Pepalang (87.5 cm)	4.86	3.35	1.63	0.15	14.35(B)	19.21	2.65	1.36	0.12	0.2	22.54
14	P2T3	Pepalang (112.5 cm)	4.7	3.33	1.62	0.14	14.35(B)	19.2	2.63	1.34	0.12	0.2	22.34
15	P3T3	Batu Ampat (0 cm)	5.35	4.76	1.33	0.16	15.00(B)	24.62	3.58	3.03	0.42	0.22	29.45
16	P3T3	Batu Ampat (12.5 cm)	5.25	4.75	1.32	0.15	14.96(B)	24.6	3.57	3.02	0.41	0.22	29.35
17	P3T3	Batu Ampat (37.5 cm)	5.21	4.73	1.31	0.14	14.87(B)	24.4	3.54	3.02	0.39	0.21	29.34
18	P3T3	Batu Ampat(50 cm)	5.03	4.03	1.33	0.14	14.78(B)	22.45	2.60	2.05	0.32	0.12	22.67
19	P3T3	Batu Ampat (62.5 cm)	4.66	3.66	1.33	0.15	12.87	19.36	2.61	0.87	0.12	0.16	19.42
20	P3T3	Batu Ampat (87.5 cm)	4.60	3.78	1.32	0.14	12.86	19.34	2.60	0.86	0.12	0.15	19.29
21	P3T3	Batu Ampat (112.5 cm)	5.16	4.43	2.21	0.20	14.98	20.45	2.54	1.54	0.14	0.09	21.07
22	P3T1	Kalonding (0 cm)	4.73	3.57	1.39	0.20	15.6 (B)	24.65	3.28	2.73	0.23	0.16	25.96
23	P3T1I	Kalonding (12.5 cm)	4.70	3.55	1.35	0.19	15.45(B)	23.43	3.25	2.68	0.22	0.15	26.89
24	P3T2I	Kalonding (35 cm)	4.65	3.54	0.76	0.17	15.42(B)	22.65	2.31	1.76	0.23	0.12	19.51

Based on the analysis of soil chemical properties, the pattern of pH distribution which tends to be the same according to depth gives an indication that in addition to the high rainfall factor as the cause of low soil pH through an intensive alkaline washing process [1, 4, 5] can also be caused by the influence of the acidic parent material [1].

The difference in the CEC at each profile at various depths is caused by differences in the distribution of clay content at various depths by soil genesis processes such as the translocation of clay from the eluviation horizon to the iluviation horizon and the transformation of silt into clay at these places. In addition, the fluctuating distribution of organic C according to depth also contributes to differences in soil CEC [6].

The variation in the base saturation of soil in each profile at various depths is caused by variations in the levels of exchangeable bases and CEC at various depths. It is indicated that this is influenced by the conversion of forest land for cocoa plantations. Perennial plants have deep roots, so the percentage of base saturation on the subsurface horizon tends to be lower than the surface horizon [7].

In general, the base saturation value of the soil profile at various depths was low based on the assessment criteria used by [8]. Variations in levels of Ca, Mg, Na, K can be swapped in each profile at various soil depths due to variations in the content of organic matter originating from the roots of decaying trees and the composition and level of weathering of the minerals in these places. The range of Ca on all profiles which is classified as low indicates that the cultivated plants have the potential to experience Ca deficiency.

The distribution pattern of N-total soil content shows a pattern that is not constant according to depth. This is in line with the soil organic-C distribution pattern which also changes according to soil depth. The main source of nitrogen in the soil for non-legume plants is organic matter because there are no soil minerals that contain nitrogen. The topsoil has a higher N value than the subsoil. This can occur because the topsoil is affected by the decomposition of organic matter from plant and animal remains [9]. in line with [10] stated that the soil organic C content decreases with increasing layer depth.

In general, the available P content (P_2O_5 Bray) is generally low with a relatively constant distribution pattern with increasing depth. This indicates that the study profile also experienced intensive washing due to high rainfall and even pore distribution with increasing soil depth.

3.5. Soil classification

The classification system used for soil grouping at the research location is the system [11]. The taxon arrangement starts from high taxon level to low taxon level in the following order: order, sub-order, great group and sub group. Soil classification is presented in table 7 dan figure 2.

Table 7. Classification of Inceptisols in Mamuju Regency.

No	Profiles Code	Villages	The Soil Classification			
			Order	Sub Order	Great Group	Sub Group
1	P1T3	Batu Papan S:02°25'55'' E:119°09'37.8''	Inceptisol	Udepts	Dystrudepts	Typic dystrudepts
2	P2T3	Pepalang S:02°25'54.3'' E:119°10'18''	Inceptisol	Udepts	Dystrudepts	Typic dystrudepts
3	P3T3	Batu Ampat S:02°26'2.2'' E:119°11'1.5''	Inceptisol	Udepts	Dystrudepts	Typic dystrudepts
4	P3T1	Kalonding S:02°20'27.3'' E:119°15'32.8''	Inceptisol	Udepts	Dystrudepts	Lithic dystrudepts

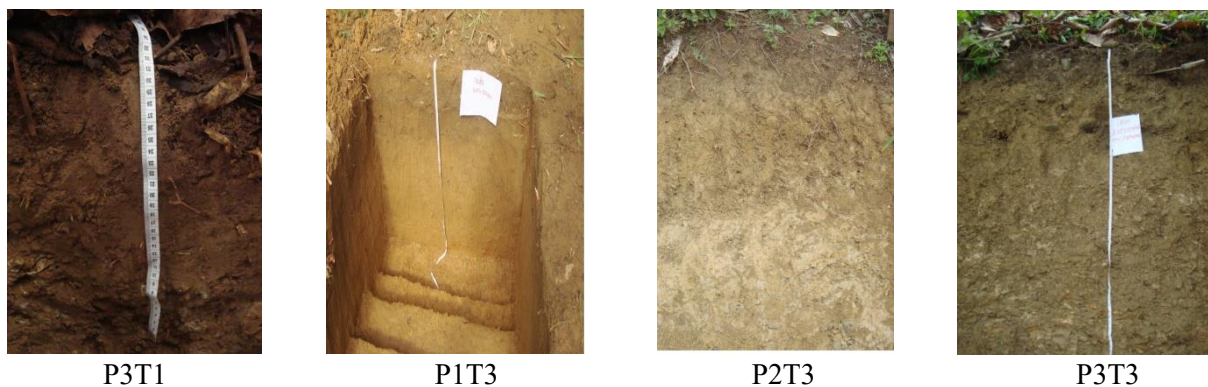


Figure 2. Section of Inceptisol profiles in Mamuju Regency.

Soil is classified as Inceptisol because it has a hick moisture regime and has an alteration horizon resulting from translocation of Fe, Al or alkaline. Most of the inceptisols have a cambic horizon and are non-brittle [12].

In the four study profiles, soil is classified into the order of inceptisols because it has a cambic sub-horizon resulting from physical alteration, chemical transformation or movement or a combination of these processes. The texture of the sand is very fine, sandy loam is very fine or finer and shows a rock structure of more than half the volume with the following properties: chroma and higher value, redder hue or higher clay than the lower horizon or above.

The hicks humidity regime so that the sub-order category is named udepts. Udepts is an Inceptisol which has a hicks moisture regime. Where the soil has never been dry for more than 90 days

(cumulative), has a three-phase system, namely solid-liquid-gas when the soil temperature is above 5 °C. Found in humid climates with an even distribution of rainfall or sufficient rainfall in the season hot. The temperature regime includes Isohithermics where the average annual soil temperature is 22 °C or higher.

The four study profiles, Udepts have no sulfuric horizon, duripan, fragipan and have no free carbonate in the soil and base saturation greater than or equal to 60% between 25 to 75 cm depth from the mineral soil surface so that they are categorized into Great Group Dystrudepts and sub The Typic Dystrudepts group for the Study Profile of Batu Papan, Pepalang and Batu Ampat, while for the Profile of the Kalonding study is Lithic Dystrudepts.

4. Conclusions

Based on the research results, it shows that most of the study profiles have lost all or part of the A horizon which is indicated by the relatively high chroma color which is basically the B horizon color. high intensity of weathering due to high rainfall and perilous source rock and relatively high content of resistant minerals. Other chemical properties such as pH, N-total, cation exchange capacity, base saturation, exchangeable bases (Ca, Mg, K, Na) and available P are generally low with a relatively constant distribution pattern with increasing depth.

In the four soil profiles, soil is classified into the order inceptisol because it has a cambic sub-horizon resulting from physical alteration, chemical transformation or movement or a combination of these processes. The hicks humidity regime so that the sub-order category is named udepts. The temperature regime includes Isohithermic where the average annual soil temperature is 22 °C or higher, so it is categorized into Great Group Dystrudepts and sub-group Typic Dystrudepts for Rock Board, Pepalang and Batu Ampat Study Profiles, while for Kalonding Study Profile is Lithic Dystrudepts.

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