The soil characteristics of landslide in Manuju District, Gowa Regency

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Abstract. Landslide in the Manuju District, Gowa Regency on January 23, 2019 had impact on material losses such as damage of residents' homes, cut off road access by the landslide, and 22 fatalities. The high rainfall at that time and hilly topography were the factors that triggered the landslide. This study aims to determine the characteristics of the soil in relation to landslides. This research was conducted by field observation of soil characteristics in the landslide area and soil test in the laboratory, namely; textures, C-Organic, and permeability with SPAW method, grain size distribution using ASTM, and shapes grain of soil fraction with the Norbury method. The soil was 20-25 cm depth, granular soil structure, friable consistency, texture dominated by sand, low C-Organic content, moderate hydraulic conductivity, the grain size was subangular. Soil characteristics at the study site showed characteristics that are susceptible to landslides.

1. Introduction
Landslides are a problem that often occurs in areas with hilly topography, with high rainfalls [1]. The occurrence of landslides not only provides material losses but also results in a decrease in land quality [2]. Landslide events can be interpreted as the transfer of soil or rock material with a large volume of mass through the sliding plane on a slope caused by gravity [3].

In principle, landslides occur because the pressure or force on the slope is greater than the ability to withstand the pressure. The ability to withstand soil pressure will be strongly influenced by rock strength and soil density, while pressure is strongly influenced by the magnitude of the slope angle, water, load, and soil density [4].

Gowa Regency is one regency in South Sulawesi province, which has landslides every year, Manuju District is one of the areas affected by a severe landslide disaster on January 23rd, 2019 [5]. This landslide has caused material losses and fatalities. Landslides also result in a reduction of land productivity due to the accumulation of top soil by landslide material, thus the land experiences land degradation resulting in the emergence of critical land [2]. According to [6], landslides will decrease physical and chemicals of soil, namely; low nutrient content, low organic matter, poor infiltration capacity, low capacity to store water, increased density, and soil penetration resistance.

Landslides that occur are strongly influenced by the weak cohesion of the soil/rock so that the grains of soil/rock can be separated from the bonds and move down by dragging other grains that are around and form a larger mass. The weak binding capacity of the soil is strongly influenced by porosity and the ability of the soil to pass water (permeability) through the soil/rock [7]. Landslides
are also greatly affected by steep slopes, changes in soil moisture/rocks due to the entry of rain water, land cover, patterns of land management, erosion by surface water (run off), and human activities such as excavations [8,9]. The aim of this study is to find out the characteristics of the soil in relation to the landslide on January 23rd, 2019 in the Manuju District, Gowa Regency.

2. Methods
This research was conducted at the location of the landslide in the Manuju District, Gowa Regency. Soil analysis was carried out at the Soil Chemical and Fertility Laboratory, Department of Soil Science, Faculty of Agriculture, Hasanuddin University. This research was conducted from March to June 2019.

This research was conducted by direct observation and taking soil samples, landslide volume measurements were also carried out to predict the amount of landslide material that fell. Soil texture samples were analyzed by the hydrometer method, C-organic matter was analyzed using the Walkey and Black method, permeability using the SPAW-Soil Water Characteristics, grain size distribution using ASTM filters, and soil grain shape by referring to the classification by David Norbury, then describing their properties associated with supporting factors such as geological conditions, soil type, slope level, rainfall, and land use.

3. Results and discussion
The research location was the worst affected area of a landslide in the Manuju District, Gowa Regency on January 23rd, 2019. The research location shown in figure 1, the Landslide Point (LP) is located at coordinates (119°38'48.66 "BT, and 5°19'32.96" LS) and Comparison Point (CP) is at coordinates (119°38'05.10 "East, and 5°19'04.33" South East Coast). Landslides that occur in the Manuju sub-district are translational type landslides (with falling material in the form of rocks, and soil. The LP affected 22 people, 15 houses collapsed due to landslides, and road infrastructure was buried. Extent of area affected by landslides is around ± 3,137 ha with an area of material falling around 1,901 ha, material thickness falling on average 2 meters, and landslide material covering location were ± 38,020 m³.
The results of the study as shown in table 1, figure 2, and figure 3 shows the depth of the soil layer at the landslide location is very shallow, the comparative point is classified as shallow, granular soil structure shows the condition of the land that is open or more nest which results in the soil becoming more saturated with water, the consistency of loose soil shows soil slab that has a bond between the particles that are not strong, the texture of sandy loam and sandy clay gives a picture of the nature of the soil dominated by sand, low levels of C-Organic soils have little effect on the improvement of soil aggregates, soil hydraulic conductivity up to rather slowly describe the nature of the soil which tends to easily escape water that correlates to the binding strength of soil particles that are not too strong. Grain size distribution shows a uniform soil gradation with soil characteristics clustered at narrow intervals.

| Code | Horizon | Depth | Structure | Consistency | Texture           | Organic Carbon | Hydraulic Conductivity |
|------|---------|-------|-----------|-------------|------------------|----------------|----------------------|
| LP   | A       | 0 - 20 cm | Granular  | Friable     | Sandy loam       | 1.63           | 2.794 cm/hour        |
| CP   | A       | 0 - 20 cm | Granular  | Friable     | Sandy clay loam  | 1.45           | 0.8636 cm/hour       |
|      | B       | 20 - 35 cm | Granular  | Friable     | Sandy loam       | 1.67           | 0.0508 cm/hour       |

**Figure 2.** Gradation curve of particle size and shape in TL A

**Figure 3.** Particle: Sub Angular
The results of soil observations in the field indicate the nature of the soil that is vulnerable to landslides. The shallow soil solum, which is 20 cm, reaches the sliding plane is a factor that supports landslides because the soil will easily get saturated with high rainfall, so the soil cohesion is low. The granular soil structure in LP shows the condition of soil that is susceptible to landslides because soil particles tend not to be strong in binding with each other. Loose consistency of the soil also provides a resolution that does not have a strong ability to support the shape or in other words unhooked and moved downward by dragging other grains in place that are visible because of the greater mass.

Test results of soil properties in the laboratory also showed properties that supported landslides. The grain size distribution in the soil is dominated by 2 mm size with a uniform gradation pattern. With sub-angular dominated grain form. Hardiyatmo in Biringkanae [10] states that uniform gradation includes poor gradation. The better the soil gradation, the greater the holding force on the soil. Soil texture in the form of sandy clay including medium coarse-textured soil with a ratio of 68% sand fraction, 16% dust, and 16% makes the soil tends to easily absorb water. The sand fraction that dominates in soil hydraulic conductivity is classified as medium so that water is very easy to enter and quickly fills pore spaces in soil conditions with moderate permeability which tends to have low cohesive properties. C-organic in soil which is expected to be able to improve aggregate and soil properties is also not able to contribute more, this is due to the low percentage of soil which is 1.67%.

Soil characteristics that support landslides if associated with conditions at LP sites with steep slope rates, with extreme rainfall the day before the landslides that reach 364 mm / day as the main causes of landslides, This can be seen in figure 4 on the chart of rainfall comparison in January 2018 where there was no landslide and January 2019 occurred landslides. Effect of water on the slope where the higher the slope, the faster the critical condition is reached (landslide prone conditions) [1,11]. Geological conditions with rock formations formed from volcanic formation activities, namely Baturape-Cindako Volcanic Rock, aged Pliocene-Plistosen. Chalid [12] stated that the Baturape-Cindako volcano rock conditions had not yet experienced a strong compacting making it vulnerable to landslides. The location’s vegetation is dominated by trees with shallow soil solum depth and steep slope, will be more supportive for landslides because vegetation will actually act as a burden. Supported by the opinion of Febryan [13], the condition of a very shallow soil solution on the slope will be easy to occur landslides because the roots of plants above it cannot withstand the material load.

**Figure 3.** Gradation curve of particle size and shape in CP A & CP B
Figure 4. Daily rainfall comparison data January 2018 and January 2019.

Comparison Point (CP) is a point used to see the difference between LP and the area with the same similarity but no landslides occur. In general, the characteristics of the soil in CP are not much different from TL, the depth of the shallow soil solum and consists of two layers namely layer A and B. Soil texture in each layer namely Layer A is Sandy Clay and Layer B Sandy which has a low cohesion ability can be seen from the criteria of the hydraulic conductivity of medium and rather slow categories. Vegetation that dominates in the form of weeds does not increase the burden when exposed to heavy rain. However, several factors support the occurrence of landslides so that TB is also an area prone to landslides.

4. Conclusions

a) Soil characteristics at Landslide Point (LP) and Comparison Point (CP) have soil characteristics with very shallow and shallow soil solum depth, granular soil structure, loose consistency, uniform soil gradation, soil texture dominated by sand (sandy loam, sandy clay loam, and (sandy clay), low C-Organic content, moderate hydraulic conductivity which is susceptible to landslides.

b) The landslide that occurred in District Manuju was triggered by extreme rainfall (very heavy) which reached 364 mm before the landslide, supported by steep slope with forest vegetation that did not have a compatibility with the depth of the soil solum.

References

[1] Ahmad A, Lopulisa C, Imran A M, and Baja S 2019 Rainfall erosivity in climate changes and the connection to landslide events IOP Conference Series: Earth and Environmental Science 280 012007)

[2] Ahmad A, Lopulisa, C, Imran A M, and Baja S 2018 Soil physicochemical properties to evaluate soil degradation under different land use types in a high rainfall tropical region: A case study from South Sulawesi, Indonesia IOP Conference Series: Earth and Environmental Science 157 012005.

[3] Bahadhorhi A M 2012 Pola sebaran titik longsor dan keterkaitannya dengan faktor-faktor biogeofisik lahan (studi kasus: Kabupaten Garut Jawa Barat) (Bogor: IPB University)

[4] Nandi, 2007 Longsor (Bandung: Geography Education Department FPIPS UPI).

[5] Tirto.id 2019 Pencarian korban tanah longsor di Gowa (Tirto.id. https://tirto.id/pencarian-
korban-tanah-longsor-di-gowa-dffJ in acces 15 February 2019).

[6] Prasetyawati C A, and Suryanto H 2012 Agroforestri pada lahan bekas tanah longsor di Kabupaten Gowa, Sulawesi Selatan (Makassar: Balai Penelitian Kehutanan) 1-13.

[7] Ahmad A, Poch R M, Lopulisa C, Imran A M, and Baja S 2018 Identification of soil characteristic on North Toraja landslide Indonesia J. of Eng. and App. Sci. (Asian Research Publishing Network (ARPN)) 13 8381-8385.

[8] Noor D 2011, Geologi Untuk Perencanaan (Yogyakarta: Graha Ilmu).

[9] Purbandini, Pratama R and Susmiandri 2019 Application of GIS for the mapping of landslide-vulnerable areas by through android-based Analytical Hierarchy Process (AHP) method in Bantul Regency IOP Conf. Ser. Earth Environ. Sci. 245 12008

[10] Biringkanae R D R 2016 Identifikasi Sifat Tanah Pada Kejadian Longsor Das Kalamisu Kabupaten Sinjai (Makassar: Hasanuddin University).

[11] Soenarmo S H, Sadisun I A, Endri Saptohartono E 2008 Kajian awal pengaruh intensitas curah hujan terhadap pendugaan potensi tanah longsor berbasis spasial di Kabupaten Bandung, Jawa Barat Jurnal Geoaplika 3 133 – 141.

[12] Chalid I 2014 Analisis Stabilitas Lereng Daerah Tabbingjai (Km 114 +460 M) Provinsi Sulawesi Selatan Jurnal Penelitian Geosains 10 25 – 31.

[13] Febryan A 2015 Tingkat bahaya longsor di lereng barat panorama puncak pato Kabupaten Tanah Datar. (Padang: University of Padang).