EROSION POTENTIAL BASED ON ERODIBILITY FACTORS IN CIMANGGUNG AND SURROUNDING REGION, SUMEDANG REGENCY, WEST JAVA, INDONESIA

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ABSTRACT

The research area around Gunung Geulis has been shifted from agricultural land into residential areas. This transformation eventually will affect the water infiltration process especially throughout the rainy season and can cause the intensity of the erosion rate to go higher. Soil erodibility is defined as the susceptibility of the soil to erosion, as the degree to which a soil is easily eroded or not. This research was conducted to determine the erodibility value in an area of ± 25 km2 which administratively belongs to the Districts of Cimanggung and Jatinangor, Sumedang Regency, West Java Province. The erodibility value can be calculated by the method introduced by Wischmeier and Smith (1978) and it is determined based on several parameters, namely texture of the soil, soil structure, permeability value, and organic (%C) content in a soil sample. The research data was obtained by engineering geological mapping of the distribution of surface soil, taking undisturbed soil samples using the hand auger method, and laboratory tests in the form of testing the physical properties of the soil. Then several laboratory tests are conducted to identify the physical properties of soil such as organic (%C) content analysis using Walkley and Black method, grain size analysis, hydrometer analysis, and permeability analysis using the falling head method. In the research area, the soil type is divided into two units, namely the Low Plasticity Silt Unit and the High Plasticity Silt Unit. Soil erodibility values around Gunung Geulis ranged from 0.118 to 0.514 0,1-ton acre hour/acre foot-ton inch which was included in the classification of a low, medium, moderately high, and high erodibility levels according to US customary dimensions.

Keywords: Erodibility, Erosion Potential, Geological Hazard, Soil Physical Properties

INTRODUCTION

Cimanggung Subdistrict and Jatinangor Subdistrict are densely populated areas located in Sumedang Regency. The population in Jatinangor District in 2011 was 105.414 people, then there was an increase in 2018 to 114.509 people. While the population in Cimanggung District in 2011 was 80,372 people to 83,714 in 2018 (Anonim, 2019). Along with the increasing number of residents in the Cimanggung area and its surroundings, the development and changes in land use around the slopes of Mount Geulis are also increasing. This causes the infrastructure development process to be irregular and land conservation is not a special concern.

The existence of a process of land-use change that does not take into account the surrounding conditions will certainly accelerate the degradation of land functions (Sulaksana et al., 2015). The degradation of the land function will also have an impact on the emergence of the erosion process in an area. In the next few years, the Cimanggung area and its surroundings are expected to be built more intensively. Uncontrolled erosion can result in phenomena in the form of critical land on sloping landforms, flooding in downstream river areas, silting of reservoirs and ports, and others (Haryanto (1994) in Sulaksana et al., 2015). Several erosion problems are also considered to be the cause of the flood disaster (Khoirullah and Sophian, 2018). Floods and landslides are examples of natural disasters that can occur due to a fairly intensive erosion process in an area.

The Cimanggung and Jatinangor areas as one of the buffer areas for the development of Sumedang Regency and also as an educational area are important reasons for proper soil management and conservation. One of the considerations in conducting land management and conservation is measuring the value of erodibility as a factor in determining the level of erosion hazard. Erosion is a natural process that occurs in nature but the process can be accelerated by human activities (Khoirullah et al., 2019). Therefore, this reason prompted the author to conduct this research in Cimanggung and Jatinangor Districts, Sumedang Regency, West Java Province with coordinates 107° 47' 6" - 107°

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49' 37.2" East Longitude and 6° 55' 4.8" - 6 57' 32.4" South Latitude and ± 25 km^2.

Figure 1. Research Area Map

RESEARCH METHOD

This research started with engineering geological mapping is intended to identify the surface condition of the soil. The object of this research is the soil resulting from weathering of volcanic rocks in the Cimanggung area and its surroundings, which are included in the MH and ML classifications based on the Unified Soil Classification Systems (USCS). Later on, in order to obtain the shallow subsurface characteristics of the soil, the hand auger or hand boring test is conducted. Determination of the point of undisturbed soil sampling is based on the distribution of lithology and type of surface soil in the study area.

The erodibility level of the soil is determined based on several parameters, namely texture of soil, soil structure, permeability value, and organic (%C) content in a soil sample. The calculation of the erodibility value shown as (Wischmeier et al., 1971)

$$K = [2.1M^{1.14}(10\text{-}4)(12-a)+3.25(b-2)+2.5(c-3)]/100$$

Where:

M: Percentage of very fine sand and silt multiplied by 100-percentage clay

a: Percentage of organic matter (% C organic x 1.724)

b: Soil structure index

c: Soil permeability class index

The K factor above is in US customary dimensions equal to 0,1-ton acre hour/acre foot-ton inch. The assessment of each parameter is obtained based on laboratory tests on samples that represent the soil from weathered rocks or called residual soil, the soil is obtained by the undisturbed sampling method. Then several laboratory tests are conducted such as organic (%C) content analysis, grain size analysis, hydrometer analysis, and permeability analysis. The M factor is determined from the percentage particle size, such as sand, silt, and clay. All of the particle percentage is obtained from the grain size analysis and hydrometer analysis. The "c" factor is obtained by permeability analysis using the falling head method. The "a" factor is obtained by organic (%C) content analysis using Walkley and Black method. While the "b" factor is collected by field observation.

RESULTS AND DISCUSSION

Geological Conditions

Based upon field observations through engineering geological mapping and descriptions, the lithology of the research area can be separated into three, specifically andesite, tuff, and volcanic breccias. Igneous rocks in the research area assumed from the megascopic analysis are intermediate igneous rocks with aphanitic grain sizes, namely andesite. In general, these rocks have a fresh color of blackish gray and have a weathered color of brownish gray. The color index of this rock is mesocratic with the percentage of mafic minerals 30%-90% with the granularity of this rock being aphanitic and the structure is massive. Megascopic mineral presence is amphibole and plagioclase. Andesite lithology has a distribution in the north-northeast of the study area and there are many areas of discontinuity.

Figure 2. Andesite Lithological Type

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In this unit, the weathered tuff is light brown and the fresh color is brownish white. Rocks have good sorting, poor gradation, closed containers, and have brittle hardness. The mineral content found in this rock is quartz, plagioclase, biotite and glass. The tuff lithology is spread in almost the entire research area.

Figure 3. Tuff Lithological Type

Rocks in this zone are matrix-supported volcanic breccia rocks. Overall, this rock has a weathered color of brownish ash and a fresh dark gray color, dominated by components with a grain size of gravel to lumps, the shape of the components is angular to slightly rounded, poorly sorted and packed open. The rock hardness is rather hard. Components are composed of andesite igneous rock with light gray fresh color, weathered brownish gray color, massive, aphanitic granularity, mesocratic color index with mafic mineral percentage 30-90%. Contains the minerals plagioclase, quartz, biotite and glass. Coarse tuff matrix with light brown fresh color and weathered.

Figure 4. Breccia Lithological Type

Engineering Geological Conditions

Based on the test of basic physical properties on ten undisturbed soil samples, the deep soil type can be divided into two units, namely high plasticity silt soil (MH) and low plasticity silt soil (ML).

High plasticity silt units fill about 40% of the study area with a wide distribution throughout the study area. In this unit, the soil is residual soil resulting from weathering of volcanic rocks. This unit is composed of reddish brown and dark brown soil, with silt grain size, medium to high plasticity. The soil in this unit has a cohesive strength with soft to slightly soft conditions. The water content is slightly moist to moist, the level of weathering is *Completely Weathered Zone* (CWZ), and the structure is homogeneous. Based on the results of laboratory tests, the plasticity index value is 16.50-32.78%; *moisture content* (w) 26.69-56.83%; *specific gravity* (Gs) 2.3891-2.5920 gr/cc; *unit weight* 1.354-2.017 gr/cm3; *void ratio* 1.308-1.896; *degree of saturation* 50.13-72.93%; porosity (n) 57.68-65.47%; *hydrometer* and *sieve* (percent gravel 0.20-6.36%, percent sand 6.68-40.40%, percent silt, percent clay 53.48-93.12%). According to the direct shear test, the unit of this land has an internal friction angle (φ) varies from 20,04°to 48,070° and the value of cohesion (c) varies from 0,1034 to 0,5174 kg / cm2. Soil units with these characteristics were found in undisturbed soil samples with a depth of 50-100 cm. Excavation in this unit is easy to somewhat difficult without using non-mechanical equipment.

Figure 5. High Plasticity Silt Units (MH)

Low plasticity silt units fill about 60% of the study area with a wide distribution in the center of the research area. In this unit, the soil is residual soil resulting from weathering of volcanic rocks. This unit is composed of reddish-brown and dark brown soil, with the grain size of silt, slightly plastic to semi-plastic. The soil in this unit has a cohesive strength with soft to firm conditions. The water content is slightly moist to moist, the level of weathering is

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Completely Weathered Zone (CWZ), and the structure is homogeneous. Based on the results of laboratory tests, the soil is dominated by fine grain size with a plasticity index value of 11.55-13.62%; *moisture content* (w) 24.96-30.77%; *specific gravity* (Gs) 2.4402-2.4808 gr/cc; *unit weight* 1.386-1,494 gr/cm^3; *void ratio* 1.075 – 1.322; *degree of saturation* 55.10 – 57.59%; porosity (n) 51.81 – 56.94%; *hydrometer* and *sieve* (percent gravel 0.42-4.04%, percent sand 11.10-16.86%, percent silt, percent clay 79.10-88.48%). According to the direct shear test, the unit of this land has an internal friction angle (φ) varies from 19,06° to 36.11° and the value of cohesion (c) varies from 0.1570 to 0.3148 kg/cm^2. Soil units with these characteristics were found in undisturbed soil samples with a depth of 50-100 cm. Excavation in this unit is easy to somewhat difficult without using non-mechanical equipment.

Figure 6. Low Plasticity Silt Units (ML)

Erodibility Value

Calculation of the erodibility value of the study area using undisturbed soil samples and surface soil samples that have been tested for basic physical properties. The use of surface soil samples and undisturbed soil samples aims to increase data variation and provide more detail when interpolating data. The summary of laboratory test result and the erodibility calculation can be seen in the Table 1.

Based on the laboratory test as seen from Figure 7, the distribution of grain size, namely very fine sand, silt, and clay was dominated in this research area. The dominant silt grain size in the soil causes the soil to be more susceptible to erosion), this is supported by the small percentage of clay grain size in the soil, making it possible to have a high erodibility value class. The erodibility value of soil material will decrease with the presence of binding forces between clay-sized particles and also decrease in soil with gravel grain size so that the greatest value of erodibility will be in materials with grain sizes of silt to very fine sand (Morgan, 2005).

Table 1. The Summary of Laboratory Test Result and Erodibility in Cimanggung

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Sample Code	Very Fine Sand (%)	Silt (%)	Clay (%)	Organic Content (C%)	c	a	b	M	K (US)	Erodibility Class (USDA)
UDS 1	8,07	45	34,54	0,75	3	1,293	4	2953,77	0,131	Low
UDS 2	6,36	51,25	17,59	0,69	3	1,18956	4	4229,8725	0,161	Low
UDS 3	5,67	46,78	37,5	1,08	4	1,86192	4	2929,42	0,152	Low
UDS 4	6,15	42,61	41,25	1,17	4	2,01708	4	2509,4875	0,143	Low
UDS 5	18,01	33,02	24,5	1,08	3	1,86192	4	2511,02	0,118	Low
UDS 6	9,18	51	28,1	0,3	4	0,5172	4	3676,08	0,179	Low
UDS 7	16,62	36,88	22,5	1,72	3	2,96528	4	2874,82	0,12	Low
UDS 8	18,98	52,5	0,98	0,84	3	1,44816	4	5217,53	0,181	Low
UDS 9	4,33	45,98	42,5	1,37	5	2,36188	4	2648,18	0,169	Low
UDS 10	2,1	82,5	10,62	0,23	4	0,39652	4	7375,95	0,27	Moderate
UDS 11	5,89	62,5	21,62	0,75	4	1,293	4	4904,64	0,2	Moderate
GT03	15,8	49,22	14,5	0,3	4	0,5172	4	4224,11	0,418	Slightly High
GT06	6,09	50,64	31	0,3	4	0,5172	4	3500,25	0,355	Slightly High
GT08	4,1	59,89	27,75	0,3	4	0,5172	4	4331,1525	0,427	Slightly High
ST06	2,15	72,5	22,78	0,75	3	1,293	4	5600,6	0,487	High
ST11	2,24	67,75	27,23	0,69	3	1,18956	4	4932,4075	0,433	Slightly High
ST26	5,96	57,75	31,57	0,69	3	1,18956	4	3957,7925	0,352	Slightly High
ST70	1,75	64,7	30,92	0,23	4	0,39652	4	4471,226	0,443	High
ST85	0,56	68	31,32	1,37	5	2,36188	4	4670,8	0,424	Slightly High
ST90	4,01	72,6	19,3	1,37	5	2,36188	4	5862,83	0,515	High
ST106	3,38	62,5	31	0,84	3	1,44816	4	4315,88	0,374	Slightly High
ST120	4	64,82	28	1,72	3	2,96528	4	4671,04	0,354	Slightly High
GT15	3,42	47,5	44,66	1,17	4	2,01708	4	2632,07	0,256	Moderate
ST36	4,83	45,32	45	0,69	3	1,18956	4	2497,43	0,235	Moderate
ST56	12,1	37	34,28	0,75	4	1,293	4	2443,74	0,254	Moderate
ST66	9,13	62,54	21,5	1,17	4	2,01708	4	4918,52	0,429	Slightly High
ST72	8,44	58,78	19,8	1,08	3	1,86192	4	4722,596	0,394	Slightly High

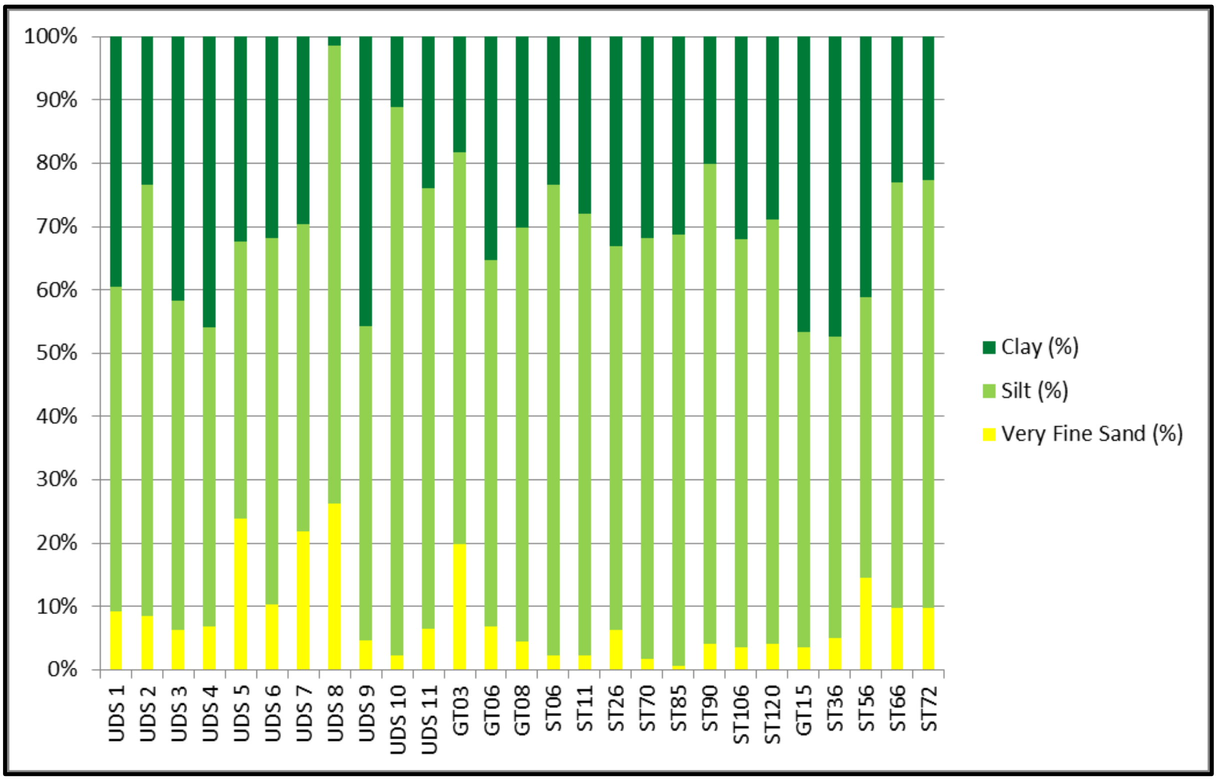

Figure 7. Grain Size Distribution in Research Area

The calculation results are based on the USDA classification in US Customary Dimensions units which are then interpolated from 27 observation points as see the distribution of erodibility classes is divided into 4, namely low, medium, moderately

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high, and high classes. The erodibility values in the study area ranged from 0.118 from UDS-05 to 0.514 from ST-90.

The low erodibility value is represented by the UDS-05, the high plasticity of the soil is caused by the value plastic index of 32.43% and the value liquid limit of 72.43%. While the low soil erodibility value class is caused by the percentage of silt grain size is only 33.02% and the clay grain size is quite large, which is 24.5%, this causes soil conditions to tend to be more stable and more resistant to erosion.

The high erodibility value class is represented by the ST-90 point, the high plasticity of the soil is caused by the value plastic index of 12.41% and the value liquid limit of 52.1%. Meanwhile, the high soil erodibility value was caused by the large percentage of silt grain size, which was 72.6%, and the percentage of clay grain size only 19.3%. The grain size of silt on the soil causes soil properties that are more susceptible to erosion, supported by a small percentage of clay grain size in this engineering geology unit, making it possible to have a high erodibility value class even though its plasticity tends to be higher.

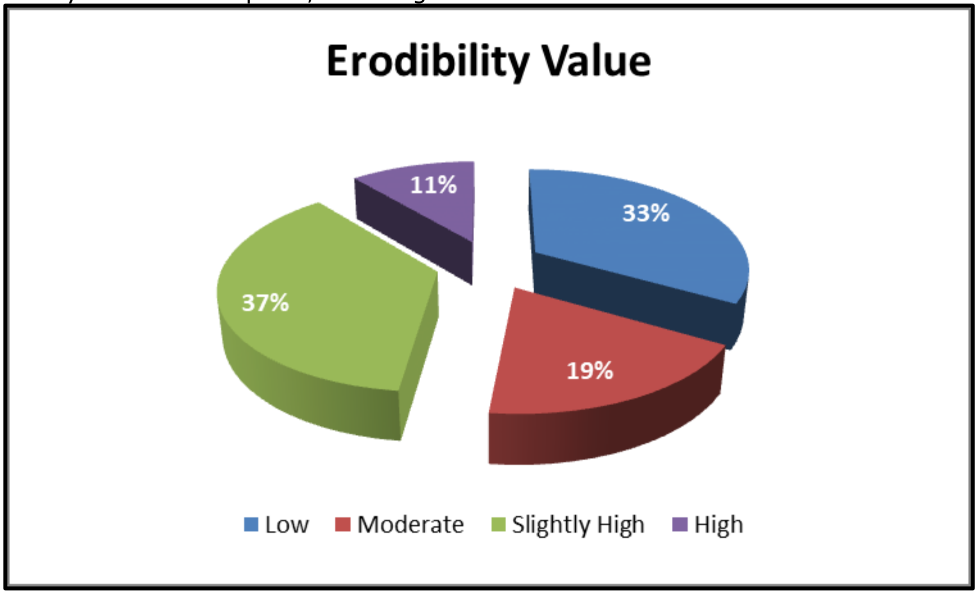

Figure 8. Distribution of Erodibility Value in Cimanggung

CONCLUSION

The Cimanggung and its surrounding area consist of low to high plasticity fine-grained soil and is signified by silt grain size. The erodibility factor is strongly correlated to the grain size, the rich silt grain size in the soil would make it a higher erodibility value and more vulnerable to be eroded during the rainy season. The soil conservation needs to be done as Cimanggung and its surrounding area will be built more intensively.

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