CHANGES OF SOIL ERODIBILITY DUE TO WETTING AND DRYING CYCLE REPETITIONS ON THE RESIDUAL SOIL

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ABSTRACT

The purpose of this study was to examine behavioral changes in the surface soil physical properties on soil erodibility factors such as degree of saturation (Sr), void ratio (e), cohesion (c), friction angle (ϕ), suction (-Uw), unsaturated permeability (k). Universal Soil Loss Equation (USLE) method was used to gain how changes in soil physical properties due to surface wetting and drying process and how it relates to soil erodibility. This research was conducted at the location of the Manting micro basin, Mojokerto Regency. While the observation of the physical soil properties and drying-wetting was conducted in the laboratory.

Key words: soil erodibility; soil properties; Manting micro basin; suction, USLE

1. INTRODUCTION

Degradation of watersheds can lead to high erosion and sedimentation into the river downstream [8]. In the watershed management required accuracy of calculation of erosion and sedimentation that can accurately determine the condition of critical watersheds and to predict the volume of sediments that cover the storage of a reservoir.

Indonesia as a tropical region has repeated of both rainy and dry season cycle. This repetition cycles will alter the soil physical capacity from initially resistant to erosion become more vulnerable or sensitive to erosion. In this process the soil through mechanical and chemical weathering of relatively rapid when compared to the subtropical regions. Rock or soil experiencing fatigue and this led to the ability of soil to resist the kinetic energy of rainfall will decrease becomes vulnerable to erosion. Besides that, conditions in Indonesia have many volcanic causes soil condition in this region is rich in clay minerals like as kaolinite, illite and montmorillonite. These clay minerals have cohesion of soil particles so strong to resist erosion. [8] Caused by repeating cycles of wet and dry, clay minerals can dissolve even disappear so that the land that originally held a strong cohesive changes become non cohesive vulnerable to erosion.

Based on the above explanation, it is important to conduct research, soil erodibility factor to consider changes in soil properties of residual soil surface. This research is important to do because the K factor based on Wischmeier nomogram has not been considered in more detail the parameters of soil physical properties such as: degree of saturation (Sr), void ratio (e), unsaturated soil permeability (kw), cohesion (c), internal friction angle (ϕ) and suction (-Uw).

2. MATERIALS AND METHODS

Determination of Soil Properties

The sample was undisturbed residual soil in which the both physical and mechanical soil properties were determined by geotechnical laboratories test [2]. Specimens that had been conditioned with a water content of both drying and wetting were repeated with the variation of wetting-drying cycles as much as 1x, 2x, 4x and 6x. Drying was done by reducing the water content of the specimens until the moisture content of samples to be; 25%, 50%, 75% and 100% of the original moisture content of field. While wetting was done by adding water to the specimens until the moisture content of water content of the specimens so that the water content of samples to be; 25%, 50%, 75% and 100% of the original moisture content of field. While wetting was done by adding water to the specimens until the moisture content of samples to be; wi +25% (wsat-wt), wi +50% (wsat-wt), wi +75% (wsat-wt) and wi +100% (wsat-wt), where wi was the initial moisture content and wsat was the saturated water content.

Negative pore water pressure (suction) measurement was done by filter paper method, where the filter paper used was Whatman No.42 Type. The test of cohesion and friction angle used in the direct shear apparatus.[3]

Unsaturated Soil Permeability

The calculation parameters of unsaturated soil permeability, kw done by using the formula Campbell (1973) based on the parameters of volumetric water content and suction which had been established by testing the soil suction and gravimetric-volumetric tests. [6]

Erodibility Parameters

Determination of erodibility, K is done by using Wischmeier nomogram.[10]

Data Analysis

Data analysis conducted to determine the physical/mechanical soil properties as degree of saturation (Sr), void ratio (e), Cohesion (C), friction angle (ϕ), dry density (d), suction (Uw) and soil erodibility (K).
3. RESULTS AND DISCUSSION

Observation of initial soil conditions
Based on the USDA (united stated of department agricultural) soil classification system, specimens were silt, while according to the USCS (unified soil classification system), specimens were ML symbol namely inorganic silt soil with low plasticity, containing fine grains of sand and clay fractions.[2]

Table 1. The test results soil properties initial conditions

<table>
<thead>
<tr>
<th>Test</th>
<th>Result of test</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consistency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Liquid limit (LL)</td>
<td>48,27</td>
<td>%</td>
</tr>
<tr>
<td>2. Plastic Limit (PL)</td>
<td>30,77</td>
<td>%</td>
</tr>
<tr>
<td>3. Plasticity Index (PI)</td>
<td>17,50</td>
<td>%</td>
</tr>
<tr>
<td><strong>Gravimetric and Volumetric</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Specific Gravity</td>
<td>2,647</td>
<td>%</td>
</tr>
<tr>
<td>2. Water Content, w</td>
<td>39,737</td>
<td>%</td>
</tr>
<tr>
<td>3. Unit Weight of Soil, (\gamma_t)</td>
<td>1,625</td>
<td>gr/cm³</td>
</tr>
<tr>
<td>4. Dry Density, (\gamma_d)</td>
<td>1,163</td>
<td>gr/cm³</td>
</tr>
<tr>
<td>5. Void Ratio, e</td>
<td>1,289</td>
<td>-</td>
</tr>
<tr>
<td>6. Degree of Saturation, Sr</td>
<td>82,122</td>
<td>%</td>
</tr>
</tbody>
</table>

**Sieve Analysis and Hydrometer**

<table>
<thead>
<tr>
<th>Test</th>
<th>Result of test</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gravel fraction</td>
<td>0,00</td>
<td>%</td>
</tr>
<tr>
<td>2. Sand</td>
<td>6,85</td>
<td>%</td>
</tr>
<tr>
<td>3. Silt</td>
<td>81,02</td>
<td>%</td>
</tr>
<tr>
<td>4. Clay</td>
<td>12,13</td>
<td>%</td>
</tr>
</tbody>
</table>

Fig. 1. Relations between parameters of water content, void ratio, degree of saturation and the suction caused by repeated wetting and drying cycles
Influence of drying-wetting on the parameters of soil properties

Influence of drying and wetting on the changes of soil properties described in graphical form the parameters relationship (Figure 1). In Figure 1 showed the relationship between changes in water content (wc) against the void ratio (e), degree of saturation (Sr) and suction (-Uw). By increasing water content, it caused the degree of saturation and void ratio increased but the suction was reduced. The increase in void ratio indicated that the soil became less dense as seen in the dry bulk density values (Figure 2).

Wetting-drying cycles repetition caused the soil became dense, visible on the fourth and sixth cycles value of void ratio decreases when compared to the first cycle at the same of value water content. However, the void ratio decreased at the sixth cycle was not followed by increasing values of suction. Seen the value of suction at the sixth cycle tend to decrease when compared to the first cycle. This phenomena might be due to silt soil specimen was more brittle different if the used was expansive clay causing an increase in cycle value of suction. Another phenomena was the sixth cycle caused the value of cohesion (C) and friction angle (\(\phi\)) decreasing when compared with the initial condition first cycle (Figure 2).

Influence of drying-wetting cycle repetitions on the unsaturated permeability

Change the value of the coefficient of permeability was caused by changes in soil physical properties. Due to changes in water content caused by wetting-drying cycles repetitions of the soil had different hydraulic conductivity. Graph showing the relationship between changes in soil properties of the permeability was presented in figure 3.

Influence of drying-wetting cycle repetitions on the erodibility

Change the value of soil erodibility was determined based on the nomogram Wischmeier was highly dependent on four parameters: the grain size, organic matter, soil structure and permeability classes. [10] However, parameter such as grain size, organic matter and soil structure classes in the study was not carried out a variation. While changes in soil structure were caused by wetting and drying cycles could not be observed in macro porous. So that changes in soil erodibility was predominantly influenced by changes in the value permeability. Changes in soil erodibility based on changes in soil physical properties caused by wetting and drying cycles as shown in Figure 4.

4. CONCLUSIONS

Based on the above results it can be concluded as follows:

a. Changes in soil moisture content would cause the parameter changes in soil properties such as degree of saturation, void ratio (e), dry
density ($\gamma_d$), suction ($-U_w$), soil permeability ($k$), shear strength indicated by changes in the parameters of cohesion ($C$) and internal friction angle ($\phi$).

b) Changes in water content above showed the changes in erodibility index ($K$), despite using nomogram these changes were dominated by changes in soil permeability, but it gave an understanding that in the calculation of land erosion (USLE/MUSLE) needed to distinguish between erodibility index in the dry season and rainy season.

![Graphs showing effect of parameters change](image)

**Fig. 4.** Effect of parameters change: water content ($w_c$), degree of saturation ($Sr$), cohesion ($C$) and dry density ($\gamma_d$) against Soil Erodibility ($K$) due to wetting and drying cycle's repetitions.

REFERENCES


