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Identification of Chemical Element Using X-Ray Fluorescence in Soil with Landslide Potential from Sandabilik Village, Tana Toraja

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Abstract

Landslides occur frequently in the South Makale sub-district. The disaster resulted in material losses and casualties. Landslides can occur due to a variety of factors. One of these is unstable soil conditions caused by the soil's physical properties, specifically weak soil cohesion (binding capacity) or rocks. This study aims to identify the mineral properties of soil in potential landslide areas in Sandabilik Village, Tana Toraja. This sample was tested using X-ray fluorescence (XRF). The soil samples collected at the landslide site were 50 cm and 100 cm deep. Sample test results show that the content of soil chemical compounds in Sandabilik Village, South Makale District, Tana Toraja Regency, is dominated by SiO_2 (Silica Oxide), both at a depth of 50 meters (72.02%) and at a depth of 100 meters (56.55%), respectively. Fe_2O_3 compounds were 15.65% at a depth of 50 meters, and 24.50% at a depth of 100 meters.

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1. INTRODUCTION

South Makale is one of the districts in Tana Toraja regency that frequently experiences landslides. Based on the mapping of landslide-prone areas, there are five classes of landslide susceptibility levels: very low, low, moderate, high, and very high. The Sandabilik Valley is classified as an area with a high susceptibility to landslides [1]. This is also supported by research using the 2D electrical resistivity method. The results of the study indicate that Sandabilik has the potential for landslide-prone areas. Measurement results show that the slip surface is located at a depth of 1.5 to 19.8 meters [2].

The landslide disaster that occurred in the Sandabilik Village caused material losses for the community. Poor weather conditions, such as heavy rain throughout the day, triggered landslides in 2010 and 2018. According to data from the Regional Disaster Management Agency (Badan Pusat Bencana Daerah) of Tana Toraja, the landslide disaster resulted in several houses being buried under landslide materials, and other residents were forced to evacuate. The factors contributing to landslides form an interconnected system, and one of them is the geomorphology of the land. The geomorphology varies from one region to another, depending on the formation processes, which can lead to differences in soil types. Certain soil types, composed of various minerals, have different influences on landslide occurrences. Some factors that influence the non-homogeneity of subsurface soil/rock and the environmental characteristics of materials include geological elements, water conditions, mineral composition, and sedimentation processes [3].

Landslides can occur when the soil is in an unstable condition. Unstable soil can be caused by the physical properties of the soil, such as soil cohesion (binding force), or weak rocks. The extent of the losses experienced by the community is due to landslides being a natural disaster that cannot be predicted in terms of timing. The low soil cohesion causes rocks or soil particles to detach from their binding and move downward, dragging other rocks or particles along with them [4]. The results of the research on the physical properties of the soil show that the soil texture in the South Makale district is predominantly composed of dust and clay fractions with a low organic carbon content. This type of soil can affect the reduction of soil permeability and increase the values of soil water content and soil plasticity index, which can trigger landslides [5]. Based on these conditions, it is necessary to conduct testing on the chemical element of landslide-prone soil using the X-Ray Fluorescence (XRF) method. The objective of this research is to determine the chemical element of soil minerals in the landslide-prone area of Sandabilik Village, Tana Toraja.

2. MATERIALS AND METHODS

The research site is located at 3° 7'15.50" S and 119° 47'43.40" E in Sandabilik Village, South Makale District. The sampling points are marked on the map in Figure 1. The X-Ray Fluorescence (XRF) method was used in this study. This method is used to identify soil samples and can analyze soil elements both qualitatively and quantitatively. The information provided includes the element types and quantities present in the material. Chemical element abundance in soil is determined by factors such as the type of oxides in the soil layer, the underlying bedrock, depth, and mineralogy.[6]. Sampling was done in a specific landslide area, with samples taken at various depths, specifically 50 cm and 100 cm.

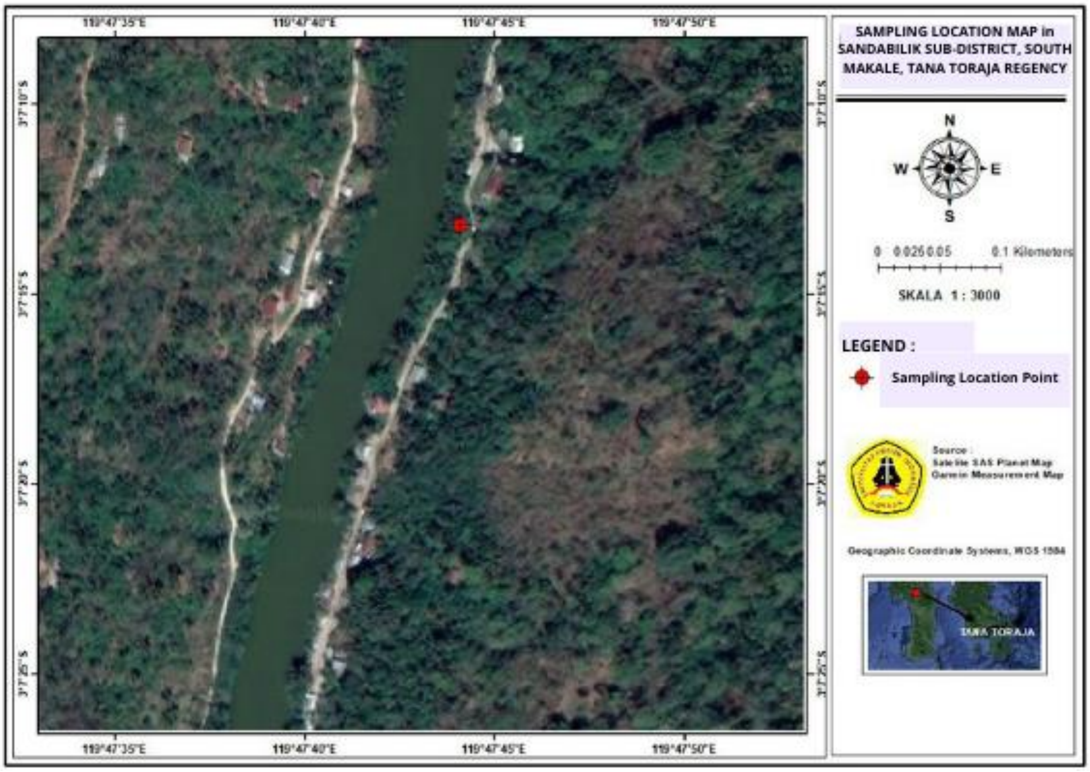

Figure 1 Map of Soil Sampling Locations

3. RESULT AND DISCUSSION

X-Ray Fluorescence was used in this study for laboratory analysis. Table 1 shows the results of the analysis of samples 1 and 2. The constituent compounds in sample 1, representing soil at a depth of 50 cm, have chemical compositions such as SiO_2, Fe_2O_3, K_2O, CaO, TiO_2, SrO, BaO, MnO, ZrO_2, and Rb_2O, according to the table. At a depth of 50 cm, the major chemical compounds in the sample are Silica Oxide (SiO_2) and Iron (III) Oxide (Fe_2O_3), accounting for 72.02% and 15.65%, respectively. Meanwhile, the chemical composition of sample 2 represents soil at a depth of 100 cm and includes SiO_2, Fe_2O_3, Al_2O_3, K_2O, CaO, TiO_2, SrO, BaO, MnO, ZrO_2, and Rb_2O The dominant chemical compounds at 100 cm depth are the same as those at 50 cm depth in sample 1, namely Silica Oxide (SiO_2), Iron (III) Oxide (Fe_2O_3), and Aluminum Oxide (Al_2O_3), with 56.55%, 24.50%, and 10.12%, respectively.

Because of the high oxidation level during or after rock formation, minerals containing compounds with oxide bonds are prone to substitution with iron (Fe2+). Landslides occur as a result of the rock's oxidized condition and extensive weathering. Quartz rocks are typically found to have the highest SiO2 content. The SiO2 content of these rocks is typically around 97%, with low aluminum and iron impurities. Rocks with the highest silica oxide content are commonly used as raw materials in the production of glass and silicon [17].

Table 1. XRF Analysis Results (X-Ray Fluorescence)

No	Parameter	Depth 50 cm (m/m%)	Depth 100 cm (m/m%)
1	SiO_2	72.02	56.55
2	Fe_2O_3	15.65	24.50
3	K_2O	5.40	3.05
4	CaO	3.45	1.76
5	TiO_2	1.47	2.30
6	SrO	0.485	0.221
7	BaO	0.398	0.309
8	MnO	0.396	0.159
9	ZrO_2	0.107	0.309
10	Rb_2O	0.142	0.074
11	Al_2O_3	-	10.12

Ferromagnetic or ferrimagnetic properties can be found in materials containing the mineral compound Fe2O3, also known as hematite [8]. One of the magnetic types found in nano ferromagnetic or ferrimagnetic structures is superparamagnetic. Landslide-affected areas typically have higher concentrations of superparamagnetic grains than nonaffected areas [9]. This is supported by Ramdhani et al.'s research, which shows a link between soil susceptibility values and landslide potential. Soils with landslide potential are dominated by ferrimagnetic materials and show values indicating that landslide soil samples contain superparamagnetic grains and have landslide potential [10].

In addition to the losses caused by landslides, sand or rocks containing iron oxide (Fe2O3) can also be utilized by the community as industrial materials. Minerals containing iron oxide compounds can be used as a raw material for gas sensors [11]. Iron oxide ceramics are semiconductors that are environmentally sensitive, making them suitable for use as gas sensors [11-13]. Smart materials are minerals obtained from nature that can be beneficial to society and have a high market value [14].

4. CONCLUSION

The content of soil chemical compounds found in Sandabilik Village, South Makale District, Tana Toraja Regency is dominated by SiO_2 (Silica Oxide), both at a depth of 50 meters (72.02%) and at a depth of 100 meters (56.55%). Following that, there were 15.65% Fe_2O_3 compounds at 50 meters and 24.50% at 100 meters.

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