Minerals of parent material as an indicator of soil fertility

by Muh Jayadi

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K Nasir, M Jayadi and A Ahmad

Soil Science Department, Faculty of Agriculture, Hasanuddin University, Makassar Indonesia

E-mail: asmit.ahmad@agri.unhas.ac.id

Abstract. Soil fertility is the ability of the soil to provide nutrients. Most of the nutrients in the soil come from mineral weathering. The higher of an easily weathered mineral is in line with soil fertility. This research aims to study soil fertility rates based on the mineral content in West Sinjai Sub-district. The methods used in this study are thin sections to identify minerals in the parent material using a polarizing microscope, calculate mineral presentation and nutrient potency classification with the presentation of mineral content minus the presentation of quartz content. The dominant mineral content found is pyroxene, amphibole, and plagioclase that resulted from the andesitic parent material. Soil fertility potential in West Sinjai based on nutrient-carrying minerals is in the range of 80-100% with good criteria. Potential nutrients contained in minerals are already available for plants.

1. Introduction

Soil fertility is the ability of the soil to provide nutrients. Nutrients in the soil come from various sources such as fertilizers, water, organic matter, but most of the soil's nutrients come from the mineral of parent material weathering [1–3]. Minerals contained in the soil are one of the main ingredients of the soil. Minerals types can be broadly differentiated into primary minerals directly formed from the crystallization of magma and secondary minerals resulting from weathering of primary minerals [4]. Mineral composition, both from sand and clay fractions, can be used to indicate the source of origin and properties of the parent material, soil charge, easily weathered mineral reserves as a source of nutrients in the soil, and weathering level or soil development [5].

Minerals in soil have a potential role in agriculture because minerals from rock contain important elements that can be used to maintain and increase agricultural land productivity. The nutrient content in minerals supports the sustainability of soil fertility. Assessment of land potential can be seen from the chemical elements it contains [6]. The higher the easily weathered mineral reserves in the soil, the more fertile the land will naturally, because the land has high nutrient reserves available in the long term through the weathering process.

This research aims to know the mineral contained in the soil is an indicator of soil fertility level. The use of this research is as information material for optimal soil management.

2. Methods

Observation and sampling of parent materials were carried out in West Sinjai District, Sinjai Regency. Analysis of soil minerals and parent material was carried out at the Geochemical and Mineralogy

Laboratory, Department of Geological Engineering, Faculty of Engineering, Hasanuddin University (figure 1). This research was conducted from July 2020 to completion.

The tools used in this research are GPS (Global Position System), a set of survey tools, camera, computer, ArcGIS 10.3, Olympus BX41 type polarizing microscope for parent material minerals. The materials used were samples of the parent material, maps of land units with a scale of 1:50.000.

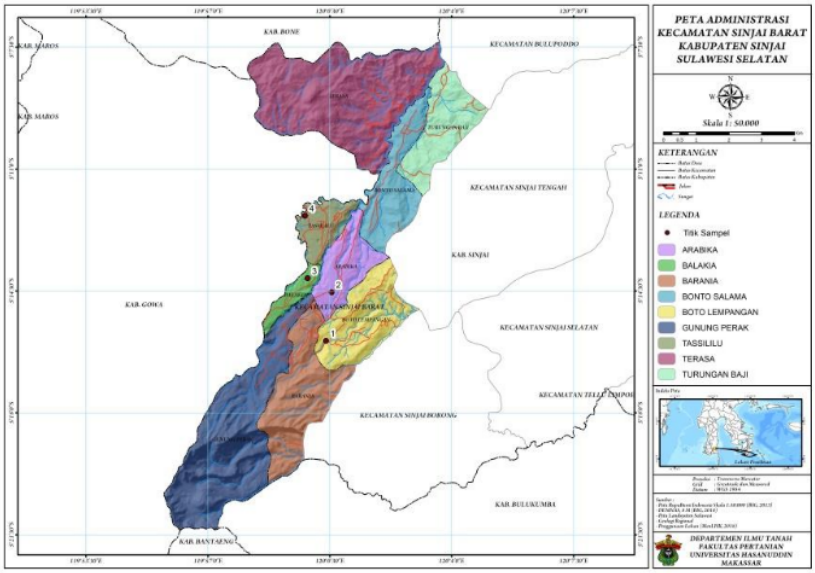


Figure 1. Study site.

2.1 Stages of preparation and mineral identification

Mineral analysis of the parent material was carried out by the petrographic method using the thin-section method [7]. The process of making preparations (thin section) and mineral observation, namely :

a. Impregnating rock samples with epoxy fluids and resin (1:1)
b. Slicing the parent material sample with a size of 0,001-0,003 mm, the incision results were observed using a polarizing microscope.
c. Identify minerals using the Kerr method [8], in cross-polarized (xpl), and plane-polarized (ppl)

2.2 Fertility potential assessment

In this stage, calculating the number of minerals in one field of observation is assumed to be 100% called the mineral counting method, after knowing the results of mineral identification in each parent material. This process includes the percentage of weatherable minerals and resistant minerals. Then, minerals are presented. According to [9], the method of assessing nutrient reserves in the soil is necessary to know. Apart from Soil Taxonomy, quartz mineral differentiation is carried out in estimating weathered mineral content (nutrient reserves), namely :

$$\boldsymbol{Nutrient\ reserves = 100 - \%quartz}$$

After knowing the percentage of weathered minerals, assessing the potential for soil fertility is carried out by looking at the criteria in assessing the potential for soil fertility (table 1).

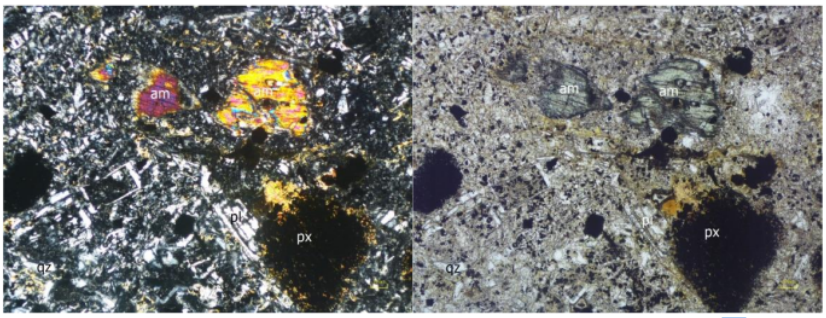
Table 1. Fertility potential assessment criteria.

Weathered Minerals	Term
100% - 70%	Good
70% - 40%	Moderate
40% - 0%	Low

Source : [9]

3. Results and discussion

The parent material found at the research site was andesitic, which was dominated by plagioclase, pyroxene, and amphibole minerals (figure 2). According to the opinion of [10], plagioclase and pyroxene or hornblende (amphibole) are the main mineral characteristics in andesitic igneous rocks. At observation point 1, the parent material's minerals are amphibole, plagioclase, pyroxene, and quartz. In xpl, amphibole has a striking color variation, plagioclase is white, pyroxene is golden brown, and quartz is clear white. In ppl, its parallel to amphibole has a greenish color, plagioclase is colorless, pyroxene is a brownish color, and quartz has a pure white color.



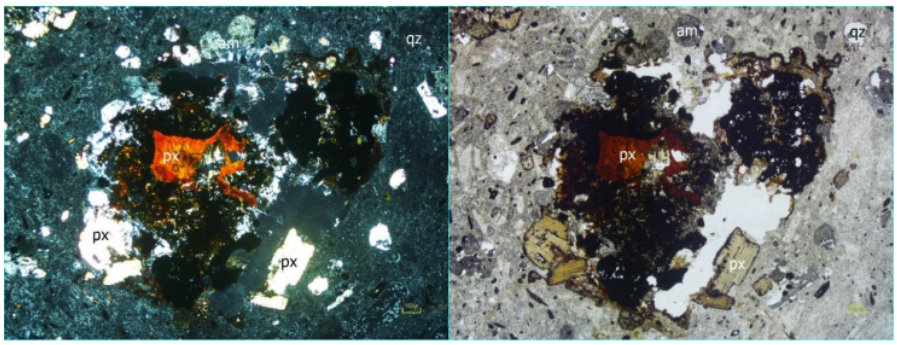
a. xpl b. ppl

Figure 2. (a) thin section of the parent material at the xpl observation consist of am (amphibole), pl (plagioclase), px (pyroxene), and qz (quartz). (b) thin section of the parent material at the ppl observation consist of am (amphibole), px (pyroxene), qz (quartz). (size 100μm).

Based on the identification of minerals in the parent material at the xpl observation, the percentage of amphibole mineral content was 40%, pyroxene minerals were 20%, plagioclase minerals were 20%, and quartz was 20%. The main material of xpl observation has weathered minerals: amphibole, pyroxene, and plagioclase, with the percentage of weathered mineral content, was 80%. So, the parent material at the xpl observation can be categorized as having good soil fertility because it has high nutrient reserves. This is supported by [11], who states that minerals such as plagioclase, amphibole, and pyroxene are classified as easily weathered minerals that release macronutrients into the soil such as Ca, Mg, Na, and K.

At ppl observation point 2 (figure 3), the pyroxene minerals with red color on the xpl and red also on ppl. There is also pyroxene with a white color on the xpl and brownish color on ppl. Amphibole has a greenish color on the xpl and pale green on ppl. In xpl, the quartz appears black, but in ppl, the quartz has a pure white or transparent color [8].

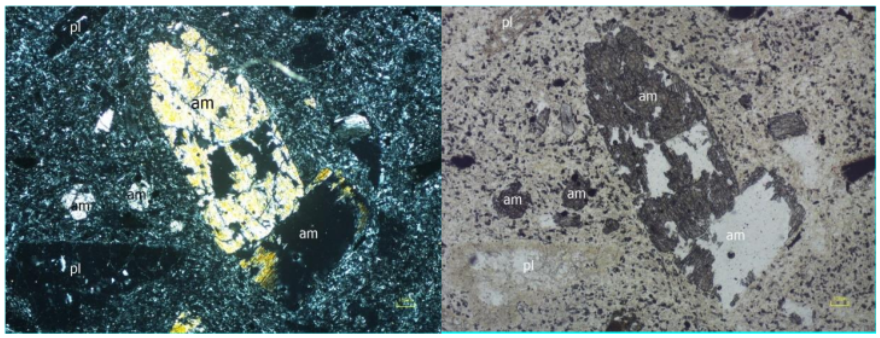
The identification of minerals in the parent material at the xpl observation, the percentage of amphibole mineral was 20%, pyroxene mineral was 60%, and quart mineral was 20%. The main material of xpl observation has weathered minerals, namely amphibole and pyroxene, with the percentage of weathered mineral content was 80% which is dominated by pyroxene minerals. So, the parent material at the xpl observation can be categorized as having good soil fertility because it has dominant reserves of Mg nutrients from pyroxene minerals. This is supported by [12], who state that Mg's source is the pyroxene group (augite).



a. xpl b. ppl

Figure 3. (a) thin section of the parent material at the xpl observation consist of am (amphibole), px (pyroxene), qz (quartz), (b) thin section of the parent material at the ppl observation consist of am (amphibole), px (pyroxene), qz (quartz). (size 100μm).

At ppl observation point 3 (figure 4) there are amphibole minerals with brownish and white colors on xpl and pale brown on ppl. Plagioclase has black and white patches on the xpl and colorless on ppl [8].

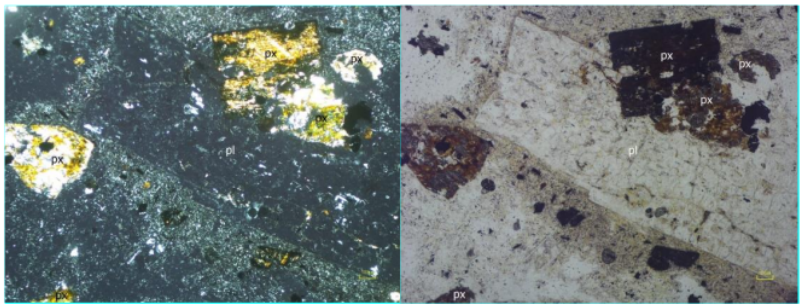


a. xpl b. ppl

Figure 4. (a) thin section of the parent material at the xpl observation consist of am (amphibole), pl (plagioclase), (b) thin section of the parent material at the ppl observation consist of am (amphibole), pl (plagioclase). (size 100μm).

Based on the identification of minerals in the parent material at the xpl observation, the amphibole mineral percentage was 66,7%, and plagioclase mineral was 33,7%. The main material of xpl observation has weathered minerals, namely amphibole and plagioclase, with the percentage of weathered mineral content was 100%. The parent material at the xpl observation can be categorized as having good soil fertility because having weathered mineral content was 100%.

At ppl observation point 4 (figure 5), pyroxene minerals with brownish yellow color were found on cross nicol and parallel nicol. Plagioclase has a black color with white patches on the xpl and colorless on ppl [8].



a. xpl b. ppl

Figure 5. (a) thin section of the parent material at the xpl observation consist of px (pyroxene), pl (plagioclase), (b) thin section of the parent material at the ppl observation consists of px (pyroxene), pl (plagioclase). (size 100μm).

Based on the identification of minerals in the parent material at the xpl observation, the percentage of pyroxene mineral was 83,3%, and plagioclase mineral was 16%. The main material of xpl observation has weathered minerals, namely pyroxene and plagioclase, with the percentage of weathered mineral content was 100% dominated by pyroxene minerals. So, the parent material at the xpl observation can be categorized as having good soil fertility because it has dominant reserves of Mg and Ca nutrients from pyroxene minerals. This is supported by [13], who state that the pyroxene mineral is a mineral carrying calcium and magnesium nutrients.

The level of soil fertility can be seen based on the weathered mineral of the parent material. When the mineral of the parent material was weathered, the nutrient elements contained will be available in the soil to become nutrient reserves for plants. Assessment of potential fertility based on nutrient reserves from the mineral of parent material is presented in table 2.

Table 2. Soil fertility potential from the mineral of parent material.

Observation Point	Quartz Content (%)	Weathered Mineral (%)	Criteria
1	20	80	Good
2	20	80	Good
3	-	100	Good
4	-	100	Good

The soil fertility level from the weathered mineral of parent material has a good criterion. The weathered mineral around 80-100% dominated by amphibole mineral, pyroxene and plagioclase mineral.

4. Conclusions

The parent material at the research location is andesitic rock and dominated by pyroxene, amphibole, and plagioclase minerals. These minerals are nutrient-carrying minerals for Ca, Mg, K, and Na for the plant. The potential of soil fertility in West Sinjai District is 80-100% with good criteria. Potential nutrient elements contained in minerals are readily available to plants.

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