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RESEARCH ARTICLE

The Content Of Heavy Metal In Turmeric (*Curcuma Domestica Val.*) In The Volcanic Rocks Oligocene-Miocene Volcano, Biting Wonogiri, Central Java, Indonesia

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Abstract

The Biting Wonogiri area is an area composed of Oligocene-Miocene volcanic deposits and volcanic deposits from Lawu Volcano. The rocks in this area consist of pyroclastic rocks, volcanic breccia, and dacite intrusions. Residents in this area more commonly grow herbal plants such as turmeric. Turmeric plants are mostly planted on old volcanic rocks, namely the Oligocene-Miocene age. By studying the planting patterns of residents, an analysis was carried out regarding the heavy metal chemical elements contained in turmeric. The research methodology was carried out using geological mapping to determine the distribution of the rocks that make up the research area and AAS analysis (*Atomic Absorption Spectroscopy*). This AAS method is used to determine heavy metal content. The heavy metal elements analyzed in turmeric were Hg, Pb, As, Fe, Al, and Mn. From the analysis results it was found that the heavy metal elements Hg, Pb, and As had very low levels, namely around 0.005-0.400 mg/Kg. Meanwhile, the elements Al, Fe, and Mg have high contents. Turmeric grown on dacite and volcanic breccia has higher Al (622.3-1362.76 mg/Kg) and Fe (271.32-806.27 mg/Kg) content compared to turmeric planted on sedimentary rock. Meanwhile, the metal element Mn varies around 6.85-122.01 mg/Kg. By knowing the content of these Western metal elements, it is hoped that turmeric, which contains heavy metal elements, can be used as a superior herbal herbal medicine. These metal elements, which are very important nutrients, come from old volcanic rocks.

Keywords: Volcanic Rocks, Turmeric, Heavy Metals, Herbs

1. Introduction

This research used turmeric of the same age at planting time and this research was located in the Biting Village area, Wonogiri Regency, Central Java Province (Figure 1). In this area, several researchers such as Yudiantoro et al. (2017) and Suproborini et al. (2017) have researched several plants that grow in the Oligocene-Miocene volcanic area in the Wonogiri area.

Heavy metals are natural components in soil. This component cannot be degraded (non-degradable) or destroyed. This compound can enter the human body through food, drinking water and air (Irianti et al., 2017). Several heavy metals such as copper (Cu), selenium (Se), iron (Fe) and zinc (Zn) are very important for the body. Heavy metals are chemical elements that can be toxic even in low concentrations, so they can affect human health (Mohammadi et al., 2017). Meanwhile, according to the group of micro elements which are a group of heavy metals that have no function at all for the body, such as: lead (Pb), mercury (Hg), arsenic (As) and cadmium (Cd). These compounds are even very dangerous and toxic to humans (Saputri et al., 2023).

Andosols are generally found in volcanic areas (Klaes et al., 2023). Soil is a very important element of the biosphere and contains several necessary metal elements. Therefore, it functions as the main constituent, for example: in plant tissue, there is carbon, oxygen, phosphorus, sulfur, hydrogen, nitrogen, calcium, magnesium, potassium, and sodium. Apart from that, several metals that cause environmental problems are found in the soil, such as arsenic, selenium, chromium, and mercury. The state of these metals determines their relative mobility, bioavailability, and toxicity so that they can be carcinogens (Bolzan, 2015).

This area is composed of several lithologies of Oligocene-Miocene age, including mudstone, sandstone, dacite, pyroclastic rock, volcanic breccia, and alluvial. The priority for taking turmeric samples is taken from turmeric that grows on soil resulting from the weathering of the rocks that make up the research area.

Turmeric or turmeric (*Curcuma domestica Val.*) is a flowering plant and is a relative of ginger, and the roots of this plant can be consumed. Turmeric is widely used as a natural yellow dye for food and textiles. It is one of the main components of curry, yellow rice, and others (Prabowo et al., 2019). Turmeric is also used as an ingredient in Austronesian religious offerings or rituals. Apart from that, turmeric is the ingredient most often used in traditional medicines in China and India. According to Pratama (2017), turmeric's absorption of Fe(II) and Fe(III) in the soil obtained absorbance values of 0.460 for Fe(II) and 0.375 for Fe(III).

The turmeric plant has extracts/chemical compounds that can be classified. Some of these chemical compounds are *curcumin/curcuminoids*, *demethoxycurcumin*, *bisdemethoxycurcumin, diacetyl curcumin,* and others. *Curcumin*/*Curcuminoids*is one of the main components of turmeric root which has many benefits for the health of the human body. *Curcuminoids* have benefits such as anti-inflammatory, antioxidant, antitumor, antimutagenic, antifungal and antibacterial, antidiabetic, healing wounds, and radioprotective, and others (Sharifi-Rad et al., 2020).

This research aims to determine the heavy metal content contained in turmeric which grows on Miocene volcanic rock. Rock types in the study area include dacite, volcanic breccia, and other sedimentary rocks. In general, turmeric grown by residents around Wonogiri is used as an ingredient for making traditional or herbal medicine. These herbal ingredients are specifically to be sent to the herbal medicine manufacturing factory in Wonogiri. By knowing the characteristics of heavy metal chemical elements from turmeric, it is hoped that turmeric planted in the rocks that make up the research area will provide characteristics of certain metal element content. This metal content can be a superior ingredient in hebal medicine. On the other hand, metal elements that humans consume excessively can be toxic to the human body.

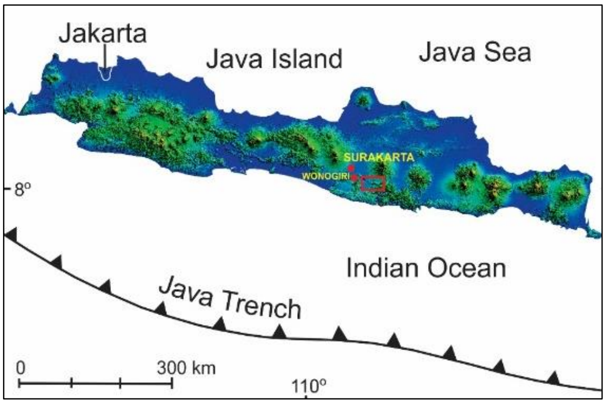

Fig. 1. Location map of the research area

2. Geological setting

Regionally, the geomorphology of the research area is a plain area, with low hills and steep areas. Plain areas of Ponorogo City and Badegan District City, Biting and Badegan Villages. In general, land use in this plain area is used as residential areas, urban areas, rice fields, gardens, and so on. Wavy areas with low relief are formed by plains, valleys, and hill ridges. This area covers parts of Badegan, Purwantoro, and Ponorogo City. Land use is generally for rice fields, residential areas and gardens, and urban areas. Meanwhile, the steep relief hilly areas are a series of tall and elongated hills composed of strongly folded sedimentary rocks of Tertiary age that are faulted and the landforms are affected by intrusive processes. Land use generally consists of production forests, tuber and medicinal plant gardens, traditional mining, settlements, and production forests. The body area of the volcano is a series of high hills due to the process of volcanism including slopes, volcanic peaks, and parasitic cones. The area includes Mount Tejokaton, Mount Butak, Randusari, Mount Bungkuk, and Karangwidodo which are composed of volcanic deposits. This area is generally used as a tuber and medicinal plant garden, production forest, mixed garden, and a residential area.

Geological structures that develop regionally as a result of tectonic activity. The geological structures are folds and faults. Fold structures (anticlines and synclines) generally develop in Miocene rocks (Semilir Formation, Dayakan Formation, Nglanggran Formation, and Sampung Formation) forming hills with low and steep relief. Meanwhile, fault structures are often found in Quaternary rocks such as the Mount Lawu Fault, and other faults that cut Tertiary rocks such as the Dayakan Fault.

Based on the geological map of the Ponorogo sheet (Sampurno and Samodra, 1997), Wonogiri's regional stratigraphy consists of alluvial deposits, young volcanic deposits, Pliocene-Oligocene sedimentary rocks, and breakthrough rocks (intrusions). *Alluvial deposits* are in the form of loose material, consisting of gravel, gravel, silt, mud, and river sediment, there are also alluvial fan deposits consisting of gravel and gravel with sand and silt inserts. Young volcanic deposits consist of rocks from volcanic eruptions from Mount Lawu, as well as volcanic rocks from other volcanic eruptions and parasitic cones that make up the area. These rocks are composed of andesite igneous rocks and pyroclastic rocks (tuff, pumice dacitic). Then the Lawu lava deposits with the main composition are andesite and breccia sedimentary rock with lava inserts. These rocks are scattered around Mount Lawu Volcano, as well as the hills around the mountain, apart from that they also occupy the slopes of the hills.

Pliocene-Oligocene sedimentary rocks sedimentary rocks consisting of several formations including Wonosari Formation, Sampung Formation, Cendono Member of Sampung Formation, Nglanggran Formation, Semilir Formation, Dayakan Formation, Panggang Formation, and Watupatok Formation. *Wonosari Formation is* composed of reef limestone, calcarenite intercalated with conglomerate reef limestone. This limestone contains foraminifera, mollusks, algae, coral, and bryozoans. Apart from that, it is filled with marl which contains plankton and benthic foraminifera. *Sampung Formation* is a rock formation consisting of repetitions of calcarenite and marl, reef limestone, calcareous mudstone, and tuffan. Calcarenite contains components of igneous rock, sedimentary rock, and pieces of foraminifera and mollusks. Marl is tuff in nature and contains many small foraminifera. Meanwhile, reef limestone is generally gray in color, and contains foraminifera, coral, algae, and bryozoa.

Member of Cendono Formasi Sampung composed of calcareous sandstone, breccia of various materials, and sandstone. Breccia of various materials is composed of andesite, basalt, limestone, sandstone, and mudstone components. This unit is in harmony with the formations below, namely the Nglanggran and Semilir Formations. *Formation Violating* is a volcanic rock with an andesite-basalt composition consisting of volcanic breccia and volcanic sandstone. The bottom of this formation is intertwined with the Semilir Formation. The Semilir Formation is a turbidite deposit dominated by pumice breccia and repetitions of gravelly sandstone, sandstone, and mudstone. The pumice breccia is partially chloritized giving it a greenish color.

Enable Formation is a repetition of sandstone and mudstone with a thickness of several tens of cm. This formation is a well-layered turbidite deposit that is exposed at a thickness of more than 60 m. Some sandstones are tuffaceous and red in color. This unit intersects with the Watupatok Formation and at the top, it intersects with the Semilir Formation and Nglaggran Formation. Locally this formation is intruded by dacite. The Panggang Formation is composed of volcanic breccia and lava with andesite and basalt composition. This rock is interbedded with sandstone.

The tuffaceous breccia base is generally chloritized and some of the lava is fractured. This unit intersects with the Watupatok formation. The Watupatok Formation is composed of basalt lava with a pillow structure, interbedded with sandstone, mudstone, and chert. This unit intertwines with the Dayakan Formation and at the top the Semilir Formation.

The intrusive rocks found in the study area consist of andesite, dacite, and basalt. The andesite intrusion rock on Mount Karang penetrates the limestone of the Sampung Formation so that it turns into marble. Dacite intrusion penetrates the Panggang Formation and Dayakan Formation on

Mount Gembes so that both units are chloritized, pyritized, and locally kaolinized. As a result of experiencing hydrothermal alteration, gold and sulfide mineralization occurs. This dacite intrusion is Tertiary magmatism that controls the alteration and mineralization zonation stages (Sukisman et al., 2021).

3. Methodology

In the research area, five turmeric samples were taken at different sampling points. The sample is expected to be representative of the lithology distribution found in the research area. The research was conducted for the first time using field monitoring methodology. This method is used to determine the geological conditions of the research area related to lithology, stratigraphy, and geological structure. Then, from the type of lithology obtained from geological mapping, turmeric that grows on the rocks that make up the research area is identified.

From the lithology identification, five turmeric samples were obtained. The collection locations were carried out in residents' gardens in the Dacite Intrusion Unit (2 samples), the Dayakan Sandstone Unit (2 samples), and the Semilir Pyroclastic Rock Unit (1 sample). Apart from that, we looked for a relatively similar age for the turmeric samples, namely around three months from initial planting. Of the five samples, laboratory analysis of heavy metal chemical elements was carried out using the AAS method (*Atomic Absorption Spectroscopy*).

Method AAS (*Atomic Absorption Spectroscopy*) is a spectroanalytical procedure method for the quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms. Atomic absorption spectrophotometer based on the absorption of light by free metal ions. The heavy metal chemical elements analyzed include mercury (Hg), arsenic (As), lead (Pb), iron (Fe), aluminum (Al), and manganese (Mn) which will be expressed in units of mg/Kg.

Apart from that, it uses petrographic analysis. This analysis is intended to determine the structure, texture, and mineral composition of rocks which are a source of nutritional ingredients for turmeric plants. The rock samples used to represent thin sections of the rock with a thickness of 0.03 mm were cut. As a result of cutting the rock, petrographic analysis is then carried out using a polarizing microscope, so that using this method the structure, texture, and mineralogy of the rock can be determined.

4. Results and Discussion

4.1 Geology of the Biting Area

In the research area based on the stratigraphic division by Samodra and Sampurno (1997), there are several rock units. The order of rock units from old to young is the Dayakan Sandstone Unit, Semilir Pyroclastic Rock Unit, and Nglanggran Breccia Unit.

The lithology (Figure 5) that makes up these rock units is as follows:

Lithostatic and lithodemic units from old to young include: the **Dayakan pyroclastic Unit,** the Dayakan pyroclastic rock in the study area is dominated by fine-medium sized tuffaceous and has a layered structure. Generally, these rocks are in a very weathered state, with parallel layers. Age of the Late on which turmeric is planted, namely: dacite, and pyroclastic rock. The petrographic analysis of the three rocks is as follows. Dacite intrusions are characterized by a bright ash color with reddish-brown stains, and a massive and vesicular structure. The quartz mineral is quite dominant in this rock and several dacite outcrops appear to have experienced intensive weathering to form soil. Petrographically, these dacite intrusions generally have a bright gray color and massive and Oligocene-Early Miocene Pyroclastic Unit. The Dayakan Pyroclastic Unit was deposited in tandem with the rock units above it and was intruded by dacite intrusions.

Semilir pyroclastic rock unit is a rock unit that is younger than the Dayakan Pyroclastic Unit. A rock unit with general characteristics of yellowish white/brownish color, welded structure, with dust grain sizes up to lapillus. Megascopically, the Semilir Pyroclastic Rock Unit has the general characteristics of being yellowish-white and welded, consisting of lithic, tuff, quartz, and feldspar. These pyroclastic rocks were deposited on land. The age of the unit is Early Miocene. The stratigraphic relationship is interwoven with older formations and aligned with the formations above them.

Nglanggran Breccia Unit, unit this rock is a rock unit that was deposited after the Semilir Formation. This rock unit is a volcanic breccia with andesite fragments. Gravel to boulder-sized fragments with a lapilli matrix cemented by silica. The age of the Nglanggran Breccia Unit referred to by Sampurno and Samodra (1997) is Early Miocene. This unit has a stratigraphic relationship that is in harmony with the layers below it and has an unconformity relationship with the alluvium deposit layer.

The **dacite intrusion unit** in the research area (Figure 2) is characterized by the presence of vesicular, inequigranular porphyritic, hypocrystalline structures with the mineral composition of feldspar, quartz, a little pyroxene, and hornblende in the groundmass of plagioclase microliths and volcanic glass. Based on Samodra and Sampurno (1997), the age of this dacite intrusion is younger than the Miocene. The alluvial deposit unit is The youngest deposit consisting of loose material with very fine grains to lumps. This alluvial unit is the youngest, namely the Holocene-Recent.

Fig. 2. Dasite intrusions exhibit a porphyritic texture with feldspar and quartz minerals surrounded by plagioclase microliths and volcanic glass.

4.1. Petrographic Analysis

Petrographic analysis was carried out on the rocks that produced the soil and the soil as soil grown by turmeric by residents at the research location. So by knowing the type of original rock and the composition of the minerals that undergo weathering to produce soil, you can know the types of heavy metal elements contained in turmeric. There are two type rocks vesicular structure. The texture shows porphyritic-hypocrystalline, fine-medium phaneritic, and anhedral-subhedral crystal forms, as well as inequigranular porphyritic. The mineral composition consists of quartz, plagioclase, pyroxene, a little hornblende, opaque minerals, and in the groundmass volcanic glass and plagioclase microlites (Figure 3). Meanwhile, phenocrysts measure 0.02 – 1.2 mm with a subhedral-anhedral crystal shape.

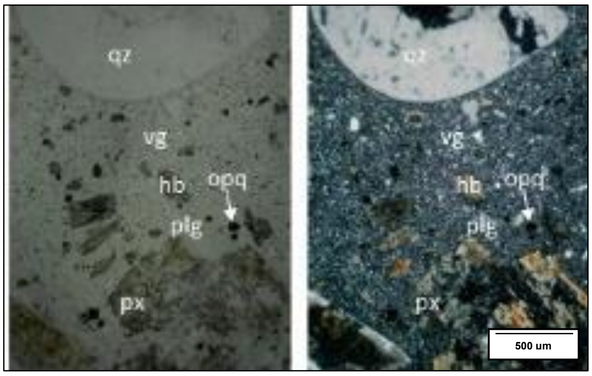

Fig. 3. Photomicrograph of dacite intrusion showing the presence of quartz embayment minerals (qz) along with plagioclase (plg), pyroxene (px), hornblende (hb), and opaque (opx) minerals embedded in volcanic glass (vg).

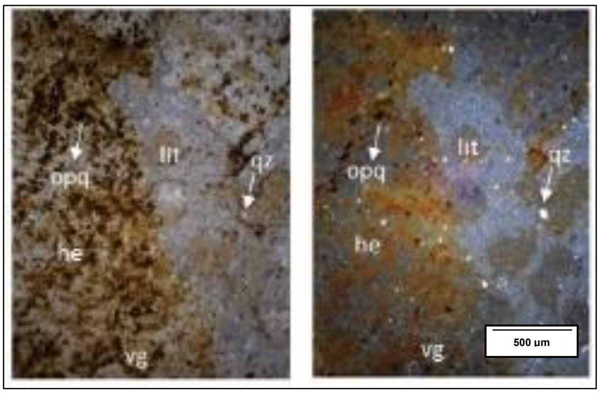

Fig. 4. Photomicrograph of pyroclastic rocks from the Dayakan Formation showing the presence of quartz (qz), lithic (lit), and opaque (opq) mineral fragments and volcanic glass (vg) matrix cemented by silica. The matrix appears to be replaced with hematite (he).

Pyroclastic Rocks of the Dayakan Formation, are rocks with the general characteristics of a yellowish-white/brownish color, with grain sizes ranging from dust to lapillus. In general, these pyroclastic rocks experience weathering with the presence of clay minerals and hematite or iron oxide. Megascopically, this rock unit has the general characteristics of a yellowish-brown color and open packing. Fragments consist of andesite, tuff, quartz, feldspar, and opaq minerals. Microscopically, the following description is obtained: brownish-gray color and medium grading. The shape of the fragment is at an angle which shows an open packing. Fragments measuring 0.05 – 0.25 mm consist of lithic, tuff, quartz, plagioclase, and opaq minerals. Fragments in the same mineral matrix and cemented by silica (Figure 4).

Microscopically, the following description is obtained: brownish-gray color and medium grading. The shape of the fragment is at an angle which shows an open packing. Fragments measuring 0.05 – 0.25 mm consist of lithic, pumice, tuff, quartz, pyroxene, plagioclase, opaque minerals, and volcanic glass. Fragments in a volcanic glass matrix and cemented by silica (Figure 6).

4.2. Heavy metal elements

Soil naturally contains metal elements including heavy metals, such as manganese (Mn), Zn, chromium (Cr), molybdenum (Mo), iron (Fe), and nickel (Ni). These heavy metal elements in low concentrations are very necessary because they are related to the function of soil biota. However, in higher concentrations, it can be toxic (Anand et al., 2019). Likewise, cadmium (Cd), mercury (Hg), lead (Pb), arsenic (As), zinc (Zn), copper (Cu), nickel (Ni), and chrome (Cr) can be very toxic in the soil (Yan et al., 2020).

The impact of heavy metals on soil and plants is the loss or change in soil quality. So the soil becomes infertile and can be toxic to plants. Copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn) are some examples of essential micronutrients for plants (Wang et al., 2022). Even though it is needed in relatively small amounts, it plays a very large role in the metabolism of plants. Manganese (Mn) comes from primary rocks which are generally in the form of ferromagnesite.

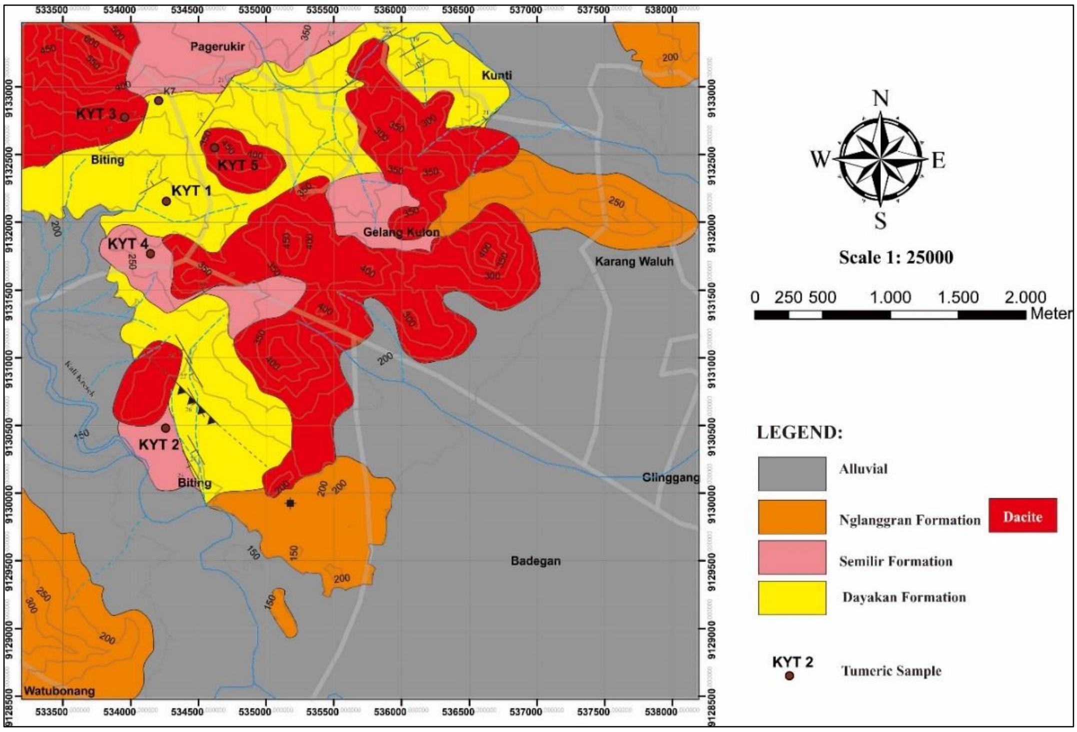

Fig. 5. Geological map of the Biting Wonogiri area and its surroundings.

The Mn element originating from these rocks is liberated through the weathering process of primary minerals (Irzon and Abdullah, 2018) and will combine with O_2, CO_2, and SiO_2 to form secondary minerals, especially pyrolusite (MnO_2) and manganite ($MnO(OH)_2$), and rhodonite ($MnSiO_3$) (Tombros et al., 2023). Manganese and iron oxides are more often found in the soil together in lumps.

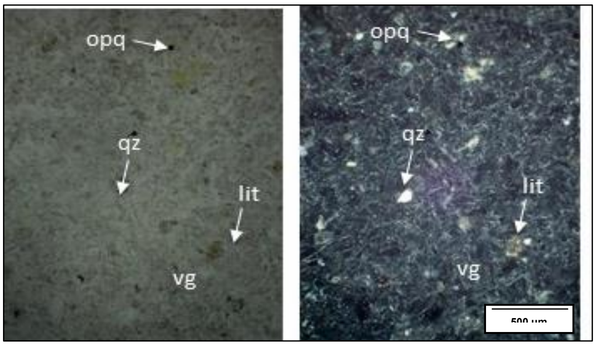

Fig. 6. Photomicrograph of pyroclastic rocks from the Semilir Formation showing the presence of quartz (qz), lithic (lit), and opaque (opq) mineral fragments and a volcanic glass (vg) matrix cemented by silica.

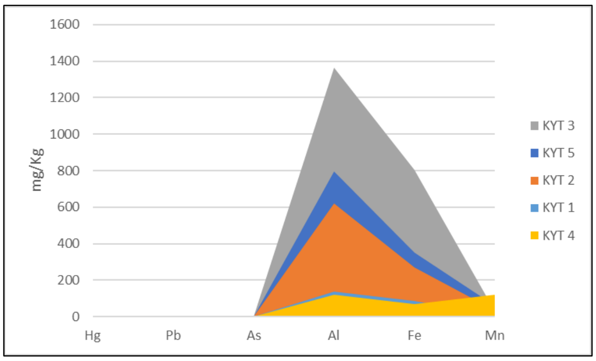

Fig. 7. Distribution of heavy metal chemical elements in turmeric in the study area.

Heavy metals are also closely related to soil organic matter levels and soil pH. Organic materials will cause the chelation of metal cations so that nutrients become available to plants. If the pH is low, the concentration of heavy metals is high and they are easily absorbed by plants (Kalavrouziotis et al., 2023). Heavy metals have stable properties, and it is difficult to explain how these metals can harm living organisms and the environment. In the presence of soil, organic materials will be able to form complex bonds with heavy metals, thus becoming insoluble metals (Wiater, 2019). Transport of chemical elements in soil includes advective transport processes, diffusive transport and chemical reactions between chemicals and soil (Yantrapalli et al., 2018). Heavy metal pollution will follow shallow groundwater flow patterns, and result in a decrease in soil fertility (Hadian et al., 2017).

In health science, turmeric or turmeric (*Curcuma domestica Val.*) can be used as an anti-inflammatory, antioxidant, antitumor, antimutagenic, antifungal, antibacterial, antidiabetic, healing wounds, *radioprotective,* and others (Peng et al., 2021). Turmeric's anti-inflammatory properties have been studied by several researchers for its application in animals and humans, including (Kepinska-Pacelik and Biel, 2023). Antioxidants are compounds that can inhibit the oxidation process of cells. Oxidation is a process that can produce free radicals which can damage cells in the body's organs.

Antioxidant effect on *curcuminoid* one of which was studied by Alabdali et.al (2021). Guneydas and Topcul (2022) stated that turmeric has antiproliferative properties in human neuroblastoma in their research, this shows that *curcuminoids.* This can inhibit the growth of malignant cells. This effect can be attributed to the antitumor benefits of turmeric.

Antimutagenicity is the effect of inhibiting genetic cell changes (Kumar et al., 2020). According to Odo et.al (2023), turmeric oil shows growth-inhibitory activity in *Staphylococcus aureus.* Shi et al. (2021) reported that the ethanol extract of turmeric showed antifungal activity in their research. The effects of *curcumin* on human keratinocyte and fibroblast tissue damage caused by hydrogen peroxide and *hypoxanthine-xanthine oxidase* to explain the mechanism of wound healing with *curcumin* (Adeliana et al., 2023). *Curcumin is* effective for inhibiting radiation-induced protein kinase C activity and has the potential as an agent *chemopreventive* (Imran et al., 2023). Curcumin is also beneficial in reducing the risk level of cancer development and also has a protective effect against radiation toxicity and the harmful effects of pesticides (Jablonska–Trypuc and Wiater, 2021).

From the results of geological mapping and analysis of heavy metal elements in turmeric in the research area, five samples of turmeric were obtained which grew in the Dacite Intrusion Unit, the Dayakan Pyroclastic Rock Unit, and the Semilir Pyroclastic Rock Unit. It is hoped that these five turmeric samples can represent turmeric samples that grow in several lithologies in the research area. The five samples were then subjected to laboratory analysis to determine the content of heavy metal chemical elements in turmeric. The method used is by using the AAS method (*Atomic Absorption Spectroscopy*). Meanwhile, the heavy metal chemical elements used are the heavy metal elements mercury (Hg), arsenic (As), lead (Pb), iron (Fe), aluminum (Al), and manganese (Mn).

The results of heavy metal analysis (Table 1 and Figure 7) show that the heavy metals Hg, Pb, and As have very low concentrations of around 0.005-0.40 mg/Kg. However, the KYT 3 sample has a very high Al and Fe content compared to other turmeric samples. This turmeric sample is located in a dacite intrusive rock unit that has weathered to become soil (Figure 8). In humans, excess Al content can increase the risk of kidney failure and neurological disorders because Al in the body is absorbed and broken down in the kidneys. Normally, the normal level of aluminum in adult human blood is >0-6 mg/mL, and the kidneys can filter and excrete around 5-10 mg per day.

Fig. 8. Turmeric plants found in the research area.

The Al content in the KYT 3 sample was 1362.76 mg/Kg. Also visible in this sample is the high Fe content. The high Fe content in turmeric means that when consumed by humans, the iron element can be used to fight iron deficiency in the blood. Very useful for pregnant women who experience iron deficiency in their blood, as well as other people who have this deficiency. In adults, to treat iron deficiency anemia, the dose of iron supplements in the form of elemental iron is 100-200 mg, twice a day. Meanwhile, the dose given to prevent iron deficiency anemia is 60 mg, once a day. However, if it is excessive, the Fe content in the blood will have negative effects, such as iron poisoning with the effects of nausea, vomiting, diarrhea, and even the risk of colon cancer. In samples in the research area, the highest Fe content was 806.27 mg/Kg.

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Meanwhile, the KYT 5 sample was a sample taken from a resident's garden and was the sample with the second-highest aluminum (796.94 mg/Kg) and iron (352.83 mg/Kg) content. The KYT 5 sample is also in rocks around the dacite intrusion. KYT samples 4, 2, and 1 are samples taken from mining areas on the same slope.

Table 1. Results of chemical element analysis of heavy metals from turmeric in the study area.

Samples	Heavy Metal Elements (mg/Kg)					
	Hg	Pb	As	Al	Fe	Mn
KYT 1 (DYK)	0.005	0.40	0.005	135.65	86.03	6.85
KYT 2 (SML)	0.005	0.40	0.005	622.30	271.32	33.45
KYT 3 (DCT)	0.005	0.40	0.005	1362.76	806.27	32.49
KYT 4 (SML)	0.005	0.40	0.005	122.01	67.89	122.01
KYT 5 (DCT)	0.005	0.40	0.005	796.94	67.89	60.43

Explanation: DYK: Dayakan Formation, SML (Semilir Formation), DCT (Dacite)

5. Conclusion

Oligocene-Miocene old volcanic rocks consisting of pyroclastic rocks, and dacite intrusions are rocks that contribute heavy metal elements such as Al, Fe, and Mn to turmeric plants.

Turmeric grown on dacite has higher Al contents compared to turmeric planted on pyroclastic rocks. Meanwhile, the elements Fe and Mn vary greatly. These heavy metal elements are nutrients that come from old volcanic rocks and are very important for herbal plants. So the turmeric that comes from the research area is a better quality turmeric for herbal medicine compared to other areas.

The high Fe content in turmeric can be used to increase iron in human blood. However, when excessive it will bring negative effects, such as iron poisoning.

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