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Morphological Study of Surface Magnetic Minerals, Case Study of North Banjarmasin Settlement Areas

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ABSTRACT− We have conducted research to determine the morphology of magnetic minerals in the soil of residential areas in the Banjarmasin area. We took the soil samples using a stainless steel shovel and prepared them in the laboratory. Sample preparation includes drying the sample at room temperature, grinding, and extraction using a magnet. Next, we analyzed the samples using scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM EDS) to determine the morphology of the magnetic minerals. The presence of magnetic minerals in nature can indicate heavy metals. The shape of a magnetic mineral can reveal whether it originated from lithogenic or anthropogenic processes. Samples from this study area are mostly made up of multidomain grains (>10–134.69 μm) that look like spheres, irregulars, angles, and prisms, as well as pseudo single-domain grains that measure 3.29–10 μm. These results indicate that in the residential soil at the research location, there are magnetic mineral grains originating from lithogenic and anthropogenic processes.

KEYWORDS : anthropogenic; EDS; magnetite; multidomain; SEM

INTRODUCTION

Identification of magnetic minerals to interpret pollution in the environment has been carried out since the 1980s (Thompson & Oldfield, 1986). Several locations, including Brazil and China (Barrios et al., 2017; César de Mello et al., 2020; Horng, Huh, Chen, & Huang, 2009; Li et al., 2019; Wang, Xue, & Zhu, 2021) have conducted interpretations of the presence of pollutants in soil using magnetic minerals.

Meanwhile, the use of magnetic mineral morphology has been widely used in environmental studies such as in the Danube River sediments, Bulgaria (Veneva, Hoffmann, & Jordanova, 2003), Dobra River sediments (Croatia) in karst areas (Frančišković-Bilinski, Bilinski, Scholger, Tomašić, & Maldini, 2014), soil due to industrial dust in Germany (Rachwał, Kardel, Magiera, & Bens, 2017), soil located in the Brynica River valley (Poland) due to mining activities (Magiera, Mendakiewicz, Szuszkiewicz, Jabłońska, & Chróst, 2016), dust on highways from the Visakhapatnam area (India) due to industry and highway activities (Goddu, Appel, Jordanova, & Wehland, 2004), and leachate from landfills in Bandung Regency (Goddu et al., 2004).

The combustion process causes differences in the morphology of iron oxide in dust, fly ash, and motor vehicles which is a human activity in urban areas has been studied by Funari et al (2018) (Funari et al., 2018), Lee et al (2020) (Lee et al., 2020), Liu et al (2018) (Liu et al., 2019), and Kristian et al (2010) (Kristian, Bijaksana, Srigutomo, & Kardena, 2010). The results of this study show differences in iron oxide morphology caused by human activities.

Banjarmasin City was the capital of South Kalimantan Province before 2024. This leads to Banjarmasin City becoming the busiest and most populous city in South Kalimantan Province. The dense activity in

Banjarmasin City has resulted in increased anthropogenic activity. This can be seen from the burning of fossil fuels produced by motorized vehicles, both land and river, local industrial activities, and household waste disposal activities.

Generally, it's important to monitor the rise in metal content in residential areas' soil (Liaghati, Preda, & Cox, 2004). The accumulation of metals in this area is several times higher than in uncontaminated areas. Therefore, monitoring these changes and determining contamination in the soil is important. We have not studied the content of heavy metals in residential soil in Banjarmasin, the level of pollution, or the source of pollution. Therefore, the purpose of this study was to identify magnetic minerals, both morphologically and type, in the soil in residential areas in Banjarmasin in order to find out the source.

MATERIALS AND METHODS

Geographically, Banjarmasin City is located at 3°16′46″ to 3°22′54″ South Latitude and 114°31′40″ to 114°39′55″ East Longitude. The Banjarmasin City area is surrounded by several rivers, namely the Barito River, Martapura River, Awang River, and Kuin River. Administratively, Banjarmasin City has an area of 98.47 km^2 or 9,846,794 ha.

The geological map sheet of Banjarmasin (Sikumbang & Heryanto, 1994) identifies the rock formations in the Banjarmasin City area as alluvium (Qa), a mixture of gravel, sand, silt, clay, and mud. At certain depths, we also found numerous plant remains and peat (Figure 1). The sampling locations were in three sub-districts in Banjarmasin City, namely North Banua, which is located in East Banjarmasin, North Kuinand Kayu Tangi, which are located in North Banjarmasin. The determination of sampling points is based on each location that has the lowest and highest magnetic susceptibility values.

Using a stainless steel shovel, six soil samples (namely 1, 2, 3, …, 6) were collected and placed in plastic clips in accordance with Gu et al.'s protocol (Gu, Gao, & Lin, 2016). The samples were then prepared in the FMIPA ULM geophysics laboratory following Novala et al.'s procedure (Novala et al., 2019), which included sample drying and sample extraction using a magnetic stirrer. The magnetic stirrer functions to stir soil samples in the aqueous medium while simultaneously attracting dissolved magnetic minerals. We then analyzed the extracted samples using an SEM-EDS instrument to determine the morphology of the magnetic minerals.

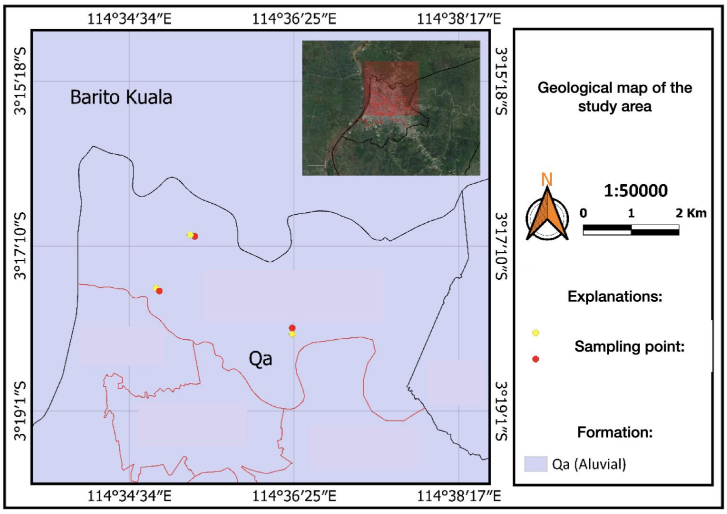

Figure 1 Geological map of the study area shows the sampling sites (Sikumbang & Heryanto, 1994)

The SEM test equipment uses a filament that functions as a cathode. The anode will produce a force that attracts electrons toward it. Two condenser lenses will focus the electron beam to a point on the sample surface. This specimen emits electrons that scatter inelastically and elastically. Elastic scattering produces secondary and characteristic X-ray electron signals, known as secondary electrons, while elastic scattering produces backscattered electron signals. The detector will detect secondary electrons or backscattered electrons from the sample surface and display them as images on the monitor screen (Madi, 2022).

RESULTS AND DISCUSSION

The SEM test results (Figure 2) reveal the presence of magnetic minerals in soil samples from residential areas in Banjarmasin. magnetic mineral morphology of samples. Based on the shape and results of EDS analysis, perfectly round magnetic mineral grains dominate the shape of the identified magnetic minerals, but there are also grains with irregular angles and those with cavities. These samples have grain sizes ranging from 3–135 µm. According to the EDS test, the elements associated with magnetic minerals are Fe, O, Mg, Al, Ca, and Si (Figure 3(b)). Based on the geology of the research area, Fe, O, Mg, Al, Ca, and Si can come from the bedrock of the area around it, which is ultramafic rock (Sikumbang & Heryanto, 1994). However, these elements can also come from anthropogenic processes (Singh et al., 2016; Smieja-Król et al., 2010). If we look at the results of this research, where the part analyzed by EDS is the spherule-shaped part of the grain, it can be stated that these elements are associated in the grain, which originates from anthropogenic processes.

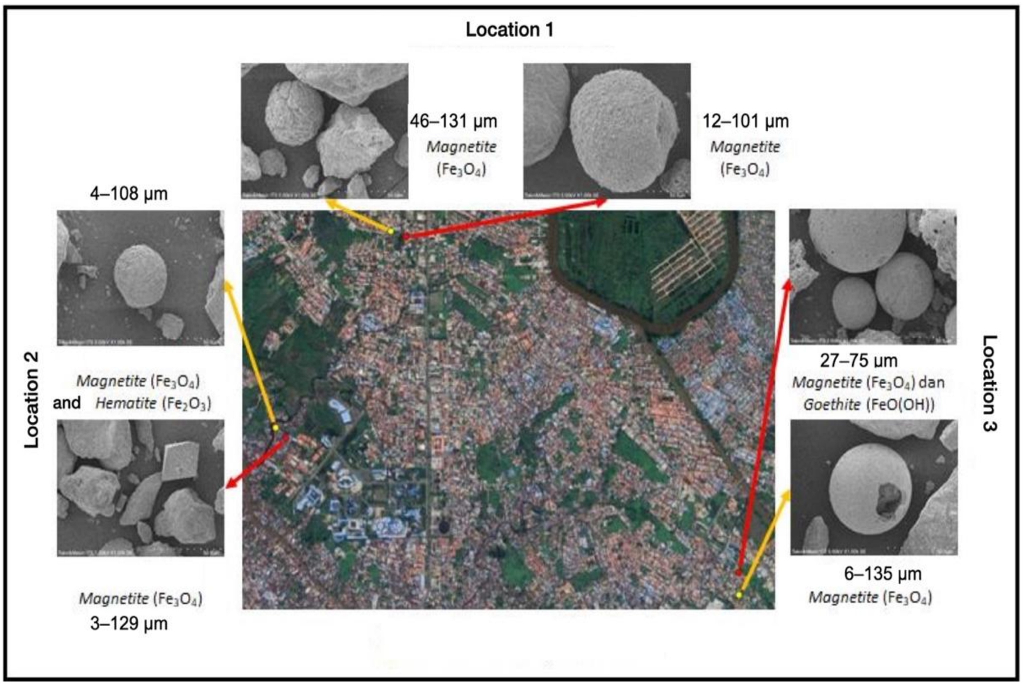

Figure 2 The research location's magnetic mineral morphology, At each location, magnetic minerals originate from anthropogenic (spherule) and lithogenic (angular and irregular) processes.

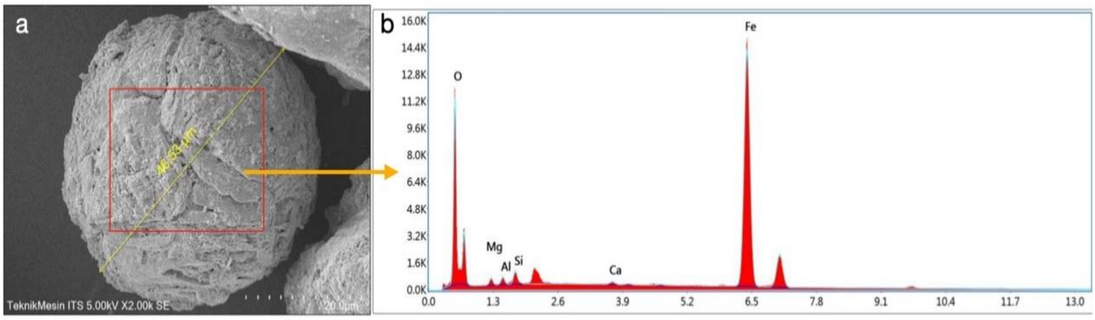

Figure 3 The selected sample of magnetic mineral grain (a) and its elements were found.

The round shape of magnetic mineral grains indicates that magnetic minerals originate from anthropogenic processes (Chris Perry and Kevin Taylor, 2006). The distribution of round grain shapes in the samples ranges from 25–80% of all photographed samples. This suggests that anthropogenic processes may have contributed to the sample. Anthropogenic processes influence the magnetic mineral's characteristic shape, which is a perfectly round magnetite mineral (Fitriani, Utami, Kirana, Agustine, & Zulaikah, 2021; Franke, von Dobeneck, Drury, Meeldijk, & Dekkers, 2007; Jordanova, Hoffmann, & Fehr, 2004; Maity et al., 2021). The findings of this research align with those of Kirana et al.'s (Kirana et al., 2020), study, which revealed the presence of octahedral-shaped natural magnetite grains and spherical grains resulting from oxidation/combustion and diagenesis processes. Rounded magnetic mineral grains are evidence of anthropogenic processes. Therefore, the magnetic minerals in soil samples from this industrial area come from human activities in the form of burning in chimneys and can also come from combustion in motor vehicle engines.

The irregular shape of magnetic minerals suggests that they originate from lithogenic processes, namely weathering of the original rock (Ananthapadmanabha, Shankar, & Sandeep, 2014). Maghemite is a magnetic mineral (Ayoubi & Adman, 2019; Chai et al., 2015).

EDS measurement results show round magnetic grains associated with the elements Fe, O, Mg, Al, Ca, and Si (Figure 3). Burning fossil materials can produce Si. Al, Ca, K, P, S, Mg, and Si are the results of abrasion (scraping) in the combustion system of motor vehicles (Lee et al., 2020).

CONCLUSION

The SEM-EDS analysis revealed that human activities caused the round shape of magnetic minerals in soil samples from the study area, while lithogenic activities caused their irregular shapes. The magnetic mineral grains have a multidomain size.

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