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Comparative study of top soil magnetic susceptibility variation based on some human activities

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Resumen

Se realizó una investigación sobre el efecto que tienen algunas actividades humanas en la susceptibilidad magnética y la susceptibilidad dependiente de la frecuencia: el estudio se realizó en Jalingo, estado de Taraba, Nigeria, en la superficie del suelo de una zona comercial, un estacionamiento de autos y una zona escolar. El objetivo fue evaluar la variación de la susceptibilidad magnética con distintos tipos de uso de la tierra y detectar los puntos más contaminados utilizando los parámetros de proxy magnéticos. Con ello se evaluó la contribución de superparamagnéticas (SP), del tamaño de un grano, a la susceptibilidad magnética del cálculo de la dependencia de la frecuencia de la susceptibilidad magnética (MS). Los resultados de las mediciones de masa específicos de susceptibilidad de baja frecuencia magnética mostraron una mejora significativa con valores que van desde 67,8 hasta 495,3 x 10^{-8} m^3kg^{-1}, con un valor medio de 191,61 x 10^{-8} m^3kg^{-1} para el Colegio Jalingo de Educación (datos JCOE); 520,1-1612,8 x 10^{-8} m^3kg^{-1} con un valor medio de 901,34 x 10^{-8} m^3kg^{-1} para el mercado principal de Jalingo (JMM) y 188.5- 1.203,6 x $10^{-8}m^3kg^{-1}$ con un valor promedio de 574 92 x 10^{-6} m^3kg^{-1} para el Motor Park Jalingo (JMP). La mejora magnética significativa indica una alta concentración de minerales ferrimagnéticos en el suelo y, por lo tanto, un aumento en la contaminación. La susceptibilidad magnética de los diferentes usos del suelo estudiados se redujo en la zona comercial (mercado)>, estacionamiento > e instalaciones escolares. Los resultados de la dependencia del porcentaje de la susceptibilidad dependiente de la frecuencia mostró que la mayoría de las muestras tenían una mezcla de SP y los granos gruesos o de dominio de múltiples granos SP <0.05μm. El valor de% χ_{fd}% rango 2,68 a 13,80%, con un valor medio de 8,67% en las muestras JCOE, 0,49 a 10,04%, con un promedio de 5,05% en las muestras JMM y 0,56 a 13,04%, con un valor promedio de 5.86% en las muestras de JMP.

Palabras clave: Contaminación del suelo, susceptibilidad magnética, susceptibilidad dependiente de la frecuencia, mineral magnético, ferrimagnético.

Abstract

An investigation of the effect of some human activities on the magnetic susceptibility and frequency dependent susceptibility was conducted on top soil samples from, a commercial area, a motor park and a school environment in Jalingo, Taraba State, N-E Nigeria. The purpose was to assess the variation of magnetic susceptibility with different land use, detect pollution hotspots using magnetic proxy parameters and evaluate the contribution of superparamagnetic (SP) grain size contribution to the magnetic susceptibility from calculation of the frequency dependence of magnetic susceptibility (MS). The results of the mass specific low frequency magnetic susceptibility measurements showed significant enhancement with values ranging from 67.8 - 495.3 x 10^{-8} m^3kg^{-1} with a mean value of 191.61 x 10^{-8} m^3kg^{-1} for the Jalingo College of Education (JCOE) data; 520.1 – 1612.8 x 10^{-8} m^3kg^{-1} with a mean value of 901.34 x 10^{-8} m^3kg^{-1} for the Jalingo main Market (JMM) and 188.5- 1203.6 x $10^{-8}m^3kg^{-1}$ with an average value of 574 92 x 10^{-6} m^3kg^{-1} for the Jalingo Motor Park (JMP). The significant magnetic enhancement indicates high concentration of ferrimagnetic minerals in the soil and hence increased pollution. The magnetic susceptibility of the different land use studied decreased in the order commercial area (market) > motor park > school premises. The results of the percentage frequency dependence susceptibility showed that most of the samples had a mixture of SP and coarse multi domain grains or SP grains < 0.05μm. The value of χ_{fd}% range from 2.68 to 13.80% with an average value of 8.67% in the JCOE samples, 0.49 to 10.04% with an a-verage of 5.05% in the JMM samples and 0.56 to 13.04% with an average value of 5.86% in the JMP samples.

Key words: Soil pollution, magnetic susceptibility, frequency dependent susceptibility, mineral magnetic, ferrimagnetic

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Introduction

The adverse effect of human impact in the environment has increased in recent years and has become a subject of global concern. The type and intensity of human activity greatly impact on the environment. With increased urbanization, the urban environment is threatened by various pollution sources released into it. This pollution ranged from indiscriminate refuse dump, sewage disposal, industrial wastes, bush burning, and emissions from industries and automobile exhaust. So, pollution has become a subject widely investigated from several fields, such as geology, geophysics, chemistry, agriculture etc. Atmospheric pollution has been identified, as one of the most harmful factors for ecosystems (Petrovsky and Elwood, 1999). Usually, heavy metals and toxic elements from industrial, vehicular and domestic emissions are released into the atmosphere and are incorporated into the environment or in living organism such as vegetation, animals and human beings. These contaminants that are released into the atmosphere, soils and sediments are rich in magnetic particles, resulting in magnetic enhancement of the urban soils and sediments. A measure of the amount of magnetic enhancement is expressed by its magnetic susceptibility and in recent years, it has been successfully used to monitor anthropogenic pollution, especially heavy metal pollution in soils (example Gautam *et al.*, 2004, Petrovsky *et al.*, 2000, Strzyszcz and Magiera, 1998, etc.).

Magnetic susceptibility is defined as the ratio of the total magnetization induced in a sample to the intensity of the magnetic field that produces the magnetization Mullins (1977).

Magnetic susceptibility measures the concentration of magnetic crystals and also gives information on the type of magnetic minerals present in a sample. Magnetic minerals present in soils may either be obtained from the parent rocks (lithogenic origin), during pedogenesis or as a result of anthropogenic activities. The magnetic mineral content of the soil can broadly be expressed by its magnetic susceptibility. Magnetic susceptibility can be used to identify the type of mineral and the amount of iron bearing minerals contained in a material. Soils are sinks to anthropogenic pollutants released into the atmosphere. Accumulation of anthropogenic ferrimagnetic particles, originating from oxidation process during combustion of fossil fuels results in significant enhancement of topsoil magnetic susceptibility. The most important magnetic mineral is magnetite and in the atmosphere it can originate from combustion (and other industrial) processes (Petrovsky *et al.*, 2000).

The first evidence of magnetic enhancement was reported by Le Borgne (1955). Subsequent studies by Mullins (1977) confirmed this phenomenon. Thompson and Oldfield (1986) further reported that the soils near urban areas and industrial zones have an increased susceptibility due to deposition of magnetic particles such as, dust of the metallurgical industries and fly ashes of the coal combustion. Since then, extensive studies of pollution and magnetic proxies for pollution have been conducted for example Alagarsamy (2009), Canbay (2010), Gautam *et al*. (2005), Kapicka *et al*. (1999), Knab *et al*. (2006), Magiera *et al*. (2006), Petrovsky *et al*. (2000), Shen *et al*. (2008), Strzyszcz *et al.* (1996) etc. Magnetic measurement is a simple, rapid and non-destructive technique that can be applied on soil/sediment samples.

The purpose of this study was to assess the variation of magnetic susceptibility with different land use, detect pollution hotspots using magnetic proxy parameters and determine the grain size of the samples from calculation of the frequency dependence of magnetic susceptibility (MS).

Materials and Methods

Geographical and Geological setting of the Study Area

Jalingo, the study area is the administrative headquarters of Taraba State which is located between latitude 6º30′ and 8º30′ North of the equator and between 9º00′ and 12º00′ East of the Greenwich meridian (Figure 1). The state has a tropical wet and dry climate, dry season lasts for a minimum of five months (November to March) while the wet season spans from April to October. It has an annual rainfall of about 8000 mm. Jalingo is a rapidly growing city without significant industrial activity, the major pollution source is the emission from traffic and power generating sets and other human activities such as indiscriminate refuse dump, bush burning etc.

The study area is underlain by the undifferentiated Basement Complex rocks which consist mainly of the migmatites, gneisses and the Older Granites. Tertiary to Recent basalts also occurs in the area. The undifferentiated Basement Complex particularly the migmatites, generally vary from coarsely mixed gneisses to