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ELEMENTAL ANALYSIS OF ITAKPE IRON ORE BY ENERGY DISPERSIVE X-RAY FLUORESCENCE SPECTROMETRY

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ABSTRACT
Elemental analysis of Itakpe Hematite by Energy Dispersive X-Ray Fluorescence spectrometry was carried out. The iron ore contained the following: Fe (29.55%) Si (24.68%), Zr(0.33%), Ti (0.19%), Zn(0.02%), Ca(0.04%), Cr(0.05%), Mn(0.05%), Nb(0.05%) and V(0.003%) respectively. The study opines that the hazards to human health caused by exposure to heavy metals are associated with a range of neurological deficits in both children and adults. The EDXRF technique can also provide a rapid evaluation of the economic potential of a geological deposits thereby providing its value both to the mining industry and to the health of the community impacted by the geological exploitation process.
Keywords: Iron ore, Itakpe, Energy Dispersive X-ray Fluorescence spectrometry, pellet

INTRODUCTION

Iron ores are made up of various minerals with different iron content and iron oxidation state, and gangue and or tailing minerals that are of no commercial value. The most prominent iron minerals are hematite, magnetite and goethite. The knowledge of the mineralogy, in particular the oxidation state of the iron oxides has direct influence on the commercial value of the ore and on processing of the ore (Enders, 2005).

Environmental exposure to products of unsafe mining and ore processing activities is associated with serious health implications. The poisoning from extraction of gold ore contaminated with lead in Zamfara, Nigeria, contributed to a health epidemic including death and long term medical conditions (UNEP, 2011). Screening, monitoring and evaluation of potential risks from exposure to geological materials associated with mining practices can be facilitated by accessible and effective tools and techniques such as Energy Dispersive X-Ray Fluorescence spectrometry (EDXRFs). The technique is also an effective method for rapid quantification of the economic potential in Nigeria's mineral resources. EDXRFs are powerful technique in analytical chemistry.

EDXRFs are rapid, relatively non-destructive chemical or elemental analysis of rocks, minerals, sediments, fluids and soils (Fisher *et al.,* 2014). Its purpose is to identify the elemental abundances of the sample. It is used in a wide range of applications, including mining, metallurgy, soil surveys, cement production, ceramics and glass manufacturing, petroleum industry, field analysis in geological and environmental studies, and research in igneous, sedimentary and metamorphic petrology etc (Fitton, 1997,Jurado-Lopez, *et al.,* 2006). EDXRFs can also sometimes be used to determine the thickness and composition of layers and coatings (Thomas, 1982). The methods is fast, accurate, non-destructive and usually required only a minimum of sample preparation. X-Ray fluorescence spectrometry systems can be divided into two main groups: Energy dispersive system (EDXRFs) and wave length dispersive system (WDXRFs). However, in XRFs, if the detector allows the determination of the energy of the photon when it is detected, it is known as energy dispersive X-ray fluorescence spectrometry (EDXRFS), but if the detector allows the determination of the wave length of the photon when it is detected after the photons are separated by diffraction on a single crystal before being detected, it is known as wavelength dispersive XRFs (WDXRFs). The WDXRFs is occasionally used to scan a wide range of wavelength (Petrovic *et al.,* 2001).

The XRFs method depends on fundamental principles, the geological sample is bombarded by high-energy, short wavelength X-rays. This radiation excites the sample and dislodges the electrons in the inner orbital causing ionization of the geological sample. With space in the lower orbital's open, electrons in higher orbitals fall into the lower ones. This releases a secondary radiation – the fluorescence from the sample. Energy is released during this process because the binding energy of a low orbital is less than that of a higher orbital. The energy released is roughly equal to the difference in the binding energies of the two orbital's involved. Both the energy and the wavelengths of the secondary radiation are much less than the original X-Rays. Characteristics of the secondary radiation such as energy and wavelength are specific to element whose atom they were released from. These can be detected and converted into computer generated data. The XRFs machines output, coupled with a quantitative analysis, will report what percent of each element is, within the sample (Russ, 1984).

The elements that can be analyzed and their detection levels depend mainly on the spectrometer system used. The elemental range for EDXRFs goes from sodium to Uranium (Na to U). For WDXRFs, the range is even wider from Beryllium to Uranium (Be to U).

The elemental concentration detection ranges can be as low (sub) ppm to 100% (Funtiea, 1996). Elements with high atomic numbers have better detection limits than lighter elements. The precision and accuracy of XRFs analysis is very high when good standards are available for instrument calibration (Robertson and Feather, 2004).

The total measurement time for a single XRFs analysis depends on the number of elements to be determined and the required accuracy and varies between 2000 to 5000 seconds. XRFs is a very sensitive technique but samples must be free of contamination (Okunade, 1999). Even finger prints on a sample can affect the results of an analysis. For accurate results the spectrometer conditions (e.g. the excitation energy of the X-ray generator) are tuned to the element to be analyzed. Inappropriate settings can lead to poor results.

The aim of this study is to demonstrate the application of EDXRFs to assess the elemental composition of iron ore samples collected from Itakpe National iron ore mining site of Kogi State and evaluate the toxicity of the mining wastes. Results of analysis reported in this study will provide a basis for developing protocols to aid in detection, evaluation, exploitation and remediation of geological hazards associated with metal ore mining and processing in Nigeria and provides a robust tool for economic evaluation and diversification of Nigeria's national resources.

MATERIALS AND METHODS

Sample Collection and Pre-Treatment

The iron ore (hematite) samples used for this study were collected from Itakpe National Iron Ore mining site in Okene, Kogi State, North Central, Nigeria. Sampling was conducted by collecting six iron ore samples from an iron ore heap, two each from the top, middle and bottom, and same were placed into labeled polyethylene homogenization container, and mixed thoroughly to obtain homogenous sample representative of the entire sampling interval. When compositing was completed the labeled homogenization polyethylene bags were closed tightly and returned to the laboratory for pre-treatment and analysis (Mason, 1983). The iron ore samples were air dried under laboratory conditions for two weeks before analysis.

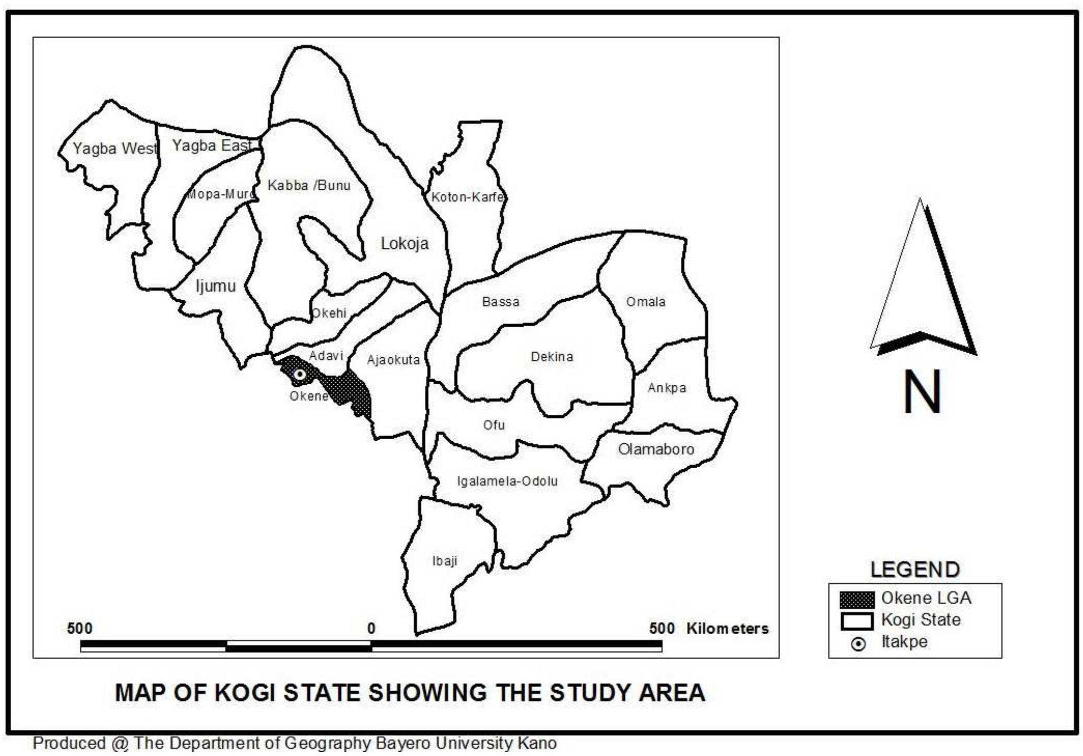

Fig. 1: Map of Kogi State Showing the Study Area

Sample Analysis

The air dried iron ore samples were ground in agate mortar and pestle and sieved to 75µm particle size. Four grammes (4g) of the sieved samples were intimately mixed with 1g of lithium tetraborate binders ($Li_2 B_4 O_7$) and pressed in a mould under a pressure of 10-15 tons/in^2 to a pellet. The pellets in triplicate were dried at 110^{o}C for 30minutes in an oven to get rid of absorbed moisture and then stored in a desiccators for analysis. The analysis was carried out using EDXRF spectrometer model Lelyweg1, 760ZEA, Almelo, Netherland. EDXRF measurements were performed using an annular 25mci 109Cd as the excitation source that emits Ag-K X-rays (22.1KeV) in which case all elements with lower characteristic excitation energies were accessible for detection in the samples.

The system consists further more of a Si(Li) detector with resolution of 170ev for the 5.90keV line coupled to a computer controlled analog to digital converter (ADC) card (Iwanczyk*et al.,* 1996). The Mo target serves as a source of monochromatic X-rays which are excited through the sample by primary radiation and then penetrate the sample on the way to the detector. In this way, the absorption factor is experimentally determined which the program used in the quantification of concentration of the elements. In addition, the contribution to the Mo-K peak intensity by the Zr-K is subtracted for each sample (De Boer, 1999).

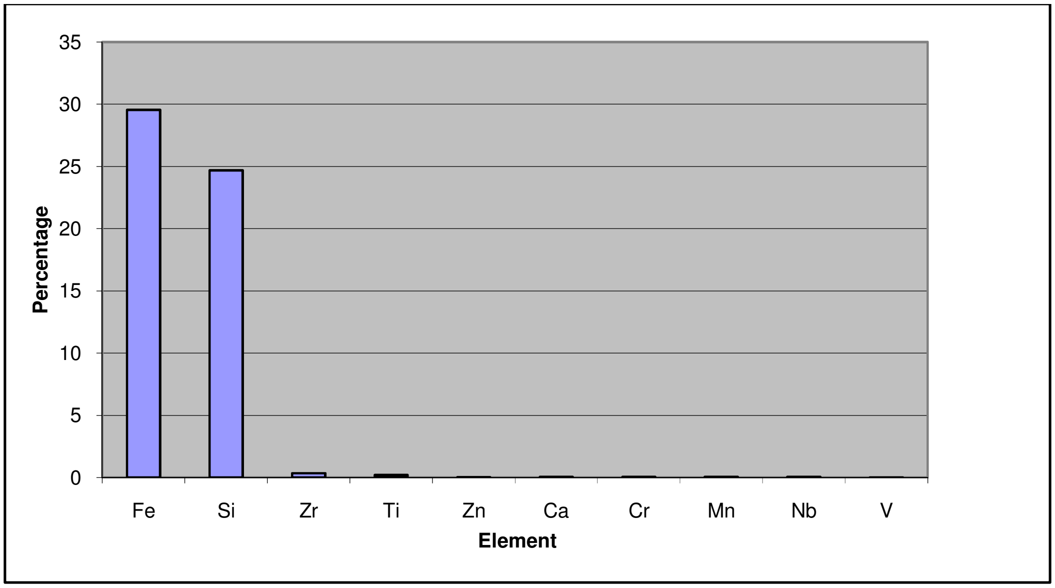

Fig. 2: Elemental Composition of Itakpe Iron Ore

RESULTS AND DISCUSSION

The studied area is shown in Figure 1. Figure 2, shows the average elemental composition of the Itakpe National iron ore as analyzed. The following are the average percentage elemental composition of the Itakpehaqematite as evaluated and include: Fe(29.55%), Si(24.68%) Zr(0.33%) Ti(0.19%), Zn (0.02%, Ca(0.04%), Cr(0.05%) Mn(0.05%), Nb(0.05%), and V(0.003%) respectively. The analytical result provides the elemental constituents of the Itakpe iron ore, baselineinformation on the anthropogenic impact of environmental pollution in the mining community and basis for planning management strategy to achieve better environmental quality. The mining sector is responsible for many of the largest releases of heavy metals into the environment of any industry. It also releases other air pollutions including sulfurdioxide and nitrogen oxides in addition to leaving behind tons of waste tailings, slag and acid drainage. Occupational and environmental exposure to heavy metals, silica and asbestos can occur during mining and milling operations. The smelting process (extracting the metal from the ore) is associated with the highest exposures and environmental releases. The hazards to human health caused by exposure to toxic metals have been thoroughly documented. These toxic metals are associated with a range of neurological deficits in both children and adults in addition to a range of other systemic effects. Exposure to airborne silica can cause lung cancer, pneumoconiosis and numerous other health effects, while pollution controls can minimize exposures to workers and surrounding communities, these safeguards are often absent in mining and smelting operations in developing countries as Nigeria. Even relatively efficient mining operations result in enormous waste, emissions to air and water, and a legacy of environmental contamination in nearby communities. Around the world, unsafe mining and smelting practices have been responsible for a continuing series of environmental and human health disasters, which cause great human tragedy and undermine social stability, economic development and sustainability goals.

CONCLUSION

This study demonstrates the application of the EDXRFs technique to obtain fast and accurate elemental composition of geological material also exposes the anthropogenic impact of the waste tailings on environmental degradation and human health. The mining industry is responsible for the largest releases of heavy and toxic metals into the environment more than any industry. The hazards to human health caused by exposure to heavy metal are associated with a range of neurological deficits in both children and adults. The EDXRF technique can also provide a rapid evaluation of the economic potential of geological deposits thereby providing its value both to the mining industry and to the health of the community impacted by the ore extraction process.

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