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TRACE ELEMENT ANALYSIS BY PIXE IN TAILINGS OF GOLD ORE SAMPLES OF MAGA MINING AREA OF DANKO-WASAGU

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Abstract: **The trace elements level in five tailings of gold ore samples from Maga mining area, Danko-Wasagu were determined using proton induced X-ray emission (PIXE) method. Si content in the samples studied was found remarkably high. Si concentrations varied from 287099.5 to 550376.7 ppm with a mean value of 398260.04 ppm. Significantly increased amount of the elements K, Fe, S, P, Ti, Ca, Cr. Ba, Sr, Zr, Cu, Rb, Zn, Sr, Cu, and Ni was observed in the samples as well. Concentrations of Fe ranged from 124072 to 333870.6 ppm with a mean of 111296.54 ppm. The mean concentrations of S, Ti, Pb, P, Cr, Ca, Ba, V, Zr, Mn, Cu, Sr, Zn, Rb, and Ni were 3623.3, 3299.3,1628.025,1263.54, 1158.22, 733.1,687.25,346.6,284.7,250.9,197.74,177.36,101.67,86.65 and 13.4 ppm respectively. But the concentrations of most elements were higher than the standard concentration. The presence of the elevated amount of the hazardous heavy metals in the area was primarily due to extremely high concentration of these elements in the gold ores being excavated from mining area. The legitimacy of the method was done by analyzing Standard Reference Material NIST (Obsidian rock) standard 278 and found to be compatible. PIXE is a multi element systematic technique used for the determination of major, minor and trace elements in the range of parts per million (ppm). My study has been carried out at the Centre for Energy Research and Development (CERD), Obafemi Awulowo University (OAU) Ile-Ife, Osun state Nigeria. Using 1.7 MeV Tandem accelerators. The X-ray spectra were measured by a Si (Li) detector and analyzed off-line using GUPIX software.**

Keywords: **PIXE, Trace elements, Tailings of gold ores.**

1. INTRODUCTION

PIXE is a powerful yet non-destructive elemental analysis technique now used routinely by Scientist. The availability of high-energy accelerators has made PIXE an attractive alternative to other conventional, multi-elemental analytical methods. The simultaneous quantification of a large number of elements in a sample makes PIXE an important analytical tool for use in diverse nuclear fields of studies. More importantly PIXE sample preparation method is simple and easy [1]. Particle-induced x-ray emission (PIXE) analysis is a variant of x-ray analysis that can detect trace elements in a wide variety of samples. Multi-channel pulse height analysis was used to develop energy dispersive detectors, which enabled simultaneous multi-elemental analysis [2]. Proton Induced X-ray emission (PIXE) is one of the most common and widely used analytical spectrometry techniques at MeV accelerators and the analysis is performed with characteristic X-rays. When charged particles with sufficient energy hit on a sample, a vacancy in the inner shells of an atom may be created. The probability of creating a vacancy is higher when the velocity of the incoming ions matches the velocity of the inner shell electrons. In the PIXE technique, these characteristic X-rays are detected by Si(Li) detector. Energy dispersive analysis of the detected signals can reveal the identity of different elements present in the sample and more importantly, by measuring the charge, i.e. the number of incoming particles, the concentration of the elements can be accurately measured [3]. The quantity of a particular element in the sample is determined from the intensity of its characteristic x-ray

emission spectrum [4].Trace elements play very important roles in living beings. Any fluctuation like deficiency or excess in their normal level in living cells may lead to physiological disorders causing various diseases like hypertension, dental caries, goitre, cancer, heart disease, gallstones, obesity, and anemia [3].

The presence of heavy metals in the tailings of ores is a severe tread to human health especially at elevated level. Some of them are Pb, Fe, Zn, Ti, V, Ni. e.t.c. If the concentration of any element in the tailings exceeds the essential limit, it becomes toxic and harmful for environment and as well as living being. It is therefore, essential to have detailed information for studies in trace elements profile of the tailings of gold ores, so that proper precautions can be taken to improve the environment of the maga area of Danko-Wasagu. PIXE is well established technique for this purpose by which the concentration of most of the elements in different tailings of gold matrices can be measured accurately in ppm [3].

2. MATERIALS AND METHODS

A. Study Area

The study area of this research is Maga mining area. Maga is a village under Danko-wasagu Local Government, which lied within the latitude of 11^0 22' 35.04'' N and longitude of 5^0 47' 43.30'' E, Zuru Emirate, kebbi State, Nigeria.

B. Materials

The five geological samples were collected from different locations of maga mining area in form of gold ore. Each sample was taken to the grinding machine of its locations for grinding into particle sizes. After grinding and processed into particles- size, the valuable materials was removed and left with tailings or leftover. Then this leftover was taken for analysis.

3. PREPARATION OF SAMPLES

After thorough mixing of the tailings of gold ores with some binding agent such as chemflex TM or polyvinylpyrrolidone, pellets are prepared with hydraulic press. Five pellets are made and thereafter fastened to the specimen holder (special ladder akin to a slide projector, which enables the analysis of many hundred in sequence).The aluminum foil paper is placed behind the pellets before it is fastened to the special ladder to avoid the masking tape sticking to the pellets. It is then meticulously lowered into the specimen chamber. Once the specimen is securely placed in the specimen chamber, the chamber is made vacuous by a special vacuum pump affixed to the chamber. The specimen is now ready for irradiation.

A. Irradiation of samples

Irradiation has to do with the bombardment of samples with energetic protons ion beam. With PIXE, Irradiation and spectrum generated are sequential. Each sample is irradiated and counted for ten minute (10 min).The projectile (proton) accelerated with 1.7 MeV Tandem accelerator at the Centre for Energy Research and Development (CERD), Obafemi Awulowo University (OAU) Ile-Ife, Osun state Nigeria, in the energies ranged from 2-3 MeV. The proton hit the target atoms in the sample which led to the atomic interactions that give off electromagnetic radiation of wavelengths in the X-ray part of the electromagnetic spectrum specific to the element contained in the sample [5]. The energy liberated in the transition from the excited state to the ground state takes the form of a characteristic X-ray photon whose energy is given by the energy difference between the initial and final states [6]. The emitted X-rays in the irradiation were detected by using Si (Li) detector and the software was used to collect and save the signals in a specific file format [6]. Irradiation is done together with Standard Reference Material (SRM) for relative quantitative calculation and quality control. The precision and trueness of the method were checked by analyzing the single SRMs under the same condition as the sample. The PIXE analysis provides high Z elements such as S, K, Ca, Fe, Cu, Zn, Br, Pb etc. and gives the accurate concentration of the most of the elements present in the samples with high accuracy. In PIXE technique GUPIX software was used to save the X-ray emission spectrum [7].

B. Data Analysis

Data were analyzed using GUPIX software that can simply, automatically and quickly fit the PIXE spectra to obtain the elemental concentrations. Elemental concentration calculation of each element C_Z is based on the following equation

$$C_z = \frac{Y}{Y_t Q \varepsilon T H}$$

Where Yt is the X-ray theoretical intensity (i.e. the yield per micro-Coulomb of charge per unit concentration), Y is the x-ray experimental intensity or yield, Q is the measured proton beam charge, ε is the efficiency of the detector and T is the transmission through any filter or absorbers between the target and the detector. H is an instrumental constant equivalent to the product of the geometrical solid angle of the x-ray detector and any systematic normalization factor present in the charge integration system [7]. GUPIX is developed in the Guelph University, Canada. It is capable to analyze PIXE spectra from thin, thick and layered targets. The choice of GUPIX was based on the fact that it uses all updated best available databases i.e. cross-sections, Fluorescence and Coster-Kronig probabilities, stopping powers, and attenuation coefficients [8].

4. RESULTS AND DISCUSSION

The study has been carried out at the Centre for Energy Research and Development (CERD), Obafemi Awulowo University (OAU) Ile-Ife, Osun state Nigeria. Using a model of 5SDH 1.7 MeV Pelletron accelerator built by the National Electrostatic Corporation (NEC), USA. This equipment was installed at CERD by the NEC, USA [9] . The trace elements in 5 tailings of gold ores samples from maga mining area in Danko-Wasagu local government, were analyzed using PlXE method and the elements Si, K, Fe, S, P, Ti, Ca, Cr. Ba, Sr, Zr, Cu, Rb, Zn, Sr, Cu, Rb and Ni were observed in the samples well above the detection limit. The content of Silicon (Si), Potassium (K) and Iron (Fe) in the tailings of ores studied were found remarkably high. Si concentrations varied from 287099.5 to 550376.7 ppm with a mean value of 398260.04 ppm, concentrations of K ranged from 20144.2 to 41904.2 ppm with a mean of 17848.62 ppm and concentrations of Fe ranged from 124072 to 333870.6 ppm with a mean of 111296.54 ppm. The mean concentrations of S, Ti, Pb, P, Cr, Ca, Ba, V, Zr, Mn, Cu, Sr, Zn, Rb, and Ni were 3623.3, 3299.3,1628.025,1263.54, 1158.22, 733.1,687.25,346.6,284.7,250.9,197.74,177.36,101.67,86.65 and 13.4 ppm respectively .But the presence of heavy metals in the tailings of ores is a severe tread to human health especially at elevated level, such elements include Pb, Ti, Zn, Ni, e.t.c.

5. CONCLUSION

The results reported in this work, proven the reliability of the 1.7 MeV Tandem particle accelerators from the Centre for Energy Research and Development (CERD), Obafemi Awulowo University (OAU) Ile-Ife, Osun state Nigeria, which guarantee the application of PIXE method of high sensitivity and precision, in a wide range of areas. From the foregoing of this research, the irradiation analysis revealed that, the total of 18 trace elements from the five samples of tailings was observed. These include: Si, K, Fe, S, P, Ti, Ca, Cr. Ba, Sr, Zr, Cu, Rb, Zn, Sr, Cu, Rb and Ni. The results at range 2-3 MeV energy revealed the presence of elevated concentration of silicon, Fe, and K their concentrations in part per million (ppm) include: 398260.04 ppm, 111296.54 ppm, and 17848.62 ppm.

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