

Geochemical Analysis of Stream Sediments from Mining Sites at Epe and Its Environs, Osun State, Nigeria

Akinyemi, F.E, Ogunrinde, I.S., Olawuni, K.F., Imodu, C.A., Adejuyigbe, T.O., Onah, C.E., Olalekan, O.S.,

^{1,2,3,5}Student, Obafemi Awolowo University Ile Ife, Nigeria.

^{4,7}Student, University of Ibadan, Nigeria.

⁶Student, University of Lagos, Nigeria.

Submitted: 01-09-2021

Revised: 09-09-2021

Accepted: 12-09-2021

ABSTRACT: This research is aimed at the geochemical assessment of stream sediments in Epe and its environs where mining activity is going on and to detect anomalous concentration of elements, which may be harmful to inhabitants of the area.

Thirty one (31) stream sediments samples were collected from the streams in Epe and its environs. The stream sediments samples were dried, sieved, and digested with aqua regia in order to extract the metals before analysis. The samples were analysed for Silver (Ag), Gold (Au) Cadmium (Cd), Cobalt (Co), Copper (Cu), Iron (Fe), Manganese (Mn), Nickel (Ni), Lead (Pb) and Zinc (Zn) using Atomic Absorption Spectrophotometer (AAS) at the Department of Geology, Obafemi Awolowo University, Ile-Ife.

The mean concentration of each elements were compared with their average abundance in shale. Some of the elements had more than one distinct population, the break in elements are Zn at 55 ppm, Mn at 90 ppm, Co at 22.5 ppm, Ag at 0.5 ppm and Cd at 2.17 ppm which indicate that they may have accumulated from different sources while Ni, Au, Fe, Pb and Cu had no break. Also, the high concentration of most of the elements are at the western half of the study area with gold, silver and cadmium having excess concentration of 3.905 ppm, 0.605 ppm and 2.69ppm respectively.

The result for some elements showed high concentration that are greater than the values required for plant and human intake using the average abundance of the elements in shale as a standard. Therefore, from the results, stream sediments at Epe and its environs are polluted locally by gold, silver and cadmium. The high concentrations are observed mainly in the mining

sites of the study area. The two control samples have generally lower concentrations of elements than those samples at active mining sites.

KEYWORDS: mining, gold, silver, anomalous concentration, AAS, geochemical

I. INTRODUCTION

Mining operations on whatever scale impact negatively on the environment, they produce large volumes of wastes that can have deleterious effects long after operations have ceased. The lifecycle of a mine has mainly three stages each of which has potentially adverse impacts on the natural environment, society and cultural heritage, the health and safety of mineworkers and communities based in close proximity to the operations. The three main stages are (beginning) exploration, middle extraction and refining that is the operation stage, and involving closure reclamation. The adverse impacts of each stage must be minimized¹⁰.

Physical processes like advection, dilution, dispersion and sedimentation as well as chemical processes such as solution reactions, precipitation, co-precipitation and adsorption onto stream sediments or suspended particles can directly or indirectly result in attenuation of pollutants. Pollution is the release of substance into the environment in the quantity that it becomes harmful which occurs as a result of the geology that deals with the natural distribution of elements from where they are crystallised to their weathered form that can be easily transported from one place to another (geogenic). Another source of pollution is anthropogenic which involve human induced activities¹⁰.

Running water (both ground and surface) plays a major role in this process of dispersion. Active stream sediments greatly approximates the composition of weathering products upstream of the sample location. The rate of dispersion of an element is governed by its degree of mobility. The degree of mobility is in turn governed by the physical and chemical properties of the element as well as the pH/Eh conditions in the environment⁷. It is generally correct to state that the mobile and semi-mobile elements are adsorbed on the clay component of such sediments.

Epe is located within the Ilesha Schist Belt, associated with gold mineralisation in Nigeria. The dominant rock type in Epe and its environs is Quartz biotite schist, which is being weathered in order to make the elements bound in the minerals that makes up the rock easily accessible for analysis. Stream sediment survey is best used for reconnaissance survey in exploration geochemistry, which is one of the main components of mapping techniques in geology.⁶ The area where this work was carried out has many gold mining activities going on which is best associated with ultramafic rock that is dominantly made of quartz feldspar, etc. The distribution and redistribution of these elements may have caused contamination in this area.

Aim and Objective of the work

The aim of this work is to determine the presence of elements in anomalous concentration in stream sediments, which may be harmful to the existence of the inhabitants in the communities at Epe and its Environs.

The objectives include:

- to collect stream sediment samples from the streams in the active mining sites and streams that are far from mining activity which will serve as control;
- to prepare, analyse and determine the concentration of different elements in each sample using Atomic Absorption Spectrometer;
- to detect anomalous concentration of elements in areas with active mining activity; and

to state the hazardous effect of those elements on the health of the people and plants in the area.

Local Geology

Geological Survey of Nigeria (1966) carried out geological mapping of Epe and its environs. The geology is discussed below. The most dominant rock type in Epe and its Environs is Schist and Amphibolite as shown in Figure A that forms part of the Proterozoic Schist Belts of Nigeria, which are predominantly developed in the western half of the country. In terms of structural features, lithology and mineralization, the Schist Belts of Nigeria show considerable similarities to the Archaean Greenstone Belts. However, the latter usually contain much larger proportions of mafic and ultramafic bodies and assemblages of lower metamorphic grade (Olusegun et al., 1995; Ajayi, 1981 and Rahaman, 1976). Next to this in order of abundance is Gneiss and Migmatite, which forms a boundary with the Schist at the west and a small portion of it at the upper east. The Migmatite-Gneiss Complex comprises migmatitic and granitic, calcareous and granulitic rocks. The biotite-gneisses are highly foliated with alternating bands of black tints imposed by biotite impregnations, alongside felsic minerals such as quartz and feldspar. Most of the mineral alignments are conformable with the foliation planes of adjacent schistose rocks. The biotite gneiss are usually medium to coarse grained; foliated and largely crystallised which are likely to form under high temperature and pressure conditions.

At the South-eastern part of the study area are quartzites and quartz schist. The quartzites in the study area might have formed in two different ways; it could have formed under high pressure of deep burial of sandstone or chert which recrystallize and results in a metamorphic rock or from sandstone at low temperature and pressure, where circulating fluids fill the spaces between the sand grains with silica cement. This kind of quartzite is also called orthoquartzite. The quartzite in the study area are the massive and schistose types with some impregnations of smoky quartz and mica. There is also an amphibolite at the South western part which is the metamorphosed dolerite or allied basic igneous rock

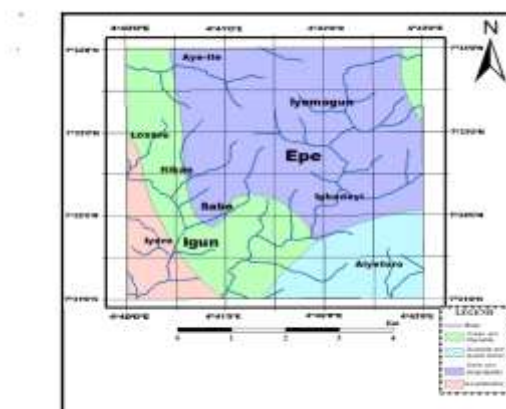


Fig A : Geological Map of Epe and its Environs (Adapted from Federal Survey of Nigeria Iwo Sheet 60, 1966).

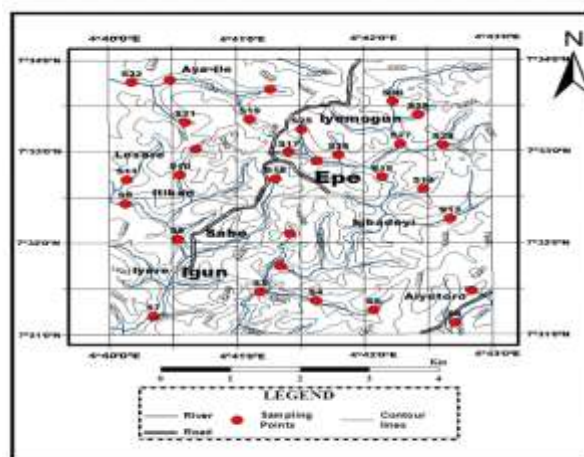


Figure B: Topographical Map of the Study Area showing the Sample Location Points.

Sample collection

Stream sediment samples were collected from the streams located at the study area. The equipment used for the field sampling include Global Positioning System, clinometer, geological hammer, a topographic map and a field note. Thirty stream sediments were collected with an extra duplicate sample to test for the instrument accuracy. The point of collection of the samples are far from bridges and other possible source of contamination. The location of the sample points are shown in Figures B and C. The samples were collected in a porous cotton material for easy draining after which they were left for few weeks to dry in the laboratory.

Sample preparation

The samples were crushed to reduce the size of the lumps and passed through a sieve of 177-micron mesh to get the size particles where the elements will be concentrated. One gram of each sample was weighed out in a conical flask by means of a meter balance. Distilled water and 10 millilitre of aqua regia, which is the mixture of concentrated hydrochloric acid and nitric acid in the ratio 3:1, was added and left on the hot plate at a temperature to enable the samples to digest. The samples were later filtered and diluted to make up to 50 ml.

Analyses

Atomic absorption spectroscopy (AAS) is a spectro-analytical procedure for the quantitative

determination of chemical elements employing the absorption of optical radiation (light) by free atoms

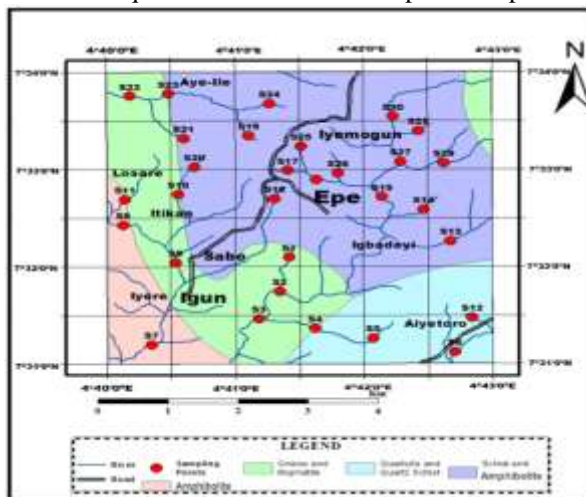


Figure C: Geological Map of the Study Area showing the Sample Location Points.

in the gaseous state. In analytical chemistry the technique is used for determining the concentration of a particular element (the analyte) in a sample to be analysed.

The underlying principles of AAS were established in the late 19th century by Robert Wilhelm Bunsen and Gustav Robert Kirchhoff, both professors at the University of Heidelberg, Germany. The modern form of AAS was largely developed during the 1950s by a team of Australian chemists. They were led by Sir Alan Walsh at the CSIRO (Commonwealth Scientific and Industrial Research Organization), Division of Chemical Physics, in Melbourne, Australia.

The atom is made up of a nucleus surrounded by electrons. Every element has a

specific number of electrons which are associated with the atomic nucleus in an orbital structure which is unique to each element. The electrons occupy orbital positions in an orderly and predictable way. The lowest energy, most stable electronic configuration of an atom, known as the “ground state”, is the normal orbital configuration for an atom. If energy of the right magnitude is applied to an atom, the energy will be absorbed by the atom, and an outer electron will be promoted to a less stable configuration or “excited state”. As this state is unstable, the atom will immediately and spontaneously return to its ground state configuration (Figure D). The electron will return to its initial, stable orbital position, and radiant energy equivalent to the amount of energy initially absorbed in the excitation process will be emitted.

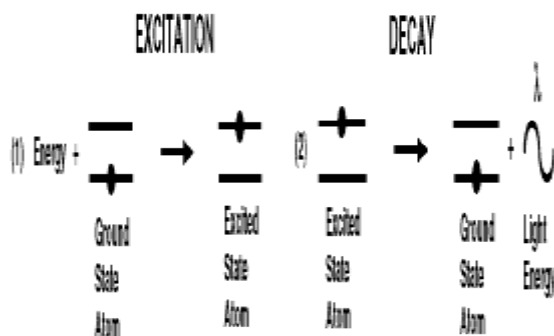


Figure D: Excitation and Decay Processes

In atomic absorption spectroscopy, if light of just

The right wavelength impinges on a free, ground state atom, the atom may absorb the light as it enters an excited state in a process known as atomic absorption (Figure E)

The light, which is the source of atom excitation, is simply a specific form of energy. The capability of an atom to absorb very specific wavelengths of light is utilized in atomic absorption spectrophotometry.

The quantity of interest in atomic absorption measurements is the amount of light at the resonant wavelength, which is absorbed as the light passes through a cloud of atoms. As the number of atoms in the light path increases, the amount of light absorbed increases in a predictable way. By measuring the amount of light absorbed, a quantitative determination of the amount of analyte element present can be made. The use of special light sources and careful selection of wavelength allow the specific quantitative determination of individual elements in the presence of others.

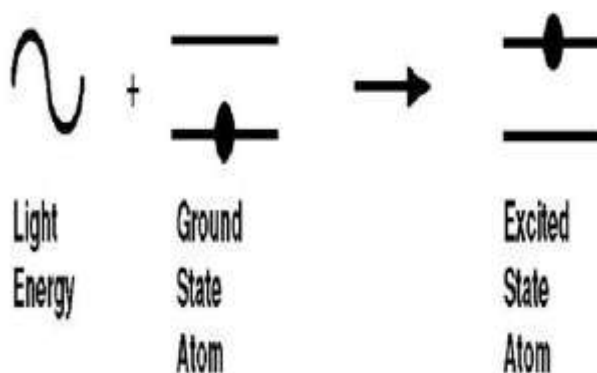


Figure E: The Atomic Absorption Process

by the number of values. The standard deviation is a measure that is used to quantify the amount of variation or dispersion of a set of data. The threshold was determined using the formula: mean + 2 (standard deviation). The geochemical data has been interpreted to disclose anomalous values using the basic statistical method.

The mean values were compared with either the U.S average, world average, average abundance in shale and excessive level of heavy metals in soils shown in Table 1. The frequency distribution of some elements show distinct populations indicated as break in concentration while other elements have no break. The break in the population of the distribution of the elements indicates that they have been amassed from different sources. The elemental concentrations in parts per million (ppm) of the various elements determined were also plotted on the actual sample

II. DATA PRESENTATION AND DISCUSSION

PRESENTATION OF RESULTS

The elements analysed include Gold, Zinc, Manganese, Copper, Lead, Cadmium, Nickel, Lead, Cobalt and Iron. The choice of the elements analysed was due to the type of rock observed in the area. Concentrations derived from the A. A. S record sheets has been multiplied by the sample dilution factor of 50 to obtain the actual concentration of each element in each sample.

Basic statistics were carried out using the Microsoft Office Excel and Statistical Package for Social Sciences. The minimum and maximum values were determined from the range of values. The mean also known as average was determined by summing up the data for each element and then dividing the sum

locations with the locality numbers on the distribution map to show the varying concentrations indicated by different colours and how it relates to the geology of a particular location.

Average Distribution of the Elements in the Study Area

The overall average concentration of elements in the study area can be explained with figure F below. Iron has the highest concentration followed by manganese, which are expressed in percentage. Other elements include zinc, lead, nickel, copper, cobalt, gold, cadmium and silver. Although gold, silver and cadmium can be said to be very low in concentration, they are regarded as contaminant in the study area where as other elements in relatively high concentration has little effect in terms of contamination when compared

with their average abundance in shale that can be likened to the standard average concentration of the

elements in agricultural soils.

Table 1: Average Abundance of Elements in Shale after Levison (1974), US average, World average, Excessive level and the Result from the Study Area in ppm.

	A g	A u	Cd	C o	C u	M n	Ni	Pb	Zn	Fe
U. S Av era ge			0.5		25	56 0	20	20	54	
Wo rld Av era ge			0.0 3		20	85 0	40	10	50	
Ex ces siv e lev el			5		10 0	15 00	10 0	20 0	25 0	
Av era ge abu nda nce in sha le	0. 05	0. 00 4	0.2	20	50	85 0	70	20	10 0	4.7 2
Th e res ult fro m the stu dy are a	0. 32	2. 51	1.5 8	12 .3 7	16	48 8.7	17 .4 2	17. 80	38. 51	2.3 2

Also, Figure G shows the concentration of each element on each sampling point in relation to one another indicating the high concentration of the elements in locality 10 which is a very large extent of an abandoned mining site. Localities 7, 11, 19, 20, and 22 are all active mining sites with high concentration of the elements. In contrast, localities 6, 12, 18, and 26 which are also mining sites but with varying degree of mining activity have low concentration of elements. Very low concentrations of the elements are also recorded in some

abandoned mining sites and streams that are far from mining activity has the lowest concentration of elements. Hence, the high concentration of the elements recorded in the study area may be connected to the mining operation going on in the area.

Generally, the western part of the study area can be said to contain higher concentration of elements with the lithology trend that ranges from amphibolite – gneiss and migmatite- schist and amphibolite complex than the eastern part of the

study area with Schist and amphibolite – quartzite and quartz schist. Similarly, the western part can be said to be of lower elevation, which favours the direction of flow of streams that may also help to concentrate elements in one part more than the other. For instance there is a water shed or divide

which is described as the high ground, separating adjacent drainage basins that forms the boundary between them² in Epe at the central part of the area which implies that streams in this area will flow to areas of lower elevation at the western part of the study area.

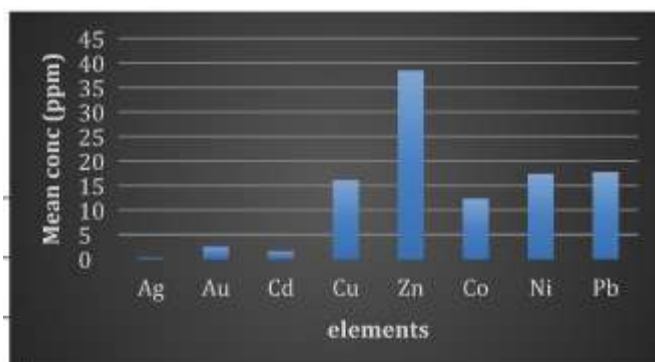


Figure F: Mean Concentration of Elements in Epe and Its Environs

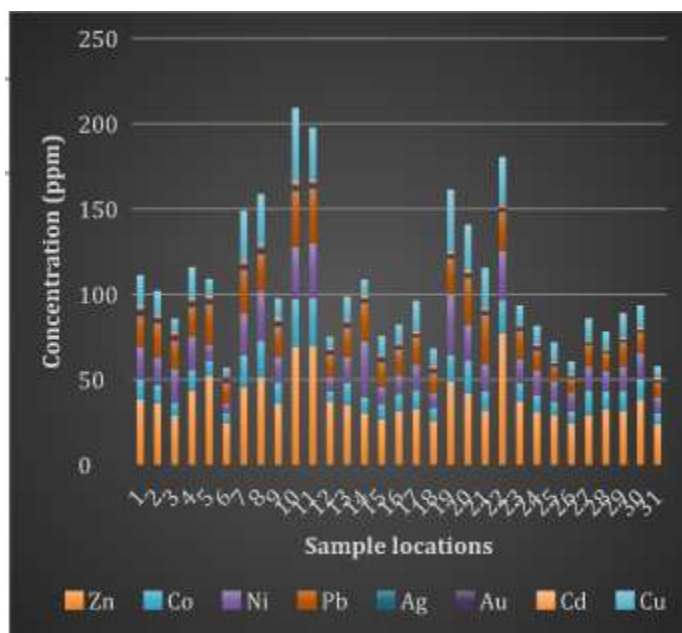


Figure G: Composite Bar Showing the Distribution of Elements in Each Sampling Points

III. CONCLUSION AND RECOMMENDATION

CONCLUSION

The distribution of the minor elements in Epe and its environs was determined mainly by the geology; as ferromagnesian minerals present in basic rocks like amphibolite would tend to have more concentration of some metals like iron cadmium etc. than light coloured minerals in acid rocks like quartzite and quartz schist will host similar metals. Similarly, the mobility of ions is another factor that can determine the concentration

of elements in the study area. The study area within the tropical region where weathering by oxidation is enhanced therefore favouring the dissolution and mobility of elements through water, which serve as a medium to concentrate the elements. In addition, the varying degree of mining activities going on in the area also affects the increase in the concentration of elements in a particular region of the study area more than the other.

The stream sediments collected from Epe and its environs was analysed for ten elements, which were chosen based on the geology of the

study area. These ten elements have varying positive correlation ranging from perfect to fairly positive linearity. The result showed that the study area is generally not contaminated with Cu, Fe, Mn, Zn, Co, Ni, and Pb but it is contaminated with gold, silver and cadmium. The removal of overburden and rocks from the mine has exposed the soil and therefore change the original soil texture and structure into states much unsuitable for crop production. Gold salt can also cause itching rash, ulcerations of the mouth, tongue and pharynx. Excess cadmium content in soils leads to a number of phytotoxic effects and challenges agricultural production. Excess Silver also inhibits the nitrogen-fixing bacteria thereby reducing the soil nitrogen content.

RECOMMENDATION

Unprofessional mining activity practised in the area should be stopped to reduce or totally stop the release of the harmful substances into the environment.

There should be a continuous assessment of current and future impacts of mining activities in the environment, which will prevent undesirable impacts and forestall outbreak of diseases among animals and human beings.

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