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Neutron Activation Analysis on Water Used For Gold Mining in Mararraban Birnin Yauri Kebbi State North-West Nigeria

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ABSTRACT
Water is a liquid of ambient condition, but it often co-exists on earth with its solid state, ice and gaseous state, water vapour or steam, water which covers 70% of the earth's surface and is vital for all forms of life. Naturally 53% of the populations rely on groundwater as source of drinking water; in rural areas this figure is even higher. The five water samples, three from processes water from the mining sites (i.eJirgi, Ruwa-Ruwa and Barkine mining sites) and two from drinking water source (i.e river and hand pump) were analysed using neutron activation analysis. The choice of this method is due to the evidence that the method is multi-elemental, non-destructive and safe. This research investigated the level of water contaminations by the concentrations of the elements present in each sample. Results indicated the presence of fifteen elements these are Al, B, Ca, Ch, Cl, Fe, Hg, K, Mg, N, Na, S, Pb and Zn. In hand pump calcium and magnesium is found to have higher concentration with 100. 0 ppm and 150.0 ppm respectively, making the water to be hard in nature. In the river water calcium and sodium has the highest concentration with 6.15 ppm and 12.0 ppm. From Barkine water sample there is presence of toxic compound sodium cyanide (NaCN) with concentration of 160 ppm, these concentration are way high above the World Health Organization (WHO) tolerable limits as such necessary action need to be to control it concentration to permissible limit. These results confirmed that water from Barkine, Jirgi, Ruwa-Ruwa and river were found to be toxic for drinking and other domestic activities, while water from hand pump is the only safe water for drinking at MararrabanBirnin Yauri.

I. INTRODUCTION

Water is a substance composed of the chemical elements of hydrogen and oxygen and existing gaseous, liquid and solid states. It is one of the most plentiful and essential of compound. A tasteless and odourless liquid at room temperature, it has the important ability to dissolve many other substances. Indeed, the versatility of water as a solvent is essential to living organisms. Life is believed to have originated in the aqueous solutions of the world's ocean and living organism depend on aqueous such as blood and digestive juices for biological processes. Water exist on other planets and moon both within and beyond the solar system. In small quantity water appears colourless but water actually has an intrinsic blue colour caused by slight absorption of ligh at red wavelength (Steven, 2023).

Pure water is the water that has been mechanically filtered or processed to remove impurities and make it suitable for use. Distilled water was formerly, the most common form of purified water but in recent years, water is more frequently purified by other processes including capacitive deionization, reverse osmosis, carbon filtering, microfiltration, ultrafiltration, ultraviolet oxidation or electrodeionization or combination of the number of the above mentioned processes (Mischissim, 2012)

Water pollution is the contamination of water bodies such as lakes, rivers, ocean and underground water by human or natural activities which can be harmful to plants and other organism that live or use the water. Waste product such industrial wastes, mining wastes and agricultural wastes often contain some amount of pollutants as a result of the material used in generating the

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waste, thereby adding to the level of water pollution (Saiduet al., 1997).

Another form of water pollution is Naturally Occurring Radioactive Materials (NORM) that emits alpha, beta and gamma radiation, these usually have elements in the Uranium and Thorium series whose radioactive gaseous daughters (radon and thorium) in particular cause an appreciable airborne particulate activity and contribute to the radioactivity of rain and groundwater, it also affect drinking water. Furthermore, spring or flowing water passes through rocks that may contain many radioactive materials as a result, the flowing water that leaches affects the soil and plants on its way, and it could also be transported into wells, boreholes and tap water through burst pipes (Saiduet, al., 2012).

The Hungarian Nobel Prize winner Albert Szent-Gyorgyi once said, "Water is life's matter and matrix, mother and medium. There is no life without water." (Walker and Sibly, 2001). If the water resources are contaminated, so is life. Providing clean drinking water for the growing population of the world is one of the most pressing issues we all stand to support in the 21st century (Walker and Sibly, 2001). Both Anthropogenic and natural processes can affect the water quality.

Gold mine development involves the planning and construction of the mine and associated infrastructure. Mining companies must obtain appropriate permits and licenses before they can begin construction. This will generally take several years, although it varies greatly depending on location. In addition to potential processing capacity, mining companies frequently construct local infrastructure and amenities to support both logistical and operational needs, as well as employee and community welfare. This development provides much long-term support for local communities, and is one of the key ways gold supports economic development (Saiduet al., 2012).

Gold production is associated with contribution to hazardous pollution (Dexter,2012). Environmentalists consider this pollution as major environmental disasters. Heavy metal contamination is an environmental concern because of their toxicity. It can cause damage to practically all organs in the body (Cyanide spill second only to Chernobyl 2000). Gold ore dumps are the source of many heavy elements such as mercury, copper, Nickel, chromium, manganese, zinc, lead, Iron etc. Water is unsuitable for human consumption if these heavy metals are found in more than 1ppm concentration (Dexter, 2012).

Though in physiochemical terms, heavy metals are defined as metals with a density at least five times greater than density of water. In medicine it is all toxic metals irrespective of their atomic weight (John, 2002). The relevant route of exposure of the public is internal, via inhalation of dust and aerosols and ingestion of food and water. Mining results in large volumes of mine tailings that may contain enhanced levels of natural radionuclide. Leaching of radionuclides can result in contaminated surface and ground water bodies and thereby exposing the members of the public to danger. Radionuclide, such as ^{226}Ra and ^{228}Ra are known to have high mobility in the environment due to their high comparative solubility in water. Most of these radionuclides are predominantly alpha emitters and alpha particles tend to cause more internal hazard than beta particles and gamma rays (Faanuet al., 2011).

When sulphide bearing minerals in the ore dumps are exposed to air or water, the sulphide transforms to sulphuric acid which dissolves the heavy metals and facilitate their passage to surface and ground water and this process is called acid mine drainage. Gold ore dumps are considered as long term manmade hazardous waste next only to nuclear waste dumps (Norgateet al., 2012). Billions of dollars need to be spent to mitigate the heavy metals pollution from worldwide gold ore dumps which are increasing every year (Norgateet al., 2012).

Most drinking water sources have very low levels of radioactive contaminants (radionuclides), most of which are naturally occurring, although contamination of drinking water sources from human-made nuclear materials can also occur. Some of the radioactive contaminants are at low levels enough to be considered for public health concern. At higher levels, long-term exposure to radionuclides in drinking water may cause cancer (USEPA, 1994). In addition, exposure to uranium in drinking water may have toxic effects to the kidney, (USEPA, 1994).

II. RELATED WORKS

Gold is a dense, soft, shiny, malleable and ductile metal with chemical symbol Auand atomic number 79**.** Gold (Au) is a lustrous yellow precious metal of Group 11, Period 6, of the periodic table. Gold has several qualities that have made it exceptionally valuable throughout history. It's attractiveness, brightness in colour, and durable to the point of virtual indestructibility, usually found in nature in a comparatively pure form. The history of gold is different from any

other metal because of it perceived value from earliest times. Gold dissolves in mercury, forming amalgam alloys, but is insoluble in nitric acid, which dissolves silver and base metals, a property that has long been used to confirm the presence of gold in any material, giving rise to the term acid test (Dexter, 2012).

Many researchers have carried out soil and water analysis using Neutron Activation Analysis.

A radiological survey and assessment was carried out at selected sites (Osiri, Mikei, Masara&Macalder) in the Migori gold mines of southern Nyanza, Kenya to determine the levels of exposure of the artisanal miners to the Naturally Occurring Radioactive Materials (NORM) and dust. The activity concentrations of K (40) and the decay products of thorium (Th-232) and Radium (Ra-226) were obtained using an innovative method of Neutron activation analysis, (Odumaet al., 2011).

A study conducted at the Osprey and Fumani gold tailings dams indicated high concentrations of, Zn-96.4, Cu-64.2, and Cr-269.3. High concentrations of these metals have toxicity potential on plants, animals and humans Using Atomic Absorption Spectrometer,(Ogolaet. al., 2010).

Radiological survey and assessment of associated activity concentration of the Naturally Occurring Radioactive Materials (NORM) in the Migori artisanal gold mining belt of southern Nyanza, Kenya. A study explores the possibility of converting an abandoned dredged mines paddock into a fish pond. The aim of the study is the assessment of the water quality conditions of nine surface water sampling points including paddocks/impoundments created by the operations of defunct dredged gold mine operations more than a decade for conversion into a fish pond. The concentrations of twenty water quality parameters (major ions, physicochemical and trace metals) were determined and compared with threshold values for protection of aquatic life to evaluate the suitability of the paddocks for development into a fish pond using NAA, (Aporiet al., 2012).

Application of NAA, for determination of As, Cr, Hg, and Se in Mosses in the metropolitan area of the valley of Toluca, Mexico. This research presents a study of environmental monitoring at different sampling sites from the Metropolitan Area of the Valley of Toluca (MAVT), Mexico, using mosses (Leskeaangustata (Tayl.) and Fabroniaciliaris (Brid.)) and soil samples. The epiphytic mosses and soils were sampled in two campaigns within two periods of the year, a rainy and dry-cold season. The selected sampling sites included Urban Regions (UR), Transitional Regions (TR), and Protected natural Areas (PA). The samples were analysed by the Instrumental Neutron Activation Analysis (INAA) to determine As, Cr, Hg, and Se principally. However, due to the versatility of the analytic technique used, other elements including Cs, Co, Sc, Sb, Rb, Ce, La, Eu, and Yb were also detected. Statistical analysis (As, Cr, Hg, and Se) was carried out with principal components and cluster analysis methods; this revealed that a good correlation exists between metal content in mosses and the degree of pollution in the areas sampled. The obtained results in mosses showed that the concentrations of As, Cr, Co, Cs, Rb, Ce, La, and Yb increased with respect to the concentrations obtained during the first sampling, whereas Se, Sc, Sb and Eu, concentrations were decreased. For As and Hg, the concentrations were similar in both sampling periods. The soil samples present the most significant concentration (Miyake,et al., 2015).

Elemental analysis of soil around IkotAbasiAluminum Smelter Plant, Nigeria (ALSCON) by Instrumental Neutron Activation Analysis. Concentration of major, minor and trace elements in soil samples around IkotAbasi ALSCON, IkotAbasi, Nigeria were determined by Instrumental Neutron Activation Analysis (INAA) technique using thermal neutron from Nigeria Nuclear Research Reactor (NIRR-1) at Center for Energy Research and Training (CERT), Ahmadu Bello University Zaria. Finding showed that 25 elements were determined in the soil element include Cr, Yb, Cs, Sb, Fe, Sm, Dy, Pa, As etc. The results show that INAA of soil samples around the studied area gave maximum values of 9.99 ± 0.41 ppm for As; 9.54 ± 1.06ppm for Sb; 7.725 ± 1.53ppm for Lu; 4.28 ± 0.81ppm for Fe and 3.24 ± 0.18ppm for Cr (Essiettet al., 2011).

The concentrations of twenty elements in ten cereals types commonly consumed in Nigeria were determined using NA). The elements are Al, As, Ba, Br, Ca, Cl, Co, Fe, K, La, Mg, Mn, Na, Rb, Sc, Sm, Sr, Th, V, Zn and the cereals are beans, guinea corn (red and white), maize (white and yellow), millet, rice (basmatic, foreign, and local) and wheat. The results obtained for these elements were compared with World Health Organization (WHO) permissible limits. It was confirmed that the concentrations of all the heavy metals studied (Co, Fe, La, Mn, Sm, Th, V, Zn) and some of the mineral elements (Ca, K, Mg, Na) in the cereal samples were below WHO permissible limits except wheat that showed a higher value in Mg (2.309 %) compared with the WHO permissible limit of 0.139%. The levels of the twenty elements

in the cereals did not exceed their permissible levels and are therefore safe for human consumption (Ugoezeet al., 2019).

Rare Earth Element (REE) in surface mangrove sediment by Instrumental Neutron Activation Analysis A study is carried out on the concentrations of rare earth element (REE) elements present in surface mangrove sediments from 10 locations throughout west coast Malaysia. In carrying out the analysis, the best and most convenient method being the instrumental neutron activation analysis (INAA). Samples were obtained, dried, crushed to powdery form and samples prepared for INAA. All the samples for analysis were weighted approximately 150 mg for short irradiation and 200 mg for long irradiation time. As calibration and quality control procedures, blank samples, standard reference material SL-1 were then irradiated with thermal neutron flux of 4×10^{12} cm^{-2} s^{-1} at the MINT TRIGA Mark II research reactor which operated at 750 kW by using a pneumatic transport facility. The REE elements of surface sediment samples in this study are Dy, Sm, Eu,Yb, Lu, Tb, La and Ce. It was found that the level of concentrations of all the REE elements varies in the range (0.35–117.4 mg/kg). The geochemical behavior of REEs in surface sediments and normalized pattern (chondrite and shale) has been studied. The degree of sediments contaminations were computed using an enrichment factor. The results showed that the enrichment factor varied in the range (0.75–6.75) (Krnshnan, et al., 2014).

Mining of solid minerals has been identified as an entry point of heavy metals into the environment, consequently polluting various components of the environment such as water and air. Five water samples and a kilogram each of selected solid minerals (Gold, tantalite and columbite) from one of the gold mines of Zamfara State were analysed for mineral and heavy metals (Mn, Zn, Pb, Mg, Al, Cd, Cr, Ni, Co and Cu) using NAA. The results revealed high concentration of Heavy metals in water which indicate significant contamination. The study concluded that there was pollution of water body especially for toxic metals like Pb and Cd (Tsafeet al., 2012).

A study was carried out on the concentrations of constituent (major, minor and trace) elements present in soil samples collected from different parts of Abuja Metropolis and their effect on the surrounding. In carrying out the analysis, the best and most convenient method being the Instrumental Neutron Activation Analysis (INAA) otherwise known as Non-Destructive Neutron Activation Analysis (NDNAA) was adopted. Soil/ Rock Samples were obtained, crushed to powdery form and samples prepared for INAA. 250 mg of the samples were fed into the nuclear reactor by means of pneumatic transfer with the aid of rabbit capsules. The irradiated samples were analyzed and the following elements were identified: Al, Ti, Ca, Mg, K, Na, V, Mn, Dy, Sc, Zn, La, Sm, Co, Th, Rb, Ce, Hf, Fe, Yb, As, Eu, Lu and U. The concentrations of these element were found in the Airport Road soil than in the other soils as seen in Fe from the following results: Airport Soil (0.4212±0.014), Airport Road Soil (1.31±0.20), Aso Radio Soil (0.6641±0.017) and Karu soil (0.528±0.013); indicating that soil in that region might favour the growth of particular plants compared with soils from other region; however there was relative distribution in the overall outcome of trace and major elements. The results and technique compared with that of Oladipos who had a total of 22 elements from 7 different clay samples indeed showed that NAA is effective method of elemental analysis (Innocent et al., 2013).

Application of Instrumental Neutron Activation Analysis for the determination of elemental Constituents and other parameters of harmattan dust around Kano. The Sahara desert is the world largest hot desert and one of the harshest environments on the planet Earth, (Mamunu, 2015). Intense heating over the desert causes convective forces to uplift sand and dust particles into the atmosphere, and carried by north-east Trades (winds) to distant places worldwide. When it reaches Coast of Guinea in West Africa, the prevailing wind is locally called the Harmattan. Ubiquitous deposition of the dust in Kano State (11o 59′ N, 8o30′E), is most eminent from November to March. Harmattan dust was, therefore, collected from 20 sites around Kano in January and February, 2009. The parameters established during the period included average gravimetric concentration of the dust, the absorbance of atmosphere, atmospheric turbidity, air density, absolute viscosity of air, and kinematic viscosity. The Coriolis force was also determined, while the average wind speed was found. In determining the turbulent nature of the wind, the Reynolds number was established; and the resulting wind power density during the season was computed. Instrumental Neutron Activation Analysis (INAA) technique was applied for elemental analysis of the harmattan dust. And it was found to be composed of 21 elements which included Al, Ca, Fe, Mn, Mg, Na, Ti, K, Br, Cr, Zn and V. Other trace elements in the dust were Sb, La, Th, Co, Ta, Sm, Sc, and U. Aluminium,

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Calcium, and Iron featured prominently with concentrations above 1000 ppm in the dust (Mamunu, 2015).

Multi-elements determination in river water by Neutron Activation Analysis, concentration of Al, Br, Ca, Ce, Cr, Eu, Fe, Hf, La, Lu, Mg, Mn, Na, Rb, Sc, Sm, Sr, Tb, Th, Ti, V, Yb, Zn, and Zr, have been measured in Tigris and Euphrates river water using neutron activation analysis in concentration with pre-concentration technique. River water sample were pre-concentrated by evaporation at 70^{o}C under the atmospheric pressure. The sample with standard reference materials were irsradiated with neutron flux of 2.3 x $10^{13}cm^{-2}s^{-2.}$(Al-Bedal and Al-Jobor, 1990).

Investigations of NORMS and possible contamination of water around gold mining sites in BirninGwari North-western Nigeria using NaI (TI) ASS Thirty six soil and thirty six water samples from gold mining sites of Birnin- gwari in Kaduna State were analyzed for potassium (K-40), thorium (Th-232), Radium (Ra-226) and heavy metals (Hg, Cu, Ni, Mn, Cr, Zn, Pb, Fe)activity. The activity of soil was determined using NaITl detector and Atomic Absorption Spectrophotometer for heavy metals concentration in water. Most of these mining sites were discovered to have a combined Th-232 and K-40 activity in excess (Th-23218.13±3.1 to 102.62±1.9 Bq/kg with mean value of 51.95 Bq/kg and K-40 19.75±6.2 to 862.20±13.9 Bq/kg with mean value of 464.65 Bq/kg) which are against World Health OrganizSation (WHO) regulations. Most of these samples contained insignificant amounts of Ra-226. The activity of radium found in all of the samples was below, WHO standard Ra-226(0.1506±.03 to 5.67±.03 Bq/kg with mean value of 2.31 Bq/kg) . In water samples Fe has higher concentration (0.69mg/l to 72.12mg/l with average of 12.21mg/l. mg/l). The concentrations of Mercury, copper, Nickel, Manganese, Lead and Iron metals were found to be above WHO and Nigeria Standard for Drinking Water Quality (NSDWQ) limit in these samples, while Chromium and Zinc was found to be below the permissible limit (Muhammad, 2019).

In most of the previous research we reviewed the researchers focus majorly on natural contaminants without putting enough consideration on human made contaminants. Our research will look into human as well as natural contaminants, since both anthropogenic and natural contaminants can affect water quality, putting more emphasis on human made contaminations.

III. MATERIALS AND METHOD

1. The main material is water sample that was collected from the three out of four mining sites and two community drinking water source,
2. Five plastic bottle was used for sample collection from each of the five sample point
3. Neutron Activation Analysis Machine which contain the following properties
4. Desktop computer running CASSY software is popular software for recording and analysing measurement data.
5. Microsoft excel was for graphical analysis.\

3.1 Sample Collection

Water sample was collected from MararrabanBirnin Yauri Mining area in the three out of the four mining sites and two community source of drinking water. In order to ensure representation, 1000ml of water sample was collected from each of the following camps, sample from indigenous camp, foreign camp, samples from the mix-up camp and two community source of drinking water for the analysis. Initial survey was carried out in the area to determine the sampling points. The selection of the sampling locations was based on the accessibility to the public and proximity to the mine. All the samples were taken to Centre for Energy Research & Training Sections (CERT) of Ahmadu Bello University (ABU) Zaria for analysis.

3.2 METHOD

The most common procedure for NAA involves encapsulating the samples and suitable standards in heat–sealed polyethylene or quartz vials and simultaneously irradiating them. Ideally, the samples are irradiated in a "lazy susan" facility that revolves around the core thereby ensuring that the samples and standards experience the same neutron affluence. Following sequential decay periods, each standard sample is analysed utilizing high resolution germanium detectors coupled to a multi–channel analyser system. Gamma ray counts accumulated in an energy region above the background counts produce photo peaks. After counting analysis is complete, these data are processed using sophisticated computer programs that smooth the spectral data and determine the net areas of gamma ray photo peaks. The program then translates the area into count rates (counts per minute or cpm). These programs are capable of resolving overlapping and complex photo peak energy regions. Additional data for decay time differences, electronic dead time losses and unresolved interferences and compares the

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sample data (cpm/weight) to the standard data (cpm/µg) to calculate elemental abundance in the sample.

3.4 Detection Limits

Elemental detection limits for NAA are variable because some elements become very radioactive and can be determined at very low levels while other elements do not become very radioactive or have very short half–lives (less than 10 seconds). Activation analysis determines the total mass of an element in a sample. A certain amount of an element like arsenic is needed in the sample for detection. For arsenic, under ideal conditions, 5µg is required. To determine 5 ppb of arsenic, 1g of sample is sufficient. To determine 0.5 ppb of arsenic, 10g of sample is necessary, etc. The production of radioactive nuclides depends on the cross sections of the specific elements. Also important is the number of gamma rays that are emitted by a radionuclide. In some cases, only a small fraction of the total emissions from a specific nuclide is in the form of gamma rays. Sample with high concentrations of element that is readily activated and emit a considerable number of gamma rays, such as Na and Sc, can generate high background count rates and raise the detection limits for the element of interest (Alfassi, 1990).

IV. RESULT AND DISCUSSION

Table 4.1 Present the results of the neutron activation analysis for the five water samples which comprised drinking water and processed water from the mining sites. After the successful analysis about fifteen elements were identified from all the water samples with different concentrations. The results were measured in part per million concentrations (ppm).

Table 4.1 Result of the Elements and their Concentration (ppm) Presents in the WaterSamples

		Sample Points				
S/N	**Elements**	**Hand Pump**	**River Water**	**Jirgi**	**Ruwa- Ruwa**	**Barkine**
1	Aluminium	0.006	0.015	0.02	0.04	0.015
2	Boron	0.007	0.007	0.007	0.007	0.007
3	Carbon	0.00	4.00	9.30	9.30	165.00
4	Calcium	100.3	6.15	10.40	10.40	10.40
5	Chromium	00.00	0.00	4.30	4.30	4.30
6	Chlorine	0.00	3.20	0.00	0.00	0.00
7	Fe	2.0	0.00	11.20	11.20	11.20
8	Mercury	0.00	0.00	2.80	2.40	0.00
9	Potassium	0.00	0.00	4.20	3.20	4.20
10	Magnesium	150.00	4.20	10.00	10.00	10.00
11	Nitrogen	0.00	0.00	0.00	0.00	160.00
12	Sodium	0.00	12.00	12.30	13.00	165.00
13	Sulphur	0.00	6.00	23.40	23.40	6.40
14	Lead	0.00	0.00	0.03	0.03	0.05
15	Zinc	0.45	0.20	2.52	2.52	0.00

The result from the Table 4.1 shows that five out of the fifteen elements were heavy metals which are believed to be toxic and have serious health concern. The heavy elements discovered are Aluminium, Chromium, Mercury, Lead and Zinc. Aluminium is present in all the samples its concentration is highest in Ruwa-Ruwa with the value of 0.04 ppm. Chromium exist in three samples, Jirgi, Ruwa-Ruwa and Barkine with equal concentration of about 4.30 ppm respectively, hand pump and river water are free from chromium.

Mercury exists in Jirgi and Ruwa-Ruwa with different concentration of 2.80 ppm and 2.40 ppm respectively. However, the Hand pump, River water and Barkine are free from the effect of mercury. Lead exists only in three samples which are processed water from the mining sites which include Jirgi, Ruwa-Ruwa and Barkine. The concentration of lead acid was found with values of 0.03 ppm, 0.03 ppm and 0.05 ppm respectively. Considering the zinc concentration it has been found with values of 0.45 ppm, 0.20 ppm, in hand pump and river water while Jirgi and Ruwa-Ruwa has 2,52 each. However it was absent in Barkine

Other trace elements found in the samples are Boron, Carbon, Calcium, Chlorine and potassium other are Magnesium, Nitrogen, Sodium and Sulphur.

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4.1.2 The result of the individual sample was analysed using line graph:

The result of elemental analysis of the individual water samples are presented in Figure 4.1 to 4.5

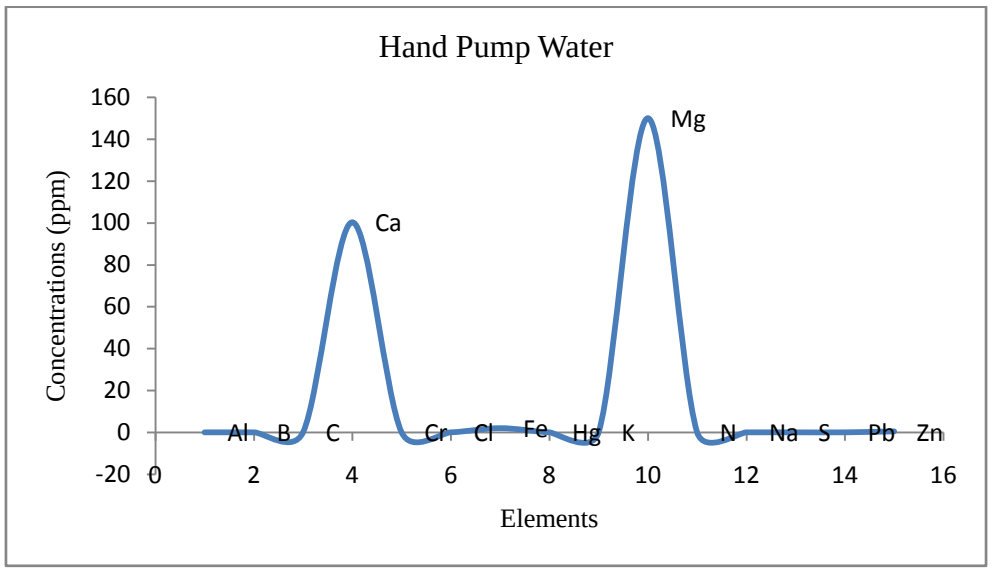

Figure 4.1 Elements and their concentrations in the hand pump

Figure 4.1 present the concentration of element found in hand pump, The results shows that Calcium and Magnesium are at higher concentration with values of 100.3 ppm and 150 ppm respectively. Three out of the five heavy metals ware also present in the hand pump. The heavy metals are Aluminium, Iron and Zinc. Among the heavy metals present in the hand pump, iron shows higher concentration with value of 2.0 ppm. Boron was also present at lower concentration.

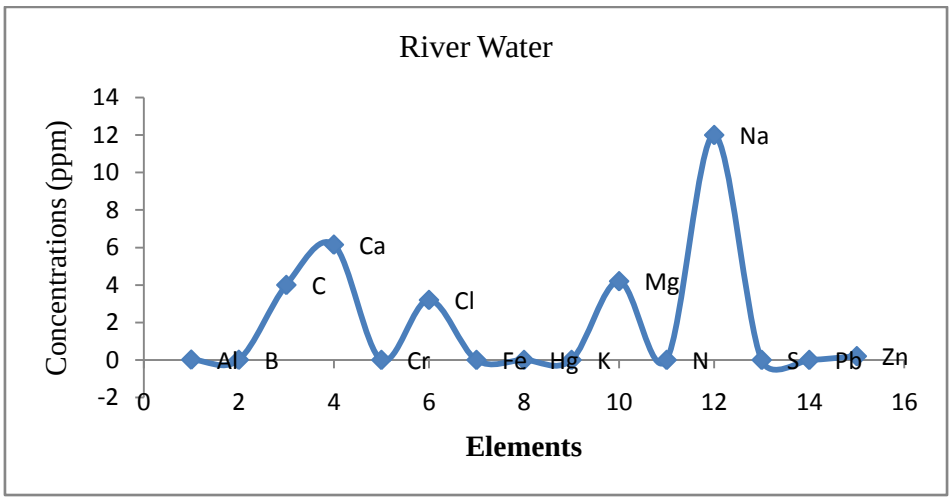

Figure 4.2 Elements and their concentrations in river water.

Figure 4.2 present the concentrations of different elements found in the river water. The result highlighted the presence of two heavy metals, Aluminium and Zinc with very low concentrations of 0.015 ppm and 0.20 ppm respectively. However, additional eight elements were also discovered, the elements are Boron, Carbon, Calcium, Chlorine, Magnesium with moderate cancentration and Sulphur with very low concentration from the analysis of river water been presented from Figure 4.2 , Sodium exist with much higher concentration than the remaining elements with 12.0 ppm.

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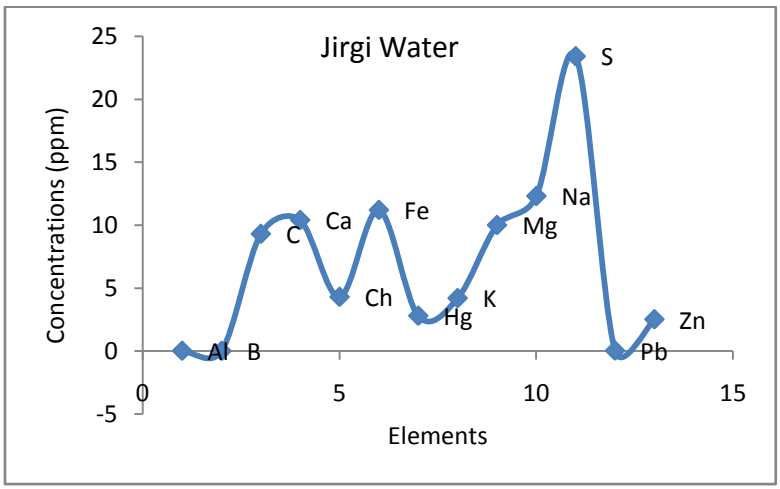

Figure 4.3 Elements and their concentrations present in Jirgi water

Figure 4.3 present elements and their concentrations found in Jirgi water, thirteen out of the fifteen elements were discovered with different concentrations. All the five heavy metals were presented in that sample, iron been the most concentrated heavy metal in Jirgi water with concentration of 11.2 ppm. Among all the thirteen elements sulphur is the most concentrated element with concentration of 23.40 ppm and the lowest concentrated element is boron with concentration of 0.007 ppm, as present in figure 4.3.

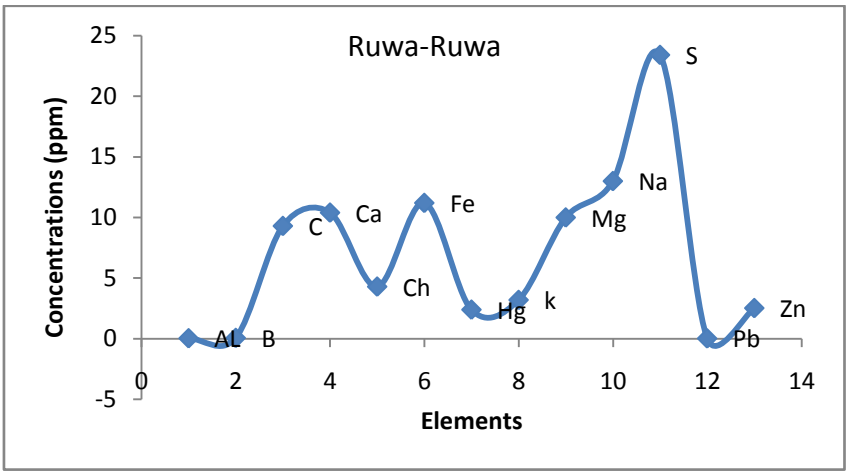

Figure 4.4 Elements present in the Ruwa-Ruwa water with their concentrations

Figure 4.4 present the result of Ruwa-Ruwa water the analysis shows presence of fourteen elements out of which six were heavy metals, the heavy metals were Aluminium, Chromium, Iron, Mercury, Lead and Zinc with values 0.04 ppm, 4.30 ppm, 11.2 ppm, 2.40 ppm, 0.03 ppm and 2.52 ppm. Iron was the most highly concentrated heavy metal while lead is the lowest among them. The analysis also shows presence of other elements, the elements are Boron, Carbon, Calcium, Magnesium, Nitrogen, Sulphur etc. with different concentrations. The analysis also shows sulphur as the most concentrated element with 23.4 ppm as compared to other elements.

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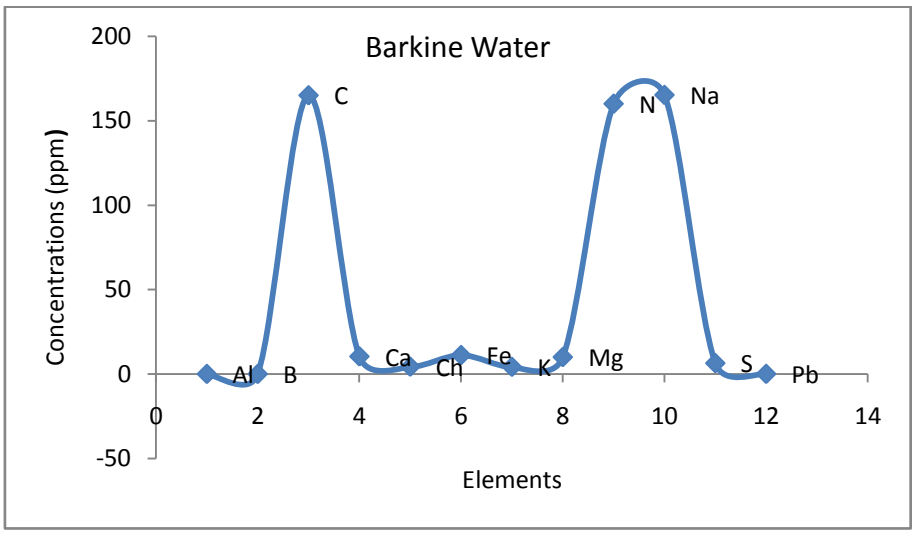

Figure 4.5 Elements in Barkine water and their concentrations

Figure 4.5 present the result analysis of Barkine water which shows the presence of four heavy metals which include Aluminium, Chromium, Iron and lead with values 0.015 ppm, 4.30 ppm, 11.2 ppm and 0.005 ppm respectively. The result also shows the presence of the more concentrated elements which include Carbon, Nitrogen and Sodium with 165 ppm, 160 ppm and 165 ppm respectively. There is also presence of another seven trace elements which are Boron, Calcium, Potassium, Magnesium and Sulphur with different concentrations although the concentrations are of low values.

Boron concentration is uniform in all the samples with fix concentration of about 0.007 ppm, although the concentration is not up to toxicity limit; it content doesn't have any health concern. Litovitz 2013, show that boron toxicity can also cause headache, hypothermia, restlessness, weariness, renal injury, dermatitis, alopecia, anorexia, and indigestion but it concentration should as high as possible ranging from 15,000 to 20,000 ppm. In infants, high boron intakes have caused anemia, seizures, erythema, and thin hair.

The elemental concentration of Calcium is high in the hand pump with the concentration of 100.3 ppm, high concentration of calcium is believe to be one of the cause of water hardness. This concentration is moderately hard, Durfor and Becker 1964 has classified hardness as follows: soft 0 to 60 mg/l, (0 to 60 ppm) moderately hard, 61 to120 mg/l, (61 to 120 ppm) hard 121 to 180 mg/l, (121 to 180 ppm) and above 180 mg/l (180 ppm).

Hardness can thus be defined as the soap-consuming capacity of a water, or the capacity of precipitation of soap as a characteristic property of water that prevents the lathering of soap. Synthetic detergents do not form such scums.

The World Health Organization (WHO) 2003 says that "there does not appear to be any convincing evidence that water hardness causes adverse health effects in humans.

Figure 4.12 is the iron concentration in the water samples. Ion in the water does not usually present health risk. Human body needs iron to transport oxygen in the blood. Most iron comes from food, since the body cannot easily absorb iron from water. Iron may present some concern if harmful bacteria have entered a well (or boreholes) or a river. Some harmful organisms require iron to grow. If there is iron in the water, it may be harder to get rid of harmful bacteria.

Mercury is found only in two out of the five samples according to Figure 4.13. Although the concentration is low despite that it present serious health risk, because mercury can continue to be accumulated in the body until it reach the toxicity level. However, people in that area are advice not used the water for consumption by whatever means. Mercury will cause severe disruption of any tissue with which it comes into contact in sufficient concentration, but the two main effects of mercury poisoning are neurological and renal disturbances. The former is characteristic of poisoning by methyl- and ethylmercury (II) salts, in which liver and renal damages are of relatively little significance, the latter of poisoning by inorganic mercury.

Potassium is an essential element in humans and is seldom it different concentration was shown in Figure 4.14. The recommended daily requirement is greater than 3000 mg (3000 ppm) which is far greater than the potassium

concentration in the used samples for analysis. Potassium occurs widely in the environment, including all natural waters. It can also occur in drinking-water as a consequence of the use of potassium permanganate as an oxidant in water treatment. In some countries, potassium chloride is being used in ion exchange for household water softening in place of, or mixed with, sodium chloride, so potassium ions would exchange with calcium and magnesium ions. Possible replacement or partial replacement of sodium salts with potassium salts for conditioning desalinated water has been suggested.

Figure 4.15, is the magnesium concentration in all the samples. There is no evidence of adverse health effects specifically attributable to magnesium in drinking water. Therefore, a maximum concentration for magnesium has not been specified.

Nitrogen is one of the elements found in higher concentration in Barkine water sample as presented in Figure 4.16. Consuming too much nitrate can affect how blood carries oxygen and can cause methemoglobinemia (also known as blue baby syndrome). Bottle-fed babies under six months old are at the highest risk of getting methemoglobinemia. Methemoglobinemia can cause skin to turn a bluish color and can result in serious illness or death. Other symptoms connected to methemoglobinemia include decreased blood pressure, increased heart rate, headaches, stomach cramps, and vomiting. According to USEPA (2017), the maximum contaminant level (MCL) for nitrate in public drinking water supplies in the United State (US) is 10 mg/l as nitrate-nitrogen (NO_3N). This concentration is approximately equivalent to World Health Organisation (WHO) guide line of 50 mg/l as NO_3 or 11.3 mg/l.

Elemental concentration of sodium is higher in Barkine water sample as presented in Figure 4.17. Sodium attracts water, and a high-sodium diet draws water into the bloodstream, which can increase the volume of blood and subsequently your blood pressure. Highbloodpressure (also known as hypertension) is a condition in which blood pressure remains elevated over time. Hypertension makes the heart work too hard, and the high force of the blood flow can harm arteries and organs (such as the heart, kidneys, brain, and eyes). Uncontrolled high blood pressure can raise the risk of heart attack, heart failure, stroke, kidney disease, and blindness. In addition, blood pressure generally rises as you get older, so limiting your sodium intake becomes even more important each year. Therefore it's very dangerous to drinking or use the water from this site (Barkine) for any consumption purpose..

level is too high, it can cause stomach pain and nausea. Similarly, high levels of sulfates in the drinking water can be problematic, particularly for infants. In many cases, the biggest problem with sulfur water is the way it tastes or smells.

Lead is one of the dangerous heavy metal that exist in nature, water samples from Jirgi, Ruwa-Ruwa and Barkine shows presence of lead at low concentration of 0.03 ppm for Jirgi and Ruwa-Ruwa while Barkine with 0.05 ppm, the dangerous part of it is that it can be continue accumulated until it reach toxicity level. EPA has set the maximum contaminant level for lead in drinking water at zero because lead is a toxic metal that can be harmful to human health even at low exposure levels. Lead is persistent, and it can be accumulated in the body over time. In children even low levels of lead in the blood of children can result in: Behavior and learning problems, Lower IQ and hyperactivity, Slowed growth, Hearing problems and Anemia etc. lead can be passed from mother to children during pregnancy and breast feeding. According to Agency for Toxic Substances and Diseases Registry (ATSDR) 2007, developing children are much more sensitive to lead exposure than adults.

Zinc is one of the daily dietary requirements of the body present of zinc in the water does not in any way present health concern.

V. CONCLUSION

In conclusion it's therefore, certain that all the mining sites produce one or more of the dangerous contaminants at different concentration to the water bodies of the mine area, the contaminant involves some heavy metals and trace elements. The poisonous elements found in the area are mercury and lead which are among the heavy metals due to their high density and atomic weight all of them are toxic there is also presence sodium cyanide one of the poisonous compound that cause death soon after exposure by all means of entry into the human body.

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