INFLUENCE OF MINING ACTIVITIES ON PHYSICOCHEMICAL PROPERTIES OF WATER AT IFEWARA GOLD MINE SITE DURING DRY SEASON, OSUN STATE, NIGERIA

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CERTIFICATION

This is to certify that this project was written by **ABDULRASAK ABDULSAMAD OLANREWAJU** with the Matric Number **(HND/23/MNE/FT/012)** supervised, read and approved as having satisfied part of the requirements for the award of Higher National Diploma in Mining Engineering Technology by the Department of Mineral and Petroleum Resources Engineering Technology, Kwara State Polytechnic, Ilorin.

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DEDICATION

This project is dedicated to Engr Agbalajobi, S.A. (FNSME) whose unwavering support and encouragement inspired me to pursue this endeavor.

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I would like to express my sincere gratitude to my parents Mr. and Mrs. Abdulrasak, A. for their guidance and support throughout this project. Their expertise and feedback were invaluable. I also appreciate the contributions of Alhaji Adebayo Oluwatoyin, and Alhaja for their assistance and insights.

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ABSTRACT

Mining has recently become an important economic activity in southwestern Nigeria, but existing studies have largely overlooked its potential to contaminate water in neighboring communities. This study focuses on the effects of physicochemical properties of water in the Ifewara gold mining area. A total of ten water samples were randomly collected from surface and groundwater sources available to the local communities. The surface and groundwater samples collected were analyzed for physicochemical properties and heavy metal concentrations using Atomic Absorption Spectrophotometry (AAS). Associated parameters related to both surface and groundwater were also examined. Surface water and groundwater samples were collected and analyzed for physicochemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), temperature, calcium, potassium, phosphate, sodium, and magnesium. Additionally, concentrations of heavy metals such as Fe, Co, Zn, Ni, Pb, Cr, and Cd were analyzed following World Health Organization (WHO) standards. During the dry season sampling, the values of pH, electrical conductivity (EC), and total dissolved solids (TDS) ranged from 5.48 to 6.99, 81.3 to 361 μS/cm, and 54 to 180 ppm, respectively. Heavy metal analysis (in mg/L) showed that concentrations of Fe, Co, Zn, Ni, Pb, Cr, and Cd in both surface and groundwater ranged from 0.240 to 9.468, 0.001 to 0.090, 0.345 to 3.172, 0.001 to 0.068, 0.001 to 0.001, 0.025 to 0.105, and 0.001 to 0.030 mg/L, respectively. The contamination level index for both physicochemical properties and heavy metal concentrations could not be determined, as samples were collected only during the dry season. Additionally, the possibility of these properties being leached due to mining activities and waste generation from the mine may have influenced the results.

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CHAPTER ONE

INTRODUCTION

1.1 MINING OPERATIONS

Mining operations produce unequal socio-economic consequences and reward on its near-by communities. This study focused on economic and environmental impacts of artisanal gold mining on near-by community of Ifewara Osun State, Nigeria. Its objectives include examining influence of mining activities on the physical and chemical properties of the water during the dry season, the socio-demographic characteristics of artisanal gold miners; describing mining characteristics; and identifying the environmental and economic impacts of artisanal gold mining on nearby communities. Gold mining is an age long economic activity in solid mineral exploration practices in Nigeria and around the world. Persistent hike in the price of gold caused by the increased competitiveness among its players and other gem stones were considered as the cause of the resurgence of this practice especially in the northern Nigeria. A number of negative environmental consequences and impact are associated with mineral exploration in Nigeria especially on the nearby communities of exploring sites. Literatures abound with reports of various devastating negative environmental impacts of gold mining in Nigeria; For example, devastating lead poisoning of children in Zamfara (Ajumobi *et al*., 2014; Haidara *et al*., 2017; Mejia 2015) and Niger States and environmental pollution due to significant emissions of mercury (used in processing) into the soil and air (Ajumobi *et al*., 2014).

Mining activities in Nigeria is characteristically artisanal and small-scale accounting for well over 90% of mining activities most especially mineral types like gold, barite, lead, zinc etc. Their practices are always unguided and not regulated due to lack of proper policies in place to control their operations (Mallo, 2012). The uncontrolled actions of these informal miners have resulted in serious environmental degradations (Prasetyo *et al.*, 2010; Girigisu *et al*., 2012), crude operational systems (Colins and Lawson, 2014, Hoadley and Limpitlaw, 2004) and loss of economy minerals (Mallo, 2012).

In regards to this, Ako *et al*., (2014) observed that most artisanal and small-scale miners handling different mineral types, work in difficult and often hazardous conditions in the without the required safe mining regulations to safeguard their mining activities. Throughout history, it is believed that the exploration of heavy metals and other elements associating with the mining of gold expose the miners to toxicity present in these metals (Girigisu *et al*., 2012). Unlike some countries in West Africa, Nigeria does not have a well-developed, large scale mining companies with sustainable and structured operation policy, therefore the majority of gold mining in the country is carried out without due regulation by artisanal and small-scale miners.

Gold veins occurrence makes Minna and its environs in Niger State, Nigeria vulnerable to highly environmental hazards such as land degradation, de-vegetation, loss of aquatic plants and animals, water pollution and air pollution, resulting from the activities of artisanal and small-scale miners (Ako *et al*., 2014). Due to the migratory style of operations, the artisanal miners often leave the dug-out area not domesticated, and this pose various dimension of hazards to human beings and animals. Apart from safety and health impacts, mercury used in processing of mined gold-veins and lead associated with gold deposits impacts the environment detrimentally.

Up to 95% of mercury used is released into the environment (Environmental Law Institute, 2014). Unlike mercury, lead dusts do not travel very far, they settle out on the ground and can easily contaminate the soil. During periods of heavy rains, the lead dust can leach into groundwater systems and contaminate them. Most mine sites are located around farmlands where the harmful chemicals may contaminate the leaves and fruits of arable and cash crops through the soil resulting to severe heavy metal contamination of water sources and poisoning of humans and animals, if ingested (Eludoyin *et al.*, 2017).

Economically, the activities in the mineral sector are not yielding the desired benefits because there are no records of payments of taxes and royalties to the government. Nigeria is losing lots of monetary value from the untapped mineral deposits and smuggling of the little that are mined out of the country. Many professionals such as geologists; mineral economists; mining engineers; etc. in the mineral industry in Nigeria believed that under the Nigerian soil are enormous wealth and riches of solid minerals but majorities of Nigerians are wallowing in abject poverty (Melodi, 2017).

1.2 AIM AND OBJECTIVE OF THE RESEARCH WORK.

1.2.1 Aim of the Research

The aim is to investigate the Influence of mining activities on physicochemical properties of water at Ifewara gold mine site during dry season, Osun state, Nigeria.

1.2.3 Objective of the Project

i. determines the physical and chemical properties of water with heavy metal such as pH, Temperature, Electric conductivity, TDS, chlorine ion, sulphide ion and nitrite ion. Also, some heavy metals contaminants such as Codmium (Co), Cadmium (Cd), Zinc (Zn) and Lead (Pb).

ii. assessment of the impact of mining activities on the water of Ifewara gold mining site, Osun State, Nigeria.

1.3 SCOPE OF THE RESEARCH WORK

This study will be assessed on how mining activities influenced the level and distribution of some physicochemical properties and heavy metals in water;

1.4 STATEMENT OF PROBLEM

The physicochemical properties of water in the Ifewara gold mining area have not adequately studied despite the potential risks posed by the mining activities to water quality. This knowledge gap raises concerns about the potential impact of mining on the environment and public health of the community.

1.5 JUSTIFICATION

This study is justified because it will provide valuable information and data on the impact of mining on water quality in the Ifewara gold mining site. The finding will help identify potential sources of water pollution and inform strategies for mitigating the effects of mining on the water resources. The study will also contribute to the existing body of knowledge on the environmental impact of mining in Nigeria.

CHAPTER THREE

LITERATURE REVIEW

2.1 MINE WATER—SURFACE WATER LINKAGES

To keep a mine operating, it needs a sustainable water management plan in place that accounts for pumping the water from the mine workings, supply of water for ore processing, dust suppression and human use. All these water streams in and around the mine need to be known to manage the water balance reliably (Punkkinen *et al.*, 2016). Predominantly, the mine dewatering affects the groundwater, but in several cases also ecological affects might occur as surface water is diverted around a mine site, especially when trans-drainage basin diversion occurs (Marcus, 1997). As long as a mine is operating, pumped water, as well as tailings dam and waste rock dump seepage water will come into contact with surface water, mostly following treatment—unless a mine operates in dry areas with a lack of groundwater. Once mining commences, the open voids will start to be filled with groundwater and the mine starts to flood, a process that usually takes years to decades. When the water level in the mine reaches the lowest discharge point, the mine water will start to discharge into the receiving water courses (Wolkersdorfer, 2008) or terminal pit lake sinks (McCullough *et al*., 2013). Those linkages between mine water and surface water can take many different forms: seepage from shallow underground workings, discharges from pit lakes, bore holes, adits, inclines, or shafts. Seepage can also occur through overburden and especially from collapsed hanging wall areas and may contribute notably to surface water contamination. For protecting the environment, shaft or adit discharge is preferable, as the water can be directed towards an active or passive mine water treatment plant.

Tailings are nearly always connected to inland waters, except when located in arid areas or they undergo submarine disposal (Dold, 2014). Tailings dam water sees various forms of linkage to surface water such as overflow, seepage water into surrounding water courses or indirectly though seepage into the groundwater, which might then emanate to the surface downstream of the tailings dam (Fortuna *et al*., 2021). Waste rock usually contains residues of the mining operation that are deemed currently economically unviable. If this material is chemically inert, the seepage water should pose no detrimental effects on the surface water other than modest increases of electrical conductivity or suspended solids content. Should the waste rock contain minerals (disulfides or efflorescent minerals) that produce acidity or elevated contaminant concentrations during weathering, the discharged seepage water may cause detrimental effects to the receiving water bodies.

2.1.1 Physico-chemical Characterization

Mining influenced water can be characterized by its physico-chemical parameters such as temperature, electrical conductivity, pH, redox potential, turbidity, color, and oxygen saturation. These are mainly interdependent from each other and normally there is no correlation between them, though temperature affects the solubility of oxygen, or pH the solubility of many metals. In addition, all these variables and parameters show high variability, ranging, for temperature, pH, and redox potential for example, from -2^0C to 58^0C, −3.6 to 13 and −500 to 900 mV, respectively. High suspended solid loads and turbidity are common for many mining influenced waters. Turbulence keeps colloid-sized particles or flocculated oxyhydroxides in suspension and results in high concentrations of iron and aluminum in the water. Metal attenuation reactions can sometimes be recognized in the water by turbidity in certain places (Schmiermund and Drozd, 1997). Mine water can discharge at elevated temperatures of up to 58 ^{0}C, resulting from either exothermic reactions or the geothermal gradient. For surface waters, the discharge of warm water can then provide habitats for non-native species, with sightings of released aquarium fish at mine water discharge points in Germany (personal observations), and a reduction of less heat tolerant species. Very often, mining influenced water is colored, whereby the color depends on the water's constituents and colors the receiving inland waters. Iron rich water has usually coloured that range between orange, brown and red, whilst copper rich effluents are greenish to blueish and nickel rich mine water has light blue to green colors. Aluminum and elevated alkalinity results in white colors. This coloring can either be due to dissolved metals (iron, copper, nickel) or to suspended precipitates, for example gibbsite.

2.1.2 Chemical Composition

The chemical composition of mine water shows a high degree of variability. This is due to the large spectrum of geological settings (Smith and Huyck, 1999) and the biological, chemical and physical processes involved (Plumlee *et al.*, 1999). In addition, the solubility of the metal hydroxides controls their concentrations in the mining influenced waters and the receiving water courses. Some of these elements in mining influenced water will appear in cationic species, such as calcium, others in anionic species like chloride writing about an element as a constituent of mine water, therefore always implies it is in its ionic form. Extremely rarely, mine water will contain elements in their elemental form; exceptions might be the non-reactive and non-toxic noble gasses. Some of these elements are found more often in mine water, such as protons, iron, copper, aluminum, arsenic, chloride or manganese, others are less abundant, such as molybdenum, selenium, mercury, vanadium, or chromium. Yet, mine water contains water, H_2O, at a concentration of 55.5 mol L^{-1} . The next group of mine water constituents comprise the main ions of water: calcium, sodium, potassium, magnesium, hydrogen carbonate, sulfate, chloride, nitrate at an average concentration of around 0.5 mol L^{-1} and the trace ions at an average concentration of 0.005 mol L^{-1}, which accounts to just 0.01% of the molar composition of water. These are average numbers, as in the case of the Iberian Pyrite Belt, the sulfate concentrations in the mine water account for approximately 2.9% of the water's ionic composition. Not only does mining influenced water have a different chemical composition depending on the type of ore deposit, host and country rock, and the chemistry of the receiving water itself, but it also changes over time. When water discharges from underground mines, the first flush effect results in elevated concentrations of the most relevant components (Younger, 1997) for a longer time span. These elevated concentrations and the low pH values will impair and color inland waters for years to decades and will have negative effects on the ecological balance compared to pre-mining conditions. One of the reasons is that many elements usually show a higher solubility and often bioavailability at low pH values (Neil *et al*., 2009; Smith and Huyck, 1999).

CHAPTER THREE

MATERIALS AND METHODS

3.1 DESCRIPTION OF STUDY AREA AND SAMPLING POINTS

Ten sample stations were established at different locations of the gold-mining community at Ifewara, Atakumosa Local Government Area, Osun State, Nigeria. It lies within latitude 07° 03’ 13” N to 07° 03’ 22” N and longitude 04° 11’ 09” E to 04° 12’ 22” E (Figure 3.1) lies about 35 km west of Ilesa town. The area is a developing resident’s layout towards the east side of the Ifewara Township. The residents of the area are of different tribes living in their own houses. The remaining parts of the open fields, apart from the gold mining pits, are used mainly by the residents for farming and cash crop (cocoa). The topography of the area in undulating, drained by river and its tributaries, it is underlain by the rocks typical of the Basement Complex of southwest Nigeria and characterized by the tropical rain forest climate. The artisanal miners haphazardly select Artisanal Gold Mine (AGM) pit sites, where gold-bearing saprolitic layers are panned (Plate 3.2) to extract gold and associated heavy minerals. Locally fabricated sluice boxes are also employed in the beneficiation of the saprolite slurries where carpets, which act as traps, are placed in these boxes while the slurries are run over them (Plate 3.1). The mine locations are within one of the six (6) classes of the Basement complex rock that is form slightly migmatised to non-migmatised, meta-sedimentary and meta-igneous rock or simply called the Schist belt. The study area is a part of Ilesa-Ife schist belt (Ademeso *et al*., 2013).

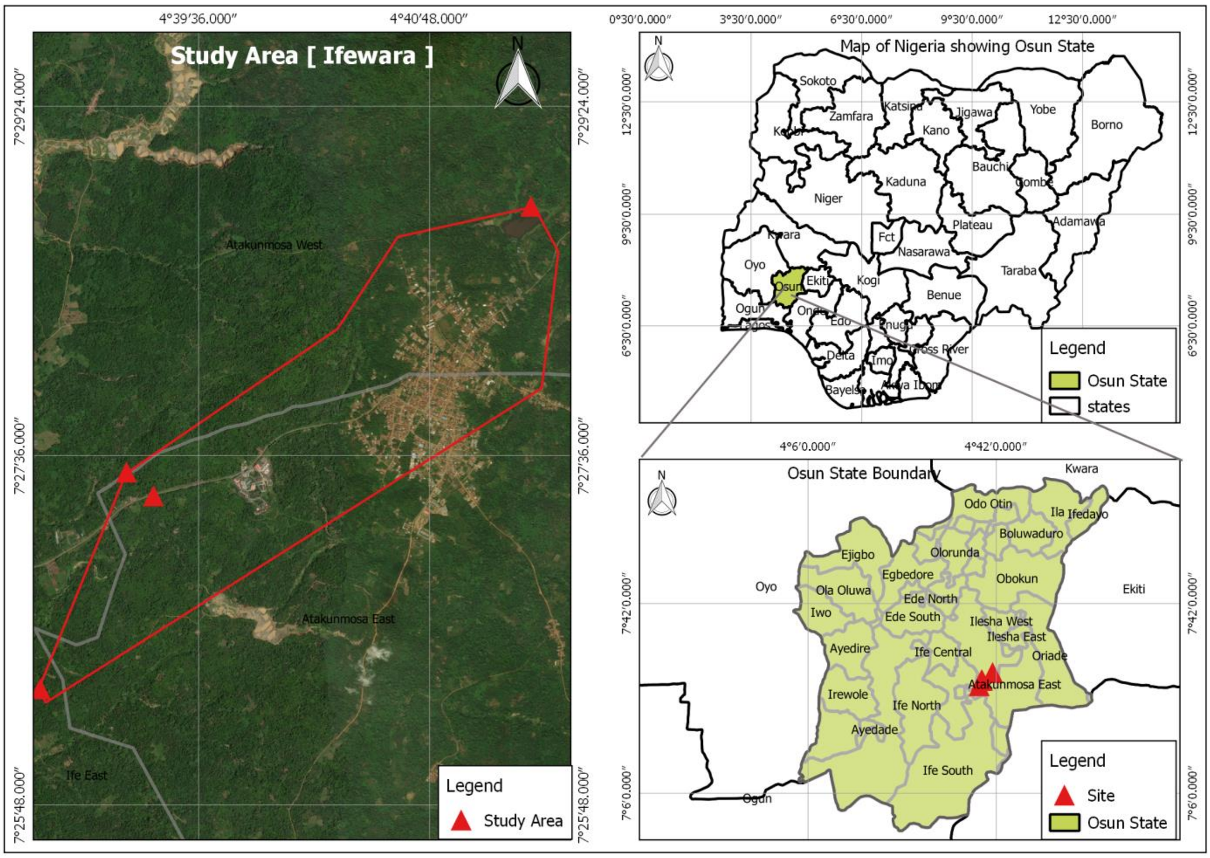

Figure 3.1: Map of the Study Area Location Ifewara, Atakumosa Local Government Area, Osun State, Nigeria.

Plate 3.1: Typical Artisanal Small-Scale Gold Mining Process in the Study Area using a Sluice Box

Plate 3.2: The artisanal miners haphazardly select Artisanal Gold Mine (AGM) pit sites, where gold-bearing saprolitic layers are panned.

Plate 3.3: Site Location with group picture with the project students and miners

Plate 3.4: Site Location with group picture with the project students and miners

Plate 3.5: Site Location with group picture with the project students

3.2 FIELD INVESTIGATION AND WATER SAMPLING

Ifewara area was selected for this study primarily due to the presence of gold mining activities in the community. Seven surface water and three groundwater sampling point were selected and their coordinates located using a Global Positioning System, GARMING 45XLS. The sampling was done in 1st of February, 2025 dry season. A total of 10 water samples were collected from both surface and ground water samples in the study area. Water samples were collected with 2.5 Litre plastic bottles, which have been rinsed thoroughly with double sample water. During sampling, relevant information like the ambient temperature, date of sampling, time of sampling and seasons of the year were recorded. Collected samples were preserved and stored in an ice-chest at temperature of 4^{o}C and transported to the laboratory for analyses. Samples were taken in separate containers for physicochemical and trace heavy metal analysis respectively. Samples for trace metal analysis were each preserved with 0.5 ml of concentrated nitric acid before transporting to the Central Research Laboratory, University of Ilorin for analysis.

3.3 SAMPLE ANALYSIS

The methods of laboratory analysis used were those specified in International analytical standards such as APHS for water quality. All equipment were duly calibrated with standard samples were analysed. All test and laboratory analyses were carried out at the Central Research Laboratory, University of Ilorin for analysis.

3.3.1 Determination of Physico-chemical Parameters

Water, pH, temperature, Electrical Conductivity (EC), TDS were analyzed in-situ during sampling using pH/TDS/Conductivity meter. Samples for water soluble anions (sulphate, nitrate, phosphate and chloride) were determined with Ion Chromatography System (ICS) model Dinonex ICS 2000. Samples for cationic water-soluble constituents (calcium, magnesium and potassium) were analysed with Dionex DX 500. Details of analytical procedures of both anions and cationic species can be found in (Taiwo, 2013; Gashi *et al*., 2013).

3.3.2 Sample Digestion for Heavy Metal Analysis

Samples for determination of cobalt, cadmium, chromium, copper, lead, manganese, nickel and zinc were collected with 500ml plastic bottles, since such metal may be adsorbed on the wall of glass bottles. About 3ml of concentrated Nitric acid was added and the samples were refrigerated at 4^{o}C before digestion. The water samples (100 ml) were digested with 10 ml concentrated HNO_3. Digestion can be carried out primarily through two methods: either through open or closed systems (Hu and Qi, 2013). Open acid digestions were carried out on a lab hotplate for 20 min in a beaker (USEPA, 1989). The samples were placed in the fume hood for a few hours to allow for digestion. Strong oxidizing acids were also added to the sample and heated throughout the wet digestion process to allow the organic components to break down (Mohd *et al*., 2019). BUCK Scientific ACCUSYS 230 Atomic Absorption Spectrophotometer (AAS) at Central Research Laboratory University of Ilorin for determination of Pb, Fe, Ni, Co etc.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Physical and Chemical Parameters

Table 4.1 show the data collected for individual surface and ground water samples and parameters with respective WHO/NSDWQ standard. The samples were labelled sample LW1, LW2, LW3, LW4, LW5, GW6, LW7, LW8, GW9 and GW10. Surface Water (LW) and Ground Water (GW) samples at the dry season in Ifewara, Osun State, Nigeria.

Table 4.1: Physicochemical Parameter of Water During Dry Season

Sample Codes	pH	EC (µS/cm)	TDS (ppm)	Temp° (°C)	Chloride (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Mg^{2+} (mg/L)	SO_4^{2-} (mg/L)
LW1	5.90	81.3	68	28	4.22	12.15	7.53	10.51	5.74	12.41
LW2	6.29	140	156	32	3.07	8.30	4.29	7.68	8.81	10.13
LW3	6.5	184	132	37.3	5.32	5.11	9.74	9.24	9.47	7.20
LW4	6.47	124	137	36.6	3.99	6.34	6.43	10.02	8.81	8.23
LW5	5.48	361	180	27.9	4.06	18.23	4.71	9.63	4.91	11.55
GW6	6.32	168	83	26.2	5.81	4.46	5.95	6.17	9.62	7.27
LW7	6.55	165	89	30.2	4.50	8.02	7.81	9.84	6.73	9.46
LW8	5.81	106	54	28.9	3.93	6.15	9.49	11.52	8.55	12.09
GW9	6.99	251	125	30.4	4.38	5.26	4.36	14.81	7.49	15.13
GW10	6.23	134	68	29.8	4.65	10.08	8.44	11.47	6.42	8.46
Range	5.48 – 6.99	81.3 – 361	54 – 180	26.2 – 37.3	3.07 – 5.81	4.46 – 18.32	4.29 – 9.74	6.17 – 14.81	4.91 – 9.62	7.20 – 15.13
WHO STANDARD	**6.5 - 8.5**	**1000**	**500**		**3.00**	**75**	**12**	**200**	**150**	

The measured pH gives the general indication that the water samples range from neutral to alkaline for dry season and the highest desirable level for pH stipulated for drinking and domestic purposes is within the range of 6.5 to 8.5 (WHO, 2004). Electrical conductivity values in all the water samples varied from 81.3 µS/cm (LW1) to 361 µS/cm (LW5) for dry season, all other water samples are within the permissible limit of 1000 µS/cm for EC in drinking water (WHO, 2004). TDS values in the sampled water bodies range from 54 mg/L (LW8) to 180 mg/L (LW5) for dry season samples while the values in the ground water, concentrations of TDS varied from 68 mg/L (GW10) to 125 mg/L (GW9). The TDS values recorded for ground and surface water samples in both seasons are within the WHO limit of 500 mg/L (WHO, 2004). Mg^{2+} concentration varied from 4.91 mg/L (LW5) to 9.47 mg/L (GW5) during the dry season for ground water and from 6.42 mg/L (GW10) to 9.20 mg/L (GW6) all exceeding the recommended limit of 0.2 mg/L set by the Nigerian Standard for Drinking Water Quality (SON, 2007). SO_4^{2-} concentrations in the surface water samples range from 7.20 mg/L in LW3 to 12.41 mg/L in LW1 (dry season) and ground water range from 7.27 mg/L in GW6 and GW10 to 15.13 mg/L in GW10 (dry season), within the WHO limit of 3.00 mg/L (WHO, 2004). There is no WHO guideline value to compare the measured Na and K values. Physico-chemical parameter values in both surface and ground water samples during the dry season in Ifewara.

4.2 Heavy Metal Concentration of Water Samples

The results of the heavy metal concentration of the sample are shown in Table 4.2. The average concentration of Fe present in the sample ranged from 0.240 at (GW9) to 9.468 at (LW2). The content of Fe was observed to be high in all the samples within mine perimeter with the control sample. This could also be observed in other heavy metals such as Co, Zn, Ni, Pb, Cr, and Cd with average results ranging from 0.001 (LW1) to 0.090 (LW2); 0.345 (GW10) – 3.172 (LW5); 0.001 (LW5) – 0.068 (LW5); 0.001 – 0.001 (Constant); 0.025 (GW6) – 0.105 (GW9); 0.001 (LW1-7,10) – 0.030 (LW8,9); respectively.

Table 4.2: Result of Heavy Metal Concentration in Samples (mg/kg) during the Dry Season

Sample Code	Fe		AVE	Co		AVE	Zn		AVE	Ni		AVE	Pb		AVE	Cr		AVE	Cd		AVE
LW1	1.687	1.779	1,733	0.001	0.001	0.001	2.935	2.935	2.935	0.016	0.016	0.016	0.001	0.001	0.001	0.051	0.051	0.051	0.001	0.001	0.001
LW2	9.468	9.468	9.468	0.090	0.090	0.090	2.656	2.656	2.656	0.097	0.097	0.097	0.001	0.001	0.001	0.071	0.038	0.055	0.001	0.001	0.001
LW3	1.070	1.070	1.070	0.033	0.033	0.033	2.993	2.993	2.993	0.009	0.009	0.009	0.001	0.001	0.001	0.013	0.039	0.026	0.001	0.001	0.001
LW4	4.791	3.511	4.151	0.002	0.002	0.002	2.943	2.943	2.943	0.006	0.006	0.006	0.001	0.001	0.001	0.031	0.031	0.031	0.001	0.001	0.001
LW5	1.447	1.447	1.447	0.030	0.030	0.030	3.172	3.172	3.172	0.001	0.001	0.001	0.001	0.001	0.001	0.056	0.056	0.056	0.001	0.001	0.001
GW6	0.784	0.784	0.784	0.034	0.034	0.034	3.063	3.063	3.063	0.002	0.002	0.002	0.001	0.001	0.001	0.025	0.025	0.025	0.001	0.001	0.001
LW7	2.814	1.901	2.3575	0.049	0.049	0.049	3.061	3.061	3.061	0.001	0.001	0.001	0.001	0.001	0.001	0.059	0.059	0.059	0.001	0.001	0.001
LW8	1.173	1.173	1.173	0.014	0.014	0.014	3.163	3.163	2.162	0.068	0.068	0.068	0.001	0.001	0.001	0.094	0.094	0.094	0.030	0.030	0.030
GW9	0.240	0.240	0.240	0.001	0.001	0.001	0.381	0.381	0.381	0.056	0.056	0.056	0.001	0.001	0.001	0.105	0.105	0.105	0.030	0.030	0.030
GW10	0.443	0.443	0.443	0.005	0.005	0.005	0.345	0.345	0,345	0.034	0.034	0.034	0.001	0.001	0.001	0.059	0.059	0.059	0.001	0.001	0.001

It could be observed that heavy metals concentration was high in the entire sample within the mine perimeter than that of the control samples in Figure 4.1 and Figure 4.2 respectively. It could be connoted that the mining activities have influences in the accumulation of heavy metals in the water.

Table 4.3: Results of the Average heavy metals concentration in the sample (mg/L) Water during the dry season

Sample Code	Fe (mg/L)	Co (mg/L)	Zn (mg/L)	Ni (mg/L)	Pb (mg/L)	Cr (mg/L)	Cd (mg/L)
LW1	1.733	0.001	2.935	0.016	0.001	0.051	0.001
LW2	9.468	0.090	2.656	0.097	0.001	0.055	0.001
LW3	1.070	0.033	2.993	0.009	0.001	0.026	0.001
LW4	4.151	0.002	2.943	0.006	0.001	0.031	0.001
LW5	1.447	0.030	3.172	0.001	0.001	0.056	0.001
GW6	0.784	0.034	3.063	0.002	0.001	0.025	0.001
LW7	2.3575	0.049	3.061	0.001	0.001	0.059	0.001
LW8	1.173	0.014	2.162	0.068	0.001	0.094	0.030
GW9	0.240	0.001	0.381	0.056	0.001	0.105	0.030
GW10	0.443	0.005	0.345	0.034	0.001	0.059	0.001
Range	0.240 – 9.468	0.001 – 0.090	0.345 – 3.172	0.001 – 0.068	0.001 –0.001	0.025 – 0.105	0.001 – 0.030
WHO Guideline	**0.3**		**5.0**		**12**		

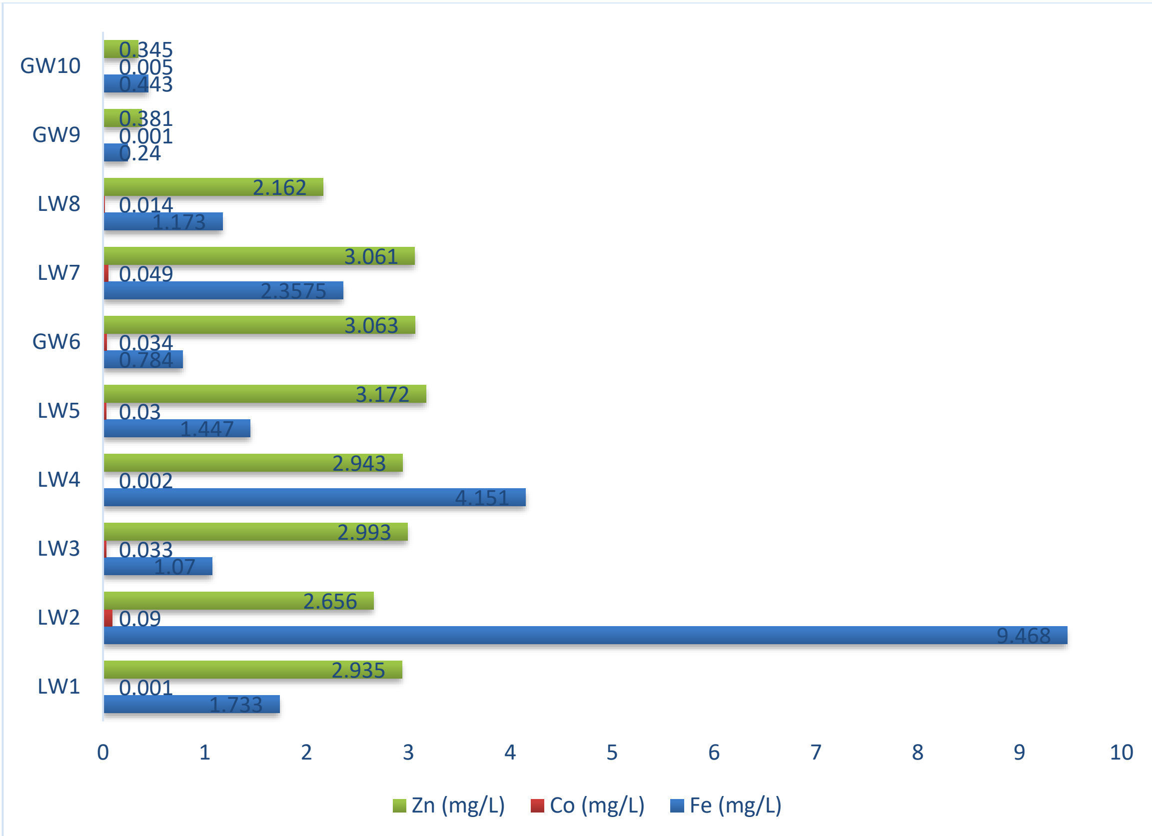

Figure 4.1: Heavy Metals Concentration of the Sample (mg/kg)

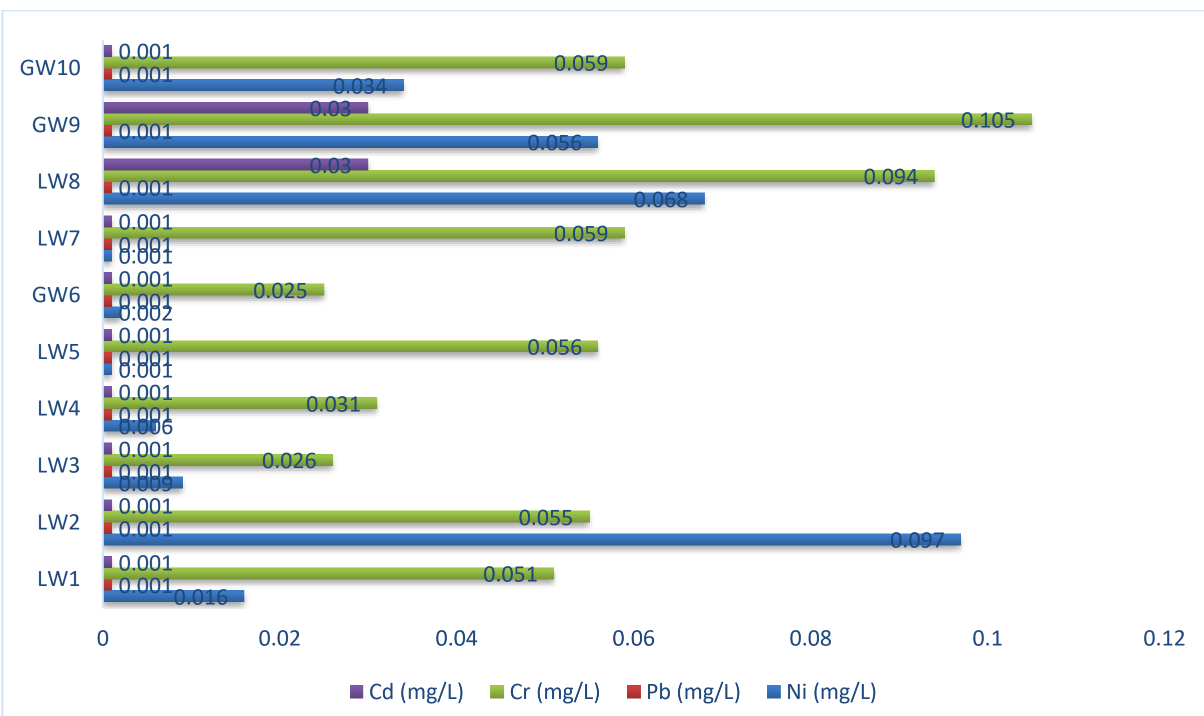

Figure 4.2: Heavy Metals Concentration of the Sample (mg/kg)

Cadmium (Cd) occurs naturally with zinc and lead in sulphide ore. Cd concentrations in unpolluted natural waters are usually below 1.0 mg/L. In this study, Cd concentrations in surface and groundwater at dry season are higher than the permissible limit. The guideline value for cadmium is given as 0.003 mg/L in drinking water by both the World Health Organization (WHO, 2004) and the Nigerian Standard for drinking water quality (SON, 2007). Previous studies show maximum levels in groundwater to be 0.003 mg/L (Kortatsi, 2004, Armah *et al*., 2010) and 0.06 mg/L (Oluwasanya and Martins, 2006). Maximum levels in surface water were less 0.05 mg/L (Kuma and Younger, 2004; Yem *et al*., 2013). The observed cadmium values show that water quality in the mine area is questionable and unfit for human consumption. As a practical measure, the guideline is set as 0.05 mg/L, which is considered to be unlikely to give rise to significant risks to health (WHO, 2004). Maximum levels in groundwater have been shown to be 0.014 mg/L, (Kortatsi, 2004; Marcovecchio, *et al*., 2007) and 0.06 mg/L (Oluwasanya and Martins, 2006) and in surface water to be 0.49 mg/L (Kuma and Younger, 2004, Marcovecchio, *et al*., 2007). Lead (Pb) is possible human carcinogen and it is also cumulative poison so that any increase in the lead burden should be avoided. The Pb value in this study revealed clear expediencies relative to the permissible limit of 0.001 mg/L set by the WHO. Previous studies also show maximum levels in groundwater to be 0.03 mg/L (Kortatsi, 2004, Armah *et al*., 2010) and in surface water to be <0.05 mg/L (Kuma and Younger, 2004; Yem *et al*., 2013). A provisional tolerable daily intake is set as 3.5 μg of lead per kg of body weight for infants. Hunan health concerns associated with lead intoxication in children include brain damage, behavioural problems, anaemia, liver and kidney damage and hearing loss (Gohar and Mohammadi, 2010; Rajaganapathy *et al*., 2011) whereas in adults poor muscle coordination, nerve damage to the sense organs, increased blood pressure, hearing and vision impairment, reproductive problems and retarded fatal development. In this respect, the lead content in the surface and groundwater within the mine area are dangerous for human health and aquatic life. Nickel (Ni) concentrations in drinking water are normally below 20 µg/L, although levels up to several hundred micrograms per litre in groundwater and drinking water have reported (Obriri *et al*., 2010). The concentrations of nickel observed in the present study are above the permissible limit of 0.07 mg/L for WHO standard and 0.02 mg/L of NSDWQ for domestic water (SON, 2007). The observed nickel values also exceed the finding of Kortatsi (2004), Oluwasanya and Martins (2006) who found maximum levels in groundwater to be 0.08 mg/L and 0.34 mg/L respectively. The presence of nickel in the mine study area is a chemical hazard to both aquatic biotas of the river as well as for human consumption. Zinc (Zn) concentration of the surface water sampled during the dry season are within the recommended limit of 3 mg/L set by WHO and NSDWQ while value from sampling point. Zinc is an essential trace element found in virtually all food and potable water in the form of salts or organic complexes (Edema *et al*., 2001; WHO, 2003). Iron concentrations are well above the recommended WHO limit of 1.0 mg/L (Highest desirable) and 3.0 mg/L (maximum desirable) except for LW2 and LW4. Fe forms rust-coloured sediment, stains laundry, utensils and fixtures reddish brown. Objectionable for food and beverage processing, can promote growth of certain kinds of bacteria that clog pipes and well openings (Kortatsi, 2007).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The main goal of this study was to assess the Influence of Mining Activities on Physicochemical Properties of Water at Ifewara Gold Mine Site During Dry Season, Osun State, Nigeria. The results from the study showed that water resources (surface and underground water) within the vicinity of the study area are contaminated. The hydrochemistry of both surface and groundwater show there are variation probably due to natural variations in geology and mining activities. The results also indicated that the values of most of the observed physicochemical parameters of water samples are found within the standards set by the WHO. The heavy metal concentrations are generally higher than the WHO recommended limit indicating threat to public health.

5.3 RECOMMENDATIONS

The recommended immediately control measures to the identified water supply and quality problem in the study area is provision of alternative water supply and treatment of metal contaminated water, in the short and medium term to protect health and wellbeing of the rural people living in the vicinity of the mine.

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