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 **RAJI QODRI OYEWUNMI** with the Matric Number **(HND/23/MNE/FT/017)** supervised, read and approved as having satisfied part of the requirements for the award of Higher National Diploma (HND) in Mining Engineering Technology by the Department of Mineral and Petroleum Resources Engineering Technology, Kwara State Polytechnic, Ilorin.

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DEDICATION

This research is dedicated to the people of Ifewara and surrounding communities who have been impacted by old mining activities may this study contribute a better understanding f the environmental effect of mining and inform strategies for sustainable resources management and environmental protection.

ACKNOWLEDGMENT

I wish to express my sincere gratitude to God, who has made this project a success and also my project supervisor Engr. S.A. Agbalajobi for his guidance and support throughout this research and the community leader and residence of Ifewara for their hospitality and cooperation during the field research work at Ifewara.

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ABSTRACT

Mining has recently become an importance economic activity in southwestern Nigeria but existing studies on their implication have mostly overlooked their capacity to the contamination of water in the neighboring communities. This study is focus on the effect of physicochemical properties of water in Ifewara gold mine. A total of ten samples water were randomly collected from surface water and ground water sources available to the communities. The surface and groundwater samples collected were analyzed for physicochemical properties and heavy metals using Atomic Absorption Spectrophotometry (AAS). Additionally, associated parameters related to the surface and groundwater quality were also analyzed to assess the overall water quality. 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. In addition, 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 for 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 concentrations (in mg/L) for both surface and groundwater samples ranged as follows: Fe (0.240 – 9.468 mg/L), Co (0.001 – 0.090 mg/L), Zn (0.345 – 3.172 mg/L), Ni (0.001 – 0.068 mg/L), Pb (0.001 – 0.001 mg/L), Cr (0.025 – 0.105 mg/L), and Cd (0.001 – 0.030 mg/L). The contamination level index could not be accurately determined for both physicochemical properties and heavy metal concentrations because samples were collected only during the dry season. The observed variations in these properties might be influenced by the flushing effect caused by mining activities and waste generation from the mine.

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CHAPTER ONE

INTRODUCTION

1.1 WATER IS A UNIQUE NATURAL RESOURCES

Water is a unique and essential natural resource to man. It has significance for the maintenance of an effective supply of food and sustenance of a productive environment to aid human and animal population (Pimentel *et al*., 2004). Increasing human population, rapid urbanization and economic expansion have brought about more demand for good water supply for domestic uses, irrigation, fish production and recreation. This has further put pressure on both the quality and quantity of water resources (Fernandez Jauregui, 2010). An important requirement for sustainable development must be to ensure the protection of water sources such as rivers, streams and lakes from pollution due to human activities. In Nigeria, surface and groundwater pollution among small towns and rural dwellers is particularly worrisome since they are more dependent than their urban counterparts on untreated water collected from rivers and streams for drinking and other domestic uses. Gold mining refers to human activities involving the mining of ores containing gold and processing them to recover the gold using techniques that vary from being rudimentary to modern. Gold mining contributes significantly to local and national economies (Bermudez-Lugo, 2008), but may impact the environment negatively in terms of water quality, degradation, loss of biodiversity and deforestation, if not controlled (Donkor *et al*., 2006). Mining affects freshwater through heavy use of water in processing ore and through water pollution from discharged mine effluent and seepage from tailings and waste rock impoundments (Balasubramaniam and Panda, 2014). Besides, considerable amount of solid waste piled in the form of huge overburden dumps, destruction and degradation of forest and agricultural lands, and discharge of effluents from mines into nearby water-bodies are some of the other associated problems that have adverse environmental impact (Tambekar *et al*., 2013). Moreover, anthropogenic activities such as mining threaten the water sources which are depended on for domestic and other uses by inhabitants of communities around the mining sites. Declining water quantity and quality in surface water of mining communities has become a matter of great concern as mining activities keep increasing, thereby depriving mining communities of access to clean and potable water. Mining by its nature consumes, diverts and can seriously pollute water resources. While there have been improvements in mining practices in recent years, significant environmental risks remain. Negative impacts can vary from the sedimentation caused by poorly built roads during exploration through to the sediment, and disturbance of water during mine construction (Protect Ecuador, 2013). Water can be polluted by chemical or biological contaminants which may be harmful to humans when consumed. Surveillance of physicochemical parameters in water resources helps to assess the suitability of such water for various uses as well as identify deterioration in water quality in order to ensure the protection of public health and the environment (Okoh *et al*., 2007). National and international standards often require the assessment of these parameters in surveillance water quality from different sources (Tebbut, 1983; WHO, 2008). Critical physicochemical parameters assessed in water include pH, temperature, turbidity, odour, total dissolved solids, total suspended solids, nitrate, orthophosphate, electrical conductivity, dissolved oxygen, biochemical oxygen demand, salinity and alkalinity among others (Tebbut, 1992; Joshi *et al*., 2009). Microbial water quality evaluation deals with the microorganisms that may be found in water. Waterborne diseases are associated with presence of pathogenic microorganisms in water and include cholera, typhoid fever and diarrhea (WHO 2011; Schwarzenbach *et al*., 2010). Disease-causing microorganisms associated with waterborne diseases belong to bacteria, viruses, fungi, protozoa and algae which can be present in surface, recreational and groundwater intended for drinking and spread via the faecal oral route (Cabral, 2010; Schwarzenbach *et al*., 2010). The aim of this study was to assess the seasonal and spatial variations in the physicochemical and microbiological qualities of surface water bodies in some gold-mining communities of Southwestern Nigeria.

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 PHYSICO-CHEMICAL ASSESSMENT OF SURFACE WATER FROM MINING ACTIVITIES

Surface water from mining activities may undergo various physico-chemical changes that can impact its quality and ecological health. This study conducted a comprehensive physico-chemical assessment of surface water affected by mining operations, with a particular emphasis on heavy metal content. Mining activities have been identified as a significant source of surface water pollution. The effluents from mining activities usually contain high levels of heavy metals, minerals and other toxic substances that can pose significant health risks to humans and aquatic life. Physico-chemical parameters are used to assess water quality and pollution levels in surface and groundwater. Due to mining activities, various factors have contributed to changes in the content of heavy metals in surface water. These factors include the discharge of acidic or alkaline mine water, leaching of heavy metals and minerals, erosion of mining wastes, and the introduction of chemicals used in mineral processing.

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2.2.1 Water Analysis

Physicochemical parameters In-situ hydro-physical parameters such as temperature (ambient and water temperature), water depth, stream/river channel width, flow rate and the grid co-ordinates of each of the sampling stations were determined. Other parameters studied were pH, conductivity, alkalinity, acidity, hardness, turbidity, true colour, total dissolved solids (TDS), total solids (TS) and total suspended solids (TSS). Major ions (calcium, magnesium, sodium, potassium, sulphate and chloride), nutrient compounds (nitrate, phosphate and organic matter), dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) were analysed according to standard procedures (Golterman *et al*., 1978).

2.2.2 Microbiological Quality

The microbiological parameters considered included total heterotrophic bacteria count (THBC), total heterotrophic fungal count (THFC) and total coliform count (TCC), using serial dilution and pour plate techniques. Assessment of antibiotic susceptibility profile of the bacterial isolates were also outlined. The zones of inhibition from the antibiotic susceptibility assay of bacterial isolates were measured, compared and interpreted using standard methods.

2.2.3 Environmental Pollution

Recently, pollution of general environment has increasingly gained a global interest. Contamination of surface and groundwater in gold mining communities is a serious environmental problem in many countries, Nigeria inclusive (Aslibekian and Moles, 2003). Heavy metal contamination of soil and water and related health impact on residents is a persistent social issue and several studies have identified human health risks subject to abandoned mines (Chung *et al*., 2005; Bada *et al*., 2012). In view of the various challenges of pollution, conformation with drinking water quality standards is a concern because of the ability of water to spread diseases within a large population. Although the standards vary from country to country, the objective anywhere is to reduce the possibility of spreading water borne diseases to the barest minimum in addition to being pleasant to drink, which implies that water must be wholesome and palatable in all respects (Edema *et al*., 2001; Awomeso *et al*., 2010). In Igun Ijesha gold city, the community depend on surface and groundwater contaminated from mining activities and so far, there is no evidence of any water quality assessment. Therefore, the aim of this study is to evaluate the physicochemical parameters and trace metals in drinking water sources in Igun-Ijesha gold mine area. The assessment is expected to determine water quality status of drinking water in the study area to ensure source and water safety

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 (Figure 3.3) 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 (Figure 3.2). 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).

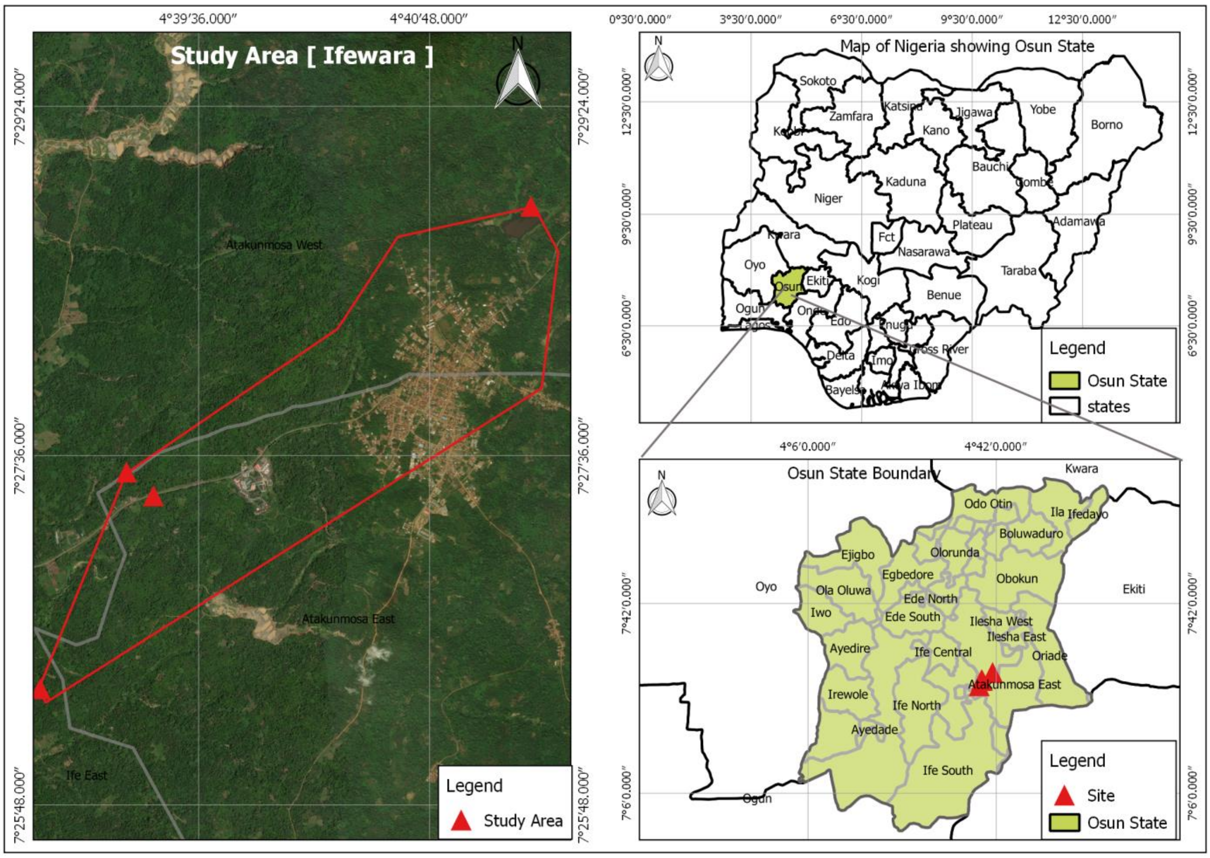

Figure 3.1: Map of the Study Area Location Ifewara, Atakumosa Local Government Area, Osun State, Nigeria.

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

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

Plates 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

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) 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**		

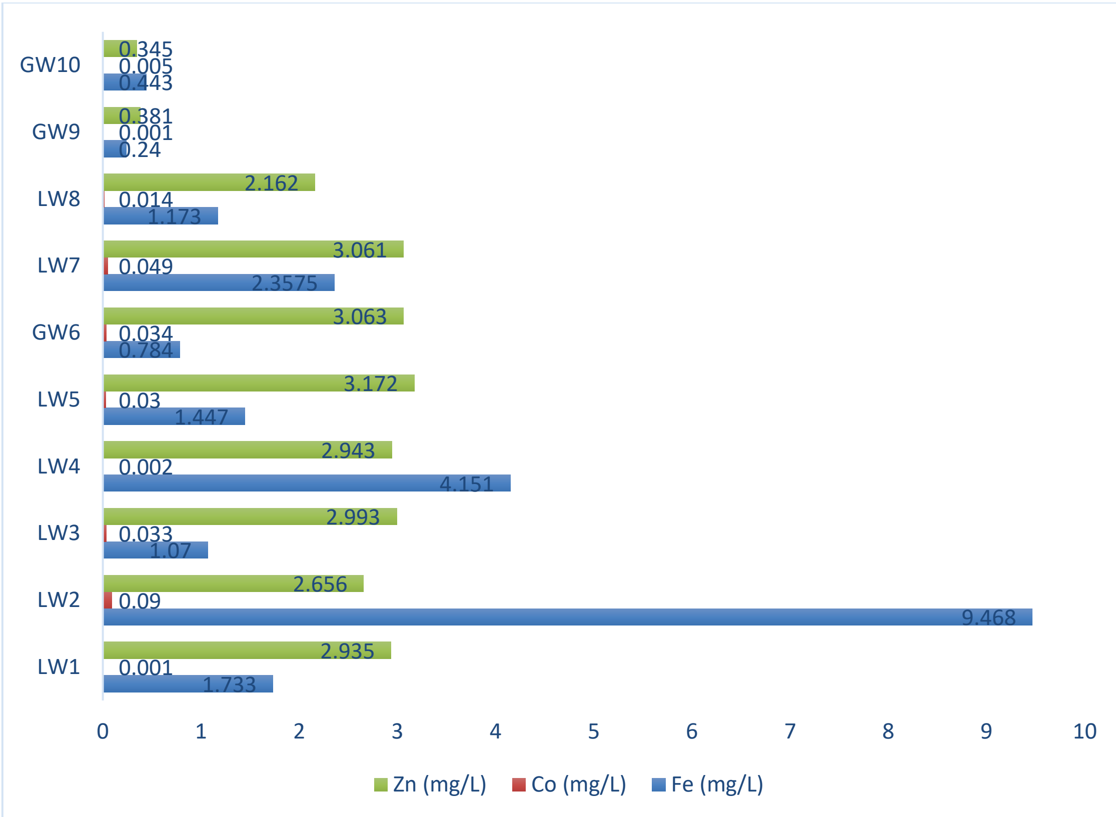

Figure 4.1: Heavy Metals Concentration of the Sample (mg/kg)

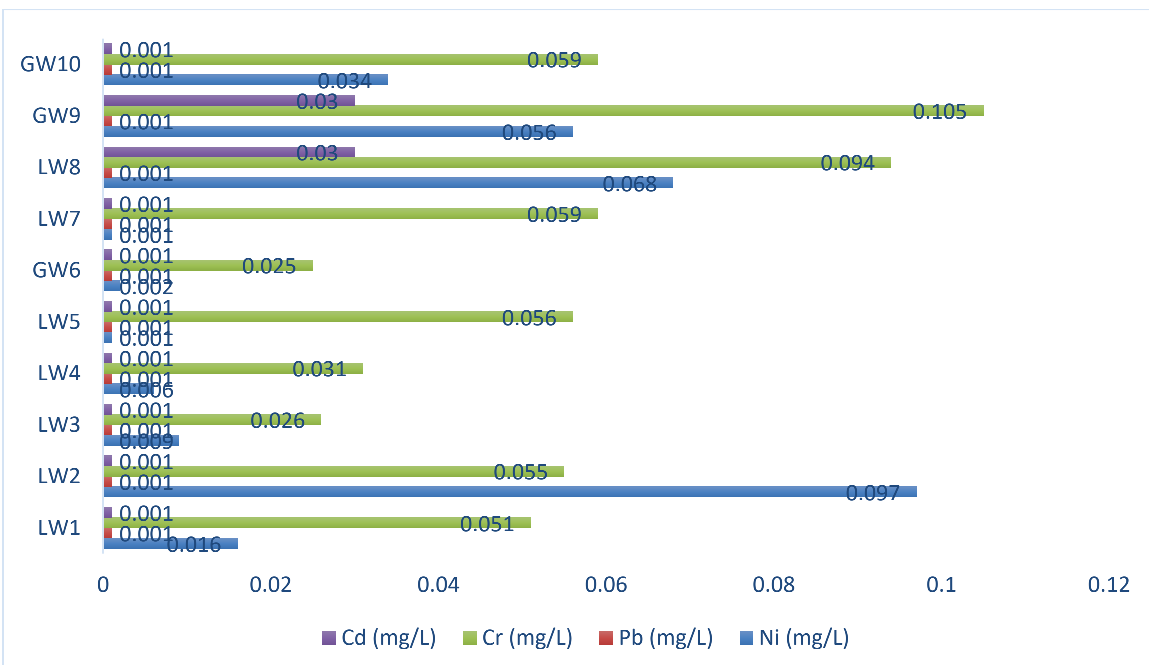

Figure 4.2: Heavy Metals Concentration of the Sample (mg/kg)

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 impact of mining activities on water quality in samples collected from the Ifewara gold mine district during the dry season. The results of the study showed that both surface and groundwater resources within the vicinity of the study area are contaminated. The hydrochemistry of both surface and groundwater shows variations, likely due to natural geological differences and the impact of mining activities. The results also indicated that most of the observed physicochemical parameters of the water samples fall within the standards set by the WHO. The concentrations of heavy metals generally exceed the WHO recommended limits, indicating a potential threat to public health.

5.3 RECOMMENDATIONS

The findings of this study have important implications for water quality management and policy. Historically, many mining communities have relied on surface water as their primary source of drinking water. However, contamination of surface water—particularly from mining activities—has made it imperative for the government and other non-state stakeholders to turn to groundwater as an alternative (Armah *et al*., 2010). The results, which identified numerous water quality hazards, also revealed that both surface and groundwater sources near the mine cannot be considered safe for drinking and other domestic uses. Policymakers need to implement appropriate regulations that mandate regular analysis of drinking water for physical and chemical parameters in mining communities. Where water sources have been tested, communities should be promptly informed of contaminant levels to enable appropriate household or communal treatment measures and support daily decisions regarding access to safe drinking water.

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