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

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TECHNOLOGY

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CERTIFICATION

This is to certify that this project was written by **OGUNOLA OLADAYO OLUWAKAYODE** with the Matric Number **(HND/23/MNE/FT/002)** 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

I dedicate this project to Almighty God for giving me the strength and knowledge to complete this project.

ACKNOWLEDGMENT

Special thanks to God Almighty for making the program a successful one and for counting me worthy to complete the programme and also for being my image for infancy to the moment. I am greatly indebted to my project supervisor in person of Engr. Agbalajobi, S.A. for his wealth of experience and guidance throughout the execution of this project and his contribution which is no small measure to the success of this project, I pray Almighty God bless you and your entire family (Amen). One honour and appreciation go to my lovely and understanding parents Mr. and Mrs. Ogunola for their financial and spiritual and moral supports throughout the period of my study may Almighty God continue to shower his mercy upon you (Amen).

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ABSTRACT

Surface water from mining activities may undergo various physicochemical changes that can impact its quality and the study conducted a comprehensive physicochemical assessment of surface water and groundwater affected by mining operations, with a particular emphasis on heavy metal content. These parameters were chosen because they serve as important indicators of water quality and potential contamination. Seven surface water samples and three groundwater samples were collected from various locations in and around the Ifewara gold mining area and analyzed using standard laboratory techniques. The assessment included the measurement of physicochemical parameters such as temperature, total dissolved solids (TDS), electrical conductivity (EC), and concentrations of heavy metals including Fe, Co, Zn, Ni, Pb, Cr, and Cd. Additionally, cations and anions such as calcium, magnesium, sodium, and phosphates, which can also impact water quality, were considered in the assessment. The physicochemical assessment revealed substantial variations in the concentrations of heavy metals, with Fe ranging from 0.240 to 9.468 mg/L, Co from 0.001 to 0.090 mg/L, Zn from 0.345 to 3.172 mg/L, Ni from 0.001 to 0.068 mg/L, Pb from 0.001 to 0.001 mg/L, Cr from 0.025 to 0.105 mg/L, and Cd from 0.001 to 0.030 mg/L. Additionally, cations and anions such as calcium (4.46 – 18.32 mg/L), potassium (4.28 – 9.74 mg/L), sodium (6.17 – 14.81 mg/L), and magnesium (4.91 – 9.61 mg/L) and Sulphate (7.20 – 15.13 mg/L) showed variability that can influence water quality across the sampled surface and groundwater bodies. Evidence of water contamination needs to be examined after sampling during the dry season to accurately attribute the levels of pollution to gold mining activities.

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CHAPTER ONE

INTRODUCTION

1.1 WATER QUALITY

Water is a universal solvent to man for various activities such as drinking, cooking, industrial and agricultural processes, waste disposal and human recreation. The two main problem men contend with are the quantity (source and amount) and quality of water in Nigeria (Adeniyi, 2004). In view of the occurrence and distribution pattern, water is not easily available to man in the desirable amount and quality. This is a problem experienced in most cities and town in the developing nations not to mention their rural settings. These factors have led to the growing rate of water borne diseases like typhoid fever and cholera experienced in this part of the world.

Water is a quality term that is most frequently used, but rarely defined, probably because it has no fixed definitions, but apparently fairly well understood by users. Thus, the quality of water is a reflection of the source environment and the activities of man, including the use and management measures. However, the desirable properties of water quality should include: adequate amount of dissolved oxygen at all time, a relatively low organic content, pH value near neutrality, moderate temperature and freedom from excessive number of infective agents, toxic substances and mineral matter (Adeniyi, 2004).

Mining process has bad impact on surrounding environment (Sumi and Thomsen, 2001; and Dasguta, 2012). The result can be unnaturally high concentration of some chemicals, such as arsenic sulphuric acid and mercury over a significant area of surface or groundwater (Kamakar, *et al*., 2012). There is potential for massive contamination of the area surrounding mines due to the various chemical used in the mining process as well as the potentially damaging compound and the metal removed from the ore (Hudson, 2012). Large amount of water produced from mine drainage, mine cooling, aqueous extraction and other mining process increases the potential for these chemicals to contaminate ground and surface water (Dasgupta, 2012).

Water pollution is a major concern in mining operation (Sumi and Thomsen, 2001; Dasgupa, 2012) spill leakage of effluent containing toxic chemical or discharge of leached from mine waste, surface runoff from overburden dumps, result degradation of water quality (Hudson, 2012 and Karmakar *et al*., 2012). It is well known that every aspect has to phases one is positive and other is negative. Mining is a major economic activity in many developing countries (Sumi *et al*., 2001 and Jhariya and Choraisia, 2010). Mining operation whether small or large scale are inherently disruptive to the environment, producing enormous quantities of waste that can have deleterious impact for decades (Sumi *et al*., 2001). The environmental deterioration caused by mining occurs mainly as a result of inappropriate and wasteful working practices and rehabilitation measures (Jhariya and Chourasia, 2010 and Mondal *et al*., 2014). The environmental problem arising due to mining activities are land degradation, degradation of forest and loss of biodiversity, soil contamination pollution, surface and groundwater pollution, noise, and vibrations. Deterioration of natural drainage system (Sumi *et al*., 2001 and Dasgupta, 2012 and Mondal *et al*., 2014) surface and groundwater pollution is one of the significant impacts of mining activity (Hudson, 2012). The mining sector uses large quantities of water, though some mines do revise of their water intake (Sumi *et al*., 2001). Mining throw sulphide – containing minerals into the air where they oxidize and react with water to form sulphuric acid and this together with various trace elements impacts groundwater both from surface and underground, (Hudson, 2012).

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 EFFECT OF MINING ACTIVITIES ON WATER

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. 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. 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, 1983; 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). 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. Therefore, the aim of this study is to evaluate the physicochemical parameters and trace metals in drinking water sources in Ifewara 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.

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

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).

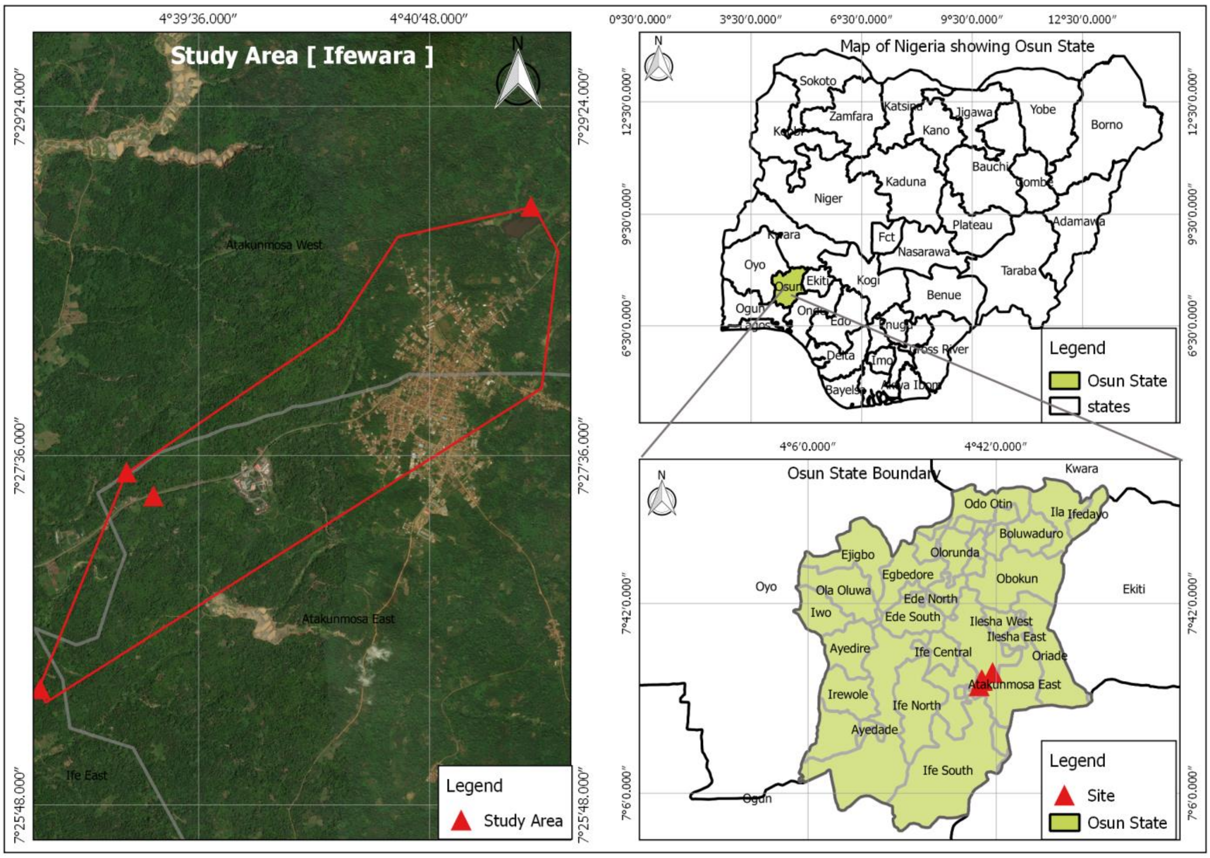

Figure 3.1: Map of the Study Area Location Ifewara, Atakumosa Local Government Area, Osun State, Nigeria.

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

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^oC 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^oC 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**		

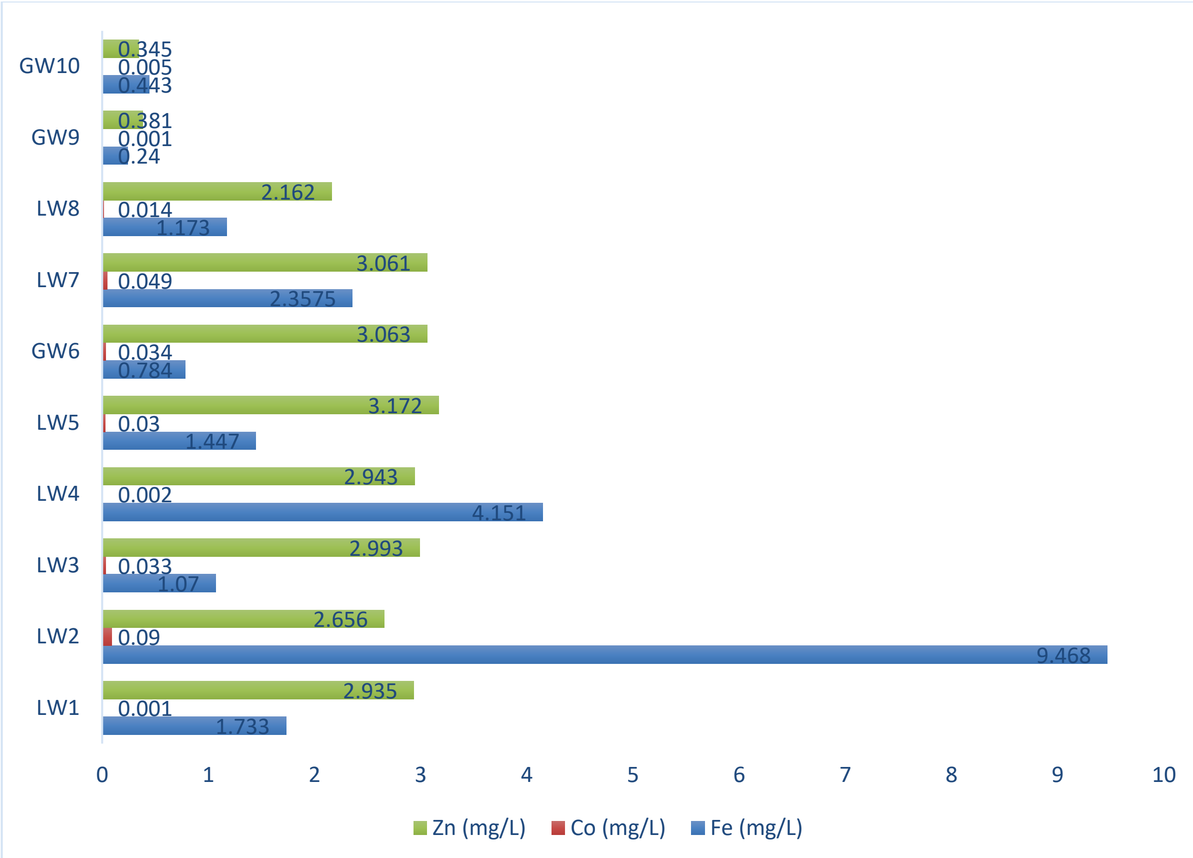

Figure 4.1: Heavy Metals Concentration of the Sample (mg/kg)

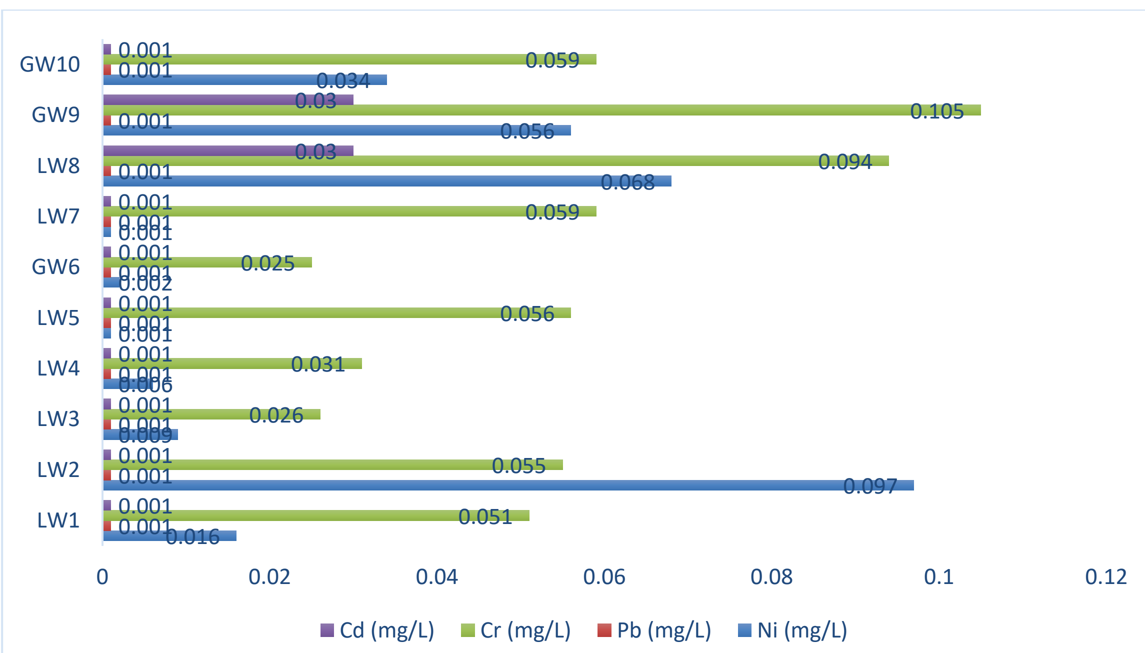

Figure 4.2: Heavy Metals Concentration of the Sample (mg/kg)

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 during the dry season. he study results 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 influence of mining activities. The results also indicated that most of the observed physicochemical parameters in the water samples fall within the standards set by the WHO. Heavy metal concentrations generally exceed the WHO recommended limits, indicating a potential threat to public health.

5.3 RECOMMENDATIONS

Piped water supply should be considered the ultimate goal for providing safe water in the study area, ensuring that clean water is delivered close to consumers. Apart from hand-dug wells and boreholes, other water supply options for the household level includes solar distillation, solar disinfection, and sand hose hold filters and engaging the services of water vendors. Overall, the results presented in this study indicate the critical need for a clearly laid out water safety planning to mitigate public health risk in the study area.

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