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

by
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Abstract

Mining has recently become an important economic activity in south-western 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 ground waters 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.

Keywords: Mining, Physicochemical Properties, Water, Gold mine and Dry Season.

1 Introduction

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 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. 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).

1.1 Artisanal and Small-Scale Gold Mining Impact on Water and Agriculture

Small-scale gold mining has served as a substantial means of subsistence for rural communities worldwide, Hilson and Hilson, (2015). Research indicates that around 15 million people have engaged in gold mining as a result of the widespread desire to become wealthy quickly Seccatore *et al*., 2024; Ros-Tonen *et al*., 2021; Akabzaa and Yidana, (2011). Artisanal gold extraction has played a substantial role in the economies of many developing countries, Akabzaa and Yidana, (2011) and Brottem, and Ba, (2019).

According to Seccatore *et al*., (2024), artisanal gold mining is primarily driven by poverty and is widespread in the remote rural areas of Africa and Asia. Scientific research has shown that artisanal gold mining has negative impacts on essential water and soil properties which in turn poses a threat to the already depleted vegetation resources in tropical countries, Hilson, Hilson, and Pardie, (2007); Alvarez-Berríos and Mitchell, (2015).

1.2 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. 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. 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 (Zhu *et al*., 2020). Knowledge of the current status of contaminants in waste water and sewage sludge, as well as their behavior after treatment.

Ande *et al*., 2021 assessed the physicochemical parameters of water and soil samples. 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.

2 Materials and Methods Used

2.1 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 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 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 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).

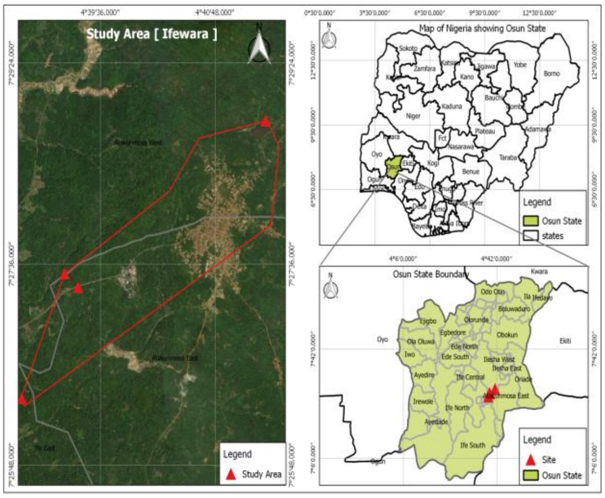

Figure 1: Map of the Study Area Location Ifewara, Atakumosa Local Government Area, Osun State, Nigeria.

Plate 1: Typical Artisanal Small-Scale Gold Mining Process in the Study Area using a Sluice Box.

Plate 2: The Artisanal Miners haphazardly select Artisanal Gold Mine (AGM) Pit Sites where Gold-bearing Saprolitic Layers are Panned.

Plate 3: Site Location with Group Picture with the Project Students and Miners

Plate 4: Site Location with Group Picture with the Project Students and Miners

Plate 5: Site Location with Group Picture with the Project Students

2.2 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 4ºC 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.

2.2.1 Sample Analysis

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

2.2.2 Determination of Physico-chemical Parameters Sub-section

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).

2.3 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 4ºC 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.

3 Results and Discussion

3.1 Physical and Chemical Parameters

Figure 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.

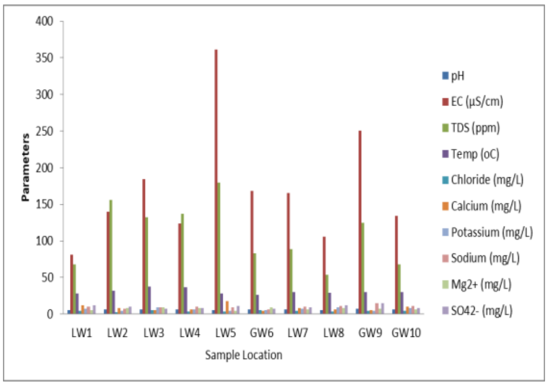

Figure 1: Physicochemical Parameter of Water During Dry Season

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). $SO4^{2-}$ 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.

3.2 Heavy Metal Concentration of Water Samples

The results of the heavy metal concentration of the sample are shown in Figure 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.

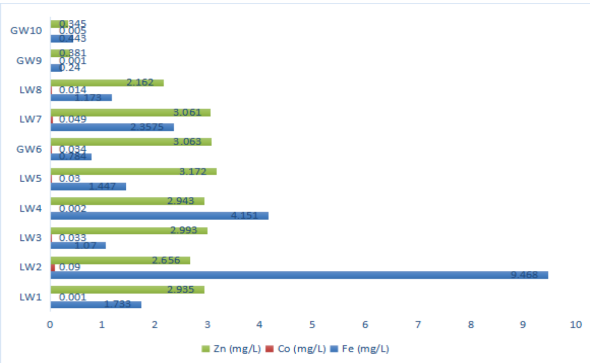

Figure 2: Heavy Metals Concentration of the Sample (mg/kg)

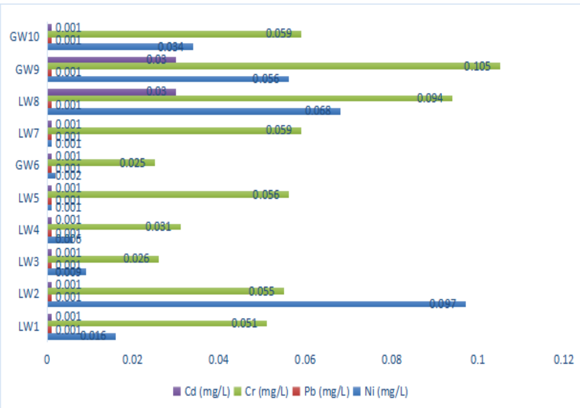

Figure 3: Heavy Metals Concentration of the Sample (mg/kg)

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 2 and Figure 4.3 respectively. It could be connoted that the mining activities have influences in the accumulation of heavy metals in the water.

3.2.1 Discussion of the Average Heavy Metals Concentration in the sample (mg/L) Water during the Dry Season

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. Human 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.

3.2 Discussion on Heavy Metals Concentration of the Sample

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. 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).

4 Conclusions and Recommendations

4.1 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.

4.2 Recommendations

The findings of this study hold several implications for water quality management and policy. Previously, most mining communities depended on surface water as drinking water source. However, contamination of surface water particularly via mining activities made it imperative for government and other non-state stakeholders to resort to groundwater (Armah *et al*., 2010). Results from this study and other studies (Obiri *et al*., 2010) have shown that the quality of groundwater is similarly, questionable. 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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References

Adeniyi, I.F., (2004). The concept of water quality in life. *Nigerian Society of Environmental Management* (NISEM), O.A.U., 1(1):2.

Ademeso, O.A., J.A Adekoya and A Adetunji, (2013). Further evidences of Cataclasis in the Ife-Ilesa Schist Belt, Southwestern Nigeria. *J. Natural Sci. Res*., 11: 50-59.

Akabzaa TM, Yidana SM. (2011). An integrated approach to environmental risk assessment of cumulatively impacted drainage basin from mining activities in Southwestern Ghana. *Environ Earth Sci*. 2011;65(1):291–312. doi: 10.1007/s12665-011-1090-0.

Alvarez-Berríos N.L and Mitchell Aide T. (2015). Global demand for gold is another threat for tropical forests. *Environ Res Lett*. 2015;10(1):014006. doi: 10.1088/1748-9326/10/1/014006.

Ande, S., Ekere, A.S., and Eneji, I.S. (2021). Determination of physicochemical parameters of water and soil samples around Owukpa coal mine, Benue State Nigeria. *Chem Search Journal,* 12(1), 120-131

Armah, F.A., S. Obiri, D.O. Yawson, E.E. Onumah and G.T. Yengoh, (2010). Anthropogenic sources and environmentally relevant concentrations of heavy metals in surface water of a mining district in Ghana: A multivariate statistical approach. *J. Environ., Sci. Health Tox. Hazard. Subst. Environ. Eng.,* 45: 1804-1813. DOI: 10.1080/10934529.2010.513296

Brottem LV, and Ba L. (2019). Gendered livelihoods and land tenure: The case of Artisanal gold miners in Mali, West Africa. Geoforum. 2019; 105:54–62. doi: 10.1016/j.geoforum.2019.07.005.

Edema, M.O., A.M. Omemu and O.M. Fapetu, (2001). Microbiology and physicochemical analysis of different sources of drinking water in Abeokuta. *Nigeria. J. Microbiol*., 15: 57-61.

Dasguta, A. (2012). Impact of mining on rural environmental and economy: A case study of Kota District, Rajasthan. *International Journal of Remote Sensing and Geoscience* (URSG), V.2, pp. 21 – 26.

Gashi, F., N. Troni, F. Faiku, F. Laha and A. Haziri., (2013). Chemical and statistical analyses of elements in river water of Moravae Binces. *Am. J. Environ. Sci.,* 9: 142-155. DOI: 10.3844/ajessp.2013.142.155

Gohar, A.V. and A. Mohammad, (2010). Epigenetic effects of carcinogens. *J. Biol. Sci.,* 10: 200-208. DOI: 10.3923/jbs.2010.200.208

Hilson G. (2016). Farming, Small-scale mining and rural livelihoods in sub-saharan Africa: A critical over-view. *Extr Ind Soc*. 2016a; 3:547–63

Hilson G, Hilson CJ, Pardie S. (2007). Improving awareness of mercury pollution in small-scale gold mining communities: Challenges and ways forward in *Rural Ghana. Environ Res*. 2007;103(2):275–87.

Hilson G, Hilson A. (2015). Entrepreneurship, poverty and sustainability: Critical reflections on the formalization of small-scale mining in Ghana: E-3312-GHA-1; London: International Growth Centre, UK Working Paper; 2015.

Hu, Z., and Qi, L. (2013). Sample digestion methods. Treatise on geochemistry (Second Edition), 15, 87-109. https://doi.org/10.1016/B978- 0-08-095975-7.01406-6

Hudson, T., (2012). Living earth, An introduction to environmental geology. *Eng. Geol. Environ*., 63: 119-132. DOI: 10.107/s10064-004-0227-8

Kumar Singh, P., Verma, P., Tiwari, A.K., Sharma, S., and Purty, P. (2015). Review of various contamination index approaches to evaluate groundwater quality with geographic information system (GIS). *International Journal of ChemTech Research*, 7(4), 1920-1929.

Karmakar, H.N., Das K.P., (2012). Impact of Mining on Ground and Surface Water, International Mine Water Association, www.imwainfo

Kortatsi, B.K., (2004). Hydrochemistry of groundwater in the mining area of Tarwa-Prestea, Ghana. Ph.D. Thesis, University of Ghana, Legon-Accra, Ghana.

Kortatsi, B.K., (2007). Groundwater quality in the wassa west district of the western region of Ghana. *West African J. Applied Ecol*., 11: 31-31. DOI: 10.4314/wajae.v11i1.45729

Kuma, J.S. and P.L. Younger, (2004). Water quality trends in the Tarkwa gold-mining district, Ghana. *Bull. Eng. Geol. Environ*., 63: 119-132. DOI: 10.1007/s10064-004-0227-8

Marcovecchio, J.E., S.E. Botte and R.H. Freije, (2007). Heavy metals, major metals, trace elements. In Handbook of water analysis, L.M. Nollet (Ed.), CRC Press: London, Mohd Fairulnizal, M.N.,

Vimala, B., Rathi, D.N. and Mohd Naeem, M.N. (2019). Atomic absorption spectroscopy for food quality evaluation. *Evaluation Technologies for Food Quality*, 145-173

Obiri, S., D.K. Dodoo, D.K. Essumang and F.A. Armah (2010). Cancer and non-cancer risk assessment from exposure to arsenic, cadmium and copper by resident adults and children in the Obuasi Municipality, Ghana. *Int. J. Human Ecol. Risk Assess*, 16: 651-665. DOI: 10.1080/10807031003788907

Oluwasanya, G.O., (2006). Assessment of rainwater harvesting in rural household water supply-a case of Otofure village, Erua/Ishan region, Edo State, Nigeria. *J. Nigerian Meteorol.* Soc., 6: 70-81.

Oluwasanya, G.O. and O. Martins, (2006). Assessment of Heavy Metals in Groundwater: Case Study of Ogun State-Southern Nigeria. *Asset Series A*, 6: 309-321.

USEPA, (1989). Risk assessment guidance for superfund, volume 1, human health evaluation Manual, EPA/54 0/1-89/002, Office of Emergency and Remedial Response, Washington, DC.

Rajaganapathy, V., F. Xavier, D. Sreekumar and P.K. Mandal, (2011). Heavy metal contamination in soil, water and fodder and their presence in livestock and products*: A review. J. Environ.*

Sci. Technol., 4: 234-249. DOI: 10.3923/jest.2011.234.249

Seccatore J, Veiga M, Origliasso C, Marin T, De Tomi G. (2024). An estimation of the artisanal small-scale production of gold in the world. *Sci Total Environ*. 2014; 496:662–7. doi: 10.1016/j.scitotenv.2014.05.003.

SON, (2007). Nigerian standard for drinking water quality. Plot 1689 Lome Street, Wuse Zone 7, Abuja, Nigeria. 535.

Sumi, L., and Thomson, S (2001). Mining in remote areas: Issues and impacts. Mining Water Canada/Mines Alerts

Tambekar, P., Morey, P., Batra, R. J. and Weginwar, R. G., (2013). Assessment of water on upstream and downstream from HLOCCM, of Chandrapur Tahasil of Chandrapur District (2012.). *Jr. of Chemical and Pharmaceutical Research.* 5 (5): 18-26.

Taiwo, A.M., (2013). Receptor modeling of industrial air pollutants. Ph.D. Thesis, University of Birmingham: UK

Tebutt T.H. (1983). Principles of Quality Control. England: Pergamon, 232.

WHO (2003). Total dissolved solids in drinking: Background document for the development of WHO guidelines for drinking-water quality: Geneva.

WHO (2004). WHO Guidelines for Drinking Water Quality. 3rd Edu., World Health Organisation: Geneva.

WHO (2008). WHO Guidelines for Drinking Water Quality. 3rd Edu., World Health Organization: Geneva.

World Health Organization (WHO), 2011. Guidelines for Drinking Water Quality, 4th Edition, World Health Organization, Geneva, 799 Switzerland 2011; 224-334.

Yem, T., N.X. Hai, N.M. Khai and N.X. Huan, (2013). Study for improving and duong lake water quality for chi Lang Nam stork island conservation and ecotourism development. *Am. J. Environ. Sci.*, 9: 218-225. DOI: 10.3844/ajessp.2013.218.

Zhu, G., Wu, X., Ge, J., Liu, F., Zhao, W., and Wu, C. (2020). Influence of Mining Activities on Groundwater Hydrochemistry and Heavy Metal Migration using a Self-Organizing Map (SOM). *Journal of Cleaner Production*, 257, 120664. https://doi.org/10.1016/j.jclepro.2020.120664

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