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Environmental Degradation: A Case Study of Rimi Gold mineralized Area, Burumburum, North Central Nigeria.

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Abstract
The study revealed the impact of artisanal mining activities in Rimi gold mineralized area. The surface and ground water around the study area were sampled and analyzed using Atomic Absorption Spectrophotometer (AAS) to determine the degree of pollution. The result of the analysis shows an elevated levels of Ag, As, Pb and Se in surface and groundwater in the study area which is above the World Health Organization (WHO) and Nigeria Industrial Standard (NIS) permissible limits thereby resulting in water pollution. However, the result of Cu, Ni, Zn and Au were within WHO and NIS permissible standards. The values of TDS in surface and ground water is above WHO permissible limits which may affect water quality parameters in the study area. The sources of these metals in water around the study area is attributed to mining activities. The pollution of water pose health risks to the people living around the area. The removal of soil and vegetation caused land degradation and deforestation while the particulates matter being released during the mining operation affects the ambient air quality in the study area. The study recommends restoration of the abandoned mining site in order to protect the environment.The treatment of surface and ground water prior to consumption will go a long way in safeguarding the health of the people around the area.
Keywords: *Environmental Degradation, pollution, restoration, health risks. Surface water, ground water*

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I. Introduction

The occurrence of gold mineralization in Rimi area leads to an upsurge in artisanal mining activities. Mining releases toxic metals that impact on human health and the environment [1]. The gold which is usually found in laterites and quartz veins in the area is being extracted from the ground without due diligence for environmental consideration. The gangue minerals associated with the gold are often left as waste rocks and mine tailings which may be washed down as run-off water or infiltrate into groundwater bodies with the possibility of causing surface and ground water pollution. The mine waste materials around abandon and active mines contains trace metals concentration which may be dispersed into nearby soils,food crops, and stream sediments [2].

Many studies such as [3],[4],[5] and [6] have shown the adverse effect of gold mining activities in relation to environment and health hazards. The incidence of high mortality rates witnessed in early 2010 amongst children in the remote villages of Zamfara State, northwestern Nigeria were due to acute Pb poisoning from unsafe gold mining activities by artisanal miners [7], [8],[9], [10], [11]. Therefore, this study is aimed at assessing the environmental degradation due to artisanal mining activities in the study area and their effect on the environment and human health.

II. Research Methods

Study Area

The study area lies within Burumburum Sheet 104 North-East and covers an area of 4 Km^2 between 11° 22′ 0″ to 11° 24′ 0″ North and 008° 58′ 0″ to 009° 0′ 0″ East (Figure 1).The area is accessible through Takai-Sumaila and towns roads. The climate of the area alternates between wet and dry seasons. The wet season seasons lasts between May to mid-October with a peak period in August while the dry season lasts from October to May. The annual mean rainfall around the study area is between 800 mm to 900 mm. The mean annual temperature is about 26°C [12], [13].

The study area is well drained by streams, tributaries and River Rimi with dendritic drainage pattern.The physiographic feature of the area is flat plain and the vegetation is typical of the Sudan Savannah belt comprising of thorny, shrubs savannah grass, baobab (adonsona digitata), and neem trees (Azadirachta Indica).

The settlement around the area include Rimi, Kompany and Fari Dutse. Rimi is densely populated compared to other adjoining villages with sparse populations. The land is cultivated for farming activities during wet and dry seasons periods which is the primary occupation of the people in the area. Some of the food grains commonly grown in the area include Maize, Corn, Millet, Beans, Ground nut, Rice, Sesame seed, Tomatoes, Sugarcane, Onion and vegetables. Animals such as Cow, Goat, Sheep and chickens are also being reared by inhabitant of the area as a means of livelihood.

The inhabitant of the settlement mined sands around the mining site for construction purposes using either Carts or Donkey to ferry the earth materials. Water from hand dug wells are used for domestic consumption while the stream water is used for washing of clothes, bathing and agricultural purpose among others. Trace metal around the mining site are dissolved and dispersed in to the nearby Rivers.

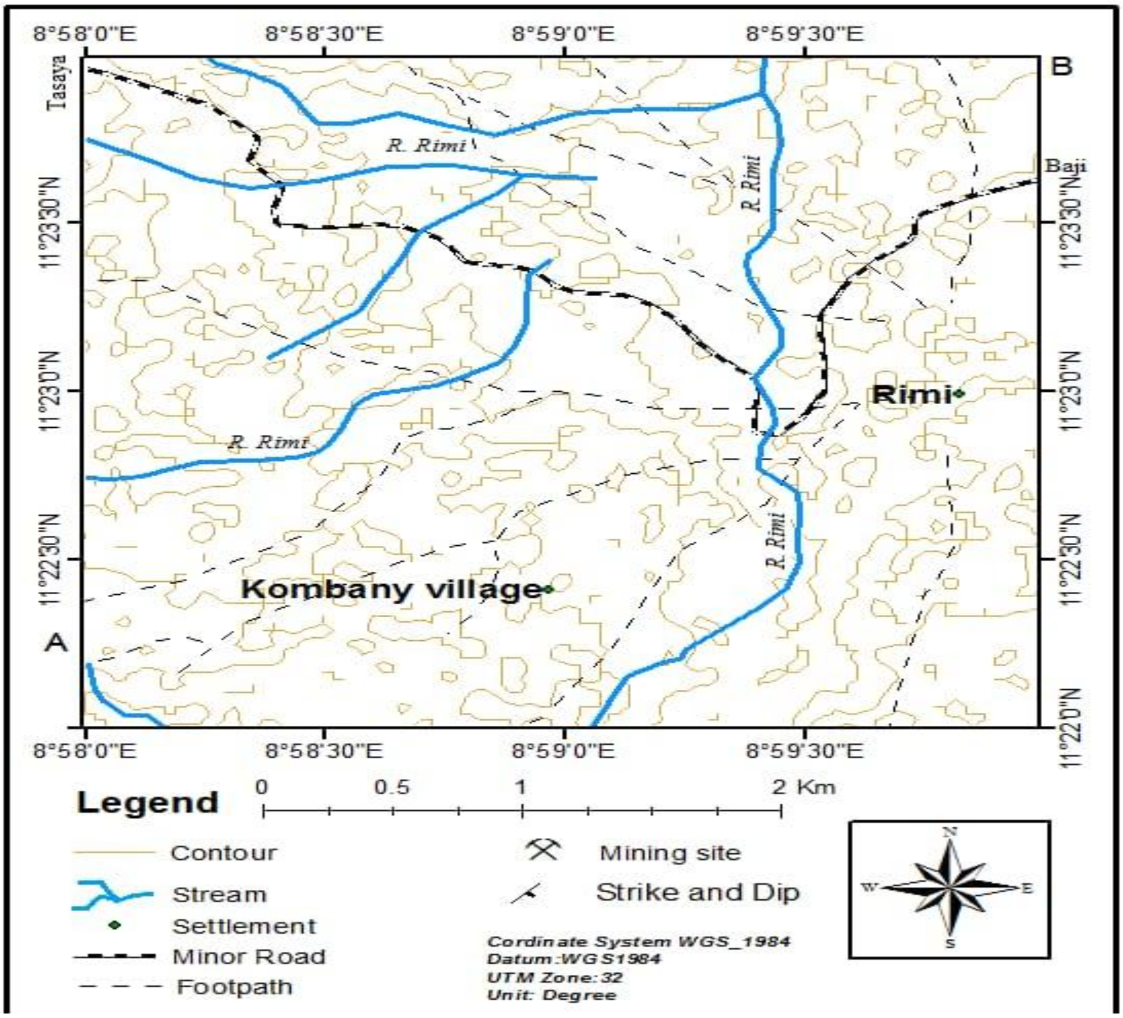

Figure 1: Location map of the study area in Rimi village.

The Geology of the Study Area

The study area is underlain by medium grained granite and occur as low lying outcrops which belongs to the member of Older granites [14] in the basement complex of Nigeria.The rock under hand specimen observation shows grey colour with equigranular textures and comprise of quartz, feldspar and biotite. The rock grain size range from 1–5 mm and cover 100% of the study area (Figure 2).

The petrographic study of the medium grained granite outcropping around Rimi revealed that quartz occurs as colourless crystals with small to medium grain size and the shape of the crystals is anhedral. The mineral has low relief, exhibits undulose extinction and constitutes 23% of the entire rock composition. Orthoclase is grey with large irregular crystals, it has high relief and contains 25%. Biotite occurs as fibrous crystal with moderate relief and comprise 35%. Chlorite and magnetite occur as accessory minerals and forms about 17% of the entire mineral composition (Plate 1).

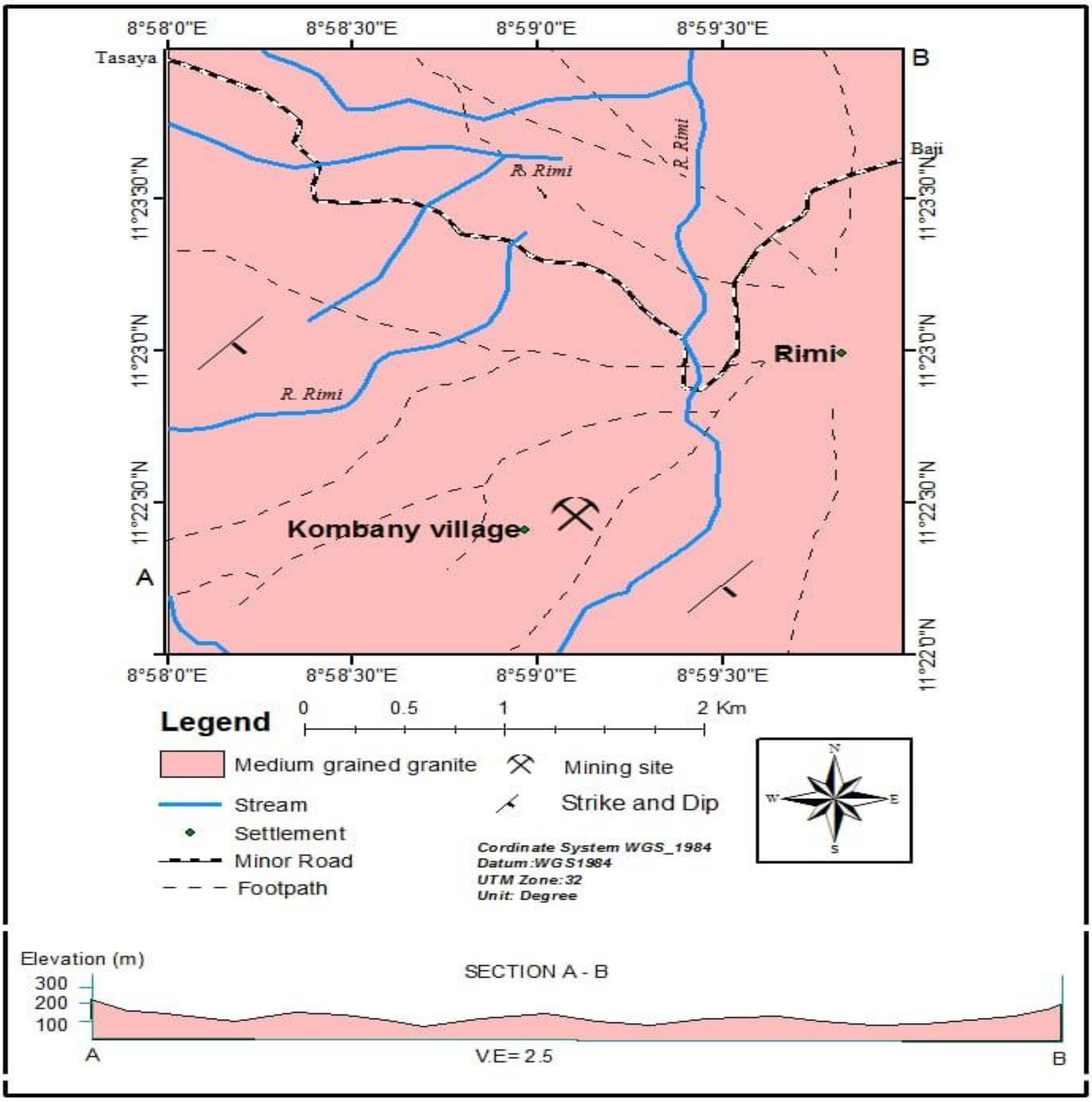

Figure 2. The geological map of the study area

Plate I: Hand specimen of medium grained granite around Rimi area Lat: 11° 22′ 0″and long: 08° 58′ 0″)

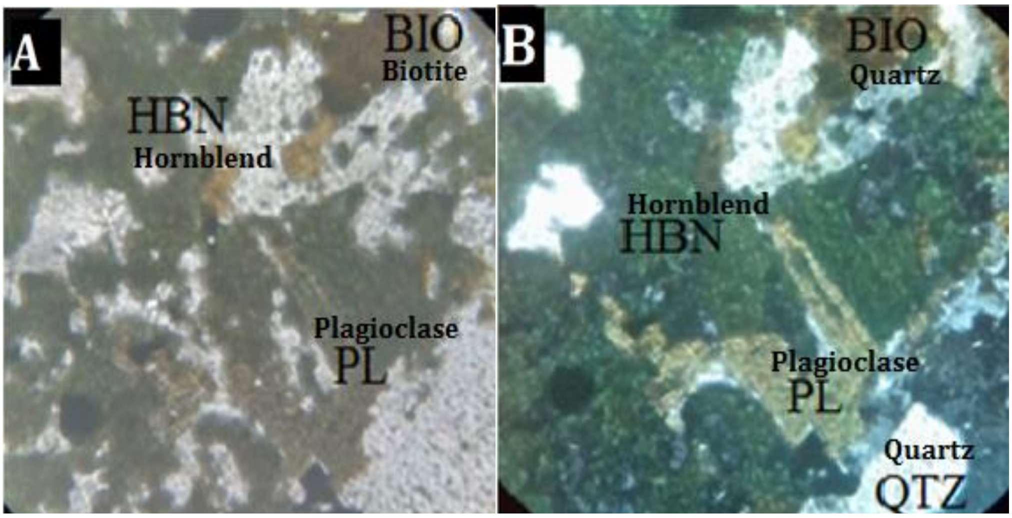

Plate V: Photomicrograph of medium grained graniteunder (a) Plane Polarized light (PPL) and (b) Crossed polarized light (XPL) (BIO)= Biotite, (QTZ)= Quartz, (HBN) =Hornblende, and (PL) =Plagioclase. Mag. =X100

III. Methodology

Twenty-five (25) surface water samples around the mining site were obtained using polyethylene sample bottle (100ml) each at intervals of 100 meters along the stream course for about 2.5 Km. Nine (9) groundwater samples were also collected randomly in Rimi Village around the mining site. One drop of HNO_3 was added to the water for preservation. Prior to sample collection, polyethylene sample bottles were thoroughly washed with the stream water and groundwater for sterilization. Other activities carried out in the field include measurement of Physico-chemical parameters (Insitu analysis) pH, TDS, DO, Eh and temperature.

After filtering the water, Samples were injected directly into Atomic Absorption Spectrophotometer (AAS). The water samples were atomized prior to the analysis of its elemental constituent. The atomizer commonly used are flames and electrothermal (graphite tube) atomizers. ('Sample Atomization-Atomic Absorption Spectroscopy Learning Module'' blog. maryville. edu. Retrieved 02-11-20017). A Perkin-Elmer Model 303 Atomic Absorption Spectrophotometry method was adopted to determine each element. All sampled waters and standards were atomized and the percent absorption observed. These were repeated and the average of the three values was obtained. The principle of using AAS in the analysis of trace elements is based on absorption of light to measure the concentration of gas phase atoms [15]. Descriptive statistics of surface, groundwater and physicochemical parameters were done using Microsoft Excel 2010 software package.

Plate II: Insitu analysis of physico-parameter of surface and ground water around mineralized area around Rimi, Sumaila Local Area, Kano Government Area, Kano. Groundwater sampling around mineralized area at Rimi, Sumaila Local Government Area, Kano

IV. Results and Discussion

Effect of mining in relation to Pollution

The artisanal miners employed the use of open cast mining methods to extract gold from the study area. This involved the clearing of vegetation and the removal of the soil overburden to extracts gold from mineralized quartz veins or laterite. The common health hazards in the area include accidental falls by artisanal miners or the caving of land into the pits. Ground water aquifers are also intercepted during the course of mining which is being pumped and discharge directly into the environment without treatment (Plate III). The activities of the miners cause adverse effects on air, land and waters around the study area.

Impact on Air quality

The removal of vegetation and soil overburden exposed the area to wind erosion thereby causing particulate matter to become airborne. The particulate matter contains toxic metals like arsenic and lead. Gas emission from mobile and stationary sources alters the serene air quality around the mining site. Noise arising from the operation of equipment around the area impacts on Noise pollution. The overall effect of air pollution affects the human health and degrade the environment.

Impact on land

Mining activities around the study area distorts the landscape and create a gory sights of waste-rock piles and open pits. Soils are contaminated as a result of wind blow dust and oil spills from the milling machine, pumping machine and generator. Both active and abandon mine site in the area are being operated without due diligence for environment degradation. Some of these abandoned mine sites serves as a breeding pools for reptiles and mosquitoes. The absence of perimeter fencing around the mining sites exposes both animal and inhabitant of the area to dangers (Plate IV).

Impact on water

The operation of artisanal miners in the study area caused erosion of soils and mine wastes with impacts on waters and terrestrial ecosystems. The mineral associated with the sediment depress the pH of surface runoff and mobilize metals that contaminates surface water or ground water. The excavated materials are crushed, milled, washed and collected in the floatation tank. During the discharge of water from floatation tank, metals are released in to surface and ground water bodies at a levels that cause pollution (Plate V).

Surface Water and Groundwater Hydro-geochemistry

The results of the physico parameters and trace elements concentration obtained from the investigation of surface water in Rimi area is presented in (Tables 1 and 2) while the summary of surface water Physico-Chemistry is given in (Table 3). Also, the result of the Physico parameters and trace elements concentration from groundwater in Rimi area is presented in (Tables 4 and 5) while the summary of groundwater physico-chemistry is given in (Table 6).

Plate III; The extraction of gold mineralized quartz vein in the study area using
Open cast mining method.

Plate IV, a: Heaps of Mine tailing offloaded near the mining site (lat:11º 22′ 12.0″, long:008º 59′ 55.6″) and abandon mine sites around the study area, b: Abandoned mining site in the study area (Lat:11º 22′ 12.5″, Long: 008º 57′ 47.6″).

Plate V, A,B,C,D: The milling and washing of mineralized quartz vein/laterites and sedimentation in floatation tank to recover gold in the study area (11º 22′ 13.7″. 008º 56′ 17.0″).

Table 1: Physico parameters of Surface water around mineralized areas in the study area.

S/No	Location	Co-ordinates		Sample ID	PH	Temperature	TDS	DO	EC
		Latitude	Longitude						
1	Study area	11º 21′44.9″	008º 59′ 08.3″	RS1	9.96	27.5	1080	1.2	160
2	Study area	11º 21′ 47.7″	008º 59′ 09″0″	RS2	9.55	21.8	1020	1.3	100
3	Study area	11º 21′ 52.2″	008º 59′ 09.9″	RS3	7.35	28.1	990	1.1	180
4	Study area	11º 21′ 56.4″	008º 59′ 11.9″	RS4	8.42	27.8	960	1.1	170
5	Study area	11º 22′ 01.1″	008º 59′ 17.4″	RS5	6.45	28.3	960	1.1	180
6	Study area	11º 22′ 03.1″	008º 59′ 21.5″	RS6	8.32	28.5	840	1.2	180
7	Study area	11º 22′ 04″0″	008º 59′ 24.0″	RS7	8.01	27.9	900	1.2	170
8	Study area	11º 22′ 07.2″	008º 59′ 28.3″	RS8	6.30	28.6	1020	1.3	190
9	Study area	11′ 22′ 09.5″	008º 59′ 31.1″	RS9	6.43	29	960	1.3	200
10	Study area	11º 22′ 13.0″	008º 59′ 32.3″	RS10	6.42	28.7	960	1.4	190
11	Study area	11º 22′ 18.1″	008º 59′ 32.4″	RS11	7.29	29.3	900	1.5	210
12	Study area	11º 22′ 21.7″	008º 59′ 31.3″	RS12	8.50	29	900	1.6	220
13	Study area	11º 22′ 25.7″	008º 59′ 31.5″	RS13	7.75	30	900	1.0	230
14	Study area	11º 22′ 30.4″	008º 59′ 31.7″	RS14	7.31	29.7	960	1.1	220
15	Study area	11º 22′ 33.5″	008º 59′ 31.8″	RS15	6.87	29.6	960	1.3	220
16	Study area	11º 22′ 36.6″	008º 59′ 31.2″	RS16	5.68	29.6	960	1.4	220
17	Study area	11º 22′ 38.9″	008º 59′ 28.8″	RS17	7.42	29	960	1.6	200
18	Study area	11º 22′ 40.0″	008º 59′ 24.0″	RS18	6.80	29.6	960	1.9	220
19	Study area	11º 22′ 44.3″	008º 59′ 24.2″	RS19	7.48	29.6	960	2.1	220
20	Study area	11º 22′ 47.7″	008º 59′ 24.3″	RS20	7.99	28.8	960	3.7	190
21	Study area	11º 22′ 50.7″	008º 59′ 24.2″	RS21	7.20	29.1	840	6.3	200
22	Study area	11º 22′ 53.0″	008º 59′ 26.0″	RS22	7.29	29.4	840	7.9	210
23	Study area	11º 22′ 54.4″	008º 59′ 28.4″	RS23	6.24	2 9.3	960	9.8	210
24	Study area	11º 22′ 56.5″	008º 59′ 31.5″	RS24	9.43	2 9.2	960	9.9	210

25	Study area	11º 22′ 58.4″	008º 59′ 34.3″	RS25	8.81	29.4	1020	10.7	210

Table 2: Chemical analysis of surface water around mineralized area in Rimi, Sumaila Local Government Area, Kano.

S/No	Location	Co-ordinates		Sample ID	Ag mg/l	As mg/l	Au mg/l	Cu mg/l	Ni mg/l	Pb mg/l	Se mg/l	Zn mg/l
		Latitude	Longitude									
1	Study area	11º 21′44.9″	008º 59′ 08.3″	RS1	0.016	1.636	0.077	0.019	-0.094	0.287	-0.529	0.069
2	Study area	11º 21′ 47.7″	008º 59′ 09.0″	RS2	0.009	1.647	0.071	0.004	-0.102	0.216	-0.350	0.035
3	Study area	11º 21′ 52.2″	008º 59′ 09.9″	RS3	0.005	1.698	0.076	0.019	-0.116	0.215	-0.470	0.055
4	Study area	11º 21′ 56.4″	008º 59′ 11.9″	RS4	0.001	1.700	0.074	0.002	-0.119	0.251	-0.402	0.023
5	Study area	11º 22′ 01.1″	008º 59′ 17.4″	RS5	0.006	1.682	0.082	-0.001	-0.112	0.208	-0.434	0.023
6	Study area	11º 22′ 03.1″	008º 59′ 21.5″	RS6	0.002	1.695	0.058	0.041	-0.123	0.188	-0.550	0.042
7	Study area	11º 22′ 04″	008º 59′ 24.0″	RS7	0.002	1.650	0.050	-0.004	-0.119	0.274	-0.688	0.052
8	Study area	11º 22′ 07.2″	008º 59′ 28.3″	RS8	0.001	1.756	0.038	-0.008	-0.121	0.323	-0.617	0.046
9	Study area	11′ 22′ 09.5″	008º 59′ 31.1″	RS9	0.004	1.730	0.046	-0.005	-0.116	0.322	-0.730	0.035
10	Study area	11º 22′ 13.0″	008º 59′ 32.3″	RS10	0.002	1.708	0.038	-0.012	-0.120	0.368	-0.788	0.060
11	Study area	11º 22′ 18.1″	008º 59′ 32.4″	RS11	0.003	1.746	0.035	-0.011	-0.119	0.361	-0.591	0.024
12	Study area	11º 22′ 21.7″	008º 59′ 31.3″	RS12	0.007	1.749	0.043	-0.010	-0.117	0.283	-0.609	0.030
13	Study area	11º 22′ 25.7″	008º 59′ 31.5″	RS13	-0.000	1.725	0.044	0.003	-0.117	0.289	-0.513	0.009
14	Study area	11º 22′ 30.4″	008º 59′ 31.7″	RS14	0.004	1.733	0.059	-0.013	-0.130	0.298	-0.454	0.018
15	Study area	11º 22′ 33.5″	008º 59′ 31.8″	RS15	0.004	1.784	0.063	-0.001	-0.121	0.291	-0.544	0.022
16	Study area	11º 22′ 36.6″	008º 59′ 31.2″	RS16	0.004	1.790	0.055	-0.017	-0.109	0.252	-0.362	0.027
17	Study area	11º 22′ 38.9″	008º 59′ 28.8″	RS17	0.003	1.807	0.082	-0.017	-0.123	0.295	-0.460	0.029
18	Study area	11º 22′ 40.0″	008º 59′ 24.0″	RS18	0.006	1.710	0.060	-0.012	-0.110	0.311	-0.357	0.030
19	Study area	11º 22′ 44.3″	008º 59′ 24.2″	RS19	0.003	1.827	0.055	-0.021	-0.134	0.245	-0.529	0.018
20	Study area	11º 22′ 47.7″	008º 59′ 24.3″	RS20	0.002	1.842	0.063	-0.025	-0.113	0.267	-0.554	0.021
21	Study area	11º 22′ 50.7″	008º 59′ 24.2″	RS21	-0.000	1.705	0.043	-0.026	-0.119	0.307	-0.641	0.015
22	Study area	11º 22′ 53″	008º 59′ 26.0″	RS22	0.003	1.688	0.024	-0.020	-0.119	0.279	-0.674	0.010
23	Study area	11º 22′ 54.4″	008º 59′ 28.4″	RS23	0.007	1.715	0.046	-0.017	-0.115	0.285	-0.589	0.020
24	Study area	11º 22′ 56.5″	008º 59′ 31.5″	RS24	0.003	1.774	0.051	-0.025	-0.111	0.294	-0.703	0.011
25	Study area	11º 22′ 58.4″	008º 59′ 34.3″	RS25	0.005	1.742	0.049	-0.026	-0.125	0.277	-0.656	0.009

Table 3: Summary of the Physico-chemistry and chemical analysis of Surface water around mineralized area in Rimi, Sumaila Local Government Area, Kano.

Parameter	Mean	Min	Max	WHO (2017)	NIS
PH	7.47	5.68	9.96	6.5-8.5	6.5-8.5
Temperature	29.40	21.8	30	30	30
TDS	745.2	840	1080	1000/500	500
DO	2.96	1.0	10.7	NG	NG
EC	196.4	100	230	400	
Ag	0.004	0	0.016	0.005	
As	1.730	1.636	1.842	0.01	
Au	0.055	0.024	0.082	ND	ND
Cu	-0.007	-0.026	0.041	2	1
Ni	-0.117	-0.134	-0.094	0.02	0.02
Pb	0.279	0.188	0.368	0.01	0.01
Se	0.552	-0.788	-0.35	0.01	-
Zn	0.029	0.009	0.069	3	3

BD=Below detection limit

Table 4: Physico-parameters of groundwater around mineralized area in Rimi, Sumaila Local Government Area, Kano.

S/No	Location	Co-ordinates		Sample ID	PH	Temperature	TDS	DO	EC
		Latitude	Longitude						
1	Study area	11º 22′ 59.5″	008º 59′ 44.5″	RGW1	9.95	25.6	1080	5.5	390
2	Study area	11º 22′ 58.1″	008º 59′ 45.5″	RGW2	8.78	25.4	1560	4.6	340
3	Study area	11º 22′ 59.5″	008º 59′ 47.6″	RGW3	7.57	25.5	3000	5.6	350
4	Study area	11º 22′ 59.9″	008º 59′ 48.7″	RGW4	8.69	25.9	3000	5.4	410
5	Study area	11º 23′ 01.8″	008º 59′ 47.3″	RGW5	7.35	25	3400	4.3	320
6	Study area	11º 23′ 02.9″	008º 59′ 48.6″	RGW6	7.75	25.1	5000	9.9	320
7	Study area	11º 23′ 02.4″	008º 59′ 48.8″	RGW7	7.28	24.8	3600	4.5	310
8	Study area	11º 23′ 03.4″	008º 59′ 50.7″	RGW8	8.60	25.4	2800	8.7	340
9	Study area	11º 23′ 05.5″	008º 59′ 50.4″	RGW9	8.51	24.8	2400	4.7	300

Table 5: Chemical analysis of ground water around mineralized areas in Rimi Sumaila Local Government Area, Kano

S/No	Location	Co-ordinates		Sample ID	Ag mg/l	As mg/l	Au mg/l	Cu mg/l	Ni mg/l	Pb mg/l	Se mg/l	Zn mg/l
		Latitude	Longitude									
1	Study area	11º 22′ 59.5″	008º 59′ 44.5″	RGW1	0.006	1.751	0.053	-0.025	-0.122	0.290	1.0743	0.009
2	Study area	11º 22′ 58.1″	008º 59′ 45.5″	RGW2	0.004	1.834	0.077	-0.030	-0.125	0.409	1.0743	0.006
3	Study area	11º 22′ 59.5″	008º 59′ 47.6″	RGW3	0.003	1.829	0.080	-0.032	-0.119	0.410	1.0745	0.008
4	Study area	11º 22′ 59.9″	008º 59′ 48.7″	RGW4	0.001	1.827	0.060	-0.029	-0.096	0.340	1.0742	0.006
5	Study area	11º 23′ 01.8″	008º 59′ 47.3″	RGW5	0.003	1.775	0.095	-0.033	-0.111	0.387	-0.305	0.014
6	Study area	11º 23′ 02.9″	008º 59′ 48.6″	RGW6	0.002	1.682	0.088	-0.027	-0.109	0.375	-0.395	0.055
7	Study area	11º 23′ 02.4″	008º 59′ 48.8″	RGW7	-0.000	1.783	0.065	-0.031	-0.130	0.331	-0.492	0.020
8	Study area	11º 23′ 03.4″	008º 59′ 50.7″	RGW8	0.001	1.698	0.063	-0.037	-0.122	0.391	-0.539	0.017
9	Study area	11º 23′ 05.5″	008º 59′ 50.4″	RGW9	-0.002	1.794	0.055	-0.035	-0.104	0.374	-0.519	0.025

Table 6: Summary of groundwater physico-chemistry around mineralized areas in Rimi Sumaila Local Government Area, Kano.

Parameter	Mean	Min	Max	WHO (2017)	NIS
PH	8.28	7.28	9.95	6.5-8.5	6.5-8.5
Temperature	25.28	24.8	25.9	30	30
TDS	2871.11	1080	5000	1000/500	500
DO	5.91	4.3	9.9	ND	ND
EC	342.22	300	410	400	
Ag	0.002	-0.002	0.006	0.005	
As	1.775	1.682	1.834	0.01	0.01
Au	0.0707	0.053	0.095	ND	ND
Cu	-0.031	-0.037	-0.025	2	1
Ni	-0.115	-0.13	-0.096	0.02	0.02
Pb	0.367	0.290	0.41	0.01	0.01
Se	0.227	-0.539	1.075	0.01	-
Zn	0.018	0.006	0.055	3	3

ND=Below detection limit

Table 7: Comparison of trace element in surface and ground water in the study area against Water Clarke concentration values (Pton)

Trace element	Surface water mean value	Ground water mean value	Clarke value
Ag	0.004	0.002	0.2
As	1.730	1.775	0.2
Au	0.055	0.0707	6.0
Cu	-0.007	-0.031	0.3
Ni	-0.117	-0.115	0.7
Pb	0.279	0.367	0.6
Se	0.552	0.227	2.5
Zn	0.29	0.018	0.8

Table 8: Comparison of trace element in surface and ground water against medium grained granite of the study area (ppm)

Trace element concentration	Surface water	Ground water	Medium grained granite
Ag	0.004	0.002	0.5
As	1.730	1.775	5.0
Au	0.055	0.0707	-
Cu	-0.007	-0.031	48.00
Ni	-0.117	-0.115	3.98
Pb	0.279	0.367	60.65
Se	0.552	0.227	-
Zn	0.029	0.018	16.66

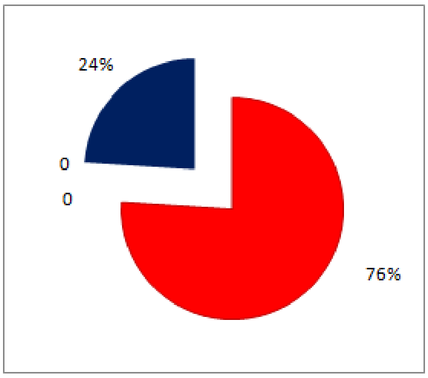

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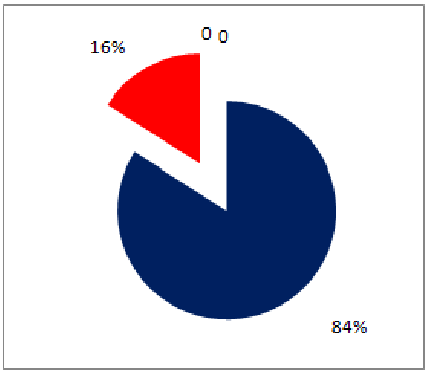
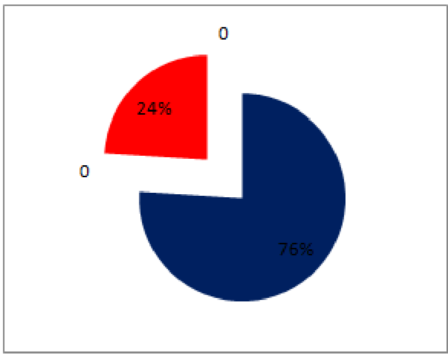
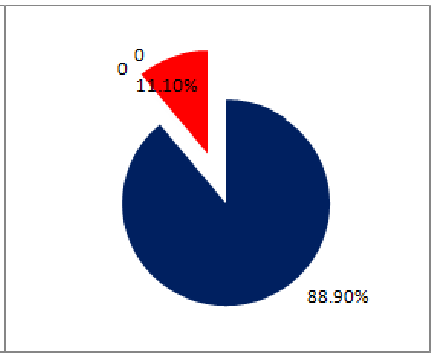
Figure 3: pH for surfacewater



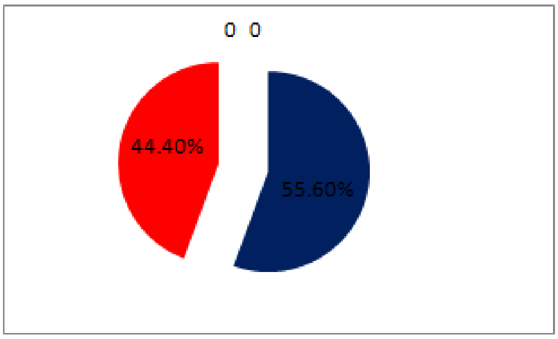
TDS%<WHO Standard %>WHO Standard
Figure 4: TDS for surface water



Ag%<WHO Standard %>WHO Standar
Figure 5: Ag for surface water



Ag %<WHO Standard %>WHO StandardFigure 6: Ag for groundwater



Se %<WHO Standard %>WHO Standard
Figure 7: Selenium in groundwater in the study area

The pH of surface water in the study area range from 5.68 to 9.96 with an average value of 7.47 (Table 3). Based on the analysis, 76% of the surface water samples showed acidic-basic index greater than WHO and NIS standards limit while the remaining 24% were below the permissible limits (Figure 3). In contrast, the pH of ground water ranges from 7.28 - 9.95 with an average value of 8.28 and all the values are above the permissible limits (Table 6). This implies that surface water is slightly acidic in nature. Whereas, the groundwater has high pH. The acidic and basic nature of this waters pose no threat to human health from their consumption [16].

The Total Dissolve Salt (TDS) for the surface water in the study area range from 840 to 1080 with an average of 745.2 (Table 3). About 84% of the surface water sampled are above WHO and NIS permissible limits while about 14% are below (Figure 4). In the ground water, the TDS for ground water sampledrangefrom 1080–5000with an average of 2871.11 and all are above the WHO and NIS standards (Table 6). The elevated levels of TDS in surface water and groundwater could be attributed to the release of inorganic salts from bedrock due to the artisanal mining activities, natural sources, sewage, and agricultural run-off in the study area.

The surface water and groundwater with average TDS values of 745.2mg/litre and 2871.11mg/litre are unpalatable [17], [18].

The temperature of the surface water in the study area ranges from 21.8°C to 30°C with average of 29.4°C and conforms to the permissible limits while the temperature of the groundwater range from 24.8 to 25.9 with average of 25.28 and also fall within the permissible limit. The temperature condition for both surface and ground water falls within WHO and NIS acceptable standards.

The Dissolve Oxygen (DO) for the surface water range from 1.0 to 10.7 with an average of 2.46 and that of groundwater range from 4.3 to 9.9 with an average of 5.91. This indicate an oxic condition for the surface and ground waters.

The Electrical Conductivity (EC) in the Rimi area range from 100 to 230 with an average of 196.4 and fall within the permissible limits for surface water. The Electrical Conductivity (EC) for ground water range from300to 410 with an average of 342.22 and is above the WHO permissible limits. This may be due to high TDS obtained in groundwater in the study area. Electrical conductivity is used for monitoring the mixing of fresh and saline water, for separating stream hydrographs and for geophysical mapping of contaminated groundwater [19].

The concentration of Ag in surface water range from 0 to 0.016 mg/l with an average value of 0.004 mg/l and is above the WHO permissible limits (Table 2). About 76% of Ag values obtained exceed the WHO permissible limits while 24% are below the WHO permissible limits (Figure 5). In the groundwater, the concentration of Ag range from -0.002 - 0.006 mg/l with an average value of 0.002mg/l and this value is above the WHO permissible limits (Table 4). About 88.90% of Ag values in the surface water exceed the WHO permissible limits while about 11.10% are below the WHO permissible limits (Figure 6). Silver found in water is believed to have originated from the gold mining activities in Rimi area. Silver is extremely toxic to aquatic plants and animals [20], [21], [22].

The value of As in surface water range from 1.636 to 1.842 mg/l with a mean value of 1.730 mg/l and all these values are above WHO permissible limits (Table 3). The value of As in groundwater range from 1.682 to 1.834 mg/l with a mean value of 1.775 mg/l and all are above WHO and NIS permissible limits (Table 6). The elevated values of arsenic obtained is due to gold mining activity in the study area [23]. [24]. [25] reported Arsenic concentrations of 0.05 and 0.14mg/l in ground and surface water. The consumption of arsenic caused blackfoo disease and cancers of the skin, lung, bladder, kidney, liver and colon have been documented among residents of Taiwan, China, [26], [27]. [28]. Arsenic is carcinogen (29) and long exposure to arsenic through drinking water could result in skin cancer [30].

The values of Au in surface water range from 0.024 to 0.082 mg/l with an average concentration of 0.055 mg/l. The value of Au in groundwater ranges from 0.053- 0.095mg/l with an average concentration of 0.0707mg/l. The permissible limits of gold were below detection limit and therefore, the concentration values could not be compared against any standards. The Au is believed to have been released to the surface and ground water from nearby gold deposit which indicate that the study area is enriched in gold mineralization. Gold is useful in the treatment of rheumatoid arthritis [30] Gold is toxic to plants and stored in its extremities such as leaves [31].

The Copper levels in surface water ranges from -0.026 to 0.041 mg/l with an average concentration of -0.007 mg/l and lies within the WHO and NIS permissible limits. The Cu values in groundwater range from 0.037 to -0.025mg/l with an average concentration of -0.031mg/l and fall within the WHO and NIS permissible limits. Cu provides antioxidant enzyme activity [32]and excessive consumption of Cu in human being causes Wilson disease" [33].

The amount of Nickel in surface range from -0.134 to -0.094 mg/l with a mean value of -0.117 mg/l and conform to WHO and NIS permissible limits. The Ni concentration in groundwater range from -0.13 to -0.096mg/l with a mean value of -0.115mg/l. and lies below WHO and NIS standards limits. The exposure to Ni dust and vapour may cause lung cancer and respiratory system disorders [34]. Ni is carcinogenic and affects the activity of α-tocopherol, the most common antioxidant in human body [35].

The Pb level in surface water range from 0.188 to 0.368 mg/l with a mean value of 0.279 mg/l which is above the WHO and NIS permissible limits. In groundwater, Pb range from 0.29 - 0.41mg/l with an average value of 0.367mg/L which is above the WHO and NIS permissible limits. High level of Pb observed in the study area is believed to have emanated from the gold mining activities around the area since Pb is usually associated with gold mineralization [36]. The higher concentration of Pb can cause damage to the central nervous system, kidney and blood, thereby leading to death. However, the lower concentration of Pb can cause haeme synthesis, psychological and neuro behavioural effects [37].

Selenium values in surface water range from -0.788 to 0.35 mg/l with an average value of 0.552 mg/l and is above the WHO permissible limits. For groundwater, concentration of Se range from –0.539 to 1,0745 with mean value of 0.227 and is above the WHO permissible limits. About 44.4.6% of the Se show values greater than WHO standards while 55.6% lies below guidelines limit (Figure 7). High level of Se may be traceable to the mining activity in the study area. Selenium plays a significance role in reducing cancer risk [38], [39], [40].

The Zn levels in surface range from 0.009 - 0.069 mg/l with an average value of 0.029 mg/l and fall within the WHO permissible limits. Also for groundwater, Zn range from 0.006 - 0.055 mg/l with an average value of 0.018mg/l. and lies below the WHO permissible limits. Zinc, an essential trace element occurs in all food and water as organic complex [41]. [42].

The trace elements in both surface and ground water in the study area are lower when compared against the Clarke values of crustal abundance which is sufficient to represent values in surface and ground waters. (Table 7). The trace elements are released into the surface and ground water from the underlying medium grained granite formation in the study area (Table 8).

V. Conclusion

The mining activities around the study area has resulted in the removal of wide varieties of floral and fauna species The open cast mining method distorts the natural landscape of the area and caused physical disturbance of the land in form of waste rock piles and open pits. In addition, the ambient air quality of the study area is affected when the particulate matter containing toxic metals are released in to the environment which is capable of causing respiratory disorders. Also, the high amount of TDS and E.C recorded in the area was due to water pollution resulting from gold mining activities in the Rimi area. The water is polluted by high levels of Ag, As, Pb and Se. The physical colour of surface water appeared to be cloudy and foamy due to anthropogenic activities in the area. The inhabitant of the study area depends largely on surface and ground water for domestic and agricultural use and the continuous pollution of these water pose health challenge to their well-being. The overall effect of mining operation in this area without the use of best practices will create ecological stress to flora and fauna species, pose great danger to the well-being of the people living around the area and eventually degrade the quality of the environment.The study strongly recommends reclamation of the degraded land by sand filling in order to restore the land to its natural form and preserve the ecological integrity of the area for a sustainable development. The study also advocates the treatment of surface and ground water by chemical precipitation where the contaminants are dissolved into insoluble solids and its subsequent removal by clarification and filtration [43]. The reverse osmosis can also be used to treat the water which is effective for removal of ionic species from solution. This process will guarantee water quality and promote general well-being of the inhabitant of the area.

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