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Environmental Impact of Mining and Pedogeochemistry of Agunjin area, southwestern Nigeria

ODEWUMI SHOLA C[1], AMINU AHMED A[2], MOMOH ABUH[3] AND BULUS JOSEPH A[3]
[1]*Geology Technology Programme, Department of Science Laboratory Technology, University of Jos, P.M.B 2084, Jos, Nigeria*
[2]*Department of Mineral Resources Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin*
[3]*Department of Geology and Mining, University of Jos, P.M.B. 2084, Jos, Nigeria*
Email: *sholaodewumi@yahoo.com*

Abstract: Agunjin area occurs in the southwestern sector of the Nigerian Basement Complex along Ajase Ipo-Igbaja road. The present study is to assess the environmental impact of mining and the extent of contaminations in the soil. Soil samples were collected at a distance of about 100-400metres in N-S and E-W direction to the mining phase in Agunjin area. Twelve Soil samples were analyzed for major oxides and trace elements using Atomic Absorption Spectrometry (AAS). The major element compositions of Na2O ranges from 0.26 to 0.50wt%, K2O ranges from 0.21 to 0.47wt%, Al2O3 varies from 0.85 to 1.50wt%, MgO varies from 1.51 to 2.83wt%, CaO ranges from 15.39 to 55.97wt%, Fe2O3 and MnO ranges from 0.087 to 0.28wt% and 0.093 to 0.14wt% respectively. Results from the studies revealed that the concentration of Cu ranges from 5.49 to 27.56ppm and Zn ranges from 0.33 to 6.59ppm. The high concentrations of the CaO, Zn and Cu in the soil could be linked to the elemental concentrations in the marble and other metasedimentary rocks in the area which were mechanically dispersed by the mining activities and surface erosion. These elements will eventually find their way into the drainage system leading to some contaminations and possibly bioaccumulations. Total environmental impact score of mining in the area is (-) 3850 indicating major injurious impact on environment and the excess of Mn in soil is hazardous to the people living in the area

Keywords: *Bioaccumulation, ecosystem, toxic elements, zinc and copper*

1. Introduction

Agunjin area occurs in the southwestern sector of the Nigerian Basement Complex (fig 1) along Ajase Ipo-Igbaja road in Kwara State. Environmental impact of mining includes erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, groundwater and surface water by chemicals from mining processes. In some cases, additional forest logging is done in the vicinity of mines to increase the available room for the storage of the created debris and soil [5]. Besides creating environmental damage, the contaminations resulting from leakage of chemicals also affect the health of the local population. Mining may cause destruction and disturbance of ecosystem and habitats, and may also disturb or destroy productive grazing and croplands [1] [2].

Mere land storage and refilling of the mine after it has been depleted is even better, if no forests need to be cleared for the storage of the debris [3]. Large amounts of water produced from mine drainage, mine cooling, aqueous extraction and other mining processes increases the potential for these chemicals to contaminate ground and surface water [9] [13]. Mining activities, through milling operations coupled with grinding, concentrating ores and disposal of tailings, along with mill wastewater, and mine also provide obvious sources of metal contamination [1]. The impact of mining on the environment as regards heavy metal pollution has also received attention worldwide [12].

Weathering, erosion and transportation lead to a redistribution of elements in the soils [14]. The water bodies around the mines are used for domestic and agricultural purposes. The accumulation of toxic trace elements in the soils ultimately leads to accumulation in the aquatic food chain, which is dangerous to man because micro-organisms and micro-flora are capable of incorporating and accumulating metal species into their living tissues from the stream sediments [12]. The present study is focused on the assessment of the environmental impact of mining and the extent of contamination in the soil of Agunjin area.

1.2. Geology of the Area

The Precambrian Basement Rocks of Agunjin area comprises of four major groups of rocks which include the migmatitic gneiss, quartzite, marble and fine to-medium grained granite. Migmatitic Gneiss is the most widespread in the Basement rocks of Agunjin area and is a grey foliated biotite and/or hornblende quartzo-feldspathic rock of granodioritic to quartz dioritic composition.

Alternating mafic and quartzo-feldspathic materials define a fine banding. The quartzofeldspathic material forms impersistent streaks a few millimeters thick which are invariably aligned parallel to the foliation as defined by the mafic minerals. The contact between the mafic and felsic materials is gradational. The mafic-ultramafic Bands are usually amphibolites, biotite and biotite hornblende schists. They are usually foliated and the foliation is parallel to that in the enclosing rocks.

Quartzites tend to form good topographic features which rise up to about 40metres above the surrounding terrains. Quartzite consists of quartz and minor amount of muscovite. They usually continue for only a few metres. Agunjin marble occurs as lensoid low lying bodies and the marble bands exposure are mainly along the river channel. They vary in colour ranging from whitish to greyish colour. The marble is composed of predominantly of calcite with minor amounts of graphite and calc-silicate minerals.

Fine to medium grained granites occur as well exposed outcrops and range in size from plutons to batholiths. The forms of the granites bodies appear to be related to the environment in which the granites were emplaced. Circular to elliptical bodies occur within the metasedimentary rocks while more elongate bodies occur in migmatite-gneiss terrains. The granitic rocks range in compositions from fine to medium grained granite and late intrusive pegmatites.

2. Mining Related Activities and their Impact on Environment

Open cast mining, marble processing, solid waste generation and its disposal, trading and transport of marble blocks, slabs and irregular marble pieces, and art and craft work are important mining and mining related activities in Agunjin marble mining area (Table-1).

Quarrying in Agunjin area is by conventional rope and bucket method and the quarries run along the strike and dip of marble bands. Large scale land, unscientific mining and ignorance of safety rules, unsegregated waste dumps, improper and incompatible land uses, improper land use and encroachment on water bodies have caused drainage blocking, land degradation, pounding and flooding of water, visual impact, loss of aesthetics, pollution, health and safety hazards.

2.1. Environmental Impact Assessment Methodology

The impact assessment was done by means of a semi quantitative graded matrix to assess the overall impact of mining and related activities on environment adopted after Natani [9] [10]. The impact values were assigned as shown in the scheme Table 2. Positive and negative signs were assigned to the impact value of each parameter to show beneficial and adverse impacts respectively (Table 2). Matrix method basically incorporates a list of project activities or actions, which affect the environment (listed in columns in matrix table) and environmental parameters (listed in rows) as shown in the Table 3. Environmental parameters were weighted so that they could be correlated to each other in terms of relative importance.

The mining activities which have impacts on various environmental parameters in Agunjin area are enumerated in Table 1 along with parameter importance values and environmental impact matrix as shown in Table 4. Impact value of each parameter was multiplied by the weightage values allotted to the corresponding parameter of Agunjin area adopted after Natani [9] [10] [11]. This gave final score in terms of environmental impact units. Summing up the final score gave environmental impact assessment of the Agunjin mining area. Significance of total environmental impact score is given in assessment value index (Table 5). The environmental impact assessment followed identification and quantification of impacts.

Mining and related activities have significant impact on soil, land use, water, air, noise, flora, fauna, health, safety and aesthetics of the Agunjin area and the impacts are marginal. However, mining and related activities have major beneficial impacts on socioeconomics of the entire area. Mining has appreciable adverse impact on human settlements in Agunjin area and slight beneficial impact on provision of civic amenities in the area.

Total environmental impact score of mining in Agunjin area as shown in Table 4 is (-) 3850 indicating major injurious impact on environment. Since, mining is location specific activity, major environmental control measures are required to be taken for mitigation of hazards, restoration of natural ecosystem and sustainable development of the Agunjin mining area similar to the report by Natani [9] [10] [11]. The Parameter Importance Value (PIV) and Total impact score (TIS) of the Agunjin marble mining area in southwestern Nigeria compare very well with PIV and TIS values of the Makrana Marble Mining Area, Rajasthan, India [10] as shown in Table 6. Both the PIV and TIS values of the study area are slightly higher than the PIV and TIS values of Makrana marble area (Table 6) indicating higher injurious impact of mining in Agunjin area compared to Makrana area, India.

2.2. Pedogeochemistry

Analytical Methods: The geochemical analyses comprising major oxides and trace elements of twelve samples of soil from Agunjin area were analyzed using Atomic Adsorption Spectrometry (AAS) at Obafemi Awolowo University, Ile Ife, Nigeria. All the soil samples were ground with mortar and pestle. The soil samples were analyzed for major oxides (Al2O3, Fe2O3T, MnO, MgO, CaO, Na2O, K2O); trace elements (Cu, Mn, Zn, P, S, N, H and C) and moisture content as shown in Table 7.

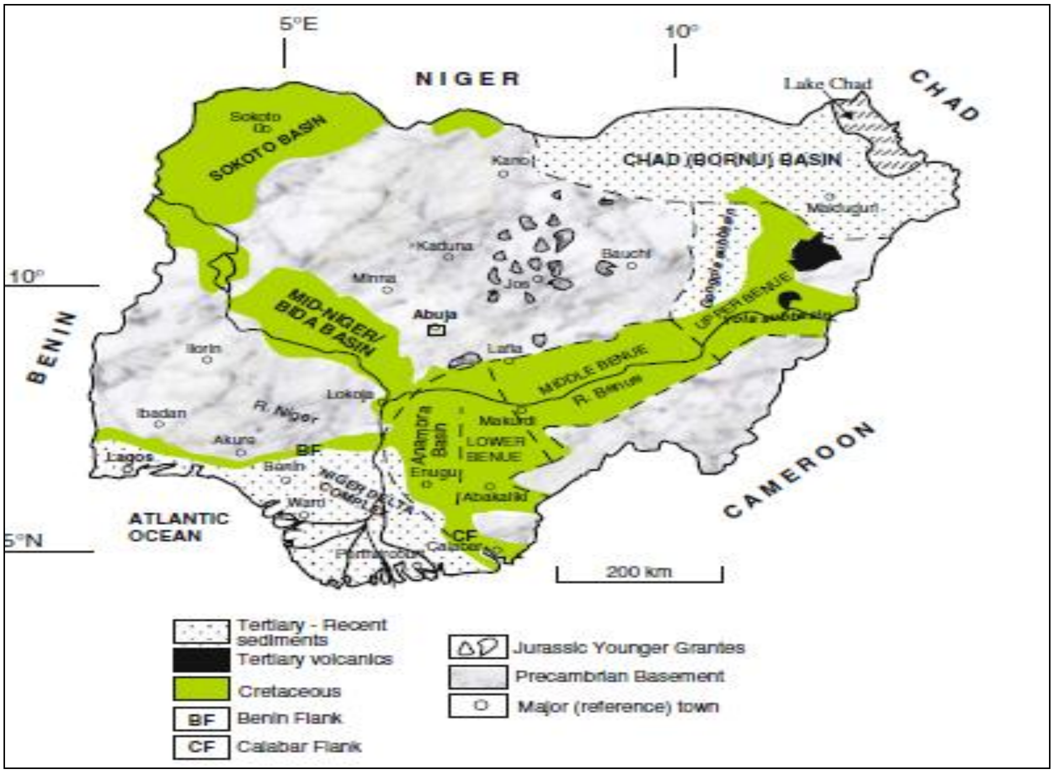

Fig 1: *Geological map of Nigeria showing the location of Agunjin area*

Table 1: *Mining and mining related activities in Agunjin marble mining area*

S/N	Mining	Mining related activities
1	Mining	Includes pitting, blasting and excavations
2	Processing	Includes edge cutting, buffing, polishing tile making and processing waste from crushing and chip making plants.
3	Waste disposal	Includes disposal of overburden which comprises of soil, silt, aeolian sand, mine muck and mining waste comprising of pegmatite, dolomite and quartzite.
4	Slurry disposal	Includes disposal of marble slurry.
5	Transportation	Mainly by trucks, water tankers, slurry tanks, mining machinery, etc.
6	Arts and Crafts	Includes activities of table tops and other handicraft items.
7	Trading	Traffic of buyers, brokers, etc. and interaction of seller, buyers and brokers.

Table 2*: Impact value and impact nature*

Impact Value	Impact nature	Remarks
0	No impact	
1	Slight impact	
2	Appreciable impact	+ sign denotes beneficial impact
3	Significant impact	- sign denotes adverse impact
4	Major impact	
5	Severe / Permanent impact	

***Table 3**: Importance value of Environmental Parameteres of Agunjin mining area, SW Nigeria*

S/N	Environmental Parameters	Ranking					Total	Weightage	Parameter Importance Value (PIV)
		1	2	3	4	5			
1	Soil and Land use					*	5	5/30	175
2	Water resources			*			3	3/30	105
3	Air and Noise				*		4	4/30	140
4	Flora and Fauna		*				2	2/30	70
5	Socio economics					*	5	5/30	175
6	Civic amenities			*			3	3/30	105
7	Health and Safety				*		4	4/30	140
8	Aesthetics			*			3	3/30	105
9	Human Settlements and historic buildings	*					1	1/30	35
	∑						30		

***Table 4:** Environmental impact Matrix of Agunjin mining area, southwestern Nigeria (without mitigative measures) (adopted after Natani, [10])*

PIV	Environmental Parameters	PROJECT ACTIVITIES							Total impact score
		Mining	processing	Waste disposal	Slurry disposal	Transportation	Art and craft	Trading	
		1	2	3	4	5	6	7	
175	Soil and Land use	-4	-3	-4	-4	-1	0	-1	-2975
105	Water resources	-3	-2	-2	-2	0	0	0	-945
140	Air and Noise	-3	-3	-3	-3	-2	-1	-1	-2240
70	Flora and Fauna	-1	-1	-1	+1	-1	+1	-1	-210
175	Socio economics	+5	+5	+2	+3	+5	+5	+5	5250
105	Civic amenities	0	0	-1	-1	-1	+2	+2	105
140	Health and Safety	-3	-1	-2	-2	-2	0	-1	-1540
105	Aesthetics	-4	-2	-3	-3	-2	+5	-2	-1155
35	Human settlements and historic buildings	-3	+2	-1	-1	-1	0	0	-140
Total Environmental Impact Score of Mining									**-3850**

***Table 5**: Assessment Value Index (Adopted after Natani, [10])*

S/N	TIS	Impact Assessment
1	Greater to (-)1000	No appreciable impact on environment
2	(-)1000 to (-)2000	Appreciable impact on environment; but not injurious in general. Mitigation measures important.
3	(-)2000 to (-)3000	Significant impact on environment. Major environmental control measures to be taken.
4	(-)3000 to (-)4000	Major injurious impact on environment, Major environmental control measures to be taken and / or site selection for the proposed project to be reconsidered within the buffer zone.
5	(-)4000 to (-) above	Alternative site for the proposed project to be selected outside the buffer zone

***Table 6**: Parameter Importance Value (PIV) and Total impact score (TIS) of the Agungin marble mining area and Makrana Marble Mining Area, Rajasthan, India [10].*

S/N	Environmental Parameter	PIV (Agunjin SW Nigeria)	TIS (Agunjin SW, Nigeria)	PIV (Makrana Rajasthan, India)	TIS (Makrana Rajasthan, India)
1	Soil and Land use	175	-2975	165	-2805
2	Water resources	105	-945	100	-900
3	Air and Noise	140	-2240	130	-2080
4	Flora and Fauna	70	-210	70	-210
5	Socio economics	175	5250	165	+4950
6	Civic amenities	105	105	100	+100

7	Health and Safety	140	-1540	130	-1485
8	Aesthetics	105	-1155	100	-1200
9	Human settlements and buildings	35	-140	35	-245

***Table 7**: Geochemical compositions of soils from Agunjin area, southwestern Nigeria*

Major Elements (wt%)	**AG1**	**AG2**	**AG3**	**AG4**	**AG5**	**AG 6**	**AG 7**	**AG 8**	**AG 9**	**AG10**	**AG11**	**AG 12**
Na_2O	0.32	0.26	0.30	0.39	0.34	0.42	0.32	0.28	0.31	0.28	0.46	0.50
K_2O	0.25	0.21	0.34	0.31	0.29	0.28	0.31	0.47	0.35	0.34	0.40	0.36
Al_2O_3	2.27	1.61	1.89	2.83	2.65	1.70	1.89	2.65	2.27	1.51	2.65	2.55
Fe_2O_3	0.14	0.23	0.28	0.08	0.158	0.171	0.173	0.087	0.21	0.112	0.138	0.152
MgO	3.45	3.75	3.18	2.01	4.03	3.55	3.75	3.91	4.08	4.06	3.81	3.93
CaO	19.59	15.39	22.04	43.73	34.98	19.24	22.04	19.77	17.32	15.74	55.97	43.73
MnO	0.14	0.14	0.087	0.053	0.14	0.093	0.081	0.061	0.14	0.050	0.065	0.086
Trace elements (ppm)												
H	0.2	0.35	0.20	0.30	0.20	0.30	0.30	0.20	0.30	0.20	0.30	0.25
C	0.62	0.66	0.56	0.59	0.70	0.55	0.62	0.51	0.59	1.01	0.23	0.94
N	0.051	0.0518	0.0543	0.041	0.061	0.0448	0.0563	0.041	0.0532	0.076	0.019	0.077
Fe	96.43	158.02	197.84	55.14	110.4	119.56	121.04	60.47	145.29	78.42	96.43	106.24
Cu	17.50	18.03	27.56	11.57	15.29	5.78	7.65	11.88	10.56	5.49	6.18	17.28
Mn	107.97	104.78	67.27	40.96	107.3	72.22	62.91	47.36	104.48	38.46	50.57	66.75
Zn	3.52	1.75	3.86	4.86	5.42	2.02	0.41	0.33	2.02	1.44	6.59	3.63
CaCl2	7.30	6.90	7.50	7.80	7.80	7.40	7.80	7.80	7.60	7.20	7.90	7.80
P	15.44	14.19	15.03	13.36	13.67	12.21	17.22	14.40	12.31	14.71	12.63	16.80
S	8.50	5.67	6.97	10.03	4.14	4.14	3.92	4.79	3.49	3.27	4.14	9.15
Moisture content	2.13	3.89	2.56	1.92	2.04	1.84	1.54	1.43	2.04	2.56	3.63	2.04

2.3. Iron

The concentration of iron in the area ranges from 55.14 to 197.84ppm (Table 7). The normal range of iron in garden soil ranges between 50 to 200ppm on a standard soil test. While values above 250ppm usually indicate something out of balance [15] but the concentration of iron in Agunjin area is within the normal range which will assist the plants in the area to draws energy to the leaf by absorbing heat from the sun and will makes the leaf darker. It will increase the waxy sheen of the crop. The normal iron concentrations as observed in the area will help the plant for the maintenance and synthesis of chlorophyll and RNA metabolism in the chloroplasts and also increases the thickness of the leaf, [which] increases nutrient flow geometrically, resulting in a production increase geometrically [15] [4].

2.4. Zinc

The concentrations of Zn in Agunjin area ranges from 0.33 to 6.59ppm (Table 7). The normal range of Zn needed for normal growth in Plant is between 3-100ppm [15]. This indicates that the Zn in the study area is within the normal range and will contribute positively to the normal growth of crops in the area and will helps to make acetic acid in the root to prevent rotting; also control blight and allows dead twigs on trees to shed off. Zinc also contributes to test weight, increased corn ear size, promotes corn silking, hastens maturity, chlorophyll formation, enzyme functions and regulates plant growth [15].

2.5. Manganese

The concentrations of Mn in the study area range from 38.46 to 107.97ppm (Table 7). When Mn value is above 50ppm may be too high [15] and Mn values in the area is above 50ppm which is exceeding the normal values in soil. Regarding manganese in animal nutrition and an excess of manganese increases the need for iron [15]. Excess of Mn can affect the central nervous system of the people [5] [12].

Researches carried out by various environmental scientists have revealed that the occurrence and geographical distribution of certain diseases could be correlated with the presence of toxic elements in the geologic environment [8] [14]**.** Bedrock geochemistry and several anthropogenic inputs are, therefore, the main controllers of heavy metal distribution in the earth's crust [6].

Most heavy metal and trace element pollution studies have focused on gold mining areas [3] [13] [5] [12]. Contaminated soils can influence the metal uptake by plants grown on them, though metal concentrations in plants vary with plant species [1] [2]. Abundance of toxic (trace) elements in natural soils is also dangerous to the plants grown on them. However, knowledge of elemental concentrations of soils on which these plants grow is highly needed to avoid related diseases.

Living organisms require varying amounts of heavy metals like iron, copper, manganese and zinc which are also required by humans. Excessive levels can be damaging to the organisms. Motivations for controlling heavy metal concentrations in streams or soils are diverse. Some of these elements are actually necessary for humans in minute amounts (copper, manganese) while others are carcinogenic affecting among others when in excess, the central nervous system (manganese,), the kidneys or liver (copper) or skin, bones, or teeth (copper) by Boadu et al., [5] and Nyarko et al.,[12]. One of the largest problems associated with the persistence of heavy metals is the potential for bioaccumulation and biomagnifications causing heavier exposure for some organisms than is present in the environment alone.

3. Conclusion

The Precambrian Basement Rocks of Agunjin area comprises of four major groups of rocks which include the migmatitic gneiss, quartzite, marble and fine to medium grained granite.

Total environmental impact score of mining in the area is (-) 3850 indicating major injurious impact on environment and major environmental control measures are required to be taken for mitigation of hazards, restoration of natural ecosystem and sustainable development of the mining area.

The high concentrations of the CaO, Zn and Cu in the soil could be linked to the elemental concentrations in the marble and other metasedimentary rocks in the area which were mechanically dispersed by the mining activities and surface erosion. These elements will eventually find their way into the drainage system leading to some contaminations and possibly bioaccumulations.

The presence of CaO, MgO, Fe_2O_3, K_2O, Na_2O and Zn in the soil will enhance proper growth of plants in the area while the excess of Mn in soil is hazardous to the people living in the area

References

[1] D. C. Adriano, Trace Elements in the Terrestrial Environment, Springer-Verlag, New York 533pp, (1986)

[2] B. J. Alloway, Soil processes and the behaviour of metals', in B.J. Alloway (ed.), Heavy Metals in Soils, *Blackie Academic and Professional, London*, 11–37, 1995.

[3] S. K. Amasa, Arsenic pollution at Obuasi Gold Mine and surrounding countryside' *Health Perspect*, 12, 131-143, 1975.

[4] A. Andersen Science in Agriculture, *Acres United States*, 156pp, 2000.

[5] M.Boadu, E. K. Osae, A. A. Golow, Y. Serfor-Armah, and B.J. B. Nyarko, Determination of arsenic in some water bodies, untreated ore and tailing samples at Konongo in the Ashanti region of Ghana and its surrounding towns and villages by instrumental neutron activation analysis. *Journal of Radioanalytical Nuclear. Chemistry* 249: 581–585, 2000.

[6] S. H. U. Bowie, and I. Thornton, Environmental Geochemistry and Health, Reidel, Dordrecht, 140 pp, 1984.

[7] A. Chatt, Epithermal instrumental neutron activation analysis for the determination of gold and arsenic in Ghanaian gold tailings using conventional and anti-coincidence counting. *Journal of Radio analytical Nuclear Chemistry* 256: 253–257, 2003.

[8] F. M. Fordyce, Z. Guangdi, K. Green and L. Xinping, Soil, grain and water chemistry in relation to human selenium-responsive diseases in Enshi district, China. *Applied Geochem*. 15: 117–132, 2000.

[9] J.V. Natani, Geoenvironmental impact assessment studies of Makrana Marble mining area, Nagaur district, Rajasthan. *Rec. Geol. Surv. India*, 133(7): 64-65, 2000.

[10] J.V. Natani, Geoenvironmental impact assessment studies of Makrana Marble mining area, Nagaur district, Rajasthan. *Rec. Geol. Surv. India*, 134(7): 63-64, 2001.

[11] J.V. Natani, Regional assessment of Marble and calc silicate rocks of Rajasthan. *Rec.Geol. Surv. India,* 135(7): 53-55, 2002

[12] B. J. B. Nyarko, Y. Serfor-Armah , J. Holzbecher, E. K. Osae, E. H. K. Akaho, D. Carboo, J. Plant and R. Raiswell, Principles of environmental geochemistry, in: I. Thornton (ed.), *Applied Environmental Geochemistry, Academic Press, London*, 1–39, 1983.

[13] Y. Serfor-Armah, Determination of total arsenic in sediments from Obuasi Gold Mines, *M.Phil Thesis, Department of Chemistry, University of Ghana*, 85pp, 1994.

[14] F. R Siegel, Environmental Geochemistry of Potentially Toxic Metals, *Springer–Verlag*, 218pp, 1984.

[15] C. Walters and C.J. Fenzau, Eco-Farm**,** *Acres United State of America*. 213pp, 1996.