Mining and its Tailing: The Environmental and Radioecological Consequent in Nigeria

Odunmbaku AbdulGaniu A.A[†a], Adewumi B.A[b], Idris Musa[c]

[a] Environemntal Science and Engineeering University of Texas El Paso Tx USA. [b] Department of Agricultural Engineering, Federal University of Agriculture, Abeokuta, Nigeria. [c] Department of Mining Engineering, Federal University of Technology, Akure Ondo State Nigeria

Abstract.

Materials of natural origin such as ore and minerals often contain high level of radioactivity caused by radionuclides of uranium and thorium series. Generally, mining operations are usually accompanied by dumping of large quantities of tailing in the environment. Tailing are rich in radioactive minerals and are dumped at close proximity. Prominent mining and milling tailing in Nigeria is as a result of several years of mining and processing of casseterite (tin ore) and (niobium ore) columbite, mining, crushing and processing of coal and phosphate rock. Of environmental importance are the tailing from mining, milling and processing of casseterite, columbite, coal and phosphate. Extraction and processing of these mineral produce tailing which are contain significant amount of radionuclide. This paper gives a review of tailing in Nigeria and it environmental impact.

Keywords: radioactivity; radionuclide; uranium; thorium; casseterite; niobium; columbite; environmental.

INTRODUCTION

Mining and related activities contributes not in little amount to the work force of the Nigeria. The economic effects of these activities are considered of high importance with little or no regard to the consequent environmental implications. Natives and small-scale enterprises usually dominate mining activities in Nigeria. The informal operators use primitive mining and processing techniques of digging and panning. Magnetic and electrostatic separator are usually employed by the small scale mill occupying area approximately 100 x 100m with a mill shade of 20 x 20 m size, an office block and the rest of area occupied by tailing and heaps accumulated over the years [1,2].

The trailing is considered non-hazardous because of the technique of mining and milling, the mining and milling waste are regarded as natural occurring radioactive materials (NORMs). The volume of trailing from local mining activities produced annually could reach a level so high that existing low level radioactive waste (LLRW) facilities would be readily occupied by NORM, if control disposal procedure is not adopted. These radioactive materials cannot just be ignored as being below radiological concern (BRC) or lower than the exemption concern level (ECLs). The IAEA [3] and the French Commissariat a l'Enerie Atomique [4] have already established exemption concentration level (ECLs) which are quite similar for natural occurring radionuclide. ECL are derived from annual dose, which is a small fraction of annual average received from a natural source of radiation by use of time dependent environmental pathway scenarios and dosimetric models.

Radiation exposure resulting from these abandoned tailing are not different from those observed from over the world. This results in contamination of vicinity [5,6] with radionuclide, contamination of the soil, ground water, biota and release of dust laden with radionuclides. Access to dump sites are not

[†] Author to whom correspondence should be addressed. Email aodunmbaku@hotmail.com

restricted, natives and informal miners have direct access and regular visit to these sites. Tailing dump sites of abandoned mines are generally not perceived as hazardous by member of the public, the tailing debris are used in intensively in construction and farming [5]. Schuler [7] report that raw materials and processed building products can vary greatly in radionuclide contents, reflecting their origin and geological conditions at site of their production. Animals also wonder on this sites grazing on pasture without restriction. WHO [8] and Health Canada [9] classified the consequences of exposure by human into carcinogenic and non-carcinogenic effects, based on radioecological risk by radiations of radionuclide isotopes and the chemical risk of heavy metals. Hazards resulting from radioactivity exposure include cancer (thyroid, breast, liver, leukemia e.t.c.), chromosome aberrations, stillbirths, Down's syndrome, respiratory diseases and liver tumors. Documented effects in other parts of the world with similar situation poses the same problems as in Nigeria. Major activities that produce tailing in Nigeria include the underlisted;

I Cassiterite and Columbite (Tin and niobium)

Tin mining in Jos plateau started in 1904, in mid 1920's more cassiterite discovery were made resulting in greater demand for more mechanized extraction techniques. These result in generation of grate amount of tailing, resulting in radioactive contamination of soil in this vicinity [5,6].

Determination of the radiological assessment of tin and columbite mining activities in Jos plateau and environ was conducted by Ibeanu [10] as indicated in Table 1, who [10] estimated the annual mean external effective dose around 100mSvy^{-1} for the tailing sites and about 10mSvy^{-1} for staying on contaminated site. These measured values are in accordance with the external dose rate performed in twelve different Malaysia [11] and Thai plant [12].

Table 1. Mean measured dose rates and annual mean external exposure

Sample	Measured dose rate(μGy h^{-1})	Annual effective external dose(mSv y^{-1})		
		Measured	Computed	Measured/Computed
Contam. soils	7.4 (5.6 – 10.8)	9.1 ±1.4	7.2 ± 1.2	1.2
Tailing sites	81.5 (58.9 – 102.7)	99.9 ± 4.8	88.9 ± 4.0	1.1
Control	0.1 (0.05 – 0.21)	0.12 ± 0.01	0.11 ± 0.01	1.1

The mean values from Table 1 [10] exceed the dose limit recommended by the ICRP 60 [13] and IAEA [15]. Since access to theses sites are not restricted, the local populace spend time and use this radiation materials. Annual exposure for worker in the processing mill ranges between 2-180mSvy^{-1} [1] far above the recommended 20mSvy^{-1} [13,15].

II Phosphate Rock (Phosphate Mining).

Phosphate rock constitutes the bulk raw materials for the manufacture of phosphate fertilizers and some phosphate base chemicals. Study by Ogunleye and his group [14] revealed that phosphate rock is prominent in the Southeast section of Iullemmeden basin, Sokoto state, and in parts of Ogun state, North-West and South-West Nigeria respectively have been documented by the Geological Survey of Nigeria and several workers [16,17]. Analysis by Ogunleye et al. [14] Table 2 indicated the rock contain enriched significant amount of uranium and thorium with average concentration of some toxic elements like As, Sb, Cr and Zn not in appreciable difference from agricultural soils. Guimond and Hardin [18] also report that phosphate rock generally have high concentrations of ^{226}Ra daughter of uranium decay.

Table 2. Elemental concentrations of Sokoto and Togolese phosphate rocks. Values in g g^{-1}, otherwise weight % where stated. [14]

Element (n = 4)	Sokoto (Mean ± SD)	Togo (Mean ± SD)	Element (n = 4)	Sokoto (Mean ± SD)	Togo (Mean ± SD)
Al %	1.45±0.03	0.74±0.15	Mo	76±2	41±2
Ca %	46.9±0.4	52.7±0.6	Ba	397±45	302±29
Fe %	2.1±0.03	0.3±0.01	Cl	—	1298±90
Na	2300±10	1086±10	I	—	0.22±0.02
Mg	—	224±4	Cs	0.40.03	—
Mn	5716±45	149±2	As	11 1	9 0.7
Sc	11.8±0.3	11.6±0.1	Sb	0.4±0.03	0.6±0.1
Ta	0.7±0.1	—	La	243±0.4	120±1
Co	19.8±0.4	1.2±0.05	Ce	474±2	225±2
Cr	28±2	75±2	Nd	233±17	100±11
Hf	1.5±0.1	0.5±0.05	Sm	56±1	25±0.5
Zr	810±105	765±66	Eu	13.8±0.2	7.6±0.1
Zn	59±5	143±97	Gd	146±9	56±6
V	65±3	68±1	Tb	9.4±0.1	3.8±0.2
Ti	—	259±41	Tm	22±1	14.2±1
Th	3.2±0.2	17.4±0.2	Yb	29±4	7.9±0.1
U	65±0.3	72±0.3	Lu	3.4±0.1	1.2±0.1
P %	15.1±0.01	15.4±0.01			

III Bituminous Coal

Nigeria coal reserve was estimated at about 2.75 billion tones and it is widely distributed over 13 states of the federation. It is largely a bituminous type [19]. Presently mining is carried out at Enugu, Okoba, and Omaraku. Like all ore, coal is also associated with natural occurring radioactive elements due to the content of ^{238}U, ^{232}Th and ^{40}K [18]. This certainly has radiological implications not only for the miners but also for the populace in the immediate environment of the mines and the users. Balogun et al., [19] determined the activity concentration of ^{238}U, ^{232}Th and ^{40}K from samples collected from Enugu The activity concentration of radionuclide determined ranged from 0.02±0.002 to 48.42±5.32 $BqKg^{-1}$. Overall natural radionuclide contribution to the radioactivity of the environment was found to be 404.16± 23.44BqKg-^{1} major contribution by coal tailing 49.5% of the above value. The outdoor and indoor exposure rates in air 1 m above the ground are estimated to be $(6.31\pm1.20)\times10^{-8}$ and $(7.57\pm1.20)\times10^{-8}$ Gy h^{-1} respectively, for the mining environment. The resulting annual effective dose equivalent estimated is $(4.49\pm0.74)\times10^{-4}$ Sv yr^{-1}, this is below dose limit levels for workers recommended by ICRP 60 [13] and IAEA [15]. Comprehensive radioecological effect of coal mining in Nigeria still need to be done.

Conclusion.

Death due to unknow causes and illness are usually experienced among local indigene of Nigeria One major cause of this may be as a result of radiation exposure. This cannot be adequately diagnose because community clinics available to the natives are not adequately equipped diagnose and treat radiation related illness. These makes it impossible to have an actual documentation of radiation related sickness and death. A comprehensive radiological assessment of the critical group, mining and related activities and need to be carried out to know the present level of radionuclide contamination and to be used for future monitoring references. Protection and relevant government agencies have much work to do in respect of inspection, regulation and enlightenment of people on the health implications of radiation exposure.

The government has made it mandatory the conduction of environmental impact assessment before mine permit are issued but most governmental ministries lack the capacity of enforcement. The licensing procedure for mineral exploration should adequately include estimate on volume of NORMS waste to be generated and disposal option to be adopted. This should include participation from all relevant government agencies, stakeholders and operators. Finally, remediation strategies need to be instituted to remediate land and to avert the continued and potential exposure to the local population including critical population group such as the children.

Acknowledgement: I am greatful to Mrs Voigt Gabriele and Prof Sergey Fesenko of the International Atomic Energy Agency Vienna Austria and the IAEA for provinding me and internship and University of Texas El Paso for the funding for attending this conference.

References

[1] Funtua, I.I., Elegba S.B., Radiation exposure from high-level radiation area and related mining and processing activities of Jos Plateau, central Nigeria, Int.Congress Series **1276** (2005) 401-402.
[2] Funtua, I.I., et al., J. Mining and Geology **40** 1 (2004) 91 - 94.
[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Principle for the Exemption of Radiation and Practice from Regulatory Control, Safety Series No. 89, I.A.E.A, Vienna (1988).
[4] Determination des valeurs de radioactive' dites valeurs de minimis, permettant l'evecuation sans conditions, CEA, ISPN, SERGD No. 92/22. Commissariat a'l'Energie Atomique
[5] Babalola, I.A., Radon measurement and assay of tailings from high natural radioactivity in Plateau State. Nigerian Journal of Science **18** (1984) 1–2
[6] Ibeanu, I.G.E., Assessment of radiological effects of tin mining activities in Jos and its environs, Ph. D Thesis Ahmadu Bello Univ., Zaria (1999).
[7] Schuler, C.H et al., Assessment of the indoor Rn contribution of Swiss building materials, Health Phys. **60** (1991) 447-552
[8] WORLD HEALTH ORGANISATION, Guideline for Drinking Water Qualities, additioanl volume to volume 2, WHO, Geneva (1998).
[9] HEALTH CANADA, Uranium in Drinking Water, Document for Public Comment prepared by Fedral Provincial Subcommitte on Driking Water, (1998)
[10] Ibeanu, I. G. E., Tin mining and processing in Nigeria: cause for concern Journal of Envir. Radioactivity, **64** 1 (2002) 59-66
[11] Chong C. et al., Gamma radioactivity level in Sn slag dump. Health Phys. **49** (1985) 1008–1010
[12] Hewson, G.S. Overview of radiation safety in the tin by-product (amang) industry of South East Asia. Health Physics **71** (1996) 225–234
[13] International Commission of Radiological Protection publication No 60, Oxford Pergamon Press (1990)
[14] Ogunleye, P. O., et al., "Radioactivity and heavy metal composition of Nigerian phosphate rocks: possible environmental implications" J. of Envir. Radioactivity **62** 1 (2002) 39-48
[15] INTERNATIONAL ATOMIC ENERGY AGENCY, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. Safety Series No. 115-I, IAEA, Vienna, (1994)
[16] Kogbe, A.C., Geology of the SE sector of the Iullemmeden basin. Bulletin, Dept. of Geology, Ahmadu Bello Univ. Zaria, Nigeria **2** 1 (1979) 355–359
[17] Okosun, E.A., The potential application of Sokoto phosphate for the manufacture of fertilizer. J. of Agric. Tech. **5** 2 (1997) 59–64.
[18] Guimond, R.J. and Hardin, J.M., Radioactivity released from phosphate containing fertilizers and from gypsum. Rad. Phy. and Chem. **34** 309
[19] Balogun, F.A., et al., Natural radioactivity associated with bituminous coal mining in Nigeria, Nucl. Instr. and Meth. **505** 1-2 (2003) 444-448