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Dusts Control operations in Ririwai Mines, Kano State, Nigeria

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***Abstract:** Respirable dust is everywhere (in the surface and underground mine) operations and its environs. Ririwai Tin mine is laden with dust of metallic particles of Arsenic (As), Chromium (Cr), Lead (Pb) and Zinc (Zn). These particles are also found in the soil. Continuous inhalation of dust could lead to irreversible diseases. This paper addresses the control of dust, using previous review of prevailing metallic concentrates. This research answers questions like which are the dust control strategies to be adopted by Ririwai tin mine to obtain best practice? What challenges will Ririwai tin mine face when applying dust control methods in their operation? What is the impact of dust laden with metallic particles on soil, water, vegetation and man in Ririwai tin mine?*

***Keywords:** Ririwai, Dust, Soil, Arsenic, Chromium, Lead, Zinc, Concentration.*

I. INTRODUCTION

Dust generation and its dispersion has been the major concern in open cast mines. Major mining activities in deep open pit mines range from exploration to the processing of end product that primarily contribute particulate matter (PM), dominantly PM10 leading to the problem of air pollution and related health hazards (like pneumoconiosis-black lungs, silicosis and asbestosis). The toxicity of the dust that is generated is dependent on a number of factors, such as the quantity of crystalline silica inhaled, particle size distribution and exposure duration. It has been observed that out of total particulates generated, the PM10 constitute one-third to half. Heavy metals trapped in dusts can cause health problems at higher exposures and destroy aquatic organism when settled and leached into the soil, and into water bodies. Its residues in contaminated habitats may accumulate in microorganisms, aquatic flora and fauna, which in turn enters the human food chain and result in health problems, like the lead poisoning problems in Zamfara State that kills more than 400 children(Galadima and Garba, 2012).

II. MINE DUST CONTROL

Dust control has to be built into every aspect of the mines planning and operation. Of critical importance is the workers and people living in the community, who needs to be enlightened of the importance of dust control, the methods which are used, procedures concerned, and the impact on non-adherence to these. The activities which require planned controls include construction, topsoil stripping, blasting, road transport, material handling/transfer systems, and rehabilitation programmes.

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Work practices then need to be planned so that control measures are integrated. Regulators are increasingly being tasked to manage regional air quality, which means that all sources need to be considered and controls need to be applied where appropriate. In essence this means that mines will increasingly have to manage their impacts through dynamic and regularly maintained source inventories, dispersion modelling and air quality monitoring (Schwegler, 2006).

Hierarchy of Dust Control

S/N	Dust Mitigation Strategies	
1	Elimination	i) Treat the dust at its point of generation
		ii) Treat the dust on its transmission path using dust suppression
2	Substitution	i) Use lesser hazardous substances
		ii) Adopt production processes that generate less dust.
3	Separation/Isolation	i) Use of physical barrier between the dust-generating task and the worker.
		ii) Use remotely operated machinery
4	Engineering Control	i) Choose appropriate equipment
		ii) Replace and maintain equipment regularly
		iii) Suppress dust by using water sprays with additive in water spray.
		iv) Use enclosures (e.g. covered conveyors, cars, etc).
		v) Rehabilitate exposed mine land
		vi) Use ventilation and filtration to minimise dust

5	Administrative Control	i) Ensure regular maintenance and housekeeping of mine workings. ii) Position personnel away from dust-generation. iii) Maintain un-tarred roads and ground conditions throughout sites iv) Provide training and information to workers on the hazards, risks and controls of dusty tasks v) Limit the duration and magnitude of exposure to dust vi) Change the location of dumping Provide adequate sign
6	Personal Protective Equipment	i) Select the most appropriate respiratory protection for the task ii) Ensure training, comfort and fit testing iii) Maintain and store respiratory protective equipment properly

III. LITERATURE REVIEW

Epidemiological studies in recent years have indicated a strong association between the occurrence of several diseases in humans, particularly cardiovascular disease, kidney related disorders, neurocognitive effects and various forms of cancer and the presence of toxic trace metals (Nwajei*et al*, 2012). Mining activities, through milling operations coupled with grinding, concentrating ores and disposal of tailings, along with mill wastewater provide obvious sources of heavy metal contamination of the environment (Ayodele and Mohammed, 2011). Heavy metals can have toxic effects on humans when they contaminate the soil or the ground water pollutant (Kabala and Singh, 2001). Metals contamination in aquatic environmental has received huge concern due to their toxicity, abundance and persistence in the environment and subsequent accumulation in the aquatic habitats (Boamponsem*et al*, 2010). The Riruwai mining area in Doguwa Local Government Area of Kano State has large deposits of columbite, granite, copper, zinc, lead and uranium (Olure-Bank A. M., 2016). The non-ferrous metallic ores found in Nigeria include lead-zinc ore, tin ore (Cassiterite), niobium ore, uranium ore, and precious metals such as (Gold and Silver) (Furqan, Ibrahim and Sunusi,2020).In 1974, the Geological Survey Department discovered uraniferous pyrochlore in Ririwai hills in Kano State and Kigo Hills in Plateau State. The grade is 0.012% uranium oxides(Karniliyus and Ekedegwa, 2006). Uranium occurrence has been reported in Ririwai area of Kano State in peralkaline and peraluminious granites with uranium content of 16-32 ppm (Obaje*et al*, 2014). Notable cassiterite-bearing veins or lodes and/or greisens occur in the Ririwai, Tibchi, Tongolo and Afu complexes -in decreasing order of mineralisation (Abimbola and Adedibu, 2018).

IV. MATERIAL AND METHODS

The literature review of metallic particles in dust and soil in the Ririwai tin mine location was captured in this paper. In it, Abdullahi, Garba and Gaiya (2017)presented results using Instrumental Neutron Activation Analytical (INAA) technique which shows As, Cr and Zn having mean concentrations of 4.25 ± 0.19 mg/kg, 43.44 ± 1.80 mg/kg and 162.92 ± 5.43 mg/kg respectively in dusts across the study area as seen in table 1.Abdullahi, Abigail and Okunola (2018) presented results using Energy Dispersive X-Ray Fluorescence (EDXRF) Spectrometer model FXL-83358 which shows Pb, As and Zn having mean concentrations of 113.54 ± 3.92 mg/kg, 6.76 ± 0.34 mg/kg and 216.89 ± 5.74mg/kg respectively in the soil across the study area seen in table 1. Zakari, Nasiru, Ahmed and Abdullahi (2015)presented results using Liquid Scintillation Analysis (LSA) which shows tailing bearing water, surface water source and domestic wate having mean value of 3.04 ± 0.14 Bq/L, 2.51 ± 0.13 Bq/L and 2.23 ± 0.11 Bq/L seen in table 1.

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Figure 1: Map of Nigeria showing study area, Kano State.)

Figure. 2: Geographical Map of Ririwai (maphil.com)

GEOLOGY OF RIRIWAI TIN MINE

It is located between latitudes 8.41 – 8.480E and longitudes 10.4 – 10.480N. It measures about 17km x 16km and covers a land area of about180km^2. It is situated approximately l40 km south of Kano in Doguwa Local Government Area (Muhammad**,** 2017). Riruwai is at the end of Kano south where it is bordered curve-linearly by Kaduna state at south and west. It shares a border with Bauchi by East and Tudun Wada at North. It has a distance of over 150km from Kano city and hence has more interaction with Kaduna and Plateau states due to their proximity (Ibrahim, 2019). The Ririwai(or Liruei) of northern Nigeria is non-orogenic with a ring-complex and an outer ring dyke of granite porphyries surrounding down-faulted volcanic and basement rocks with a core of composite granitic rocks made up of biotite, aegirine arfvedsonite and albite arfvedsonite granites (Ogunleye and Garba, 2006). It is greisenized granite with related quartz veins. The Mesozoic Younger Granite ring complexes form part of a wider province of alkaline anorogenic magmatism. The granitic rocks are characterized by high values of Sn, Nb, Zn, Ta, Li, Rb, and F but ore-forming processes are related to postmagmatic changes.

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They occur in a zone 200 km wide and 1,600 km long extending from northern Niger to south central Nigeria (Nuhu, 2009). Ririwai is owned and managed bt the Nigeria Mining Corporation. Its declared mineral reserves stands as: Measured (582,668t- 0.7% Sn, 2.56% Zn); Indicated (2,247,683t - 0.61% Sn, 2.05% Zn) and Demonstrated (2,830,351t - 0.63% Sn, 2.15% Zn - (Musa, 2014).

The scope of this study aims and **targets**Ririwai underground tin mine that was closed in 1984. It sought to establish and propose best dust control methods using literature review of metallic particles in dust and soil in the location. It will be beneficial in suggesting helpful methods of dust control and hence provide clues to preserve the environment through the methods. This research is significant to address dust control methods in Ririwai tin mine which will add its quota to sustainable policy-making at the industry level. The Limitation of this work is proximity, time and insufficient information from the internet. Researchers chose to study dust control in Ririwai Tin mine as it impacts on the environment.

Figure 3A:Opencast mining site in Riruwai; Source: Adopted from Umar 2016

Figure. 3B : Destroyed terrain after open cast mining in the area; Source: Adopted from Umar 2016

Figure 4: Ririwai tin mine Outcrop

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Figure 5: Ririwai tin ore

V. DATA AND METHODOLOGY

Data Review and Analysis

Table 1: Mean values for different analysis techniques used on Ririwa tin mine location

Metallic Particles	In dust using INNA (mg/kg)	In soil using EDXRF (mg/kg)	In water using LSA (mg/L)		
			In tailing bearing water (Bq/L)	In surface water (Bq/L)	In domestic water (Bq/L)
Lead, Pb		113.54 ± 3.92			
Arsenic, As	4.25 ± 0.19	6.76 ± 0.34			
Zinc, Zn	162.92 ± 5.43	216.89 ± 5.74			
Chromium, Cr	43.44 ± 1.80				
Tin, Sn					
Radon, Rn			3.04 ± 0.14	2.51 ± 0.13	2.23 ± 0.11

Comparing Data of Metallic Particles Concentration in the Dust and In the Soil Using Inna (Abdullahi, Garba and Gaiya, 2017) and Edxrf (Abdullahi, Abigail And Okunola, 2018).

Abdulllahi, Garba, and Gaiya (2017)collected ten (10) dust samples on filter papers mainly within the Ririwai tin mines inside active pits using air sampler in some locations and stating the concentration of As, Cr and Zn in table 2.

Table 2: Sampling locations and the concentration of As, Cr and Zn in dust samples

Sample I.d.	Sampling Locations			Samples Concentration		
	NORTH	EAST	ELEVATION	ARSENIC, As (mg/Kg)	CHROMIUM, Cr (mg/Kg)	ZINC, Zn (mg/Kg)
1	100 44′ 35.3 ″	0080 45′ 16.4 ″	856m	0.61± 0.10	52.80 ± 1.80	215.00 ± 7.00
2	100 44′ 36.7 ″	0080 45′ 15.8 ″	856m	0.28 ± 0.05	47.30 ± 1.60	306.00 ± 6.00
3	100 44′ 33.8 ″	0080 45′ 17.8 ″	856m	0.34 ± 0.02	21.00 ± 1.50	111.00 ± 7.00
4	100 44′ 32.3 ″	0080 45′ 21.0 ″	858m	0.27 ± 0.06	43.90 ± 1.40	142.00 ± 4.00
5	100 44′ 30.3 ″	0080 45′ 27.0 ″	862m	0.15 ± 0.01	37.60 ± 1.70	142.71 ± 7.00
6	100 43′ 48.2 ″	0080 44′ 57.1 ″	896m	0.49 ± 0.12	40.20 ± 1.90	92.10 ± 0.22
7	100 43′ 49.1 ″	0080 44′ 53.4 ″	894m	1.29 ± 0.20	33.60 ± 1.40	80.90 ± 3.90
8	100 43′ 48.5 ″	0080 44′ 53.0 ″	895m	3.39 ± 0.34	62.70 ± 2.60	194.00 ± 9.00
9	100 43′ 50.2 ″	0080 44′ 58.7 ″	892m	5.60 ± 0.63	32.60 ± 1.80	233.33 ± 3.20
10	100 43′ 49.5 ″	0080 44′ 59.2 ″	894m	30.10 ± 0.40	62.70 ± 2.30	112.20 ± 7.00

Mean				4.25 ± 10.19	43.44 ± 1.80	162.92 ± 5.43
Maximum				30.10 ± 0.63	62.70 ± 2.60	306.00 ± 9.00
Minimum				0.15 ± 0.01	21.00 ± 1.40	80.90 ± 0.22
Standard Deviation				8.778569 ± 0.192616	12.67716 ± 0.368782	68.53087 ± 2.437871

Also, Abdullahi, Abigail, Okunola (2018) collected ten (10) soil samples at ten different locations around the study area, at 10cm depth of digging, stating the concentrations for Pb, As and Zn in table 3.

Table 3: Concentration of Pb, As and Zn in soil samples

Concentration In (Mg/Kg)				
Serial Number	Identification	Zinc (Zn)	Arsenic (As)	Lead (Pb)
1	Sample 1	420.55 ± 7.68	5.85 ± 0.35	189.40± 4.76
2	Sample 2	161.78 ± 5.16	5.20 ± 0.28	100.24± 3.68
3	Sample 3	57.58 ± 3.62	5.62 ± 0.40	3 47.75 ± 2.78
4	Sample 4	75.04± 3.93	6.34 ± 0.24	65.22 ± 3.06
5	Sample 5	60.19± 3.56	5.94 ± 0.22	62.64 ± 2.93
6	Sample 6	181.64 ± 5.39	7.22 ± 0.55	69.71 ± 3.31
7	Sample 7	188.18± 5.90	8.55 ± 0.31	114.07±4.12
8	Sample 8	178.29 ± 5.77	8.10 ± 0.31	118.10 ± 4.14
9	Sample 9	581.34 ± 9.64	9.16 ± 0.42	218.00 ± 5.64
10	Sample 10	264.31 ± 6.72	5.60 ± 0.35	150.30 ± 4.73
Mean		**216.89 ± 5.74**	**6.76 ± 0.34**	**113.54 ± 3.39**

VI. RESULTS AND DISCUSSION

Re-Calculating and Re-Organizing Table 2 and 3 / Plotting Their Graphs

Table 4: Metallic concentrates in Dust

Concentration In (Mg/Kg)		
Arsenic, As	Chromium, Cr	Zinc, Zn
0.14	19.50	77.00
0.16	22.50	84.80
0.21	30.80	91.88
0.23	32.20	92.32
0.32	32.20	104.00
0.33	34.40	105.20
0.33	35.90	118.00
0.36	38.30	119.20
0.37	39.30	135.71
0.51	42.10	138.00
0.61	42.50	146.00
0.71	45.30	149.71
1.09	45.70	185.00

Table 5: Metallic concentrates in the soil

Concentration In (Mg/Kg)		
Arsenic (As)	Lead (Pb)	Zinc (Zn)
4.92	44.97	53.96
5.25	50.53	56.63
5.48	59.71	61.20
5.50	62.16	63.75
5.22	65.57	71.11
5.72	66.40	78.97
5.95	68.28	156.62
6.02	73.02	166.94
6.10	96.56	172.52
6.16	103.92	176.25
6.17	109.95	182.28
6.58	113.96	184.06
6.67	118.19	187.03

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1.49 3.05	48.90 51.00	203.00 208.00
3.73	54.60	222.00
4.97	60.10	230.13
6.23	60.40	236.53
29.70	65.00	300.00
30.50	65.30	312.00

7.77 7.79	122.24 145.57	194.08 257.59
8.24	155.03	271.03
8.41	184.64	412.87
8.74	194.16	428.23
8.86	212.36	571.70
9.58	223.64	590.98

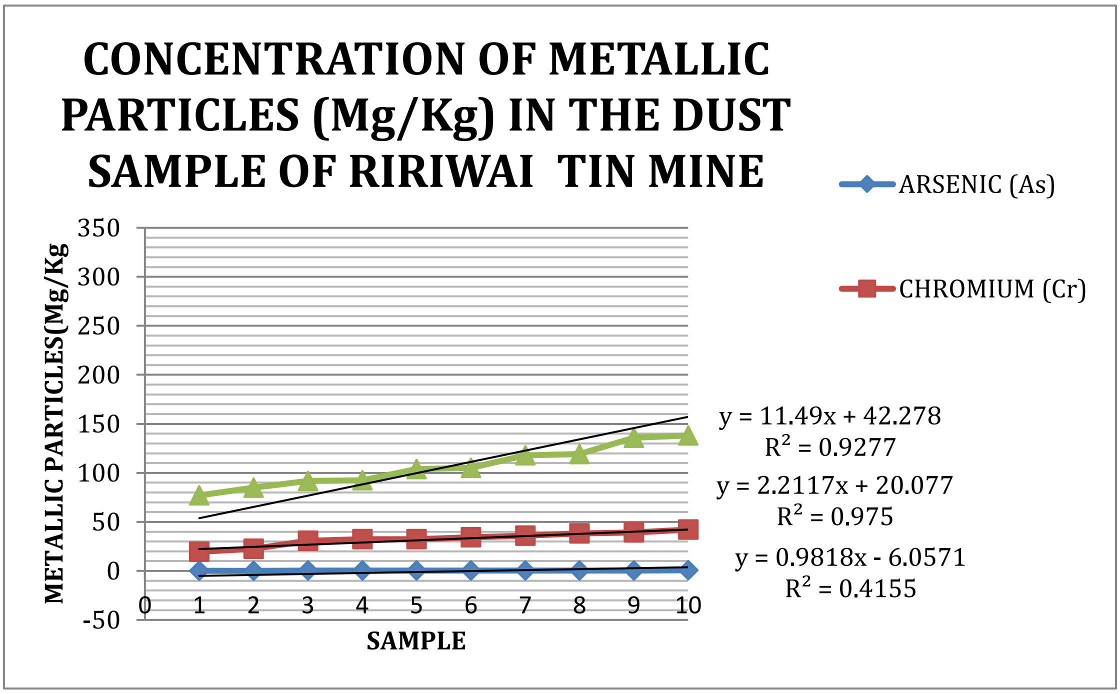

Figure 6: Metallic concentrates in the dust particles of Ririwai tin mine

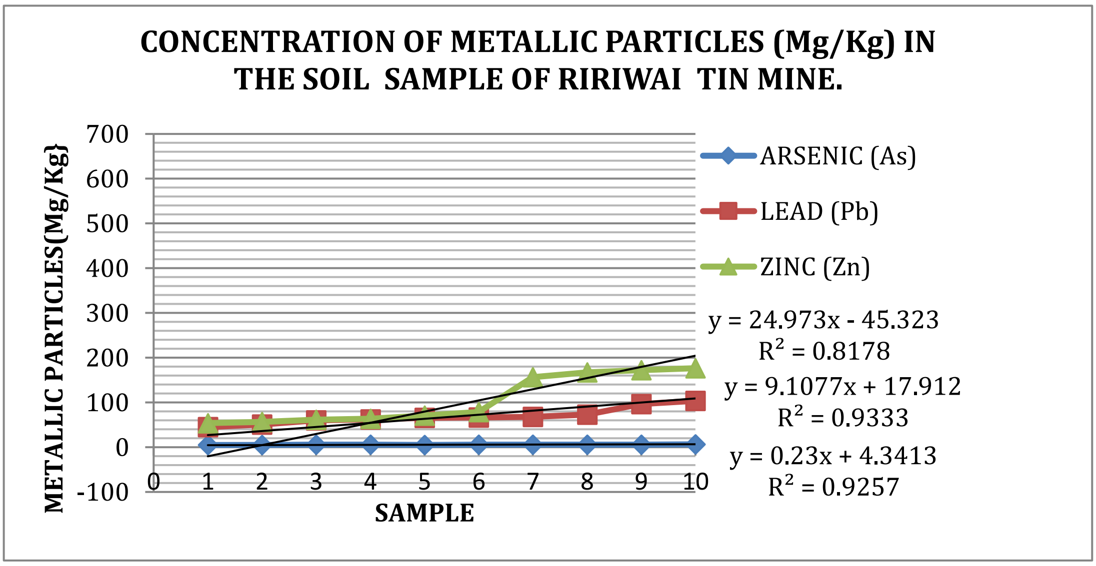

Figure 7: Metallic concentrates in the soil particles of Ririwai tin mine

Table 6: Equations for Linear Plots and Regressions

Environment	Metallic Particles	Linear Equation	Regression	Gradient (Dy/Dx)
IN DUST	Arsenic(As)	$y = 0.981x + 6.057$	$R^2 = 0.415$	0.981
	Chromium(Cr)	$y = 2.211x + 20.07$	$R^2 = 0.975$	2.211
	Zinc (Zn)	$y = 11.49x + 42.27$	$R^2 = 0.927$	11.49

IN SOIL	Arsenic(As)	y = 0.23x + 4.341	$R^2 = 0.925$	0.23
	Lead (Pb)	y = 9.107x + 17.91	$R^2 = 0.933$	9.107
	Zinc (Zn)	y = 24.97x - 45.32	$R^2 = 0.817$	24.97

From table 6, it can be deduced that the distribution of Arsenic, Chronium and Zinc in dust has a distribution value of 0.98mg/Kg, 2.211mg/kg and 11.49mg/kg respectively. So also, the spread of Arsenic, Lead and Zinc in the soil are 0.23mg/Kg, 9.107mg/kg and 24.97mg/kg respectively. I therefore confirm the concentration of zinc to be the highest which agrees with the results cited in literature of study.
According to the regression correlation coefficient, there is variation in the samples from the dust and the soil. The regression variation in concentration of Arsenic is higher in the dust than in the soil. Thus, the need for this paper to consider 'dust control' since Arsenic is highly hazardous to the environment.

VII. CONCLUSION

Though Ririwai tin mine closed up in 1984, yet there is still prevalence of metallic particles in the dust around its locality and in the soil. This may seriously affect the health of people living in the mining environment. Dust controls should thus be built into all mine areas that surrounds it. These controls will put checks to reduction and considerable elimination.

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