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HEAVY METALS EXPOSURE THROUGH QUARRY OPERATION IN AGO IWOYE, OGUN STATE, NIGERIA

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Abstract: Global mortality and morbidity due to environmental pollution are on the increase, while a substantial proportion of the total burden of diseases has have also been linked to environmental factors among which is human exposure to toxic chemicals through anthropogenic activities. Quarrying is a form of mining activity with associated environmental and health consequences; the extraction processes cause the release of heavy metals into the air and groundwater of host communities. In this study, we investigate the impact of quarry activities on serum concentration of Arsenic, Copper, Manganese, and Zinc in volunteers from quarry host communities in Ago Iwoye, Ogun State, Nigeria was investigated. Forty-seven (47) participants were recruited from quarry host communities (exposed), while forty-seven (47) participants were recruited as controls (non-exposed). Atomic Absorption Spectrophotometric measurements of selected metals were performed on Buck 210 VGP. Serum Copper, Manganese, and Zinc were significantly higher in exposed participants than in non-exposed participants ($P < 0.001$) which might be a consequence of the existence of quarry operational activities in the communities.

Keywords: Heavy metals, quarrying operations, environmental pollution, host communities

Introduction

Environmental pollution is the greatest threat facing humankind; it has been adjudged as the foremost causes of disease and death. Over a quarter of the burden of diseases has been heavily linked with environmental issues, including overexposure to toxic chemicals through natural and anthropogenic sources and processes (Pruss-Ustun *et al.*, 2016). Nine million premature deaths were estimated to have resulted from pollution-related diseases in 2015, which accounted for 16 per cent of global mortality for the year. Also, 12.7 million deaths which account for 23 per cent of global mortality 23 per cent of global are attributable to adjustable environmental influences. Despite the undesirable effect of environmental pollution on humans and immediate environment, this destructive activity has continued unabated in developing countries because of feeble public health laws and policies, poverty, lack of adequate information on environmental pollution forms and modes of exposure (Mamtani *et al.*, 2011).

There is growing apprehension about potential for exposure to Heavy Metals around the world due to drastic increase in their worldwide output as a result of their routine applications in solid mineral exploration, mining, public infrastructure construction, industries, metal technology. Nearly 4 million people in developing countries die each year due to environmental pollution emanating from quarrying, sandblasting and emission of dangerous chemicals (Bhattacharjee *et al.*, 2018).

In recent years, global public health concerns associated with environmental contamination by Arsenic, Copper, Manganese, Zinc among other metals are on the increase, this is due to rising human exposure to these Heavy Metals through mining activities which include quarrying (Masindi and Muedi, 2018). Quarrying involves mediation with the natural environment in complex and intricate ways which requires drilling, blasting, and the use of machinery to grade rock materials thereby exposing host communities to environmental and health hazards (Ayodele *et al.*, 2014). The environmental impacts of quarry mining include erosion, the formation of sinkholes, and contamination of air, soil and water (Sonter *et al.*, 2018). Health effects associated with quarrying activities are of note; the impact of noises pollution from rock blasting operation is known to include stress, discomfort, shock, increased pulse rate, loss of sleep, fatigue and damage to the hearing system (Akinluyi *et al.*, 2019). The inhabitants of hosting communities are at risk of inhaling the quarry dust, which can cause respiratory and pulmonary problems (Mandal and Pal, 2020; Oyinloye and Olofinyo, 2017). Also, dust generated from granite quarrying contains a high percentage of silica, and inhaling such dust can result in silicosis which is capable of disabling an exposed person and can subsequently lead to death (Pope III *et al.*, 2002).

Different stages of quarry mining processes cause permeation of metals into environmental media like soil, water, and plant species around the operation areas. Arsenic, Manganese, Copper, and Zinc among others have been reported to be associated with quarry activities because of their presence in significant levels in soil, dust, water, and plant species in Quarry host communities (Ayodele *et al.*, 2014; Tiimub *et al.*, 2015). The quarry mining operations cause leaching of heavy metals into groundwater, surface water, and further release into the ambient air which is capable of causing excessive exposure to heavy metals by residents of the quarry host communities (Ali *et al.*, 2019).

In the light of possible health threats that heavy metals pose to residents of quarry host communities due to their infiltration into their water sources and air, it is important to determine the level of exposure to these metals in these communities, In this study, we investigate the impact of quarry activities on serum concentration of Arsenic, Copper, Manganese, and Zinc in volunteers from host communities in Ago Iwoye, Ogun State, Nigeria to establish preliminary data on the communities and raise possible alert where potential threat to human life is found to exist.

Heavy Metals are ubiquitous natural elements with high atomic mass and density; they exist mostly in low concentrations (Koller and Saleh, 2018). Some Heavy Metals are indispensable trace elements with functions vital for biological processes that steer metabolism (Prashanth *et al.*, 2015). Heavy Metals can be noxious at elevated concentrations because they form free radicals either by direct electron transfer involving metal cations or as a consequence of metal-mediated inhibition of metabolic reactions thereby causing oxidative stress (Jaishankar *et al.*, 2014). Human exposure to these metals has also risen disturbingly as a result of their increased usage in numerous manufacturing process and technical interventions (Mahurpawar, 2015). Exposure to heavy metals can also be occupational-related while for most people, the foremost routes of exposure to these toxic elements are through the air, food, and water (Morais *et al.*, 2012). The contamination chain of heavy metals follows a cyclical pattern: industry, atmosphere, soil, water, foods, and humans (Morais *et al*., 2012). Toxicity and the resultant threat to human health due to environmental contaminants are usually a function of concentration; It is well-known that chronic exposure to heavy metals and metalloids at comparatively low levels can cause adversative effects (Castro-González and Méndez-Armenta, 2008).

Arsenic

Arsenic is one of the most toxic metals extensively dispersed naturally in the biosphere, it is present in the air, water, soil (Pimparkar and Bhave, 2010; Curkovic *et al*., 2016). Arsenic is found in inorganic and organic forms and in different oxidation states (Hughes *et al*., 2011). Exposure to Arsenic occurs through the oral route, inhalation, and dermal contact (Matschullat, 2000). Ingestion of excessive quantities of inorganic Arsenic can cause vomiting, circulatory system disorder, nervous system disruption, blood cell production reduction, liver enlargement, skin decolouration (Machado *et al*., 2020; Shankar *et al*., 2014).

Copper

Copper is a metallic element that either occurs as free metal or associated with other elements in compounds, it is present in rock, soil, water, and in the air (Tabelin *et al*., 2018). Most Copper compounds occur in +1 Cu (I) and +2 Cu (II) valence states (ATSDR, 2004), The three major routes of human exposure to Copper is through inhalation, dermal contacts with contaminated soil and water and ingestion (Gaetke *et al*., 2014). Exposure to excessive Copper can cause headaches, dizziness, weakness, and gastrointestinal symptoms like vomiting and diarrhoea while long term exposure to extreme level can cause liver cirrhosis, cardiovascular disease (Bosta *et al*., 2016).

Manganese

Manganese is a naturally occurring and vital nutritious element, comprising approximately 0.1% of the earth's crust; it is the twelfth most abundant element (Röllin and Nogueira, 2019). It occurs naturally in soil, rock, water, and it is released into waterways mainly through the erosion of rocks and soil (O'Neal and Zheng, 2015). Manganese exists in eleven (11) oxidative states while the most biologically important Manganese compounds are those that contain Mn^{2+}, Mn^{4+}, and Mn^{7+} (ATSDR, 2012). Mn is distinctive among other toxic elements because it is an important trace element required for human life activities, with both insufficiency and excess of it, having disadvantageous health effects (Röllin and Nogueira, 2019).

Manganese exposures occur through oral and inhalation in a number of environmental media and nutritional sources like water, soil, and air (O'Neal and Zheng, 2015). Acute and chronic Manganese exposure can cause impairment of motor and cognitive function and other central nervous system pathology (Yin *et al*., 2010; Koh *et al*., 2014). Also, excessive exposure to Manganese by infants can affect their growth and mental development while its deficiency may result in host of healthy defects like defective lipid and carbohydrate metabolism, infertility, heart and blood pressure disorder (Koh *et al*., 2014).

Zinc

Zinc is one of the most common elements in the Earth, it constitutes 0.02% of Earth's crust, it can be found in the air, soil, and water (El Sayed *et al*., 2011; Wuana and Okieimen, 2011). Zinc has two common oxidation states Zn (0) and Zn (+2). There are three (3) main routes of exposure to Zinc; they are through inhalation, dermal contact and ingestion (Qu *et al*., 2012). Excessive inhalation of Zinc compounds causes the development of Metal fume fever, which is characterized by chest pain, cough, dyspnoea, nausea, malaise, and leukocytosis (Plum *et al*., 2010). Also, ingestion of intolerable quantity of Zinc causes gastrointestinal disturbances such as vomiting, abdominal cramps, and diarrhoea (Plum *et al*., 2010).

Materials and Methods

Study area

This study was conducted in Lugbedu and OkeNugbo, Quarry operation communities of Ago Iwoye, Ago Iwoye is a town in Ijebu North local government area of Ogun State, Nigeria. collected from residents of the communities. They share the geographical coordinates (6° 56' 32.492" North 3° 55' 17.594" East) (Fig. 1). Blood samples were collected from residents of the communities.

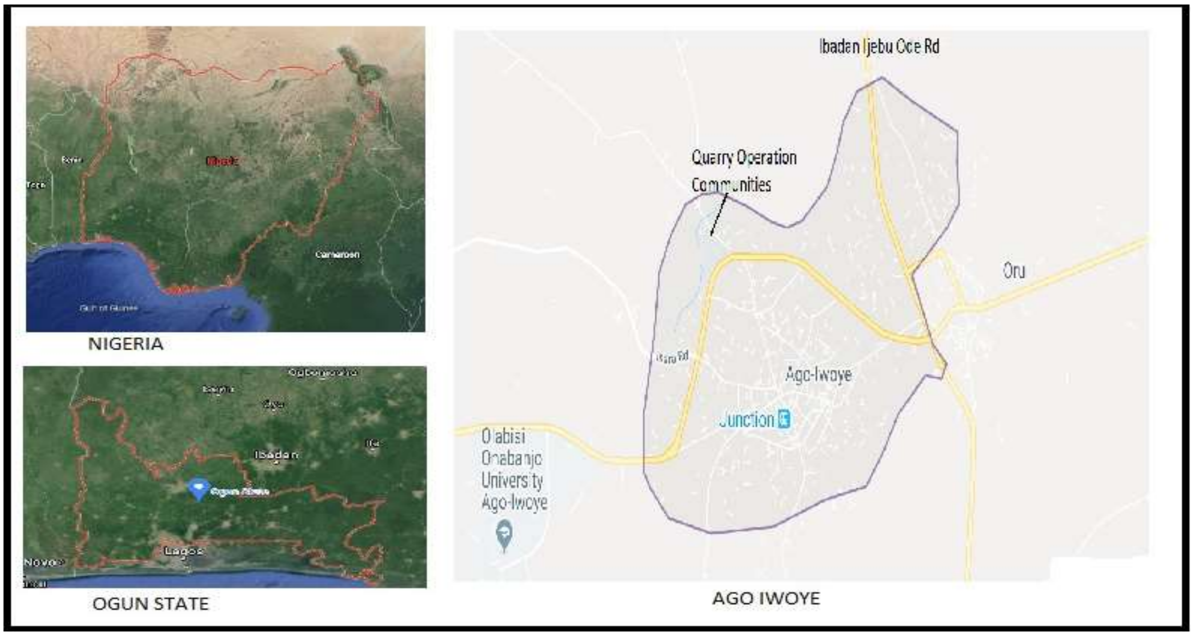

Fig. 1: Map showing the location of the study area

Study design

The study is a cross-sectional study aimed at investigating the impact of quarry activities on levels of selected heavy metals in serum concentration of residents of quarry operation communities of Ago Iwoye, Ogun State, Nigeria. Exposed participants were defined as residents of Lugbedu and Oke-Nugbo (the Quarry operation communities) while Non-exposed participants were defined as residents of ItaMerin (the control community) in Ago Iwoye.

Ethical consideration/informed consent

The Ethical approval was obtained from the Health Research Ethical Committee of Olabisi Onabanjo University, Teaching Hospital, Sagamu, Ogun state. Informed consents were obtained from participants before enrolment for the research study, the participants were informed about the objectives and procedures of the study and they were assured of confidentiality, voluntariness and protection. The investigation was carried out at no cost to the volunteers.

Study sampling

Purposive sampling method was used for this study. Nighty-four (94) apparently healthy participants who are between age 18 and 60 years were enrolled for this research study. Forty-seven (47) participants were recruited from exposed communities while Forty-seven (47) participants were recruited from the non-exposed community as control participants.

Sample collection and preparation

10.0 ml of blood was collected through venepuncture from antecubital veins with sterile disposable needles and syringes into anticoagulant-free tubes (red top tubes) The blood sample was allowed to clot, retracted, and centrifuged with Surgilac Centrifuge 80- 2 at 3000 RPM for 5 minutes after which the Serum was separated into the plain bottle and stored at -20°C till the time of analyses (WHO, 2002).

Determination of serum arsenic, copper, manganese and zinc

The serum Arsenic, Copper, Manganese, and Zinc measurement were performed using an Acetylene Flame Atomic Absorption Spectrophotometer (AAS) on Buck 210 VGP Model (Rucker *et al*. 2008). De - proteinsation was done by putting 1.0 ml of Serum in the test tube and adding 3.0 ml of 2M HCL as described by Banjoko *et al*. (2012). The supernatant was aspirated into flame Atomic Absorption Spectrophotometer (AAS) after adjusting the wavelength at 193.7, 324.8, 279.5, and 213.9 nm for Arsenic, Copper, Manganese and Zinc estimation, respectively. The concentration was displayed electronically and the results were expressed as µg/dl and µg/l.

Quality assurance and control

Blanks, blind duplicates, and standard concentrations were analyzed for quality assurance and quality control purpose, each sample was analyzed thrice, and the mean value was used for the experimental data. The analytical errors of the experimental data were within 5% during analysis process.

Statistical analysis

Statistical Package for Social Sciences, version 22 was used for data analyses. Results were expressed as mean ± Standard Deviation, Probability (P) values < 0.001 were considered as significant.

Results and Discussion

Figure 2 shows the distribution of age groups of the participants. Age group (41 – 50) has the highest number of participants from exposed and non-exposed groups while the age group (< 31) has the lowest number of participants from exposed group and age group (51 – 60) has the lowest number of participants from non-exposed group.

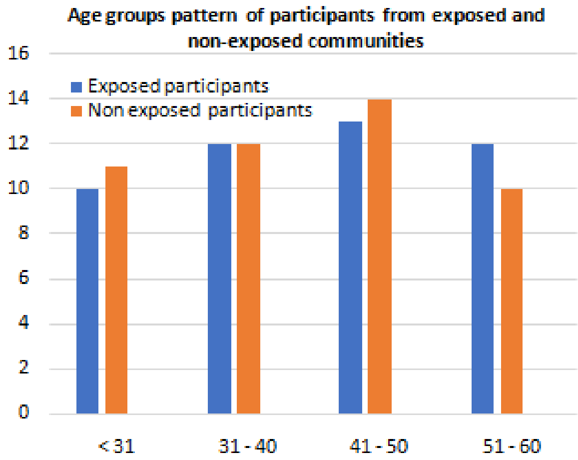

Fig. 2: Age groups pattern of participants from exposed and non-exposed communities

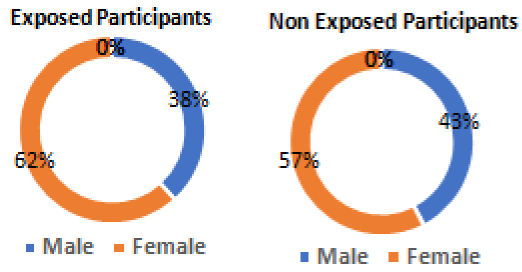

Fig. 3: Gender pattern of participants from exposed and non-exposed communities

Figure 3 shows the gender pattern of participants, the participants of this study in both exposed and non-exposed group were mostly female.

The comparative concentration of serum heavy metals between male and female participants from exposed and non-exposed communities are summarized in Table 1 and 2, respectively. Independent sample t-test confirms the statistical insignificance of the differences of concentration of metals between the two sexes in the exposed and non-exposed communities (p >0.001). This is in consistence with Olsson *et al*. (2002) who reported no significant difference in intake of metals by male and female sexes. This is also supported by previous literature (Baran and Wieczorek, 2013; Ibeto and Okoye, 2010; Wilhelm *et al*., 1994) who did not find appreciable differences between concentration of metals in samples of two sexes in population of urban, rural or industrial regions.

Table 1: Comparative concentration of selected serum heavy metals between male and female exposed participants

Metals	Exposed (Gender)	N	Mean	S.E	t test	p-value
Arsenic (µg/l)	Male	18	0.168	0.017	0.938	0.353
	Female	29	0.150	0.011		
Copper (µg/dl)	Male	18	126.565	1.403	-0.588	0.559
	Female	29	127.992	1.976		
Manganese (µg/l)	Male	18	10.453	0.562	-0.601	0.551
	Female	29	11.037	0.679		
Zinc (µg/dl)	Male	18	115.169	1.620	-0.443	0.660
	Female	29	116.194	1.520		

S.E – Standard Error; P-value significant at p-value < 0.001; **shows that P-value is significant

Table 2: Comparative concentration of selected serum heavy metals between male and female non-exposed participants

Metals	Non-exposed	N	Mean	S.E	t test	p–value
Arsenic (µg/l)	Male	20	0.174	0.005	-0.588	0.559
	Female	27	0.179	0.004		
Copper (µg/dl)	Male	20	96.020	1.265	1.213	0.231
	Female	27	93.768	1.292		
Manganese (µg/l)	Male	20	7.281	0.190	1.277	0.208
	Female	27	6.983	0.142		
Zinc (µg/dl)	Male	20	101.016	0.704	1.177	0.245
	Female	27	99.642	0.931		

S.E – Standard Error; P-value significant at p-value < 0.001; **shows that P-value is significant

Table 3: Comparative concentration of selected serum heavy metals between exposed participants and non-exposed participants

Metals	Groups	N	Mean	S.E	t test	p - value
Arsenic (µg/l)	Exposed	47	0.157	0.001	-1.947	0.056
	Non-Exposed	47	0.177	0.002		
Copper (µg/dl)	Exposed	47	127.445	1.325	20.265	0.000**
	Non-Exposed	47	94.726	0.922		
Manganese (µg/l)	Exposed	47	10.814	0.469	7.671	0.000**
	Non-Exposed	47	7.110	0.116		
Zinc (µg/dl)	Exposed	47	115.801	1.116	12.222	0.000**
	Non-Exposed	47	100.226	0.615		

S.E – Standard Error; P-value significant at p-value < 0.001; **shows that P-value is significant

Table 3 shows a comparison of selected serum heavy metals between participants from exposed and non-exposed groups. The result revealed that the mean serum concentration of the metals was statistically significantly different between exposed participants and non-exposed participants, increased levels were observed in all except for Arsenic. This research result is in agreement with Ogbanchi and Akubugwo (2013) who reported a higher concentration of Copper and Zinc among in Rabbits exposed to quarry dusts more than the unexposed Rabbits. The result is also consistent with Tiimub *et al*. (2015), Etim and Adie (2012), Lago-Vila *et al*. (2017) who reported increased concentration of Copper, Manganese, and Zinc in groundwater, dust and soil around the quarry mining site. The results is supported by Osuocha *et al*. (2013) Ayodele *et al*. (2014), Osuocha *et al*. (2016) who reported increased levels of Copper and Manganese in soil and plant species around quarry mining sites and these media are potential sources of the exposure of these heavy metals to humans (Tchounwou *et al*., 2012).

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

Conclusion

The health risks associated with heavy metals have been known for a long time, but exposure to them is increasing due to an increase in the establishment of mining sites, industrial zones and other forms of hazardous human anthropogenic activities (Mandal and Pal, 2020; Morais *et al*., 2012; Tchounwou *et al*., 2012). The resultant toxic damages are largely depended on the route of exposure, concentration and persistence of the metals at its site of action (Langman and Kapur, 2006), these metals react with the endogenous target molecules such as receptors, membrane system, enzymes, DNA, cellular structural proteins and lipids, and critically alter their biologic functions, producing structural and functional changes that result in toxic damages (Jaishankar *et al*., 2014) which can culminate in several adverse health effects like metal induced carcinogenesis, disruption of central nervous system and damages to vital organs such as the brain, kidney, lungs, liver due to oxidative stress induced by free radical formation (Al-otaibi *et al*., 2018; Jaishankar *et al*., 2014). This research provides evidence of statistical significant exposure to Copper, Manganese and Zinc in these quarry host communities in Ago Iwoye, Ogun state, Nigeria and there is need for further research on exposure assessment of other toxic metals through quarrying activities and health and well-being assessment of these on the inhabitants to appraise the impact of quarry mining on their health.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author, [F.A], upon reasonable request.

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