Journal of Environment Pollution and Human Health, 2019, Vol. 7, No. 1, 34-38
Available online at http://pubs.sciepub.com/jephh/7/1/5
Published by Science and Education Publishing
DOI:10.12691/jephh-7-1-5

Impact of Heavy Metal Mining on Hepato-Renal Indices in Inhabitants of Enyigba, Ebonyi State, Nigeria

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Received April 09, 2019; Revised May 13, 2019; Accepted June 27, 2019

Abstract Heavy metals can bioaccumulate and may become nephrotoxic at low concentrations. As developing countries becomes industrialized and urbanized, heavy metal pollution is likely to reach disturbing levels. This study was carried out to determine the impact of heavy metal mining on the hepato-renals parameters of some inhabitants in the lead-zinc area of Enyigba community in Ebonyi State. A total of 120 subjects (89 male and 31 female) comprising 60 artisan miners resident in the mining area (37.40 ± 9.08 years) and 60 control subjects (35.30± 9.59yrs) were randomly recruited into the study. Plasma levels of renal parameters and liver enzymes were determined using standard biochemical methods. The results showed non-significant difference (P>0.05) on the mean serum liver enzymes between the artisan miners and control subjects. There was also non-significant differences on the mean serum electrolytes (Na^+, K^+, Cl^-, HCO_3^-) between the two groups while the serum creatinine was significantly higher in the artisan miners relative to the control (P<0.05). The results also indicate that the length of exposure as measured by the number of years residing in the community had no significant effect on the liver enzymes and renal parameters (P>0.05). The results generally indicate that the hepato-renal parameters of the artisan miners are within normal but do not imply that they may not be at risk to mining related diseases.

Keywords: *heavy metals, artisan mining, hepato-renals, Enyigba*

Cite This Article: Ogbonna Nwabueze Daniel, Ugwu Chidiebere Emmanuel, Obi Ejeatuluchukwu, Suru Stephen Monday, Oguaka Victor Nwabunwanne, Ogueche Peter Nnamdi, and Meludu Samuel Chukwuemeka, "Impact of Heavy Metal Mining on Hepato-Renal Indices in Inhabitants of Enyigba, Ebonyi State, Nigeria." *Journal of Environment Pollution and Human Health*, vol. 7, no. 1 (2019): 34-38. doi: 10.12691/jephh-7-1-5.

1. Introduction

Heavy metals pollution is a global threat to the environment as they are widely present in the earth's crust, in air, water and food, especially in mining areas [1]. The distribution of heavy metals is greatly influenced by activities of organisms, climate, topography, availability of parent materials and time [2]. Heavy metals are known to bioacculamate and are hepatotoxic and nephrotoxic even at low concentrations [3].

Exposure to heavy metals are associated with multiple sources (batteries, industrial processes, paints, water pipes, welding, mining activities, gasoline, etc) and pathways (dust, soil, food, air, and water) [4]. The increased level of environmental pollutions by toxic heavy metals from various sources, calls for great concern, because of its impact on human health. These harmful effects have been well documented [5,6].

Illegal mining activities have been seen as one of the foremost factor for environmental pollution [7]. It releases great amount of heavy metals into the surrounding thereby exposing both plant and animals to health hazards. Ingestion of large amount of heavy metals like cadmium (Cd), lead (Pb), copper (Cu), can cause severe damage to the liver and kidney cells. Cadmium can also accumulate in kidney where it damages filtration process and causes excretion of essential proteins and sugar from the body [8].

In Nigeria, a report on lead poisoning incident in Zamfara State claimed over 400 lives of children due to illegal mining of gold and exposure to contaminated soil and household dust in gold ore processing villages [9].This incidence has triggered a growing concern on the lethal effects of heavy metals and also instigated greater research activities into biological effects of heavy metals pollutants in different parts of the world including Nigeria. Thus the need to assess some parameters such as kidney and liver function biomarkers that can be utilized in the early detection and diagnosis of heavy metals effects especially on the occupationally exposed.

Blood enzymes are known biomarkers of acute hepatic damage, thus their bioassay can serve as a diagnostic tool for assessing liver necrosis [10]. Many of these enzymes such as aspartate transaminase (AST), alanine transaminase (ALT), and alkaline phosphatase (ALP) are released from the liver after its cellular damage and failure due to xenobiotics. The liver is the major site of intermediary metabolism and synthesis of many important compounds, the site of conjugation and detoxification of potentially toxic substances and the site of glycogen storage. These roles make it ideal for assessing the toxic effect of a particular substance. Findings abounds as regards use of kidney and liver function parameters as indication of pathological effects of a sub-lethal concentration of heavy metals on animals [2,11-15] and in humans [16,17].

However, these liver and kidney function parameters respond differently to different heavy metals. Some researcher, have reported high levels of liver enzymes and normal kidney parameters in lead and cadmium exposed subjects [2,3,16]. Since these artisan miners have resided in the mining area for at least ten years and may have been exposed, it becomes ideal to evaluate the impacts of these heavy metals mining on hepato-renal parameters. Thus the study evaluated the risk of heavy metal mining on the hepato-renal indices of artisan miners resident in Enyigba community in Eboyi State, Nigeria.

2. Materials and methods

2.1. Study Area

This study was carried out in Enyigba, Abakaliki, Ebonyi state which lies between north latitude 6˚9′ to 6˚14′ and east longitude 8˚5′ to 8˚10′ and covers about 54.56km^2. The city is in the mid of the South Eastern Nigeria and lies within the mineralized zone of lead-zinc deposits of the river Benue trough which stretches hundreds of kilometers North Easterly from Zurak [18].

2.2. Subjects and Sample Collection

This is a cross- sectional study. A total of one hundred and twenty (120) subjects comprising sixty (60) artisan miners that have been residing for 10 years in the mining community, Enyigba, Abakaliki, Ebonyi State, and sixty (60) control subjects who had no history of exposure to heavy metals were selected from Ndubia, a town that is about 145 km from Enyigba. The test subjects were recruited from five mining pits. The control subjects were age and sex matched. The community heads of both communities were approached and their support and approval obtained. Thereafter, adults in both communities were approached and the rationale for the study was explained to them. Those who gave an informed verbal consent were recruited for the study. Participants less than 18 years and have not resided for more than 10 years were excluded in the study. Those with previous or present history of tumor or toxicity and any debilitating illness were also excluded. The same protocol and equipment were used for data collection which was performed in three batches. The researchers trained the field data collectors and supervised collection and collation. The questionnaires were specifically designed to ascertain indices such as age, sex, level of education, marital status, number of years of residence (duration of exposure), and use of safety gadgets among others. Ten (10) mls of venous blood were collected from each subject during morning hours by venipuncture technique from the cubital fossa into well labeled metal-free plain test tubes [19]. Ethical clearance was obtained from the Ethical Committee of the Faculty of Health Sciences and Technology Nnamdi Azikiwe University, Nnewi Campus.

2.3. Biochemical Analysis

Serum electrolytes were determined using ion selective electrode (ISE-SFRI-4000] [20]. Serum bilirubin, urea, creatinine, and, liver enzymes were determined using kits procured from Randox diagnostics, UK.

2.3. Statistics

Data analysis was done using SPSS statistical software version 19.0 while t-test was used to test the statistical significance of intergroup difference. Correlation coefficient was calculated by the Spearman method. All $P \leq 0.05$ was considered statistically significant.

3. Results.

Table 1 represents the levels of serum liver enzymes in the heavy metal exposed and the control subjects. In Table 1, the result shows that there were no significant difference (P>0.05) in the mean serum levels of total and conjugated bilirubin. The mean serum levels of aspartate transaminase, alanine transaminase, and alkaline phosphatase were not significantly different in the heavy metal exposed and control groups (P>0.05).

However, in Table 2, the mean serum levels of sodium, potassium, bicarbonate, and chloride ions were relatively higher in the artisan miners than in the control (P<0.05). The results also show that the mean serum levels of creatinine was significantly higher (P<0.05) in the artisan miners compared to the control while, the mean serum urea concentration was not significantly different between the two groups (P>0.05).

From the results in Table 3, there was progressive non-significant increase in liver enzymes although the artisan miners residing for ≥20 years recorded the highest values. The results also show that there was no significant difference in the mean serum renal parameters with the number of years of exposure (P>0.05) except the mean serum bicarbonate ion which significantly increased with the number of years of exposure (P<0.05).

The results in Table 4 showed non-significant correlation with duration of exposure.

Table 1. Serum levels of some liver enzymes in the artisan miners and control group.

Parameters	Test group (n=60)	Control group(n=60)	t-test	p-value
Total Bilirubin(umol/l)	13.61±3.74	13.54±3.97	0.097	0.923
Conjugated Bilirubin(umol/l)	2.71±1.26	2.87±1.13	-0.647	0.519
Aspartate Transaminase(U/L)	12.06±4.16	12.50±4.28	-0.503	0.616
Alanine Transaminase(U/L)	5.52±2.17	5.43±2.54	0.186	0.853
Alkaline Phosphatase (U/L)	66.13±25.13	59.80±20.31	1.250	0.214
Age (years)	37.43±9.08	35.30±9.59	1.099	0.274

Results are mean ± standard deviation of triplicate readings. Values with *are significant (P<0.05).

Table 2. Serum renal parameters in the artisan miners and control group

Parameters	Test group(n=60)	Control group(n=60)	t-test	p-value
Sodium (mmol/l)	140.53±6.62	139.00±5.32	1.150	0.252
Potassium (mmol/l)	4.39±0.81	4.14±0.74	0.935	0.352
Chloride (mmol/l)	99.60±7.27	99.40±4.28	0.142	0.887
Bicarbonate(mmol/l)	29.18±4.88	27.50±4.46	1.665	0.098
Urea (mmol/l)	4.20±2.39	4.46±2.57	-0.506	0.614
Creatinine (umol/l)	90.33±16.43	77.40±12.84	3.926	<0.001*

Results are mean ± standard deviation of triplicate readings. Values with *are significant (P<0.05).

Table 3. Liver and renal parameters with duration of exposure to heavy metals

Parameters	10-14yrs(n=28)	15-19yr (n=20)	≥20yrs(n=12)	P-values
TB(mmol/l)	13.5±3.9	13.54±3.65	15.8±1.27	0.49
CB(mmol/l)	2.64±1.30	2.73±1.24	3.4±0.53	0.51
AST(mmol/l)	11.95±4.05	12.17±4.31	12.75±5.74	0.92
ALT(mmol/l)	5.5±2.26	5.53±2.13	5.75±1.71	0.98
ALP(mmol/l)	65.20±26.43	68.07±24.11	64.75±15.95	0.88
Na(mmol/l)	140.51±6.95	139.8±5.4	146.25±8.99	0.19
K(mmol/l)	4.46±0.78	4.3±0.88	4.2±0.83	0.61
Cl(mmol/l)	99.7±6.83	99.47±8.47	98.75±4.11	0.96
Ur(mmol/l)	4.36±2.39	3.99+2.49	3.68±1.91	0.72
Cr(mmol/l)	92.73±17.59	85.97±12.90	89.25±21.11	0.19
HCO_3^-(mmol/l)	29.61±5.08	28.47±4.04	28.5±8.19	0.001*

Results are mean ± standard deviation of triplicate readings. Values with *are significant (P<0.05).
Legend:
TB = Total bilirubin; CB = Conjugated bilirubin; AST = Aspartate transaminase; ALT = Alaninne transaminase; ALP = Alkaline phosphatase; Na = Sodium; K = Potassium; Cl = Chloride; Ur = Urea; Cr = Creatinine; $HCO3^-$ = bicarbonate.

Table 4. Correlation of exposure to heavy metals with renal and live parameters

Parameters	n	R	p-value
Duration of exposure vs sodium	60	0.091	0.396
Duration of exposure vs potassium	60	0.151	0.155
Duration of exposure vs chloride	60	-0.129	0.224
Duration of exposure vs bicarbonate	60	-0.035	0.743
Duration of exposure vs urea	60	-0.099	0.355
Duration of exposure vs creatinine	60	-0.181	0.088
Duration of exposure vs total bilirubin	60	0.066	0.535
Duration of exposure vs direct bilirubin	60	0.065	0.544
Duration of exposure vs AST	60	0.068	0.527
Duration of exposure vs ALT	60	0.119	0.263
Duration of exposure vs ALP	60	0.089	0.402

Legend: AST = Aspartate transaminase; ALT = Alanine transaminase; ALP = Alkaline phosphatase.

4. Discussion

The mean serum levels of renal parameters of the artisan miners showed no significant difference when compared with the controls except creatinine which was significantly higher in the artisan miners when compared with the control. Similarly, their concentrations did not differ appreciably when compared with increase in length of exposure except bicarbonate which increased significantly with increase in length of exposure. These findings are in agreement with the findings of Dioka *et al.* [3], who reported a normal level of renal parameters in heavy metal exposed subjects. However, other researchers have reported that occupationally exposed subjects had higher mean blood renal parameters [15,16,21] than their controls. This disparity in the reports may be due to the fact that the kidney is a regenerative organ that is capable of replacing its damaged cells. Renal impairment becomes obvious only when about 50% of the nephrons have been damaged. Thus at that point the levels of serum renal parameters become higher than normal in the blood. Therefore our findings suggest the ability of the kidneys to cope with metabolic stress. A close look at the results shows that there are apparent increases in the level of some renal parameters such as sodium, potassium, chloride, and bicarbonate in the artisan miners population when compared with the control group. The serum level of urea rather tends to decrease in the artisan miners when compared with the control. These apparent increases might be due to increased metabolic burden on the nephrons of the kidney an indication of oxidative stress in line with the report of other researchers [15,16,21]. Other workers have also reported a similar increase in potassium, sodium, bicarbonate and chloride with increase in duration to heavy metals [22]. The established induction of an increase of sodium ion by heavy metal is an indication of activation action on the monovalent cation transport in the plasma.

The observed increases in the levels of creatinine and bicarbonate may be as a result of increased muscle mass wasting associated with the mining activities and its associated air pollution respectively. However, regular monitoring of levels of these parameters may be necessary in order to detect earlier sudden increases that may lead to organ damage.

In Nigeria heavy metal exposure may be an overlooked risk factor for chronic kidney disease. More studies and effort should be made to address the problem of heavy metal pollution in Nigeria with the integration of these measures into preventive programs. Similarly, among the preventive and intervention measures cited by Alebiosu and Ayodele [23] for the control of renal diseases, is the reduction in the exposure to heavy metals. Although, these indicate knowledge and awareness of possible role of some heavy metals in the etiogenesis of some chronic diseases, heavy metal assay as diagnostic guide in patient management is often omitted in most healthcare settings.

Serum levels of liver enzymes are biomarkers of acute hepatic damage thus their bioassay can serve as a diagnostic tool for assessing necrosis of the liver cells. In the present study the serum levels of bilirubin, transaminases and alkaline phosphatase in the artisan miners shows apparent increase when compared with the controls. Their serum levels also increases with the increase in duration of exposure, with alanine transaminase showing higher increase with increase in duration of exposure. These findings do not agree with the findings of Sipos *et al*. [21] and other researchers who reported high levels of liver enzymes in heavy metals exposed subjects. This might be due to differences in the subject of study. Sipos *et al.* [21] worked on animals whereas, the present study is on human subjects. Hepatocytes are capable of regenerating themselves following damage due to metabolic insult. Similarly, the liver function markers tend to respond differently to different heavy metal at different time. Osuala *et al*. [15] reported that cadmium significantly decreases liver enzymes such as ALT, AST, total bilirubin, ALP etc. The observed difference in the reports might also be due to enhanced utilization in corticosteriodogensis and/or a decreased de novo synthesis.

However, the observed apparent increases need to be closely monitored to avoid uncontrollable increases that might lead to liver injury. Many of these enzymes such as aspartate transaminase (AST), alanine transaminase (ALT) and alkaline phosphatase are released from the liver after its cellular damage and failure due to xenobiotics. The liver is the major site of intermediary metabolism and the synthesis of many important compounds, the site of conjugation and detoxification of potentially, toxic substances and the site of storage of glycogen.

5. Conclusion

Despite the apparent mean normal values of the serum renal and liver parameters of the artisan miners, caution must be taken to limit exposure rate among the mining community.

Conflict of Interest

The authors have no conflict of interest with regards to this publication.

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