



Evaluation of some heavy metals concentration in body fluids of metal workers in Kano metropolis, Nigeria



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ABSTRACT

Metal workers in urban Kano constitute a major workforce with a considerable population. The present work was aimed at obtaining baseline data on the extent of metal ion concentration in body fluids (urine and blood) of sampled population in the area. The investigation involves interaction with sampled population as well as blood and urine sample collection for heavy metals analysis. The health problems associated with the practice identified by respondents include: metal fume fever; eye and skin irritation; dizziness and respiratory problems; lack of or inadequate protective devices during activity were also reported. Laboratory investigation of urine samples by Atomic absorption spectrophotometry indicated higher concentrations for Manganese (Mn), Lead (Pb) and Nickel (Ni); in blood samples, there were higher concentrations of Manganese (Mn), Lead (Pb), Chromium (Cr) and Nickel (Ni). Metal workers of urban Kano are at risk because of the concentration of Mn and Pb in particular. There is the need to monitor occupational activities that are responsible for pollution and with serious health risk.

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1. Introduction

The processes of manufacturing metal from ores into final products are operations that require high temperature. During these operations metal fumes that are released into air contain both microscopic and sub microscopic particles. Metal fume is one of the most common sources of such particles. Metallic fume, which is a typical industrial aerosol referred to a complex mixture of materials of the welding rod and metal oxides [1,2].

Metal work is common activity in which up to two percent of the working populations in industrialized countries have been engaged in some forms of metal works [3].

Adverse health effects have resulted by the release of airborne particles into the environment through metal works. Higher incidence of pneumonitis, bronchitis and metal fume fever were reported by metal workers that were permanently exposed to high concentrations of metal fumes [4].

Metal fumes are solid particles that came from the base metal, coatings on the base metal and other metal consumables. These metal aerosols are oxidized and can form small particles made up of a complex mixture of metal oxides on contact with air. Metal

workers are subsequently exposed to these complexes through respiration pathways. The fumes generated from the process of welding are composed of at least 13 metals that include cadmium (Cd), manganese (Mn), mercury (Hg), beryllium (Be), chromium (Cr), iron (Fe), lead (Pb), molybdenum (Mo), nickel (Ni), vanadium (V), zinc (Zn), cobalt (Co) and antimony (Sb) [5]. The chemicals contained in these gases and fumes depend on factors such as: the type of metal being welded, type of welding conducted, ingredients that forms electrode, time and intensity of exposure, presence of coatings on the metal and ventilation [6].

High risk of lung cancer has been associated with occupational exposures to metal fumes. However, the causal relationship is affected by the lack of a clear dose–response and exposure to other agents [7].

Determination of metal concentrations in body fluids is usually used as a biomarker of exposure. Atomic Absorption Spectrometry (AAS) is a suitable technique to monitor metals during occupational exposure with a sensitive and rapid screening method [8].

Metallic work is one of the widespread economic activities in urban Kano. Virtually, most houses, business premises and institutions use these metal products. Most of the workshops are situated either in open spaces or relatively enclosed setting so as to attract more customers. As such, the fumes and the dusts are released into the environment (atmosphere) while the workers are exposed directly to most of the metal dust/fume pollutants. The extent of

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exposure, the levels of metal contaminants in the body or body fluids or tissues of the workers is not documented or even understood in urban Kano. Obviously, these metal workers can have elevated concentrations of some heavy metals in their body which might consequently be above the set standard limit elsewhere.

Valuable data obtained from the present study would provide a baseline information for setting the standard limits to exposure by the relevant body in Kano (The state Ministry of Environment/Health) and would also assist in control measures. The significance of biological exposure to toxic compounds and their effects has become increasingly relevant for establishing occupational and environmental limits of harmful substances such as metals.

The aim of the study was to assess the metals concentration from body fluids of metal workers in Kano metropolis through; surveying the profile of metal workers in Kano metropolis; determination of the concentrations of metals, including cadmium, chromium, lead, manganese and nickel in blood and urine samples of experimental group workers and control group (non metal workers).

2. Materials and methods

2.1. Study area

The study area was Kano state which was located at the northern part of Nigeria. Kano metropolitan encompasses eight local governments. The sampling sites were along both Jakara and Gabari road all located at Kano Municipal.

2.2. Experimental design

Metal workers ($n = 20$) were sampled through random sampling from two major sites within Kano metropolis: Jakara and Gabari roads. The control group ($n = 20$) were selected randomly from the population with no history of exposure to metal fumes. Control groups do not differ from metal workers in gender, age and smoking habits [9].

All subjects were informed of the objective of the study and their consent was obtained. Ethical clearance from ethical committee of the state ministry of health was also obtained.

2.2.1. Questionnaire (design and administration of structured questionnaire)

An interviewer questionnaire was used for general population studies [10]. Data on sex, age, and social habits (e.g smoking and alcohol consumption) were collected. The questionnaire also included data on medical history, such as metal allergy as well as lifetime working experience in the industry, minimum daily working hours with the metals, use and type of exposure protective devices, the place of residence, number of years spent as a metal worker and presence of symptoms of metal contamination so as to ascertain that the effects are from metal works.

2.2.2. Blood samples collection

Blood samples were collected from test subjects in the morning around 7 and 8 am. 5 ml of blood samples were collected through venipuncture. Samples were collected in a royal blue EDTA tube. The collection site on the subject body was washed with soap and water, followed by alcohol (70%) swab. Blood was collected by venipuncture using a phlebotomy needle. EDTA tube was inverted about 8–10 times to prevent clotting. Each specimen tube was attached with an identification label. Specimens were stored at 4 °C [11].

2.2.3. Urine sample collection

Working clothes worn by the test subjects were removed prior to sample collection to prevent incidental dust from contaminating the sample. Subjects washed and dried their hands thoroughly with clean water prior to collecting urine. A clean plastic container for sample collection was used. Hand gloves were used during the collection process so as to prevent contamination. Urine was collected in a 10 ml aliquot tube, tightly covered and properly labeled. Specimens were maintained at 4 °C and taken to the laboratory for subsequent analysis [11].

2.2.4. Determination of metals concentration

Atomic Absorption Spectrometry (AAS) standard solutions for Cr, Cd, Mn, Ni and Pb (Titrisol grades) were used to build up the calibration curve. They were prepared from a stock solution of 1 g L⁻¹ for each metal by successive dilutions with distilled water.

2.2.4.1. Digestion of whole blood. Concentrated nitric acid was added to the blood sample (5 ml) that was stored previously at 4 °C for analysis. Microwave was used for the digestion of the blood samples. For digestion of the samples, 4.0 ml of the sample and 10.0 ml of a mixture of concentrated hydrochloric acid and nitric acids (5 ml conc. HCl + 5 ml conc. HNO₃) were transferred into a 125 ml pressure-resistant bottle. The samples were digested for 4 min at 300 W. The digestion was stopped when a colourless solution was obtained and then it was evaporated to dryness. The solution was diluted to 25.0 ml with de-ionised water [12,13].

2.2.4.2. Digestion of urine. Concentrated nitric acid (1 ml of acid dL⁻¹ of urine) was added to the aliquots that were stored previously at 4 °C for analysis. Microwave was used for the digestion of the urine samples. For digestion of the samples, 5.0 ml of the sample and 10.0 ml of a 1:1 mixture of concentrated hydrochloric acid and nitric acids (5.0 ml conc. HCl + 5 ml conc. HNO₃) were transferred into a 125 ml pressure-resistant bottle. The samples were digested for 4 min at 300 W. The digestion was stopped when the solution became colourless. It was then evaporated to dryness and was diluted to 25.0 ml with de-ionised water [13].

2.2.4.3. Atomization atomic absorption spectrometry analysis

The procedure used was that of [14] using Atomic Absorption Spectrophotometer model 68000 Shimadzu Japan.

2.3. Data analysis

Data analysis was performed using Sigma Stat 3.5 statistical software for Windows as follows: The metals concentrations of test subjects was compared with the control in both blood and urine samples. These were carried out using Students *t*-test. Correlation analysis was carried out to check whether there is a relationship between different variables. All analysis was performed at 5% confidence level.

3. Results and discussion

Table 1 shows the profile, duration of exposure and health history of both metal workers and control groups. The mean age and duration of exposure of the sampled population was highlighted. The protective device used was sun glasses and health problems that result from the work include eye, respiratory and metal fume fever.

Table 2 shows the mean concentration of metals in urine at different exposure rates of metal workers. Pb has the highest concentration while Cd has the least. Among the metals examined, only Mn showed a significant relationship with duration of exposure.

Table 1
Profile and health history of sampled population in Kano metropolis.

Characteristics	Metal workers (n=20)	Control group (n=20)
Age (Yrs)	32.7 ± 12.5	25.4 ± 5.40
Exposure (Yrs)	15.4 ± 11.9	0
Protective devices	Sun glasses (100%)	None
Health problems	89%	None
Eye problems	30%	None
Respiratory complications	74%	None
Metal fever	55%	None

The mean concentration of Mn, Cd and Cr has not exceeded the standard set by ACGIH [15].

Table 3 shows the mean concentration of metals in urine among various age groups of metal workers. Pb has the highest concentration while Cd has the least. All metals do not show a significant relationship with age groups. The mean concentration of Mn, Cd and Cr has not exceeded the standard set by ACGIH [15].

Table 4 shows the mean concentration of metals in blood at different exposure rates of metal workers. Pb has the highest concentration while Cd has the least. All metals do not show a significant relationship with duration of exposure. The mean concentration of Cd has not exceeded the standard set by ACGIH [15].

Table 5 shows the mean concentration of metals in blood among various age groups of metal workers. Pb has the highest concentration while Cd has the least. Mn showed a significant relationship with age groups. The mean concentration of Cd has not exceeded the standard set by ACGIH [15].

Symptoms of metal contamination which include: metal fume fever, dizziness, headache, metal taste, dry cough, flu-like feeling,

eyes and skin irritation were reported in 89% of the metal workers as seen in Table 1. Exposure to metal fumes has been known to cause so many health complications such as shortness of breath, eye and nose irritation. In addition, the respondents with serious severe symptoms confirms seeking medical attention particularly eye problems. It is therefore not surprising because eyes are the major sites of contact with metal fumes. The respondents did not provide any precautionary measures taken other than sun glasses. Perhaps their understanding is that sun glasses shield the eyes from the intensity of the light but do not serve adequate protection from fumes and dusts of metals going into the eyes.

The concentration of five metals was determined in both blood and urine sample of test subjects and control. Lead (Pb) has the highest concentration while Cadmium (Cd) has the least concentration. The sequence of metals concentration can be described as follows: In blood, Pb > Ni > Mn > Cr > Cd while in urine, Pb > Ni > Cr > Mn > Cd both in order of decreasing concentration. The concentration of Mn in blood ranges from 0.0023 mg/l to 0.0276 mg/l and from 0.003 mg/l to 0.0277 mg/l in urine. The concentration of Pb in blood ranges from 0.0127 mg/l to 0.5284 mg/l and from 0.0063 mg/l to 0.4123 mg/l in urine. The concentration of Cd in blood ranges from 0.0001 mg/l to 0.0128 mg/l and from 0.0002 mg/l to 0.0084 mg/l in urine. The concentration of Cr in blood ranges from 0.0013 mg/l to 0.0275 mg/l and from 0.0013 mg/l to 0.0307 mg/l in urine. The concentration of Ni in blood ranges from 0.0015 mg/l to 0.0549 mg/l and from 0.0008 mg/l to 0.0450 mg/l in urine.

The concentration of Mn in blood was higher in 70% of metal workers. The values obtained indicated that it has exceeded the biological limit of 0.01 mg/l as set by ACGIH [15]. Similarly, the concentration of Pb was higher in 44% of metal workers. The con-

Table 2
Mean concentrations (mg/L) of heavy metals in urine at various exposure rates of metal workers in Kano metropolis, 2015.

Exposure (Yrs)	Mn* (mg/l)	Pb** (mg/l)	Cd** (mg/l)	Cr** (mg/l)	Ni** (mg/l)
0–10	0.0072	0.1622	0.0022	0.0147	0.0143
11–20	0.0088	0.1693	0.0022	0.0165	0.0166
21–30	0.0105	0.1514	0.0029	0.013	0.0195
>30ACGIH (2008)	0.0141	0.231	0.003	0.0166	0.0258
	0.03	0.05	0.005	0.025	0.002

* p < 0.05 = significant relationship.

** p > 0.05 = no significant relationship.

Table 3
Mean concentrations (mg/L) of heavy metals in urine among various age groups of metal workers in Kano metropolis, 2015.

Age groups (Yrs)	Mn** (mg/l)	Pb** (mg/l)	Cd** (mg/l)	Cr** (mg/l)	Ni** (mg/l)
15–25	0.0073	0.139	0.0021	0.013	0.0167
26–35	0.0091	0.183	0.0022	0.017	0.0140
36–45	0.0106	0.198	0.0035	0.0142	0.018
>45ACGIH (2008)	0.0112	0.205	0.0027	0.0142	0.021
	0.003	0.05	0.005	0.025	0.002

* p < 0.05 = significant relationship.

** p > 0.05 = no significant relationship.

Table 4
Mean concentrations (mg/L) of heavy metals in blood at different exposure rates of metal workers in Kano metropolis, 2015.

Exposure (Yrs)	Mn (mg/l)	Pb (mg/l)	Cd (mg/l)	Cr (mg/l)	Ni (mg/l)
0–10	0.0136	0.193	0.0018	0.0145	0.0182
11–20	0.0154	0.170	0.0022	0.0124	0.0175
21–30	0.0142	0.207	0.0022	0.0141	0.020
>30 ACGIH (2008)	0.0181	0.223	0.0025	0.0178	0.0253
	0.01	0.2	0.005	0.0005	0.0005

* p < 0.05 = significant relationship.

** p > 0.05 = no significant relationship.

Table 5

Mean concentrations (mg/L) of heavy metals in blood among various age groups of metal workers in Kano metropolis, 2015.

Age groups (Yrs)	Mn [*] (mg/l)	Pb ^{**} (mg/l)	Cd ^{**} (mg/l)	Cr ^{**} (mg/l)	Ni ^{**} (mg/l)
15–25	0.0132	0.1801	0.00176	0.01265	0.01861
26–35	0.01258	0.17	0.002257	0.01409	0.01776
36–45	0.01182	0.1926	0.00161	0.0149	0.01514
>45	0.02253	0.2111	0.00185	0.01634	0.02
ACGIH (2008)	0.01	0.2	0.005	0.0005	0.0005

* $p < 0.05$ = significant relationship.** $p > 0.05$ = no significant relationship.**Table 6**

Mean concentrations (mg/L) of heavy metals in urine among various age groups of metal workers and control groups in Kano metropolis, 2015.

Age groups (Yrs)	Mn ^a	Mn ^b	Pb ^a	Pb ^b	Cd ^a	Cd ^b	Cr ^a	Cr ^b	Ni ^a	Ni ^b
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
15–25	0.0073	0.00902	0.139	0.1504	0.0021	0.00273	0.013	0.0175	0.0167	0.01404
26–35	0.0091	0.0062	0.183	0.1291	0.0022	0.0009	0.017	0.0198	0.014	0.02949
36–45	0.0106	0.0051	0.198	0.1393	0.0035	0.0013	0.0142	0.0251	0.018	0.0825
>45	0.0112	–	0.205	–	0.0027	–	0.0142	–	0.021	–
ACGIH (2008)	0.003	0.003	0.05	0.05	0.005	0.005	0.025	0.025	0.002	0.002

^a Metal workers.^b Control groups.**Table 7**

Mean concentrations (mg/L) of heavy metals in blood among various age groups of metal workers and control groups in Kano metropolis, 2015.

Age groups (Yrs)	Mn ^a (mg/l)	Mn ^b (mg/l)	Pb ^a (mg/l)	Pb ^b (mg/l)	Cd ^a (mg/l)	Cd ^b (mg/l)	Cr ^a (mg/l)	Cr ^b (mg/l)	Ni ^a (mg/l)	Ni ^b (mg/l)
15–25	0.0132	0.008	0.1801	0.125	0.00176	0.00205	0.01265	0.01912	0.01861	0.0295
26–35	0.01258	0.0054	0.17	0.184	0.00226	0.00138	0.01409	0.01484	0.01776	0.0222
36–45	0.01182	0.0093	0.1926	0.2272	0.00161	0.0018	0.0149	0.0055	0.01514	0.0332
>45	0.02253	–	0.2111	–	0.00185	–	0.01634	–	0.02	–
ACGIH (2008)	0.01	0.01	0.2	0.2	0.005	0.005	0.0005	0.0005	0.0005	0.0005

^a Metal workers.^b Control groups.

centration of Pb in blood has exceeded the biological limit of 0.2 mg/l as set by ACGIH [15]. The concentration of Cd in blood was higher in 1.7% of metal workers which exceeded the biological limit of 0.005 mg/l as set by ACGIH [15]. The concentration of Cr and Ni in blood of all metal workers has exceeded the biological limits of 0.0005 mg/l and 0.0005 mg/l respectively as set by ACGIH [15].

The urine concentration of Mn was higher in 85% of the metal workers exceeding the biological limits of 0.003 mg/l as set by ACGIH [15]. Similarly, the concentration of Pb was higher in 85% of metal workers exceeding the biological limit of 0.05 mg/l as set by ACGIH [15]. Concentration of Cd in urine was high in 8% of metal workers exceeding the biological limit of 0.005 mg/l as set by ACGIH [15]. The concentration of Cr in urine was high in 10% of metal workers exceeding the biological limit of 0.025 mg/l as set by ACGIH [15]. However, the urine concentration of Ni was as high as 86% of metal workers exceeding the biological limits of 0.002 mg/l as set by ACGIH [15] (Table 7).

The differences between the concentration of metals in blood and urine of metal workers and control groups were determined by student *t*-test. In blood sample, there was a statistically significant difference in concentration of Mn, Cr and Ni ($p < 0.05$) between metal workers and control group as seen in Table 7. [16] revealed a significant higher concentration of Cr and Ni in whole blood of welders than in control. However, there was no significant difference in concentration of Pb and Cd between metal workers and control. In urine sample, there were no significant differences in concentration of Mn, Pb, Cd, Cr between metal workers and control. However, there was a significant difference in concentration of Ni between metal workers and control groups ($p < 0.05$) (Table 6).

Pearson product moment correlation was performed to determine significant relationship between variables. There were no relationship between metals in blood and urine. There was a relationship between the concentration of Mn in blood and age ($p < 0.05$). For Pb, Cd, Cr and Ni in blood, there were no relationship with age. There was no relationship between the concentration of metals in urine and age ($p > 0.05$).

No relationship was found between the concentration of Mn, Pb, Cd, Cr, Ni in blood and years of exposure ($p > 0.05$). However, there was a relationship between the concentration of Mn in urine and years of exposure ($p < 0.05$) but no relationship was found between other metals and years of exposure for urine ($p > 0.05$).

4. Conclusion

Based on the findings of the study, it was concluded that metal workers of urban Kano have various metals concentration in their urine and blood which also exceeded the minimum biological limit set by ACGIH [15]. The age and years of exposure of the metal workers had played an important role in metal contamination. The presence of Pb and Cd in the control group raised the issue of possible atmospheric spread of some of the metals with serious public health concern. Metal works as currently practiced in urban Kano should be closely monitored by relevant environmental protection agencies such as National Environmental Standards and Regulations Enforcement Agency (NESREA), Federal Environmental Protection Agency (FEPA) and Ministry of Environment etc. The relative ignorance of the metal workers about the health risks they are exposed to as well as the public should be addressed through an articulate occupational safety measures for practitioners.

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