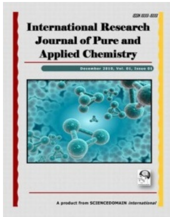

International Research Journal of Pure & Applied Chemistry
5(1): 20-29, 2015, Article no.IRJPAC.2015.003
ISSN: 2231-3443

SCIENCEDOMAIN *international*
www.sciencedomain.org

SCIENCEDOMAIN

A Study of the Bioavailability and Impact of Habits on the Occupational Exposure of Electronic Repairers to Lead (Pb), Cadmium (Cd) and Chromium (Cr) in Kaduna Metropolis-Nigeria

Muhammad Abubakar Lawal[1*], Adamu Uzairu[1] and Muhammad Sani Sallau[1]

[1]Department of Chemistry, Ahmadu Bello University, Zaria, Kaduna, Nigeria.

Authors' contributions

All three authors together designed the study. Author MAL carried out the work and drafted the first manuscript. Authors AU and MSS read and edited the first manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IRJPAC/2015/12580
Editor(s):
(1) Wenzhong Shen, State Key Laboratory of Coal Conversion, Institute of Coal Chemistry, CAS, China.
Reviewers:
(1) Anonymous, University of Alberta, Canada.
(2) Anonymous, St. John's College, Dr Bhim Rao Ambedkar University,Agra, India.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=650&id=7&aid=6006

Original Research Article

Received 8th July 2014
Accepted 14th August 2014
Published 8th September 2014

ABSTRACT

The bioavailability of lead (Pb), cadmium (Cd) and chromium (Cr) in blood and urine samples of electronic repairers in Kaduna-Nigeria was assessed using Fast Sequential Atomic Absorption Spectrophotometry. The mean blood concentrations of Pb, Cd and Cr in the subjects were 29.33±4.80, 7.78±10.57 and 24.78±21.77µg/dL, respectively. The mean urine concentrations of Pb, Cd and Cr were 24.18±2.98, 6.81±10.05 and 14.78±4.20µg/dL respectively. Positive Pearson correlation coefficients were observed between Pb/Cd, Pb/Cr and Cd/Cr in all samples and they indicate the metals are likely from same pollution source. The mean concentrations of the metals in all samples were higher than the WHO, ILO and ACGIH standards, implying the repairers are occupationally exposed and are subject to serious health concerns. Social habits like smoking were found to significantly affect the concentrations of these metals. The level of education, use of safety devices, period of exposure, the nature of electronics and the age of the electronic repairers were also found to remarkably affect the concentrations of the metals. However, the sources of food eaten at work were found to have no significant effects on the levels of the metals present.

**Corresponding author: Email: malawal@abu.edu.ng;*

Keywords: Bioavailability; lead; cadmium; chromium; occupational exposure; electronic repairers.

1. INTRODUCTION

Virtually all occupations have some level of hazards inherent in them. According to the World Health Organization (WHO) report in 1998, there were about 250 million cases of work related injuries through the year worldwide [1]. More recent reports estimate work related diseases at 160 million every year while more than 2.2 million occupational deaths and 250 million industrial accidents occur every year worldwide [2,3]. The cases of work accidents reported in Nigeria was 82 in 2001, 62 in 2002, the figures progressively increased until it peaked in 2005 with 120 cases reported and dropped by half in 2006 with 57 cases [4]. These figures are much smaller compared to the reality on ground as many cases of work accidents are not ever documented or reported [5]. Work accidents or occupational accidents constitute an important cause of sickness and absence in industries, particularly in developing countries [6].

Occupations are a major source of exposure to heavy metals in adults; these occupations are an integral part of human lives since survival is heavily dependent on them. Thirty-eight per cent of the male working population in Nigeria are engaged in agriculture (20% of women) and 56% of the female working population are engaged in sales and service occupations (19% of men). Twenty-one per cent of men and 9% of women are engaged in skilled manual trades and 16% of men and 8% of women in professional and technical jobs [7]. No matter how small the fraction of these metals that pose a threat at the work place, it becomes obviously dangerous considering that most people normally engage in such occupations for a substantial part of their lives (usually to old age) and spend more than 8 hours a day at work especially in poor developing countries.

Exposure to heavy metals was identified as the second most common occupational hazard among female electronic workers in China [8], this occupational exposure of electronic repairers to heavy metals is an important risk factor for cancer [9]. Amyotrophic lateral sclerosis (ALS) (a neurodegenerative disease affecting the motor neurons of the spinal cord and brain) has been reported in workers of electronic manufacturing industry and has been strongly linked to high exposure to lead metal [10]. However, there are virtually no published works on assessment of the occupational hazards of electronic repairers in Nigeria.

Biomarkers such as blood (whole blood) and urine have been used to monitor lead, cadmium and chromium exposure [11-14].

Nigeria, just as most other developing countries lacks accurate and up to date statistical figures on occupational exposure to lead, cadmium and chromium. With a lot of researches conducted on different occupations to assess hazards and exposure; welders [15], nurses [16], auto mechanics, painters [17], sawmill workers [18] e.t.c. there are no reported studies on occupational exposure of electronic artisans, hence this study was conceived. The study was focused at assessing the level of exposure of the repairers to lead (Pb), cadmium (Cd), chromium (Cr) and habits affecting the level of exposure.

2. MATERIALS AND METHODS

Kaduna occupies a central position in the northern part of the Nigeria, with an estimated current population of 7,474,369 in 2013 (using 3.18% growth rate as allowed by the National Population Commission). It shares common borders with Niger, Kano, Bauchi, Plateau, Zamfara and Katsina States and to the South-West, the State shares a border with the Federal Capital Territory, Abuja (the capital of Nigeria) It has a long historical significance as it was the capital of the old northern Nigeria (between 1917 and 1967). The Map of Kaduna state showing the locations of the workshops of electronic repairers (sample collection points) is shown in Fig. 1.

Ten electronic repair shops within Kaduna metropolis were the points of collection of samples from ten (10) volunteer electronic repairers. Although not all areas of the metropolis were covered due to low cooperation, it is hoped that the samples collected and analyzed will be a representation of the real situation.

1ml of whole blood was collected in 5ml EDTA tubes using a stainless needle and syringe. The blood samples were then shaken and frozen till further treatment. 20ml Urine samples were collected in acid-washed, decontaminated 20ml polyethylene tubes. Urine samples were then acidified with reagent grade concentrated HNO_3 (1% v/v) and frozen till further treatment. 0.5ml of blood and urine samples were digested using conventional wet acid digestion as reported by Memon, A-R et al. [19]; 0.5ml of blood and urine was directly taken into a Pyrex flask, 3ml of freshly prepared mixture of concentrated HNO_3-H_2O_2 (2:1, v/v) was added and allowed to stand for 10minutes. The flask was then covered with a watch glass and digested at 60-70ºC for 1-2 hours, the digest was treated with 2ml nitric acid and few drops of H_2O_2, heated on a hot plate for about 80°C until a clear digested solution was obtained. The excess acid mixture was evaporated to a semi-dried mass, cooled and diluted with 0.1mol/dm^3 nitric acid.

The concentrations of the metals were then determined using Varian AA240FS Fast Sequential Atomic Absorption Spectrometer. Validation of the digestion method of analysis used and certification of the instrument as good enough for the analysis was done by carrying out a recovery experiment. This was done by spiking the predigested blood, urine samples with 10cm^3 of multielement metal standard solution (MESS) (20ppm of Pb, Cd and Cr). All statistical analyses were performed using computer Microsoft Excel and SPSS package.

3. RESULTS AND DISCUSSION

The percentage recoveries observed for the metals in the blood samples ranged from 94.73–98.57% and the range in urine samples was 96.45–99.26%. Pb metal had the highest percent recovery in all samples, the trend of the percent recoveries of the metals in the samples was generally Pb>Cr>Cd except in the blood samples where Cd had a greater percent recovery than Cr (Cd=97.01% and Cr=94.73%). Table 1 shows the percent recoveries of the metals in the blood and urine samples. Similar percent recoveries have been reported in different studies by other researchers who used MESS in spiking blood, urine, nail and hair samples to ascertain recoveries; a recovery profile of Pb>Cd in blood samples was reported by Yahaya et al. [20]. The results are also consistent with a range of 93.6 to 107.8% reported for Cr, Cd, Mn, Ni and Pb in whole blood, urine, saliva and hair [21]. Hence, the method of digestion and the instrument of analysis can be said to be suitable for the analyses.

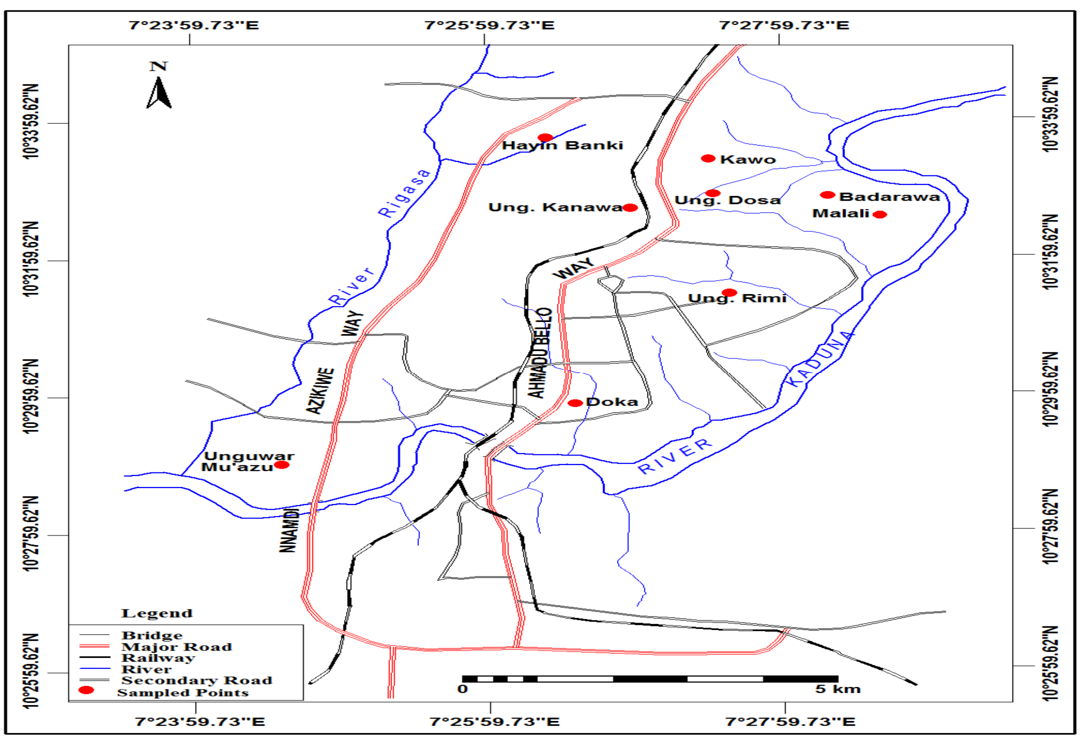

Fig. 1. Map of Kaduna metropolis showing sample collection points

Table 1. The percentage recoveries of Pb, Cd and Cr in blood and urine samples

Metal	Percent recoveries (%)	
	Blood	Urine
Pb	98.57	99.26
Cd	97.01	96.45
Cr	94.73	98.86

Results of Pb, Cd and Cr analyses in blood samples of subjects

The distribution profile of the metals in the blood samples as depicted by Fig. 2 shows Pb metal been generally highest in the blood samples except for subjects 3 and 4 where the Cr levels instead were highest, thus the general trend of the metals in the blood can be said to be Pb>Cr>Cd. The mean Pb concentration in the blood samples of the subjects was observed to be 29.33±4.80µg/dL, with a minimum of 23.40µg/dL observed in subject 7 and a maximum of 39.5µg/dL in subject 3. Several surveys have shown that people who work in lead-related industries have higher blood lead levels than other people [22-26]. The mean blood levels for the occupationally exposed group has been reported to vary between 28.5±17.3 (SD), µg/100ml, (28.5±17.3µg/dL) and 35.5±15 (SD), µg/100ml (35.5±15µg/dL) [17].

The mean Cd concentration in the blood samples was observed to be 7.78±10.57µg/dL with a minimum of 0.50µg/dL observed in subject 8 and maximum of 27.30µg/dL in subject 3. Musa et al. [27] reported a similar value for exposed population in Zaria, Kaduna-Nigeria. A mean Cr concentration of 24.78±21.77µg/dL was observed, the minimum of 0.90 µg/dL observed in subject 8 and maximum of 63.40µg/dL in subject 3.

The peak values of Pb, Cd and Cr observed in subject 3 may not be unconnected to the smoking habit of the subject, the low level of education and awareness coupled with the long period in the job as gathered from the questionnaire issued. Smoking increases the risk of heavy metals concentration in the body and cigarette brands in Nigeria have been linked to high Cd content as reported by Iwegbue [28]. Similar range of concentration of Cd in blood was reported by Njoku and Ibe, they reported a blood Cd range of 0.058-0.0072mgdm^{-3} (equivalent to 0.72-5.8µg/dL) for electronic technicians in Imo state–Nigeria [24].

Correlation coefficients of the metal pairs in the blood samples show a significant positive correlation between Pb/Cd (r=0.765506, at P<0.01), positive correlations were also observed for Pb/Cr pair (r=0.838648, at P<0.001) and Cd/Cr (r=0.853709, at P<0.01). These high positive correlation values indicate the metals are likely from the same source (i.e. pollution source).

The distribution of Pb, Cd and Cr in the urine samples of the subjects are shown in Fig. 3, the distribution shows Pb metal been the highest in all subjects except for subjects 3 and 10 where Cr concentrations were peaked against Pb concentrations, thus the trend can generally be represented as Pb>Cr>>Cd. Subject 3 showed the highest level of Pb of 31.1µg/dL while subject 2 showed the least level of Pb of 21.4µg/dL, the mean value of Pb observed was 24.18±2.98µg/dL. Pb in urine (urine-Pb) is considered to reflect Pb that has diffused from plasma and is excreted through the kidneys [29]. A mean value of 6.81±10.05µg/dL was observed for Cd metal; the highest in subject 4 with a value of 26.10 µg/dL and the least value of 0.50µg/dL observed in subject 2. Cr metal had a mean value of 14.78±14.20µg/dL with a minimum of 0. 00µg/dL (BDL) in subject 8 and a maximum of 40.50µg/dL in subject 3. It could be hypothesised also that, the slightly higher value of Cd observed in the urine sample of subject 4 may also be linked to the smoking habit of subject 4, however, the higher value of Cd observed in the urine sample of subject 4 over subject 3 (inspite of subject 3 having a higher blood Cd level) may be related to the nature of diet and the effectiveness of the excretion of Cd from the body through urine since urinary levels are a reflection of how much metal is being cleared from blood by the kidneys during a relatively brief interval (hours) [29].

Correlation coefficients of the metal pairs in the urine samples show a significant positive correlation between Pb/Cd (r=0.6794, at P<0.01), positive correlations were also observed for Pb/Cr pair (r=0.6606, at P<0.001) and Cd/Cr (r=0.8071, at P<0.01). These positive correlation values indicate the availability of the metals are related and are likely from the same pollution source.

Table 2 shows the concentrations of the metals in the blood and urine samples by the different categories.

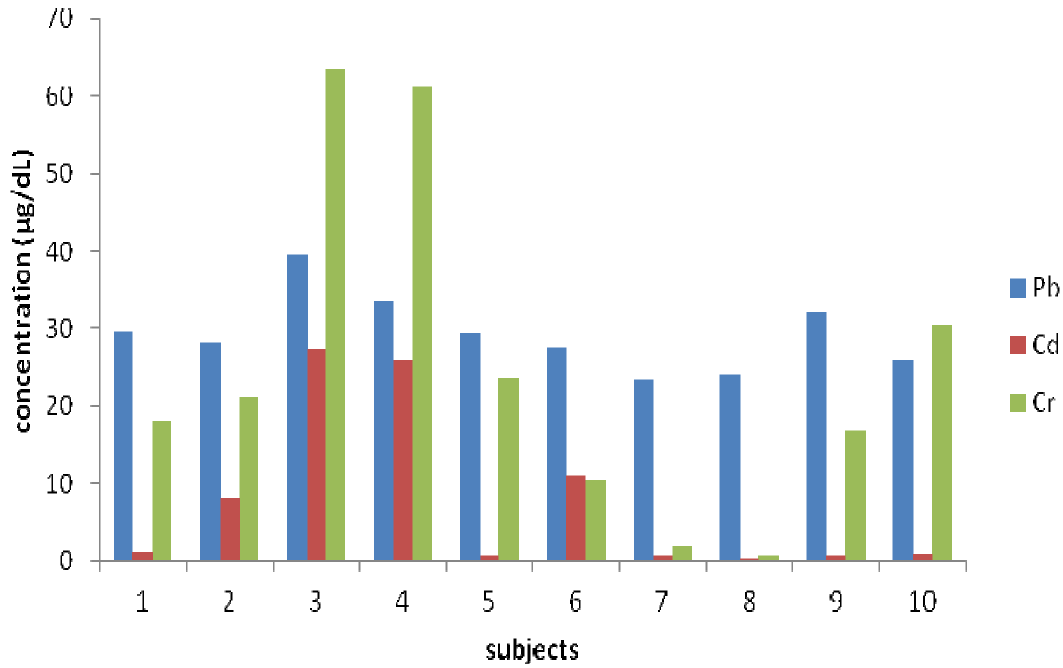

Fig. 2. The distribution of Pb, Cd and Cr (µg/dL) in blood samples of electronic repairers

Results of Pb, Cd and Cr analyses in urine samples of subjects

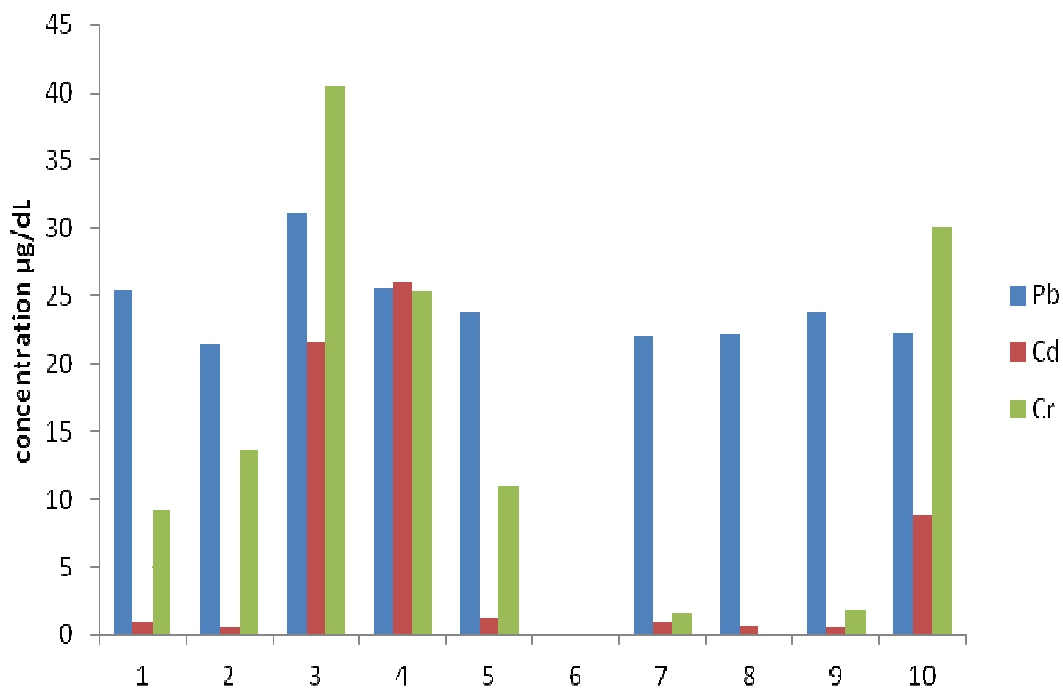

Fig. 3. The distribution of Pb, Cd and Cr (µg/dL) in urine samples of electronic repairers

Concentration of Pb, Cd and Cr in the subjects by the different categories

Table 2. The effects of some factors on the concentration of the metals (µg/dL) in the blood and urine samples

S/N	Category		Blood			Urine		
			Pb	**Cd**	**Cr**	**Pb**	**Cd**	**Cr**
1	Smoking	Yes (n=2)	36.50±4.24	26.60±0.01	62.25±1.63	28.30±3.96	23.80±3.25	32.90±10.75
		No (n=8)	27.54±2.95	3.00±4.00	15.41±10.36	23.00±1.39	1.96±3.03	11.99±10.28
2	Education	Primary school (n=2)	34.40±7.21	14.10±18.67	43.45±28.21	27.50±5.09	11.40±14.28	25.70±20.93
		Secondary school (n=6)	29.50±2.87	8.05±9.75	26.35±18.23	23.66±1.83	7.38±11.04	19.34±8.48
		Diploma (n=2)	23.75±0.50	0.65±0.21	1.40±0.71	22.15±0.07	0.80±0.14	0.80±1.13
3	Brand of electronics	General electronics(n=9)	29.91±4.70	8.59±10.88	28.60±22.46	24.43±3.08	7.58±10.46	16.63±13.98
		Inverter (n=1)	24.10±0	0.50±0	0.90±0	22.20±0	0.70±0	0.00
4	Use of protective devices	Yes (partial) (n=2)	26.80±3.82	0.85±0.95	9.50±12.16	21.80±0.57	0.80±0.14	4.60±6.51
		No (n=8)	29.96±5.02	9.51±11.25	28.60±22.46	24.29±3.30	8.53±10.92	17.69±14.75
5	Duration in the job	<15 years (n=6)	27.82±3.01	3.87±4.58	16.48±9.68	22.98±1.59	2.34±3.62	11.27±11.69
		>15 years (n=4)	31.60±2.87	13.65±7.48	37.23±15.17	25.68±1.93	12.40±6.65	19.17±8.80
6	Age	25-30 (n=5)	27.84±1.51	2.42±1.45	17.68±4.61	22.98±0.71	2.34±1.62	11.27±5.23
		30-35 (n=3)	27.03±1.54	4.17±3.47	11.63±6.55	23.05±0.85	1.00±0.30	5.45±5.45
		35-40 (n=1)	39.50±0	27.30±0	63.40±0	31.10±0	21.50±0	40.50±0
		>40 (n=1)	33.50±0	25.90±0	61.10±0	25.50±0	26.10±0	25.30±0

3.1 Smokers and Non Smokers

As expected the levels of all three metals were significantly higher in smoking electronic repairers than in non smoking repairers as clearly shown in Table 2. This may not be unconnected with the high level of heavy metals in common cigarette brands in Nigeria as reported by Iwegbue et al. and Akpoveta et al. [28,30]. The average content of cadmium in cigarette available in Nigeria is 1.28µg per cigarette and a person who smokes 20 cigarettes per day is estimated to increase his daily cadmium retention by approximately 1µg/day (0.53–1.65µg/day) [31]. Smoking is known to increase blood cadmium level; the American Conference of Governmental Industrial Hygienists notes that smoking is a significant source of cadmium exposure and median levels in blood of smokers are between 1.4 and 4.5µg/L (0.14µg/dL and 0.45) as reported by Kang et al. [32], the Cd values for smokers far exceeds the normal range of Cd for smokers who are not occupationally exposed, this points to a significant contribution of occupational Cd to the total blood Cd level. It could be concluded that smoking in electronic repairers further exposes the workers to these metals and therefore increases the burden of these metals on the body.

3.2 Level of Education

The test subjects were grouped with respect to education into three groups; those with higher education (diploma, degree, e.t.c), those with secondary school education (high school) and those with primary school education or less. The distribution of the metals with respect to level of education can also be seen in Table 2.

The mean values for the concentration of the metals in the subjects based on the level of formal education, show the concentrations of Pb, Cd and Cr significantly decreased as the level of education increased. This indicates, the higher the level of education the better the practice and adherence to safety measures and as well greater hygiene in the work place. The increased education translates into increased awareness and knowledge of the possible dangers of these metals and better knowledge of safe practice. Similar relationship between education and level of exposure awareness was established in a study conducted in Mombasa to assess the health effects of lead exposure among Jua Kali (informal sector) workers: out of those who were aware of lead toxicity, 3 out of a possible 50 were from primary school representing 5%. 3 out of a possible 44 were from secondary school representing 6.8% and 2 out of a possible 11 were from college, representing 18% [33]. The situation among electronic repairers in Nigeria is no different from that of the general population as has been reported, for instance, limited knowledge and awareness of domestic sources of lead exposure and its health effect among the populace in Nigeria has been reported [34].

3.3 Brand of Electronics Specialized In

All but one subject do repairs in general electronics (TV, Radio, pressing iron, household electrical appliances, e.t.c), one of the subjects previously worked on general household electronics but has since switched his practice to coupling and servicing of inverters for about six years prior to this study, the figures for the concentrations of Pb, Cd and Cr obtained from the category specialized in inverters when compared with those specialized in general electronics to date were observed to be lower. Plausible explanation for the decrease in the available and accumulated Pb level may be due to the fact as gathered from the field that dealing in inverters meant less handling and use of solders however increased risk of cadmium from cadmium in batteries. The Pb levels may agree well with this explanation, but the decreased levels of cadmium and chromium observed could not be explained using this argument.

3.4 Use of Protective Devices

The level of safe practice was found to significantly affect the concentration of the metals observed. The subjects who imbibed some safety measures (not adequate) were found to have reasonably lower Pb values and much lower Cd and Cr values. The values of Pb observed in users of safety devices may not be much lower compared to non users, as they leave their hands bare unprotected while working but with gas mask to protect them from Pb dust, the risk of Pb ingestion from hands is still present

3.5 Length of Period in the Job

The distribution of Pb, Cd and Cr based on the length of period in the job is shown also in Table 2. As expected the concentrations of the metals in the blood and urine samples were in direct relation with the number of years in the job; the more the number of years in the job the more frequent and longer the exposure to these metals, hence, the higher the concentrations (for example, the affinity for SH-groups by Cd makes Cd likely to accumulate in keratin-rich tissues like nails and hair and consequent re-introduction into the blood). Buchancova et al. [35] in their work reported 'Cd levels in blood, urine, and hair significantly increased in relation to duration of exposure to industrial metals'.

3.6 Age

The range of the ages of the repairers was between 25 and 45, hence the subjects were grouped into four groups: 25-30, 31-35, 36-40 and 41-45. Pb concentrations in body tissues for example nails have been reported to depend on the subject's age [36]. From the result, a weak relationship which gets stronger with the age is observed between the concentrations of the metals and the age of the subjects i.e. there is a greater tendency of the retention (bioaccumulation) of the metals in the system with age, there is then a subsequent gradual reintroduction of the metals into the blood stream from these stored body compartments. This may be explained by the fact that with age the function of the various systems declines, hence the ability of the body to excrete the ingested metals decreases. Kowal et al. [37] reported similar result for Cd, in the report Cd levels increased with age in urine and all tissues.

4. CONCLUSION

The results of the research show the level of exposure of electronic repairers to lead, cadmium and chromium to be of concern. The concentrations of the metals were high in the repairers; the mean values for all the metals were higher than the World Health Organization and ILO standards. The trend of the metals in the biological samples was generally found to be Pb>Cr>Cd. Personal and social habits like smoking were found to affect the concentrations of these metals. The level of education, use of safety devices, period of exposure (length of period in the job), the nature of electronics and the age of the electronic repairers were also found to remarkably affect the concentrations of the metals. However the source of food eaten at work was found to have insignificant effects on the levels of the metals present.

5. RECOMMENDATION

Maintaining an adequate level of hygiene greatly reduces the risk of exposure to the metals. It is therefore advised that there should be a separate area where eating and drinking can be done without risking contamination by lead and other metals, a working cloth should be provided which should remain within the facility to avoid 'taking home' these metals from work. The working area should be properly ventilated and kept clean. Rich diets in protein, vegetables, iron and calcium should eaten regularly by electronic repairers as low dietary concentrations of calcium and protein promote absorption of metals like cadmium from the intestinal tract of experimental animals Friberg et al. [38].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World Health Organization. Life in the 21st century a vision for all. The world health report, Geneva; 1998.
2. Bankole RA, Ibrahim LO. Perceived influence of health education on occupational health of factory workers in Lagos State, Nigeria. British Journal of Arts and Social Sciences. 2012;8(1):57-65.
3. International Labour Organisation (ILO). Introduction to Occupational Health and Safety. 2011. Assessed 22 December; 2012. Available:http://actav.itcilo.org/actavenglish/teclearn/osh/intro/inmain.htm.
4. International Labour Organisation (ILO). Nigeria: Report of the National Occupational Safety and Health Information Centre (CIS) Geneva, Switzerland. 2006. Assessed 22 December 2012. Available: http://ilo.org/legacy/english/protection/safework/cis/.../pnga_mlpid.pdf.
5. Omokhodion F. Occupational health in Nigeria. Occupational Medicine. 2009;59(3): 201.
6. Asogwa SE. Guides to occupational health practice 1st ed, Enugu fourth dimension publishing company; 1978.
7. National Population Commission (NPC) [Nigeria]. 'Nigeria Demographic and Health

Survey2003' Calverton, Maryland: National Population Commission and ORC Macro; 2004.

8. Yu W, Lao XQ, Pang S, Zhou J, Zhou A, Zou J, Mei L, Yu IT. A survey of occupational health hazards among 7,610 female workers in China's electronics industry. Archives of Environmental and Occupational Health. 2013;68(4):190-195.
9. 't Mannetje A, Bencko V, Brennan P, Zaridze D, Szeszenia-Dabrowska N, Rudnai P, Lissowska J, Fabiánová E, Cassidy A, Mates D, Foretova L, Janout V, Fevotte J, Fletcher T, Boffetta P. Occupational exposure to metal compounds and lung cancer: Results from a multi-center case-control study in Central/Eastern Europe and UK. Cancer Causes Control. 2011;22(12):1669-1680.
10. Oh SS, Kim EA, Lee SW, Kim, MK, Kang SK. A case of amyotrophic lateral sclerosis in electronic parts manufacturing worker exposed to lead. Neuro toxicology. 2007;28(2):324-327.
11. Foo SC, Khoo A, Heng A, Chua LH, Chia SE. Metals in hair as biological indices for exposure. International Archives of Occupational and Environmental Health. 1993;65(1):583-586.
12. Jarup L, Elinder CG, Spray G. Cumulative blood-cadmium and tubular proteinuria: A dose–response relationship. International Archives of Occupational and Environmental Health. 1988;60:223–229.
13. Manton WI, Malloy CR. Distribution of lead in body fluids after ingestion of soft solder. Britian Journal of Industrial Medicine. 1983;40(1):51-57.
14. Stridsklev IC, Schaller KH, Langård S. Monitoring of chromium and nickel in biological fluids of stainless steel welders using the flux-cored-wire (FCW) welding method. International Archives of Occupational and Environmental Health. 2004;77(8):587-591.
15. Sabitu K, Ilyasu Z, Dauda MM. Awareness of occupational hazards and utilization of safety measures among welders in Kaduna Metropolis, northern Nigeria. Annals of African medicine. 2009;8(1):46-51.
16. Amosu AM. The level of knowledge regarding occupational hazards among Nurses in Abeokuta, Ogun state Nigeria. Current research journal of biological sciences. 2011;3(6):586-590.
17. Fatoki OS, Ayoade D. Lead assay in blood of occupationally and non-occupationally exposed donors. International Journal of Environmental Health Research. 1996;6(3):195-200.
18. Osagbemi GK, Rukayat TL, Aderibigbe SA. Awareness of occupational hazards, health problems and safety measures among sawmill workers in North Central Nigeria. TAF Preventive Medicine Bulletin. 2010;9(4):325-328
19. Memon A-R, Kazi TG, Afridi HI, Jamali MK, Arain MB, Jalbani N, Syed N. Evaluation of Zinc status in whole blood and scalp hair of female cancer patients. Clinica Chimica Acta. 2007;379(1-2):66-70.
20. Yahaya MI, Shehu A, Dabai FG. Efficiency of extraction of trace metals from blood samples using wet digestion and microwave digestion techniques. Journal of Applied Science and Environmental Management. 2013;17(3):365-369.
21. Olmedo P, Pla A, Hernández AF, López-Guarnido O, Rodrigo L, Gil F. Validation of a method to quantify chromium, cadmium, manganese, nickel and lead in human whole blood, urine, saliva and hair samples by electrothermal atomic absorption spectrometry. Analytica Chimica Acta. 2010;659(1-2):60-67.
22. Bagci C, Bozkurt AI, Cakmak EA, Can S., Cengiz B. Blood lead levels of the battery and exhaust workers and their pulmonary function tests. International Journal of Clinical Practice. 2004;58:568–572.
23. Bener A, Almehdi AM, Alwash R, Al-Neamy FRM. A pilot survey of blood lead levels in various types of workers in the United Arab Emirates. Environment International. 2001;27:311–314.
24. Njoku PC, Ibe FC. Heavy metals accumulation in electronic technicians in Imo state. Journal of Chemical Society of Nigeria. 2009;34(1):20-22.
25. Suwansaksri J, Teerasart N, Wiwanitkit V, Chaiyaset T. High blood lead level among garage workers in Bangkok, public concern is necessary. Bio Metals. 2002;15:367–370.
26. Whittaker SG. Lead exposure in radiator repair workers: A survey of Washington State radiator repair shops and review of occupational lead exposure registry data. Journal of Occupational and Environmental Medicine. 2003;45:724–733.
27. Musa A, Garba M, Yakasai IA, Odunola MT. Determination of blood levels

of cadmium and zinc in humans from Zaria, Nigeria. New Clues in Sciences. 2011;2:49-54.
28. Iwegbue CM, Nwajei GE, Eguavoen O. Metal distribution in some brands of cigarette ash in Nigeria. Journal of Environmental Science and Engineering. 2009;51(2):93-96.
29. Barbosa F, Tanus-Santos JE, Gerlach RF, Parsons PJ. A critical review of biomarkers used for monitoring human exposure to lead: Advantages, limitations and future needs. Environmental Health Perspective. 2005;113(12):1669-1674.
30. Akpoveta OV, Osakwe AS, Egharevba F, Osaro KI, Akpoveta AV, Osazuwa EJ, Okoh EB, Okwagi P, Aweatefe JK, Odjighere M, Weltime OM. A comparative evaluation and toxicity assessment of heavy metals in commonly smoked cigarette brands and local tobacco snuff purchased and consumed in Nigeria. Research Journal of Environmental Toxicology. 2011;5:359-368.
31. Nnorom IC, Osibanjo O, Oji CJ. Cadmium determination in cigarettes available in Nigeria. Afri J. Biotech. 2005;4(10):1128-1132.
32. Kang, MY, Cho, SH, Lim, YH, Seo, JC, Hong YC. Effects of environmental cadmium exposure on liver function in adults. Occupational and Environmental Medicine. 2013;70(4):268-273.
33. Ashraph JJ, Kinyua R, Mugambi F, Kalebi A. Health effects of lead exposure among Jua Kali (informal sector) workers in Mombasa, Kenya: A case study of the "Express" Jua Kali workers. International Journal of Medicine and Medical Sciences. 2013;5(1):24-29.
34. Adebamowo EO, Agbede OA, Sridhar MKC, Adebamowo CA. An examination of knowledge, attitudes and practices related to lead exposure in south western Nigeria. BMC Public Health. 2006;6:82.
35. Buchancova J, Vrlik M, Knizkova M, Mesko D, Holko L. Levels of selected elements (Fe, As, Cd, Pb, Zn, Mn) in biological samples from ferrochromium workers. Bratislavské lekárske listy. Bratislava Medical Journal. 1993;94:373–386.
36. Nowak B, Chmielnicka J. Relationship of lead and cadmium to essential elements in hair, teeth, and nail of environmentally exposed people. Ecotoxicology and Environmental Safety. 2000;46:265-274.
37. Kowal NE, Johnson DE, Kraemer DF, Pahren HR. Normal levels of cadmium in diet, urine, blood, and tissues of inhabitants of the United States. Journal of Toxicology and Environmental Health. 1979;5(6):995-1014.
38. Friberg L, Kjellstrom T, Nordberg G, Piscator M. Cadmium in the environment-II; A toxicological and epidemiological appraisal, US Environmental Protection Agency. Washington DC; 1975.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=650&id=7&aid=6006