Available online at www.elixirpublishers.com (Elixir International Journal)

Pollution

Elixir Pollution 162 (2022) 55979-55983

ISSN: 2229-712X

Assessment of Human Specimen Heavy Metals of Some Selected E-Waste Miners in Ghana

Sam, A. and Duncan, B
Department of Chemistry Education, University of Education, Winneba-Ghana.

ARTICLE INFO

Article history:
Received: 6 December 2021;
Received in revised form:
9 January 2022;
Accepted: 17 January 2022;

Keywords
Assessment,
Heavy-Metals,
E-Miners,
Human Health,
Digestion.

ABSTRACT

The purpose of this study was to assess the heavy metals in blood and urine samples of some selected electronic miners (e-miners) in Accra-Ghana. An assessment of heavy metal concentrations in exposed workers is essential in order to monitor and reveal the impact of these metals on human health. Fifty (50) samples of human blood and urine were taken to the laboratory and stored at 4°C until digestion and analysis processes. The results obtained showed that, generally, respondents had more amounts of Cu in their urine (Mean = 0.1844, SD = 0.1245), Cr (Mean = 3.373, SD = 0.8229) in their blood. The study concluded that there is the need for immediate intervention by government and stakeholders for the sake of the community and environment at large. Based on the findings it was recommended immediate government intervention in terms of controlling and regulating the activities of the metal scrap miners with regards to both means of collection and disposal/burning. Further, NGOs, corporate organisation and individuals with the necessary resources can provide capacity training for the elderly involved with such trades. Finally, the capacity of the metal scrap recycling plant has to be enlarged or more of such plants should be built by the government.

Introduction

According to Okoro, Alao, Adebayo and Basheer (2015), a heavy metal is any metal or metalloid of environmental concern. The term originated as a result of the harmful effects of cadmium, mercury and lead, all of which are denser than iron. It has since been applied to any other similarly toxic metal, or metalloid such as arsenic, regardless of density (Abdulrehman, et al., 2012). These toxic metals can be found in used or slightly used electrical and electronic appliances dumped in some African countries like Ghana.

Most people in Ghana cannot afford to buy brand new electrical and electronic appliances which have a longer life span and so depend on these “slightly used” ones, what is popularly termed “second-hand” or “home use” in Ghana. These electrical and electronic appliances which are imported from developed countries are cheaper than new appliances but have a shorter life span. After a few months or even days, these second hand or slightly used electrical and electronic appliances become obsolete and are disposed-off by their users most of whom discard these appliances, also known as e-waste, on refuse dumps where e-waste scavengers collect them. E-waste scavengers go through refuse dumps in Accra and its surrounding towns and gather these e-wastes. Indeed, some residents sometimes deliberately reserve or keep their e-waste and sell them to these e-waste merchants, who also sell to individuals and industries to earn some income.

E-waste products contain intricate blends of plastics and chemicals which when not properly handled can be harmful to people and the environment (Adaramodu, Osunogum & Ehi-Eromosele, 2012). Adaramodu, et al (2012) continued that it is estimated that 20-50 million tons of electric and electronic waste are generated per year out of which 75-80% is shipped to countries in Asia and Africa for recycling and disposal. In these countries recycling of e-waste is performed with limited and often no environmental or worker health precautions.

In Ghana second-hand electrical and electronic equipment imports such as mobile phones, television sets, computers, stereos and radios set frequently come from Europe and North America, and this flow of equipment has increased by nearly a factor of three between 2003 and 2008 (Amoyaw-Osei et al., 2011). While some of these pieces of electronic and electrical equipment could be sold for reuse, not all of the devices imported during this time were useful. For example, approximately 30–40% of all electronics imported into Ghana were non-functional (Amoyaw-Osei et al., 2011; Schluep et al., 2011), and of these approximately 50% were repaired locally and sold, while the other 50% was deemed unusable and became designated as e-waste, which amounted to approximately 40,000 tonnes of imported e-waste in 2010 (Schluep et al., 2011).

In recent years, Agbogbloshie has come under media scrutiny due to the negative health and safety conditions at the site. In 2013, the site was ranked among the world’s top ten toxic threats by the Blacksmith Institute and Green Cross Switzerland (Bernhardt & Gysi, 2013). The aim of the present investigation is to determine the level of heavy metal pollutants such as cadmium, chromium, copper, mercury and lead in the blood, nail and urine samples of people working at the E-waste site at Agbogbloshie, Ghana. Almost all electrical and electronic appliances in Accra end up at the e-waste site at Agbogbloshie (a suburb and slum in the Capital) where they are burnt in the open to extract copper metals. Even though the site has not been designated as a dumping site for

Tele:
E-mail address: arkofuls@yahoo.co.uk

e-waste by the Accra Metropolitan Assembly, it has unofficially been accepted as the e-waste site for Accra, so almost everything e-waste ends up there.

A cross-sectional study was conducted at the Agbogbloshie e-waste dumpsite, one of the largest informal recycling sites for e-waste in Africa, located in Accra, the capital of Ghana. About 40,000 people live and work in this highly polluted environment, permanently laden with dense smokes from the burning of e-waste. While used electrical equipment, such as obsolete computers, refrigerators and old television sets, are manually dismantled at numerous small workshops, and plastic materials, including coated wires and cables, are also burned using scattered open fires in order to retrieve valuable metals (Feldt, et al 2014).

Men, both young and old work on this e-waste site and are directly exposed to heavy metals that may be associated with the burning of the appliances. An assessment of heavy metal concentrations in exposed workers is essential in order to monitor and reveal the impact of these metals on human health. The objectives were to (1) identify the heavy metals in the blood and urine samples of e-waste miners; (2) assess the concentration of heavy metals in the blood and urine samples of e-waste miners.

Methodology

Study Area

Accra with a population of about 4 million is the capital of Ghana [population of about 29.77 million (2018)] million) and the largest city in terms of industrial establishment and infrastructural development. Over 70% of Ghana's manufacturing capacity is located in Accra. Agbogbloshie scrap market located in Accra is the main center for the recovery of materials from e-waste. Situated on the bank of the Odaw River and in the upper reaches of the Korle Lagoon, the Agbogbloshie site started as a food stuff market for onions and yam. Over the years, it grew into a slum with people dealing in all kinds of scrap on a large scale. The scrap dealers discovering the place as a good location for business later registered with the National Youth Council as the Scrap Dealers' Association of Ghana, and the land was leased to them in 1994 (Amoyaw-Osei et al., 2011).

The scrap yard has grown steadily into a popular recycling area and is reputed to be the dumping ground for disused computers, TVs, and other electronic and electrical devices as well as household waste. Thus, to date, Agbogbloshie has become the hub of informal ‘recycling’ industry in Ghana. People trying to make ends meet manually disassemble components and heavily pollute the area through the burning of cables and smashing of computer monitors and other electronic devices to retrieve metals and Cu from plastics in which they are encased to sell.

While they busily and incessantly burn the cables, the immediate environment is engulfed in thick black smoke, which takes hours to clear. Because it is a continuous act done daily, there is no respite for people living in the environs or those who move in and out of the area. Much of this activity is carried out by young men, mostly using rudimentary tools and with no protective equipment. The map of the study area in Ghana is illustrated in Figure 1.

Ghana has an unregulated and unrestricted import regime for second hand electrical and electronic equipment (EEE). Therefore, any e-waste could enter the country under the guise of second hand EEE without detection. The demand for EEE in Ghana continues to grow by the day and in 2009, the EEE imports into Ghana added up to 215,000 tons and a per capita import of 9 kg (Amoyaw-Osei et al., 2011). Most of the e-waste comes from Europe and North America (Amoyaw-Osei et al., 2011).

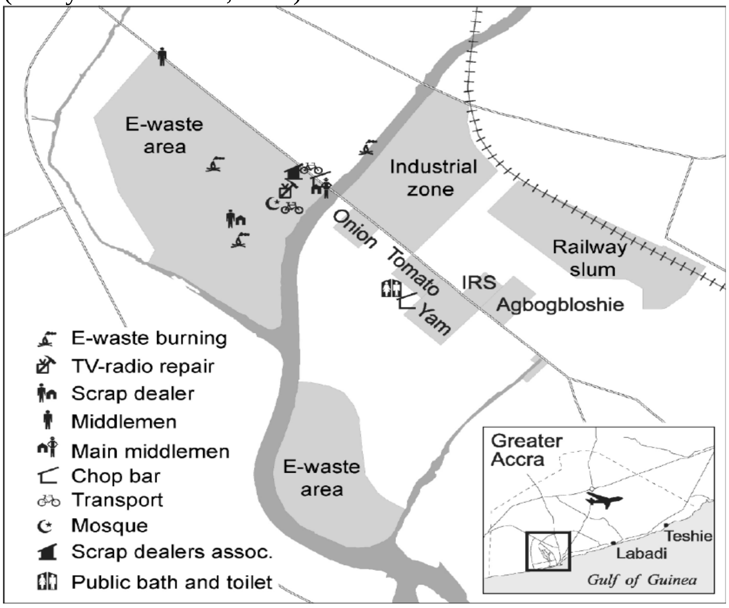

Figure 1. Map showing Agbogbloshie e-waste site
Source: Grant and Oteng-Ababio, 2012.

Sample and sampling method

The samples under investigation were collected from Agbogbloshie, Accra. The study protocol was approved by the University of Education, Winneba and permission was obtained from the Accra Metropolitan Assembly (AMA) and the Environmental Protection Authority (EPA) in Ghana. A total of fifty (50) healthy adult e-waste miners were involved in the study. These volunteers were taking through a sensitisation exercise on the research being conducted and the importance of it. Participants were then given the opportunity to ask questions before taking their samples.

Questionnaire surveys were administered to all the participants under informed consent. The data collected from the survey were name, age, gender, weight, height, body mass index, temperature, blood pressure. The following information was also sought, duration of working on e-waste site, whether there was any frequent ailment, whether they used any form of protection and other information the participant wanted to willingly give to the researchers.

✓Aliquots of 4ml of whole blood sample with EDTA anticoagulant were taking from each volunteer using sterilized syringe.

✓Volumes of about 10ml of urine were collected into a sterilized urine container.

Samples were taken to the chemistry laboratory of the Ghana Atomic Energy Commission (GAEC) and stored at 4°C until digestion and analysis processes.

Blood Sample preparation

Digestion Protocol Using SINOE JUPITER-A Microwave Acid Digestion

0.5g of blood sample was weighed into a previously acid washed labelled 100ml polytetrafluoroethylene (PTFE) Teflon bombs. Next, 7 ml of concentrated nitric acid (HNO_3, 65%), was added to each sample in a fume chamber. The samples were then loaded on the microwave carousel. The vessel caps were secured tightly using a wrench. The complete assembly was microwave irradiated for 25 minutes using SINEO JUPITA-A microwave digestion programme as stated in Table 1.

Table 1. Digestion Programme

Step	Temp T/ ^oC	Time (t)/min	Power of 8-10 vessel (W)/w
1	130	10	400
2	150	5	400
3	180	10	400

Source: Shangai Sineo Microwave Chemistry Technology Co. Ltd. January 2015

After digestion in Table 1, the Teflon bombs mounted on the microwave carousel were cooled in a water bath to reduce internal pressure and allow volatilized material to re-stabilize. The digestate was made up to 20ml with double distilled water and assayed for the presence of Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg) and Lead (Pb), using VARIAN AA 240FS- Atomic Absorption Spectrometer in an acetylene air flame.

Urine sample preparation

Digestion Protocol for Using SINOE JUPITA-A Microwave Acid Digestion

5ml of Urine sample was weighed into a previously acid washed labelled 100ml polytetrafluoroethylene (PTFE) Teflon bombs. Next, 6ml of concentrated nitric acid (HNO_3, 65%), 0.4 ml perchloric Acid ($HClO_{4,}$ 70%) was added to each sample in a fume chamber. The samples were then loaded on the microwave carousel. The vessel caps were secured tightly using a wrench. The complete assembly was microwave irradiated for 25 minutes using SINEO JUPITA. After the digestion, the Teflon bombs mounted on the microwave carousel were cooled in a water bath to reduce internal pressure and allow volatilized material to re-stabilize. The digestate was made up to 20ml with double distilled water and assayed for the presence of Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg) and Lead (Pb) using VARIAN AA 240FS- Atomic Absorption Spectrometer in an acetylene- air flame. Reference standards used for the elements of interest, blanks and duplicates of samples were digested the same conditions as the samples. These served as internal positive controls. Reference standards used were from Fluka Analytical, Sigma-Aldrich Chemie GmbH.

Quality Control and Quality Assurance techniques were used during the analysis. Blanks were prepared to check on contamination during sample preparation. Also, duplicates were done to check the statistical reproducibility (standard deviation < 8%) of the method.

Results and Discussion

Analysis of metals in Blood of respondents

The results from the analysis of responses regarding the analysis of metals in the blood of respondents are presented. Blood samples of respondents were tested to determine the residual deposits of Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg) and Lead (Pb) that existed for respondents as stated in Table 2.

Table 2. Analysis of metals in Blood of respondents

Metal	Mean	Std. Dev.	Concentration of metals		Permissible level (OSHA)
			Min/mg/L	**Max/mg/L**	
Cr	*3.37 ±0.116	0.823	2.08	4.88	0.50
Cd	*0.09 ±0.006	0.040	0.08	0.36	0.30
Cu	*1.73 ±0.201	1.422	0.12	3.80	0.10
Pb	*1.09 ±0.154	1.087	0.004	2.64	0.05
Hg	*0.27 ±0.059	0.420	0.04	1.40	0.10

Source: Field data (2020); N=50; *Error for each estimate represents 95% confidence limits

Table 2 shows respondents had more amounts of Cr (Mean = 3.37 ±0.116, SD = 0.822) in their blood. This was followed by dominant amounts of Cu (Mean = 1.73 ±0.201, SD = 1.422), Pb (Mean = 1.09 ±0.154, SD = 1.087), Hg (Mean = 0.27 ±0.059, SD = 0.419) and Cd (Mean = 0.09 ±0.006, SD = 0.0398). Further frequency analysis of responses regarding the deposits of Cr in the blood of respondents showed that 28 respondents, representing 56% of the sample, had deposits as low as 2.36 mg/L of Cr in their blood and as high as 4.76 mg/L of Cr in their blood. As noticed, this left 22 respondents, who made up 44% of the sample, who had deposits of Cr in their blood as low as 2.08 mg/L and as high as 4.88 mg/L.

Further frequency analysis regarding the deposits of Cd in the blood of respondents showed that 48 respondents, representing 96% of the sample, had 0.08 mg/L of Cd in their blood. This left 2 respondents, who made up 4% of the sample, and had between 0.012 mg/L and 0.36 mg/L of Cd in their blood. Additional analysis of Cu in the blood of respondents showed that 31 respondents, representing 62% of the sample, had significant amounts of Cu in their blood. The results showed that these respondents had as low as 0.12 mg/L of Cu in their blood and as high as 3.44 mg/L of Cu in their blood. This left 19 respondents, representing 38% of the sample, who had deposits of Cu as low as 0.24 mg/L and as high as 3.8 mg/L in their blood. Subsequently, analysis of Pb in the blood of respondents showed that 44 respondents, representing 88% had deposits of Pb as low as 0.004 mg/L in their blood and as high as 2.64 mg/L in their blood. This left 6 respondents, who made up 12% of the sample, and had deposits of Pb as low as 1.48 mg/L in their blood and as high as 2.56 mg/L of Pb in their blood.

The results can also be compared to levels reported from national biomonitoring programs elsewhere. Despite being within a "normal range" according to Iyengar and Woittiez (1988), the blood Cd and Pb levels were elevated compared to the OSHA permissible levels. For example, the mean value reported here for Cr and Cu were 7.0 and 17.0-fold higher, respectively, than corresponding OSHA value reiterated in Table 2.

Finally, analysis of Hg in the blood of respondents showed that 43 respondents, representing 86% of the sample had deposits of Hg as low as 0.04 mg/L in their blood and as high as 1.36 mg/L in their blood. This left 7 respondents, who made up 14% of the sample, and deposits of Hg as low as 0.14 mg/L in their blood and as high as 1.4 mg/L in their blood. The Pb and Hg detected were also higher in 21.8 and

Table 3. Analysis of metals in urine of e-waste miners.

Heavy Metals	Mean	Std. Dev.	Concentration of metals		Permissible level (OSHA)
			Min/mg/L	**Max /mg/L**	
Cr	*0.17 ±0.024	0.168	0.004	0.592	0.5
Cd	*0.16 ±0.041	0.287	0.008	0.708	0.3
Cu	*0.18 ±0.018	0.125	0.012	0.372	0.1
Pb	*0.02 ±0.004	0.030	0.004	0.136	0.05
Hg	*0.01 ±0.0008	0.006	0.004	0.028	0.1

Source: Field data (2020); N=50; **Error for each estimate represents 95% confidence limits*

3.0-fold higher than the OSHA levels set in this study. However, the only body micronutrient (Cd) recorded a value lower than its corresponding permissible level. Both Pb and Cd have been detected at elevated levels in the region's dust (Atiemo et al., 2012), sediment (Chama et al., 2014), and soil/ash (Otsuka et al., 2012), all of which according to these authors are likely exposure sources.

Analysis of metals in Urine of respondents

In this section, the results from the analysis of responses regarding the analysis of metals in the Urine of respondents are presented. Respondents' urine was tested to determine the amounts of Chromium (Cr), Cadmium (Cd), Copper (Cu), Lead (Pb) and Mercury (Hg). This is reflected in Table 3.

The result from Table 3 shows that, generally, respondents had more amounts of Cu in their urine (Mean = 0.18 ±0.018, SD = 0.125). This was followed by dominant amounts of Cr (Mean = 0.17 ±0.024, SD = 0.168), Cd (Mean = 0.16 ±0.041, SD = 0.287), Pb (Mean = 0.02 ±0.004, SD = 0.030) and Hg (Mean = 0.01 ±0.0008, SD = 0.006). Further frequency analysis of responses regarding the deposits of Cr in the urine of respondents showed that 13 respondents, representing 26% of the sample, had 0.004 mg/L of Cr in their urine. This was followed by 4 respondents, who made up 8% of the sample, who had 0.012 mg/L of Cr in their urine. Again 3 respondents, representing 6% of the sample, had 0.204 mg/L of Cr in their urine. This left about 30 respondents who had between 0.08 mg/L and 0.592 mg/L of Cr in their urine.

Furthermore, frequency analysis regarding the deposits of Cd in the urine of respondents showed that half of the respondents, representing 50% of the sample, had 0.008 mg/L of Cd in their urine. This was followed by 4 respondents, representing 8% of the sample, who had 0.012 mg/L of Cd in their urine. The results also showed that 4 respondents also had 0.024 mg/L of Cd in their urine. This left 21 respondents, who made up 34% of the sample, and had between 0.016 mg/L and 0.708 mg/L of Cd in their urine.

Analysis of Cu in the urine of respondents showed that 19 respondents, representing 38% of the sample, had significant amounts of Cu in their urine. The results showed that these respondents had from 0.012 to 0.372 mg/L of Cu in their urine. This left 31 respondents, representing 62% of the sample, who had deposits of Cu as low as 0.0012 mg/L and as high as 0.372 mg/L in their urine. Additional analysis of Pb in the urine of respondents showed that 37 respondents, representing 74% had 0.004 mg/L in their urine. This left 13 respondents, who made up 26% of the sample, and had between 0.008 mg/L of Pb and 0.136 mg/L of Pb in their urine.

Finally, analysis of Hg in the urine of respondents showed that 40 respondents, representing 80% of the sample had 0.04 mg/L of Hg in their urine. This left 10 respondents, who made up 20% of the sample, and had between 0.012 mg/L and 0.028 mg/L of Hg in their urine.

In our current study, from the Urinary data in Table 3, when this was compared to the study by Srigboh et al. (2014) who previously measured several urinary elements in 58 male e-waste Agbogbloshie workers sampled in 2014, April; there were 4 urinary elements common between our studies, and of these the mean values reported by Srigboh, et al. (2014) for Cr, Hg and Pb were within the OSHA permissible range we report here. Specifically, for urinary Cu, the mean level reported 2-times higher than the OSHA permissible level. The reasons for these higher exposures were not clearly stated in other studies. For urinary Cu, we noted that 38% of the participants had levels exceeding 0.1mg/L, a permissible value reported by the OSHA in Table 3, and this elevated value should be of possible health concern to the respondents.

Conclusions and Recommendations

The study intended to determine the metal deposits in specific body parts of scrap dealers at Agbogbloshie market in Accra. The study gathered data by collecting blood and urine samples of respondents and determined the amounts of Chromium (Cr), Cadmium (Cd), Copper (Cu), Lead (Pb) and Mercury (Hg) in those samples. Results obtained showed that, generally, respondents (e-waste miners) had more amounts of Cu in their urine (Mean = 0.184 ±0.018, SD = 0.125). This was followed by dominant amounts of Cr (Mean = 0.170 ±0.024, SD = 0.168), Cd (Mean = 0.163 ±0.041, SD = 0.287), Pb (Mean = 0.016 ±0.004, SD = 0.030) and Hg (Mean = 0.007 ±0.0008, SD = 0.0061). The results obtained showed that, generally, respondents had more amounts of Cr (Mean = 3.373 ±0.116, SD = 0.823) in their blood. Therefore, although Cr was found more often in the blood and urine of respondents, other metals like Cu were also dominant in the samples collected. There is the need for immediate government intervention through the Accra Metropolitan Assembly (AMA) in terms of controlling and environmental regulation the activities of the metal scrap miners with regards to both means of collection and disposal/burning. Protective materials should be given to e-miners freely by the AMA to protect them from the dangers associated with the trade/ practices they are involved-in.

References

Abdulrehman, F. I., Akan, J. C., Chellube, Z. M. & Waziri, M. (2012). Levels of Heavy metals in human hair and nail samples from Maiduguri Metropolis, Borno State, Nigeria, *World Environment*, 2(4): 81-89.

Adaramodu A. A., Osuntogun A. O. & Ehi-Eromosele C. O. (2012) Heavy metal concentration of surface dust present in e-waste components: The Westminister electronic market, Lagos case study, *Resources and Environment,* 1(1):1-5.

Amoyaw-Osei, Y., Agyekum, O.O., Pwamang, J.A., Mueller, E., Fasko, R., & Schluep, M. (2011). *Ghana e-Waste Country Assessment. Retrieved from* http://www.basel.int/Portals/4/Basel%20Convention/docs/eWaste/EwasteAssessment Ghana.pdf on 05.05.2021

Bernhardt, A., & Gysi, N. (2013). *The world's worst 2013: The top ten toxic threats*. Blacksmith Institute and Green Cross; Switzerland.

Feldt, J.N., Fobil, J., Wittsiepe, M., Wilhelm, H., Till, A., Zoufaly, G. & Burchard, T. G.(2014). High levels of PAH-metabolites in urine of e-waste recycling workers from Agbogbloshie, Ghana. *Science of the Total Environment*, 466–467 pp. 369-376.

Grant, R. & Oteng-Ababio, M. (2019). Ideological traces in Ghana's urban plan: How do traces get worked out in the Agbogbloshie, Accra? *Habitat International*, 83, 1-10.

Okoro, A., Adebayo, G. & Basheer, A. (2015). Evaluation of Heavy and Trace Metals in Fingernails of Young School Children and Adults in Ilorin, Kwara State, Nigeria. *Journal of Applied Science and Environmental Management, 19*. 319-324.

Schluep, M., Hagelüken, C., Meskers, C., Magalini, F., Wang, F., Thiébaud, E., Kuehr, R., Maurer, C. & Sonnemann, G. (2011). Market potential of innovative e-waste recycling technologies in developing countries. *Environ Impact Assess Rev.*; 30:28–41

Srigboh, R.K., Basu, N., Stephens, J., Asampong, E., Perkins, M., Neitzel, R.L., & Fobil, J.(2016). Multiple elemental exposures amongst workers at Agblogbloshie electronic waste (e-waste) in Ghana. *Chemosphere,* vol. 164, Pages 68-74.