Electronic waste risk assessment and management in Ghana

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1. Introduction

Electronic waste is the term used to describe old End Of Life (EOL) electronic appliances that have been disposed of by their original users [1]. Such appliances may include broken cell phones, old computers, TV sets, iPods and other obsolete gadgets that no longer serve relevant purpose [2]. Most common in e-waste streams are computers. Globally 20 to 50 million tons of e-waste are generated annually [3,4]. Many electronic products contain numerous toxic chemicals and materials including heavy metals such as arsenic, antimony, berrylium, cadmium, chromium, copper lead, mercury, nickel, zinc and organic compounds of chlorine and bromine. These pose risk to health and environment when disposed of [5]. Typically EOL computers have approximate distribution of e-waste as follows: glass (24.8 wt%, plastics (23 wt%), precious metals (0.02 wt%), Iron (20.47 wt%), lead (6.3 wt%), aluminium (14.17 wt%), copper (6.93 wt%) and others (4.3 wt%) [6].

Inspite of the opportunities that exist for returning EOL computers and other e-waste to the supply chain through recycling, in developing countries unlike developed countries, the lack of robust institutional, regulatory frameworks and human capacity undermine such initiatives. Further due to the relatively high cost involved in managing e-waste in developed countries compared to developing countries, Used Electrical and Electronic Equipment (UEEE) have found final resting place in many developing countries [7]. Compliance with environmental regulations increases the cost of e-waste disposal in developed countries and intense pollution activities tend to migrate towards developing countries where such robust regulations do not exist [8]. Between 50 to 80% of e-waste from industrialized countries is exported to recycling centers in developing countries [9] because environmental regulations are relatively weak and recycling and disposal practices often take place in largely inappropriate and unregulated manner with little or no concern for potential impacts on human health and environment [10,11].

In Ghana, the demand for computers and accessories is phenomenal as a result of increasing electronic literacy. The government's ICT policy which sought to increase computer literacy saw an increasing import of used computers into the country as a result of the fact that many Ghanaians are unable to afford brand new computers. Very often, most of these computers are near their end of life (EOL) and are a threat to the environment when finally discarded. Despite this, many underemployed people have found an opportunity in making a living through metal recovery from this discarded e-waste. However the approach used is crude.

The overall objective of this study is to investigate through a systematic review of the literature and through primary research the sources and flow of UEEE import into Ghana and the environmental risk associated with material handling and metal recovery from e-waste as currently practiced in Ghana. The specific objectives include the following:

- Document the sources and flow of UEEE import into Ghana
- Investigate scrap yard and current e-waste recycling and disposal practices in Ghana

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- Assess the environmental risk associated with e-waste collection, recycling and disposal in Ghana
- Make recommendations to improve e-waste management in Ghana

2. Literature Review

It has been reported that 85% of UEEE imports into Ghana came from the EU [12,13]. The problem of transboundary movement of e-waste is due to lack of national regulation and weak enforcement of law in member countries that have ratified the Basel convention [14]. The Basel convention regulates transboundary movement of hazardous waste and prohibits the transboundary shipment of hazardous waste to countries that do not have the capacity to manage them in an environmentally sound manner [15]. Although the importation of UEEE offers Ghanaians the opportunities to acquire and use these appliances, most of such appliances are eventually disposed of within a year [13]. This suggests that some of the UEEE imported into the country are already near EOL and may imply weak or inadequate custom control. Another law controlling the movement of hazardous waste which may be contained in electronic waste is the Bamako convention which bans the importation of hazardous waste into Africa and seeks to regulate the transboundary movement of hazardous waste within Africa [16]. Ghana is a signatory to the Bamako convention but has not transposed its provisions into National law. Existing national legislation regarding UEEE and e-waste is the Energy efficiency regulation (LI 1932) of 2008 which bans the importation and sale of used refrigerators and air conditioners into Ghana. However this law is targeted more at energy efficiency and phasing out of ozone depleting substances and is not targeted at hazardous substances contained in UEEE/E-waste per se. Specifically therefore there are no laws in place to regulate the importation of second hand computers which has been a menace in the country [17].

There are health and environmental effects associated with e-waste. For example exposure to lead dust or fumes causes multiple disorders such as neurological, cardiovascular and gastrointestinal diseases and exposure to cadmium fumes or dust can result in kidney and respiratory system malfunctioning [9]. In Ghana increased levels of polychlorinated biphenyl (PCB) and polybrominated diphenyl ethers (PBDEs) found in breast milk have been linked to informal e-waste recycling activities [18].

Scrap metal workers typically work between 8.5 and 12 hours a day, 7 days per week [19]. Daily revenues vary greatly between US$ 0.22 and US$ 9.50. Clear stratifications within the scrap metal business were identified: collectors freely collect available waste (e.g. on waste dumps) and find themselves at the lower income side while recyclers tend to have their own workshops to store and sell scrap metal and are typically at the higher income side. Regarding value creation, it was estimated that countrywide activities in refurbishing and scrap metal collection and recycling (including e-waste) generate between US$ 106 and 268 million [20].

However despite the economic benefits for such e-waste workers, many work on average six years and then exit the industry [17]. The crude methods used during metal recovery and the concomitant health effects have been blamed for the high turnover rate of e-waste workers [17]. This fact informs this study to ascertain the risk exposure of e-waste workers.

3. Conceptual framework

Used electrical and electronic equipment when imported into the country are sold to wholesalers who in turn sell to retailers who then sell to the end user. However on arrival some of these gadgets are none functional which are sent for refurbishment and sold to the end user. Some of the imported UEEE are already at EOL and are either disposed off in open waste dumps or channeled through an inefficient recycling process. Here crude methods such as use of hammers, chisels, stones and screw drivers are used to separate plastic casings from cathode ray tubes (CRT). Plastics are burnt

for metal recovery-Al, Fe and Cu and sold at the supplier market. In the process, hazardous substances are released into the soil and the environment and might be washed into streams thereby contaminating the aquatic ecosystem. Based on our framework, we posit that to effectively manage e-waste, one must understand the flow into the country and the risk to health and environment among others. An understanding of the flow pathways can inform the design of a framework to minimize risk due to e-waste exposure.

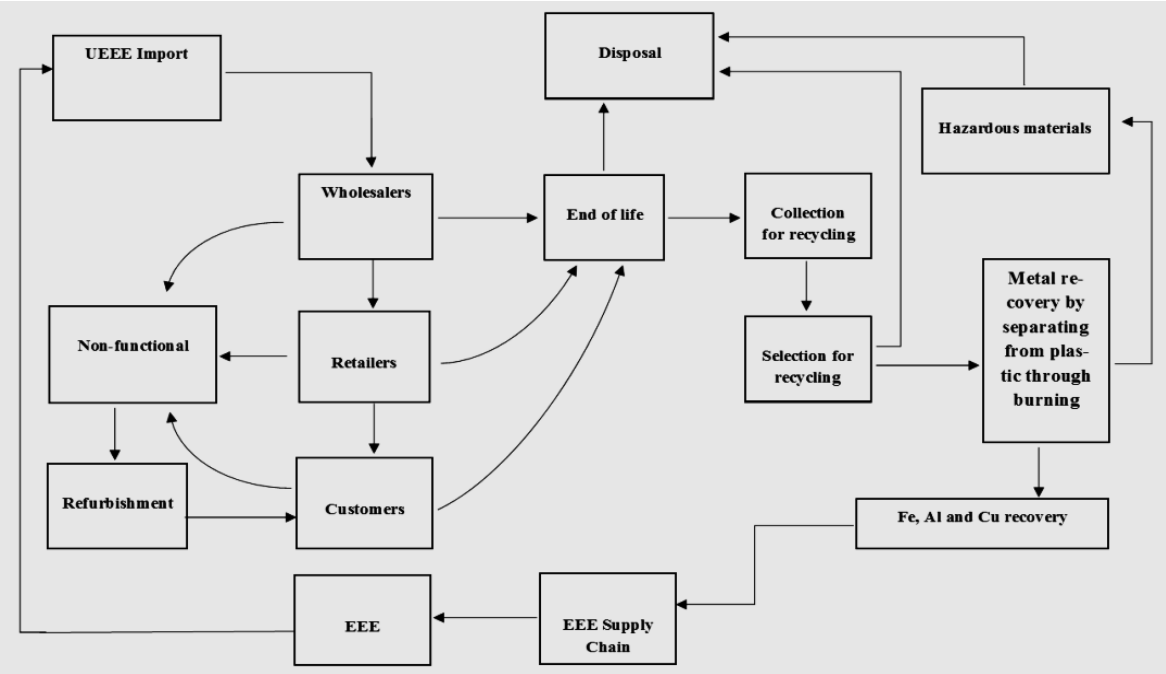

Figure 1: UEEE flow pathway in Ghana

4. Methodology

4.1. Study Area

Agbogbloshie has become infamous for its sea of discarded e-waste. It is located in Accra, Ghana on the western coast of Africa. While there are other e-waste sites in Ghana, Agbogbloshie is the main hub for trading activities related to e-waste. Such activities include, dismantling, recycling and disposal. Agbogbloshie's reputation as the hub for e-waste activities may be due to its peculiar characteristics. It is made of up of migrant communities of different ethnic origin occupying land whose ownership has not been properly defined. Thus against a mindset of being temporary residents coupled with lack of regulation of their activities due to undefined land rights, it is a free for all place where e waste is dumped and burnt for metal recovery with potential threat to human health and the environment.

4.2. Sources and Types of Data collected

Data collected is based on multiple sources. In this study we used a mixed method approach to collect primary data. Qualitative methods such as participant observation and focus group discussion have been used in addition to quantitative methods especially in the determination of heavy metal concentrations in soil and urine samples of e-waste workers.

4.3. Determination/Analysis of UEEE flow

Source data for imports of UEEE (volume and country of origin) came from secondary source- the customs excise and preventive service (CEPS) documentations of imports. This was then analysed for trends, volumes, sources by country and region.

4.4. Determination of Heavy metals in soil and urine samples of e-waste workers

To assess the level of environmental and human exposure to hazardous chemicals contained in E-waste, environmental and biological samples were collected and analyzed in the laboratory in July, 2013. Heavy metal levels in soil and urine were determined using VARIAN AA 240FS Atomic Absorption Spectrophotometer and results expressed in mg per kg. The values were compared to a control site at Mataheko, 3 km away in order to establish clearly whether contamination is due to e-waste activities.Ethical clearance was sought and permission granted for the urine samples to be analysed. All metals analysed have known uses in electrical and electronic equipment and therefore globally associated with e-waste for which they are likely to be released into the environment during e-waste recycling processes such as open burning.

4.5. Interviews and participant observation

Through focus group discussions and participant observation undertaken in May 2014, we were able to observe and document first hand hazards and potential risk associated with collection, dismantling, recycling and disposal. Observations unlike interviews where data obtained is based on the perception of interviewees, produces data based on the observer's insight and perceptual sense [21]. Thus we used observations to ascertain practices of e-waste workers and how those practices are consistent with or deviate from expected practice with a view of bridging the gap between expected practice and what is being done currently.

5. Results and Discussion

5.1. UEEE flow

Most of the UEEE imported into Ghana originate from Europe and North America. Indeed among the top 5 exporting countries to Ghana, the United Kingdom leads with 36.41% of the total flow among these 5 countries (Figure 2). Between 2004 and 2010, cumulative total flow of 49,651,508.3kg of UEEE was imported into Ghana. Many importers are of the view that some UEEE imported into the country are non-functional. This agrees with estimates that in 2009, 30% of UEEE imports into the country were non-functioning and effectively e-waste [19]. Import of non-functioning UEEE into Ghana is inconsistent with the Basel convention which prohibits export of e-waste into regions where its management in an environmentally sound manner is not guaranteed [15]. It behooves therefore on both country of export and import to ensure that no international law in relation to transboundary movement of waste is contravened.

Analysis of UEEE flow into Ghana by region reveals that between 2004 and 2010, over 86% of e-waste/UEEE flows into Ghana come from Europe and North America. On the other hand, of a total of 74,014,545.90 kg of UEEE, the Carribean contribute only 0.02% of this flow into Ghana (Figure 3).

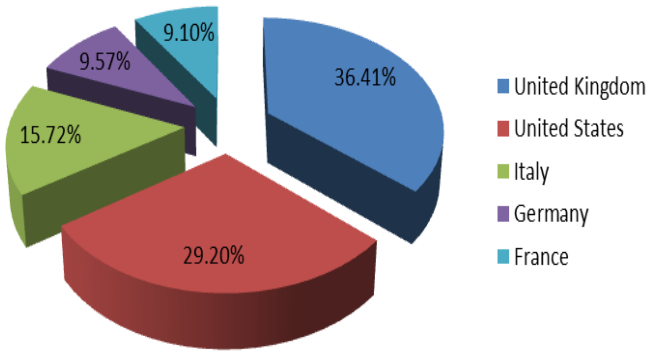

Figure 2: Flow of used computers into Ghana among the top 5 exporting countries (2004-2010)

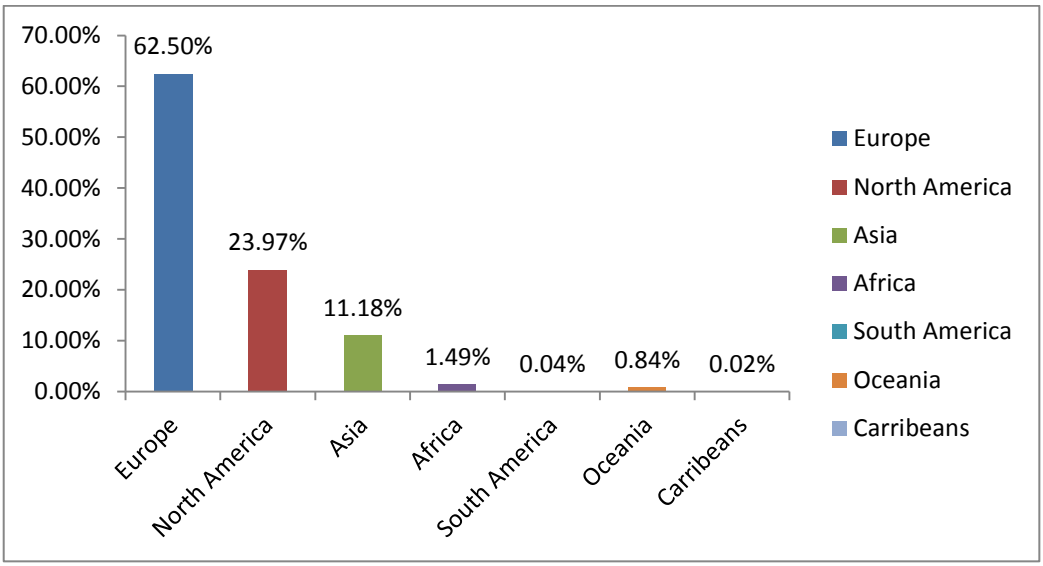

Figure 3: Flow of used computers into Ghana by regions (2004-2010)

5.2. 5.2. E-waste Risk assessment

Risk of contamination to environment and humans increases when there is a hazard. Hazard exists when there is any source of potential damage, harm or adverse health effects on the environment or human under certain conditions. Hence substances such as Pb, Cd etc may pose a hazard under certain conditions. Risk on the other hand is the chance or probability that a person or the environment will be harmed or experience an adverse health effect if exposed to a hazard. Hence in situations where it becomes easier for hazardous substances to come into contact with humans and the environment, the greater the risk. To assess the level of environmental and human exposure to hazardous chemicals contained in E-waste, heavy metal levels in soil and urine of e-waste workers were determined.

Heavy metals concentration in soils at Agbogbloshie were significantly higher than at the control site (Figure 4) This suggest that the high levels of heavy metals at Agbogbloshie compared to Mataheko is not due to high background level and suggest the soil contamination is due to dismantling and disposal practices at the site.

Similarly, urine samples of 8 e-waste workers at Agbogbloshie compared to 8 none e-waste workers at Mataheko reveals high levels of Zn, cu and Pb compared to none e-waste workers. This suggest a higher risk exposure at Agbogbloshie e-waste site compared to none e-waste workers at Mataheko.

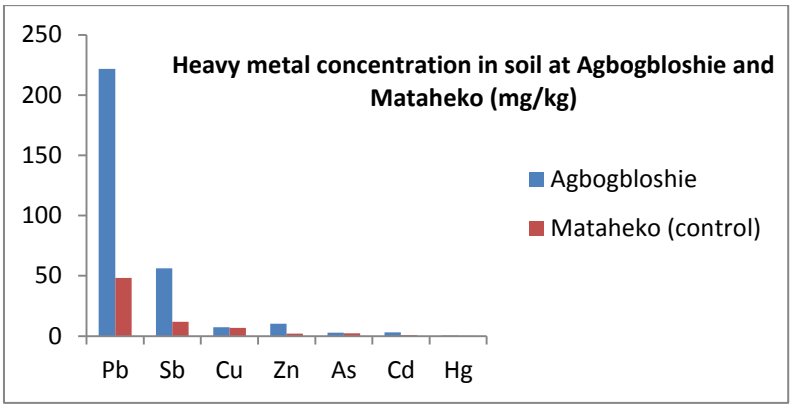

Figure 4: Heavy metal concentration in Agbogloshie e-waste site compared with control at Mataheko

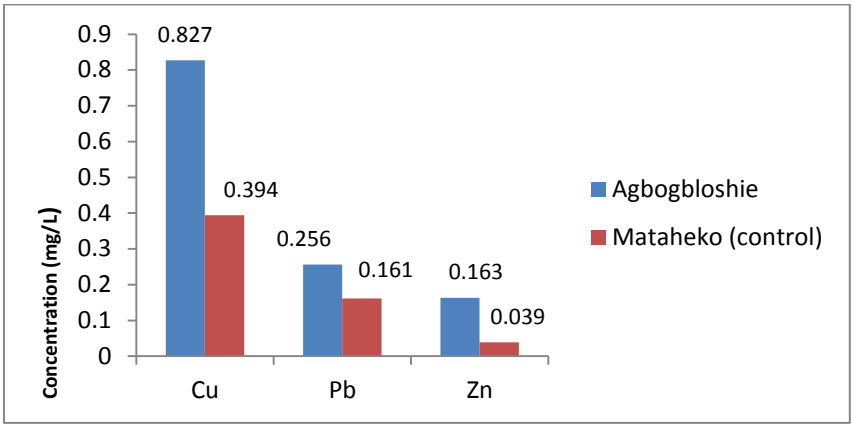

Figure 5: Heavy metals in Urine of e-waste workers at Agbogbloshie and a control site

5.3. Risk Due to Handling and Disposal practices

Based on participant observation and focus group discussion of 15 e-waste workers at Agbogbloshie during collection, dismantling/recycling, refurbishing and disposal we identify factors including collection with rudimentary equipment and manual dismantling using rudimentary equipment such as stones, chisels and hammers as well as long working hours with little or no personal protection as contributing to the high exposure and risk of e-waste workers to hazardous substances.

E-waste activity	Characteristic of the practice	Potential risk to health and environment	Risk reduction strategy
Collection	Collection with rudimentary technologies; moving around buying/ searching discarded e-waste in push-carts, sacks and basic tools for several hours without PPE	Some exposure to hazardous chemicals; potential risk to skin due to cuts, Exposure to Pb dust fumes etc	Use of PPE,
Dismantling/ Recycling	Manual dismantling, use of rudimentary equipment such as stones, chisels and hammer to separate plastic casings; poor working environment. Long contact peri-	Exposure to hazardous chemicals; potential risk to skin due to cuts, Exposure to Pb dust fumes known to cause multiple	Reduce long contact hours Use PPEs Worker rotation if activity is formal-

	od, open burning of cables and wires to gain copper metals for sale. No PPE	disorders etc	ized Automate system and isolate worker
Refurbishment	Cleaning computers, repair works, No PPEs	Exposure to dust fumes etc	Use PPEs, Good house keeping
Disposal	Open waste dumps, Intense open burning for value recovery from e-waste.	Exposure to dust fumes, Potential cuts by sharp objects, burn, inhalation of dust fumes, dermal contact	More efficient value recovery through increased recyclates to reduce disposal Landfill instead of open dumping

Table 1: Observed e-waste related activities, risk exposure and suggested risk reduction strategies

6. Conclusion

The current management practice regarding e-waste is not the best. Mostly crude methods are used for e-waste dismantling and material recovery. Flow of E-waste into Ghana comes mostly from Europe and North America. Activities in the e-waste recycling chain include manual dismantling, open burning to recover metals and open dumping of residual fractions. Such practices release hazardous chemicals into the environment. Indeed comparing heavy metals concentration in urine of e-waste workers with those of the control group, it was observed that urinary Cu (mean 0.827 mg/L) and zinc (mean 0.63 mg/L) levels for Agbogbloshie e-waste workers were significantly high compared with those of the control. Considering the fact that e-waste trading and recycling activities provide participants with livelihood opportunities, and considering the risk posed to health and environment, we make the following recommendations:

- Need to improve enforcement of related transboundary regulation in both countries of destination and countries of origin
- Enactment of national e-waste legislation and improvement of enforcement of existing legislation
- Strategies aimed at extending product life cycle of used computers such as formalizing repairs and refurbishment of UEEE through training and loan grants to small businesses involved in UEEE repairs
- Restricting the age limit of UEEE imported into country to minimize near end of life computer imports
- Sharing of information, experience and intelligence among relevant enforcement agencies in tackling issues of transboundary e-waste shipment.
- Mainstream education on e-waste impact among scrap dealers with a view to establish a culture of risk reduction through the use of Personal Protective Equipment (PPE)

Establish a national formal e-waste management system in place with sound environmental management framework since e-waste contains both beneficial and toxic substances. In summary therefore, consideration should be given to formalizing the current e-waste recycling regime in the country since it provides people with livelihood alternatives. Legislation regulating the import of UEEE and restriction of those near EOL, provision of personal protective equipment (PPE's), regulation of the activities of scrap dealers and increased port security to reduce the import of none functional UEEE's could help reduce the current menace e-waste inflicts on the Ghanaian society.

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