CURRENT E-WASTE MANAGEMENT IN GHANA AND FINLAND

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ABSTRACT

Electronic waste or e-waste is one of the issues increasing in developed and developing nations around the world. It includes a huge number of segments with substantial materials containing dangerous substances that can affect human health and the environment. Past study reveals the e-waste generated annually is calculated to be 20-50 million metric tons of which 50% to 80% finds its way to developing countries like Ghana, Nigeria and other part of Africa and keeps on increasing day by day. With absence of proper infrastructural facilities and strategies for its recycling and reusing have had critical implication for the management of electronic waste in Ghana.

The purpose of this thesis was to provide a concise illustration of Ghana's present e-waste situation, the extent of the issue, disposal, recovery, and recycling tasks. Another aim was to discuss how to improve the condition by adopting Finland's e-waste management approach.

Keywords E-waste, Health Hazard, Environmental Hazard, Toxic chemical, and biological leaching.

Pages 43 pages

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1 INTRODUCTION

The recent telecommunication innovation on electronic devices has not only benefited the communication`s industry but also the entire world making access to information easier than before. The realization of sound disposing of the end of life electronic devices has become a worldwide problem that needed attention globally. The purpose of this thesis is to investigate the e-waste management practices in Accra Ghana West Africa.

The aim of the thesis is to compare e-waste management practices in Accra Ghana and that of Finland. The focus is on electronic waste management in Agbogbloshie a suburb within Accra the capital of Ghana. Therefore, through this report, any references to waste are regarded as electronic waste or WEEE.

Mankind request for electronic gadgets is making the world's fastest growing waste stream. This waste stream is increasing day by day. The United Nations called it a tidal wave of e-waste. While more electronic gadgets are a portion of the issue, it can be an enormous portion of the solution. A more computerized and associated world will help and accelerate progress towards the United Nations Sustainable Development Goals (SDGs), offering phenomenal opportunities for developing economies. style should be more formal: it is obvious that we will see a part less of our valuable minerals, metals, and resources dumped into a landfill. The advantage to industry and laborers as well as the health of individuals and the environment can be gigantic. It is pivotal we quickly utilize a more circular vision in this sector. The financial arguments are solid. If we look at the material value of our wasted gadgets, universally this sums up to $62.5 billion, three times more than the yearly yield of the world`s silver mines, according to the information contained in the new World E-Waste Report. By collecting this important asset, we will produce significantly less CO2 outflows when compared to mining the earth's hull for new minerals. UN env. Report Davos, 1.2019)

A circular electronics system in which resources are not extricated, utilized, and wasted, but re-used in incalculable ways make conventional sustainable employments and retain more value within the industry. That is why handling this issue head-on is presently seen as the pivotal task for worldwide organizations, including the International Telecommunication Union (ITU), the International Labour Organization (ILO), the United Nations Environment Program (UNEP) and other individuals of the e-waste Consolidation. ITU member states for instance, as of late set a target to increase the worldwide e-waste recycling rate to 30%. (Ryder, ILO 1.2019 World economic forum annual meeting.) The thesis is a collection of researches and studies related to electronic waste and its impact on humans and the environment. Despite the dangers of recycling e-waste in

unprofessional ways, people in the developing countries rely on it as their source of income making it more troublesome to control and manage it in an environmentally friendly way due to a lack of employment.

2 BACKGROUND

The world is producing more than 40 million tons of e-waste every year, and at slightest a few of it consolidates dangerous materials. According to a recent PACE/UN report, worldwide e-waste generation is on track to reach 120 million tons per year by 2050 if current patterns proceed. The yearly value of worldwide e-waste is presently at over $62.5 billion. In 2017 alone, more than 44 million tons of electronic and electrical waste were created universally, which likens to more than 13 lb. for everyone on the planet. “Although used electronic equipment makes up a generally little amount of the overall waste stream, their transfer may be a source of concern for a few reasons,” the National Conference of State Councils (NCSL.2018) points out. For example, electronic gadget generation requires a significant sum of resources—metals, plastics, and glass—many of which can be recuperated through recycling. For illustration, the generation of one desktop computer takes at slightest 530 lb. of fossil fuels, 48 lb. of chemicals, and 1.5 tons of water. Cell phones are moreover resource-intensive, being composed of valuable metals such as silver, gold, palladium, and copper. “Recovering these and other materials through recycling uses a fraction of the energy required to mine new metals,” In the presence of dangerous materials such as lead, nickel, and mercury in a few electronics make safe disposal especially vital. These metals may posture dangers to human health or the environment in case improperly handled. (Schultz, NCSL 9.2018).

On the 24 January 2019 e-waste conference was held in Davos Switzerland to discuss worldwide e-waste generation which is on track to reach 120 million tons per year by 2050 in the event that current patterns proceed, according to a report from the Platform for Accelerating the Circular Economy (PACE) and the UN E-Waste Consolidation released at Davos today. Less than 20% of e-waste is formally reused, with 80% either finishing up in landfill or being casually reused much of it by hand in developing nations, exposing laborers to dangerous and carcinogenic substances such as mercury, lead, and cadmium. e-waste in landfill sullies soil and groundwater, putting food supply frameworks and water sources at risk. United Nations Report 1 2019). A developing nation like Ghana has challenges of handling electronic waste due to inadequate resources to tackle the problem; hence, the primitive method by the informal sector is rampant for the recovery of precious metals from the e-waste. This recycling method by the informal sector has caused serious health disorders among the workers, the community, and the rivers nearby. Although, a few researchers have all looked at different perspectives of e-

waste circumstances in Ghana, e.g.by (Oteng-Ababio, 2010, p.191; Caravanos et al., 2011, pp.16-25.) there are still the following questions to be answered: What are the e-waste management practices and disposal methods used in Accra, what are health and environmental impacts of current recycling exercises in Ghana,? What are the health and environmental dangers associated with e-waste handling in Accra, and what can Ghana extract from Finland e-waste management? This research, therefore, looks for answers to these challenges that will address and help in accomplishing the overall objective of e-waste management in Ghana by studying Finland's e-waste management technologies for solving the e-waste problem in the West African country.

2.1 **LEGISLATION**

Electronic waste became a treat and challenge to humans and the environment by the process in which it's being handled after the end of life of the device in the late 1980s. Nations came together to find common ground in solving electronic waste problems. It was with a view of these challenges that Legislation on the control, handling, and shipment of electronic waste was established in 1989.The Basel Action Convention. Its purpose was to safeguard the trans-boundary shipment of e- waste from one country to another. There were 170 states with 63 parties who approved the 1995 amendment to the convention (SBC,1989) Industrialized mechanics of materials.

Countries such as the European Union have established extensive legislation such as legal regulations, system coverage, system financing, producer responsibility and ensuring compliance. There were other directives and legislation which were established by the member states on February 2003 on e-waste and RoHS which safeguard the handling of electronic waste among the member states; among these legislations are EU,2003a, 2003b) which asset in Annex1B;There are directives which include, Directive 2011/65EU, Directive 2012/19/EU as well as the RoHS Directives which are, RoHS 1 Directive 2002/95/EC, RoHS 2 Directive 2011/65/EU. All these legislations and directives were set by the EU for the safe management of (WEEE) and it has proven to be very effective. The United States of America has a system called state by state regulation which means that each state has its own legislation on the handling of e-waste. Other nations around the globe have some form of legislation regarding the management of e-waste.

2.2 **E-waste Management**

Many nations have created the definition of e-waste, but the primary definition is from the European Union (EU) order that characterizes e-waste as "electrical or electronic equipment waste that incorporates all

components, subassemblies, and consumables that are a portion of the item at the time it is discarded. The Basel Convention 1989 states that e waste contains a wide range of electronic gadgets that have been disposed of and includes huge household gadgets, such as fridges and discard air conditioners, cell phones, individual stereos, and computers. On the other hand, the Organization for Economic Cooperation & Development (OECD) portrays e-waste as any machine utilizing an electric control supply that has come to its end-of-life. Uncontrolled disposal of e-waste can be harmful to human well-being and the environment since e-waste contains poisonous substances and heavy metals. However, in case the waste is properly managed, it can end up an opportunity that produces high returns since e-waste also contains profitable materials, such as gold, silver, platinum, and palladium. E- waste management in industrialized countries is not as challenging as in developing countries. Whereas the developed countries have the technology for handling e- waste, developing countries are having difficulties dealing with the management of e-waste. These wastes are dumped in the developing countries where systems are not in place to handle and manage. They dumped it on the poor countries as a means of gifts or donations. The transboundary movement of e-waste across continents is demonstrated below in figure 1

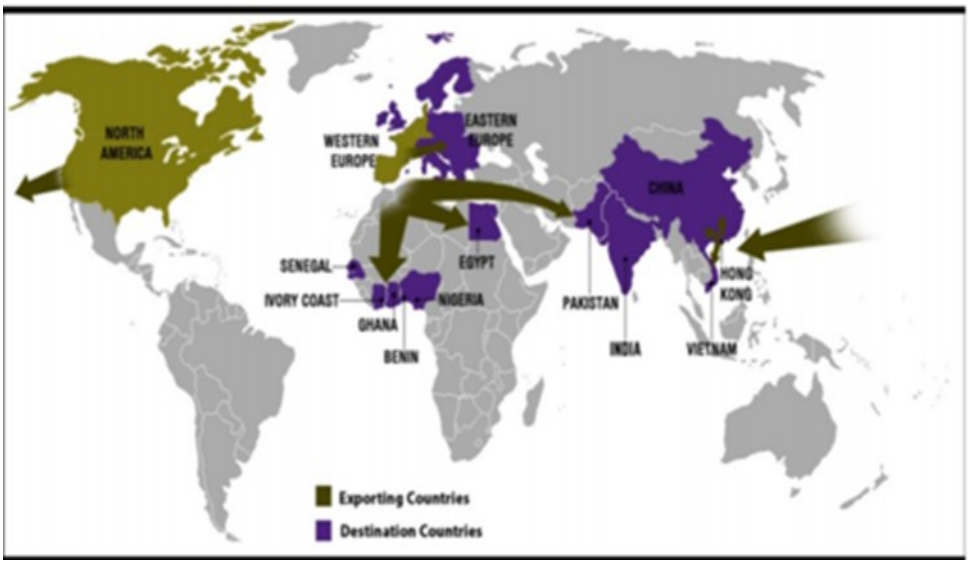


Figure 1 legal and illegal e-waste trade across continents
(Greenpeace report e-waste Ghana 8.2008; Basel Action Network, 1989)

The worldwide amount of e-waste recorded in 2016 was around 44.7 million metric tons (Mt), or 6.1 kg per tenant. It is assessed that in 2017, the world e-waste era will exceed 46 Mt. The sum of e-waste is anticipated to increase to 52.2 Mt in 2021, with a yearly growth rate of 3 to 4%. In 2016, Asia was the region that produced by distant the biggest sum of e-waste (18.2 Mt), taken after by Europe (12.3 Mt), the Americas (11.3 Mt), Africa (2.2 Mt), and Oceania (0.7 Mt) being the smallest in terms of total e-waste generated, Oceania was the highest generator of e-waste per occupant (17.3 kg/inh), with 6% of e-waste reported being collected and reused. Europe now is the largest generator of e-waste per resident with

an estimate of 16.6 kg/inh; in any case, Europe has the highest collection rate (35%). The Americas produce 11.6 kg/inh and collect 17% of the e-waste generated in the nations, which is comparable to the collection rate in Asia (15%). However, Asia creates less e-waste per occupant (4,2 kg/inh). Africa produces 1.9 kg/inh and small data is available on its collection rate. The report gives territorial breakdowns for Africa, Americas, Asia, Europe, and Oceania. Figure 2 beneath shows the global amount of e-waste generated.

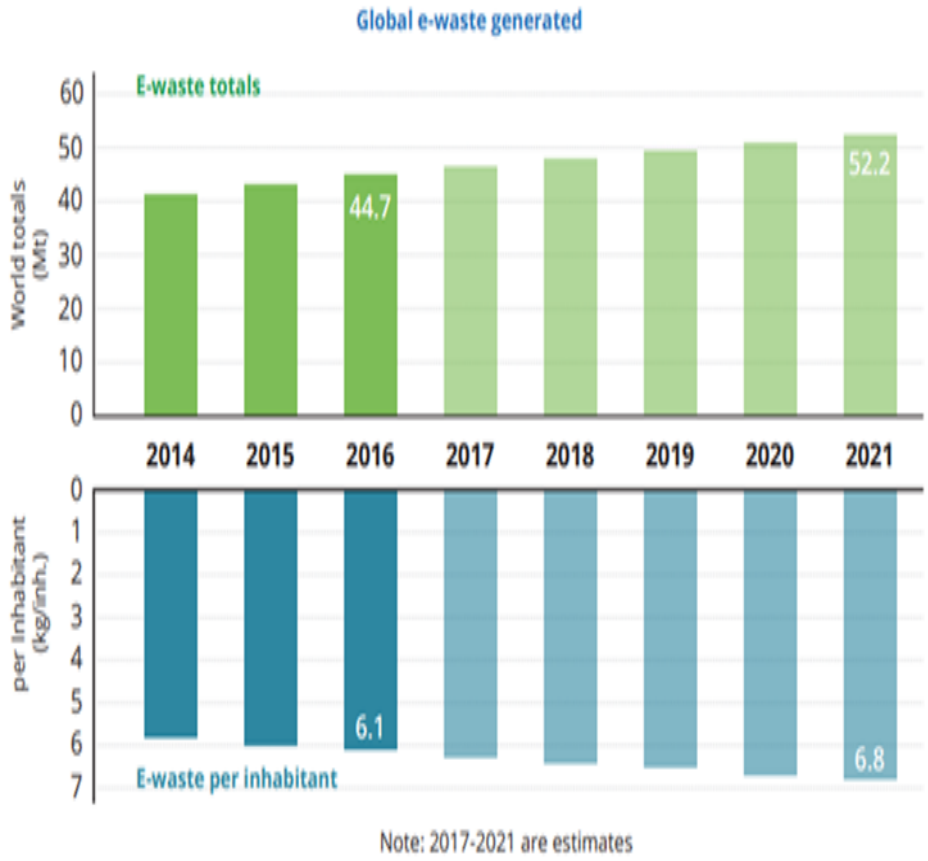


Figure 2 Global e-waste Monitor

Out of the 44.7 Mt, roughly 1.7 Metric tons are tossed into the waste in higher-income countries and are likely to be burned or land-filled. Universally, only 8.9 Mt of e-waste is recorded to be collected and reused, which corresponds to 20% of all the e-waste produced. However, approximately around one quarter or 9.3 million metric tons is made up of individual computerized gadgets such as computers, shows, smartphones, tablets, and TVs. Family apparatuses, as well as warming and cooling apparatus account for the rest. The global amount of e-waste in 2016 is basically comprised of Little Equipment (16.8 Mt), Large Hardware (9.1 Mt), Temperature Exchange Equipment (7.6 Mt), and Screens (6.6 Mt). Lights and Little IT represents a little segment of the worldwide amount of

e-waste generated in 2016, 0.7 Mt and 3.9 Mt separately. Estimates of e-waste totals per category in 2016 are shown in figure 3 below.

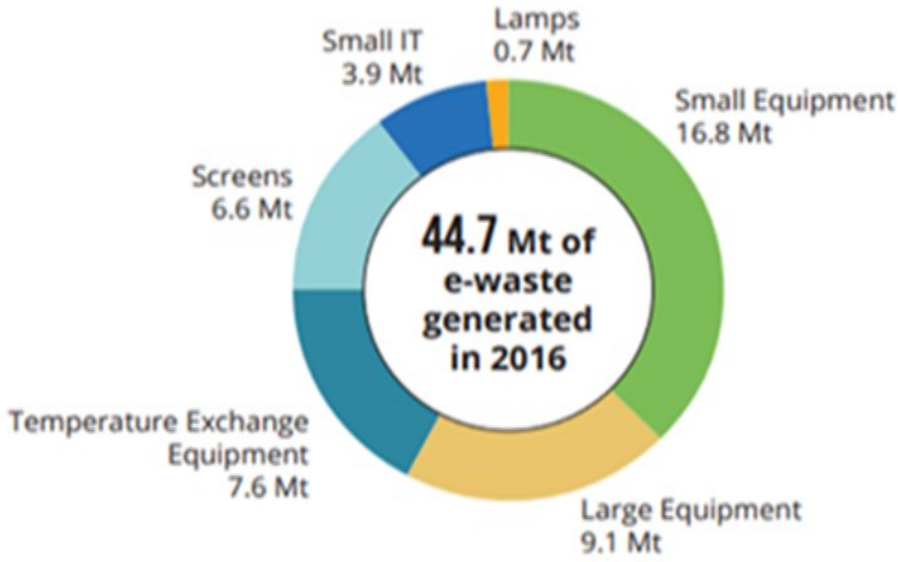


Figure 3 Global e-waste generated 2016

The distinction of e-waste generated in developed versus developing nations is very huge. The richest nation within the world in 2016 generated an average of 19.6 kg/inh, while the poorest generated only 0.6 kg/inh.

Table 1 selected definitions of e-waste.

Reference	Definition
EU WEE Directive (EU 2003a)	Electrical or electronic equipment which are defined as waste including all components, sub-assemblies which are classified as EU WEE Directive consumables being part product at the time of the directive of (EU 2003a). Directive 75/442/EEC Article 1 a define waste as any object or substance which the holder disposes of under the provisions of national law.
Basel Action Network (Puckett and Smith 2002)	E-waste is a broad and a growing range of electronic devices ranging from large household device such as refrigerators, air conditions, mobile phones, stereos computers and consumer electronics which has been discarded by their users. (Puckett and Smith 2002)
OCED (2001b)	Any appliance that uses electrical power supply that has reached its end of life.
SINHA (2004)	Any electrically powered appliance that no longer satisfies the current owner for its intended use
STEP (2005)	E-Waste refers to reverse supply chain which collect products no longer desired by a given consumer and refurbishes for other consumers recycles or otherwise Processes wastes.

3 AIMS AND OBJECTIVES

The objective of this thesis is to look at the present e-waste management practices at Agbogbloshie in Accra Ghana, investigate the environmental and health effects and the challenges related to effective management with e-waste within the region, compare to Finland e-waste management and incorporate the best Finland practices into Ghana e-waste management. The reason behind the study is to search for answers to address the e-waste hazards in the Accra region of Ghana.

This thesis seeks to provide answers to the following questions
1. What are the e-waste management practices and disposal methods used in Accra, Ghana?
2. What are the health and environmental dangers associated with e-waste handling in Accra?
3. What can Ghana learn from Finland e-waste management?

3.1 Scope and Study limitations

The study is focused on e-waste management in Ghana and technology from Finland of which if applied will improve Ghana's e-waste management. The lack of data on the e-waste management in Agbogbloshie scrapyard made it difficult putting this together. There was no liable company that handles the e-waste management within the metropolis. The environment protection council whose mandate is to regulate and manage e-waste disposal do not have the resources to do their work. E-waste was being treated as municipal waste that makes information gathering terribly tough. There is legislation in place, but it has not been enforced; therefore, the activities of e-waste by informal workers continue. The final emphasis will be on e-waste management. The Finland system of e-waste management will be used as a model foundation as a path for Agbogbloshie e-waste scrapyard in Accra. There will be challenges in handling e-waste management initiatives in Agbogbloshie due to the high population density in Accra.

4 RESEARCH DESIGN

Research suggests repeating a look for something and certainly assumes that the earlier search was not comprehensive and complete within the

sense that there's still room for improvement (Walliman N, 2011, pp. 5-93) Research subsequently may be a handle of inquiry- based on earlier information. It can be characterized as an efficient way of asking questions, a systematic strategy of inquiry. Research design may be a structure that leads to the execution of a research formula and the analysis of information. The importance of selection analysis pattern relies on the choices and arrangements given which are part of the research method. This could incorporate problems like understanding conduct and the meaning of that conduct in its specific context: therefore, the case analysis was chosen for this reason.

There exist several research plans in science that are appropriate for environmental and improvement studies. The case study plan was an alternative based on the reality and chance to check whether the hypothetic models of managing e-waste extremely worked among visual world circumstances, giving the perfect exercise of logical hypothesis and genuineness. In this study, after the literature review which was conducted to pick up the understanding of the existing information of e-waste management the essential research question was defined. (Bryman et.al.,2008, pp.261-276)

4.1 **Empirical design**

The empirical case analysis is conducted to address a difficult finding of what is happening or finding bits of information or equivalent. The research case is often conducted to demonstrate events in their setting whereas the illustrative case considers a happening with its impacts and may not seem spontaneous relationship. The mixture of formulas was used in this analysis to grasp information on the management of e-waste within the metropolis and to clarify the strategy concerned in coping with e-waste and eventually link its management approach to any environmental danger which will prevail to cause an impact. A case study could use a broader data collection instrument like perception and interviews with distinctive people and permits comprehensive study. Triangulation is mixing numerous information collection procedures and interviews to upgrade the legitimacy and quality of research. Legitimacy and quality procedures were used to ensure the standard of the study outcome. Legitimacy problems indicate whether degree concept truly measures the precise issue, it is assumed to measure.

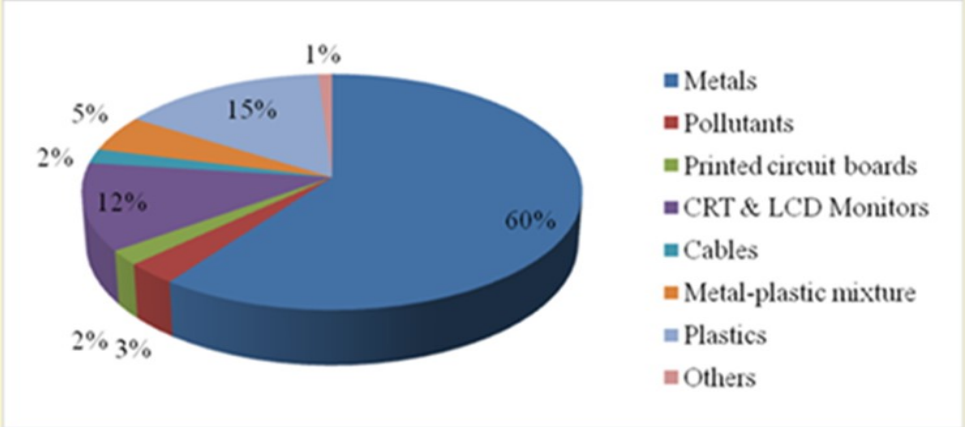
Whereas quality concerns the problem of consistency of estimation particularly when each internal and external legitimacy was used. Within the case of inside legitimacy underline the constancy of conclusions drawn from factors with innovative connections. The significance of inside legitimacy in informative case studies is clear in detail of values with offhand. Contrary to legitimacy that concerns the address of whether the results of a study may be generalized beyond context was justified by

choosing tests that were representative and enough to portray the e-waste danger on the universal or broader level. (Yin,2003, pp.5-15)

5 THE COMPOSITION OF E-WASTE

There are many components in e-waste that are valueless such as plastic, steel casings, circuit boards, glass tubes, wires, resistors, capacitors. Fluorescent tubes, flat panel displays, and various elements. Given the various materials found in e-waste it is difficult to generalized material composition for the whole waste stream. Plastics are the second- largest part by weight representing close to 21% of e-waste. Nonferrous metals together with precious metals represent close to 13% by weight of e-waste and with copper accounting for 7%. There are thousands of different parts that are within e-waste which makes it hazardous such as lead, mercury, and arsenic flame retardant. Green peace has concluded that e-waste that finds its way to Ghana from the United States and Europe are done illegally (Bridgen et al., 2008, pp.1-23). The wealth of metals contained in e-waste is also very high. For instance, 1 ton of e-waste contains up to 0.2 tons of copper which might be sold for about five hundred euros at the current world price. The association of plastic manufactures in Europe released their statistics of material consumption in electrical and electronic products in western Europe in 1995 and the composition in e-waste at that time was as follows 38% ferrous,28%nonferrous,19% plastics 4% glass, 1% wood, and 10% others. In general, printed circuit boards scrap contains approximately 40% metal,30% plastics and 30% ceramics. The typical metal scrap in printed circuit boards consists of copper (20%), iron (8%), tin (4%), nickel (2%), lead (2%), zinc (I %), silver (0.2%), gold (0.1 %), and palladium (0.005%), Polyethylene, polypropylene, polyesters, polycarbonates and phenol formaldehyde are the typical plastic components. E-waste composition by percentage demonstrated in table 2 below (Widmer et.al.,2005, pp.436-458).

Table 3.E-waste material composition by percentage. (Nartey, k. Bonn (2016)



5.1 **The sources of e-waste**

The sources of e-waste equipment such as computers are typically discarded by individual households and small businesses not because they are broken but because new technology has left them outdated or undesirable. New software technology is usually incompatible with older hardware or designs, so customers are forced to shop for new ones. Other sources of e-waste are derived from giant companies' establishments and government institutions. E-waste also comes from original equipment manufacturers that generate e-waste once units coming back off production line do not meet the quality standards and should be disposed of. Lighting installations and machines such as sodium lights, fluorescent tubes, sewing machines, surveillance equipment, garden cutters, coin slot machines and electronic toy items are also classified as e-wastes. The sources of e-waste vary, and each source has its own frame of harmfulness which makes it fundamental to be disposed of correctly to ensure the environment and health of human beings. Figure 4 below show the sources of e-waste.

Figure 4 sources of e-waste Source. (ijirset

5.2 **Hazard in e-waste**

E-waste may be a crisis not because of its growing amount but because of its harmful ingredients. E-waste contains over 1000 completely different substances of which are dangerous to human health and the environment. These dangerous substances are lead, mercury, cadmium, arsenic, selenium, hexavalent metal, polychlorinated biphenyls (PCBs) and brominated flame retardants that make hydrocarbon emissions incinerated. Table 2 shows the hazardous materials and their effect on humans (Puckett & Smith,2002, pp.7-197).

Table 4 hazardous materials and effects on humans (IJAR 2017)
(ISSN: 2320-5407 Int. J. Adv. Res. 5(1), pp. 1425-1430)

E-Waste Component	Processed Used	Adverse Health Effects
Americium	The radioactive source insmoke alarms.[5]	It is known to becarcinogenic
Lead	Solder, CRT monitor glass,lead-acid batteries, some formulations of PVC. A typical 15-inch cathode ray tube may contain 1.5 pounds of lead,but other CRTs have been estimated as having up to 8 pounds of lead.	Adverse effects of lead exposure include impaired cognitive function, behavioral disturbances, attention deficits, hyperactivity, conduct problems and lower IQ. These effects are most damaging to children whose developing nervous systems are very susceptible to damage caused by lead, cadmium, and mercury.
Mercury	Found in fluorescent tubes (numerous applications), tilt switches (mechanical doorbells,thermostats),[8] and flat screen monitors.	Health effects include sensory impairment, dermatitis, memory loss, and muscle weakness. Exposure in-utero causes fetal deficits in motor function, attention and verbal domains.[6] Environmental effects in animals include death, reduced fertility, and slower growth and development.
Cadmium	Found in light-sensitive resistors, corrosion-resistant alloys for marine and aviation environments, and nickel-cadmium batteries. The most common form of cadmium is found in Nickel-cadmium rechargeable batteries. These batteries tend to contain between 6 and 18% cadmium. The sale of Nickel-Cadmium batteries has been banned in the European Union except for medical use. When not properly recycled it can leach into the soil, harming microorganisms and disrupting the soil ecosystem. Exposure is caused by proximity to hazardous waste sites and factories and workers in the metal refining industry.	The inhalation of cadmium can cause severe damage to the lungs and is also known to cause kidney damage.[12]Cadmium is also associated with deficits in cognition, learning, behavior, and neuromotor skills in children
Hexavalent chromium	Used in metal coatings to protect from corrosion.	A known carcinogen after occupational inhalation exposure.[6] There is also evidence of cytotoxic and genotoxic effects of some chemicals, which have been shown to inhibit cell proliferation, cause cell membrane lesion, cause DNA single-strand breaks, and elevate Reactive Oxygen Species (ROS) levels.
Sulphur	Found in lead-acid batteries.	Health effects include liver damage, kidney damage, heart damage, eye and throat irritation. When released into the environment, it can create sulphuricacidthrough sulphur dioxide.
Brominated Flame Retardants (BFRs)	Used as flame retardants in plastics in most electronics. Includes PBBs, PBDE, DecaBDE,OctaBDE, PentaBDE.	Health effects include impaired development of the nervous system, thyroid problems, liver problems.[9] Environmental effects: similar effects as in animals as humans. PBBs were banned from 1973 to 1977 on. PCBs were banned during the 1980s.
Beryllium oxide	Filler in some thermal interface materials such as thermal grease used on heatsinks for CPUs and power transistors,[11] magnetrons, X-ray-transparent ceramic windows, heat transfer fins in vacuum tubes, and gas lasers.	Occupational exposures associated with lung cancer, other common adverse health effects are beryllium sensitization, chronic beryllium disease, and acute beryllium disease.[10]

5.3 **Hazard of improper disposing and recycling of e-waste**

There are hazards in handling and disposing of e-waste which associates with serious health and environmental implications if disposed of improperly. E-waste can lead to serious environmental pollution. Once e-waste is landfilled or incarnated it poses vital contamination issues. landfills leach toxins into groundwater and incinerators emit nephrotoxic air pollutants together with dioxins and furans. Figure 5 below shows environmental catastrophe.

Figure 5 polluted river near Agbogbloshie 7.2019

5.4 **Hazard of landfilling of e-waste**

All landfills spill. Landfills are not secure through their lifetimes and an amount of chemical and metal leach can happen. This is often much more regrettable for an older or less demanding dump destination. Around 70% of the heavy metals (counting mercury and cadmium) found in landfills comes from electronic hardware that has been disposed of. These heavy metals and other perilous substances found in hardware can contaminate groundwater and create other environmental public health dangers US EPA, 2001,p.298) In landfill wherever certain electronic gadgets are essentially pulverized and broken, mercury and polychlorinated biphenyls (PCBs) are released and enter the air. once plastics containing brominated fire retardants (BFRs) like polybrominated diphenyl ethers (PBDEs) or metal are landfilled, each PBDE and the metallic component might leach into the soil and groundwater.

5.5 **Hazard of incinerating of e-waste**

Another strategy for treating e-waste is burning. Because of the assortment of different substances found in e-waste, burning of e-waste, such as uncontrolled fires at a landfill is especially dangerous. For occurrence, copper is a catalyst for dioxin formation when flame-retardants are burned. Open-air burning of plastics is utilized as a simple strategy, but it is foremost unsafe sort of burning e-waste. The dangerous aftermath from open-air burning influences all workers' health and the atmosphere causing serious problems in these neighbourhoods.

Figure 6 nephrotoxic air pollutant at Agbogbloshie scrapyard.Field work.7.2019.

5.6 **Hazard of improper recycling of e-waste**

Whereas appropriately managed recycling may be the key to the successful management of e-waste, inappropriate regulation and ecologically unsound recycling may result in increased environmental,

public, and worker exposure to dangerous materials. Within the past, ecologically unsafe recycling operations have resulted in poisonous dangers and costly treatment costs. The recycling of e-waste discharges hazards containing heavy metals such as lead and cadmium: Another issue with heavy metals and halogenated substances in untreated e-waste happens during the destroying Process. Most electronic items are designed in a way that creates dismantling troublesome. Components in these items are ordinarily compacted and patched into a tight encasing space. So, when there is a need for appropriate destroying of e-waste, the shredder waste can have a high concentration of lead and around 95% of the PCB contained in capacitors ends up within the shredder tidy. This implies that inappropriate recycling of e-waste just moves the risks into another kind of waste stream or just into the auxiliary stream that inevitably require disposal without really solving the issue. Halogenated substances contained in e-waste, brominated fire retardants, are of concern amid the expulsion of plastics and a portion of plastic recycling methods. These chemicals make e-waste recycling unsafe for laborers. There are significant dangers associated with taking care of recycling and disposal of e-waste. (Osinbajo and Nnorom, 2007, pp.489-501)

6 CASE STUDY GHANA

Ghana is located on the West Coast of Africa surrounded by other nations such as Ivory Coast, Burkina Faso, and Togo. The capital of Ghana is Accra where electrical and electronic waste has become an e-waste republic by some writers. Ghana has 10 major urban communities comprising Accra, Kumasi, Tamale, and Takoradi where business activities happens each day. Much of the import are electrical and electronic items that are transported to these urban areas bringing about accumulation of e-waste. However, this investigation is focused on the Agbogbloshie zone inside Accra. It is one of the biggest e-waste dumps on the planet. The Agbogbloshie e-waste Processing site is situated on the banks of the Odaw river and the Korle Lagoon northwest of the central business area of the capital between degrees 5◦ 32' 30''N and 5◦ 33' 30'' N and on longitude 0◦ 13' 30''W. The AEPS seals a place where there is generally 6.2 ha. The Accra Metropolitan Authority has boundaries within the south with the Gulf of Guinea, inside the east with La Dade Kokopo and Ledzokuku regions, inside the north with Ga East and Adenta Districts, and inside the west with Ga Central and Ga South Districts. The Agbogbloshie e-waste Processing Site is known to be the center and biggest e-waste handling area in Ghana. In Figure 7 below there is a map of Ghana.

Figure 7. Map of Ghana (googlemap.com)

6.1 **Accra**

The capital and biggest city of Ghana is Accra having a population of 2.27 million. The Greater Accra metropolitan area (GAMA) has 4,519.273 occupants (GSS, 2015). Agbogbloshie e-waste Processing Site (AEPS) suits around 40 thousand individuals who are essential Ghanaians and foreign nationals from West Africa. The indigenous ethnic group within the AEPS is Ga's (Agyei-Mensah &Oteng-Ababio,2012, pp.1-21) Many of the tenants or workers within the AEPS are from northern Ghana. Despite the distinction age bunches inside the AEPS, the workforce is mostly youth ranging from 15 and 35 years old. Also, youngsters as youthful as 11 years were in the e-waste business. E-waste trade and foodstuff sellers are the most widely recognized occupations inside the AEPS. AEPS alone employs between 4500 and 6000 people. Recognitions made during this research uncover that a couple of workers stay near their place of work with their families while others live 100 m over the Odaw river inside the settlement called Sodom and Gomorrah. The research was focused on the suburb of Accra called Agbogbloshie. The AEPS lies inside the savanna zone with two stormy seasons and a yearly Rainfall average of 730 mm during the rainy periods. The zone has uniform temperatures reaching out from a month to month of 24.7◦C in Admirable (coolest) to 28◦C in March (most blazing) and a yearly normal of 26.8◦C. Accra is close to the equator with uncommonly uniform daylight hours during the year and high relative dampness reaching out from 65% in the late morning to 95% around evening time. Winds are fundamentally west-south-west to north-east with a breeze speed stretching out from 8 to 16 km/hr (Vincent N,J Bonn, 2016) Northern Ghana encounters its blustery season from April to mid-October while Southern Ghana encounters its stormy season from March

to mid-November. The tropical atmosphere of Ghana is moderately gentle for its scope. The harmattan, a dry desert wind, blows in north-east Ghana from December to March, bringing down the moistness and causing more sizzling days and cooler evenings in the northern part of Ghana. Table 5 shows Ghana climate data. (Amoyaw-Osei et al.,2011, pp.60-73)

Table 5 Ghana weather by month. www.climate data.com/Ghana

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	27	28.2	28.7	28.3	27.4	26.5	25.5	25.4	25.9	26.4	27.1	27
Min. Temperature (°C)	21.4	22.3	23.5	23.4	22.9	22.3	22	22.3	21.9	22.1	22.2	21.3
Max. Temperature (°C)	32.7	34.1	33.9	33.3	32	30.7	29.1	28.6	30	30.8	32.1	32.7
Avg. Temperature (°F)	80.6	82.8	83.7	82.9	81.3	79.7	77.9	77.7	78.6	79.5	80.8	80.6
Min. Temperature (°F)	70.5	72.1	74.3	74.1	73.2	72.1	71.6	72.1	71.4	71.8	72.0	70.3
Max. Temperature (°F)	90.9	93.4	93.0	91.9	89.6	87.3	84.4	83.5	86.0	87.4	89.8	90.9
Precipitation / Rainfall (mm)	18	32	91	152	250	295	295	291	329	323	63	13

The variety in the precipitation between the driest and wettest months is 316 mm |. The variety in yearly temperature is around 3.3 °C | 37.9 °F. The temperatures are highest on average in March, at around 28.7 °C | 83.7 °F. At 25.4 °C | 77.7 °F overall, August is the coldest month of the year.

6.2 History of electronic waste in Ghana

ICT learning began in the year 2000. It has seen an immense improvement because of the move from manual/paper or similarity to the electronic system by most regulatory companies and workplaces. The government of Ghana in 2003 introduced a module called ICT for Improvement (ICT4AD) with the vision to use ICT as the quickest and viable monetary and social advancement, henceforth changing the country into a data rich-learning based and development-driven economy ICT4AD, 2003). These strategy methods were the headway of information communication and Innovation in various instructive organizations over the country. Making the three education levels in Ghana essentially optional during this period that the convergence of EEE began coming into the nation as gifts, some as aid.

Figure 6 below illustrates the flow of e-waste.

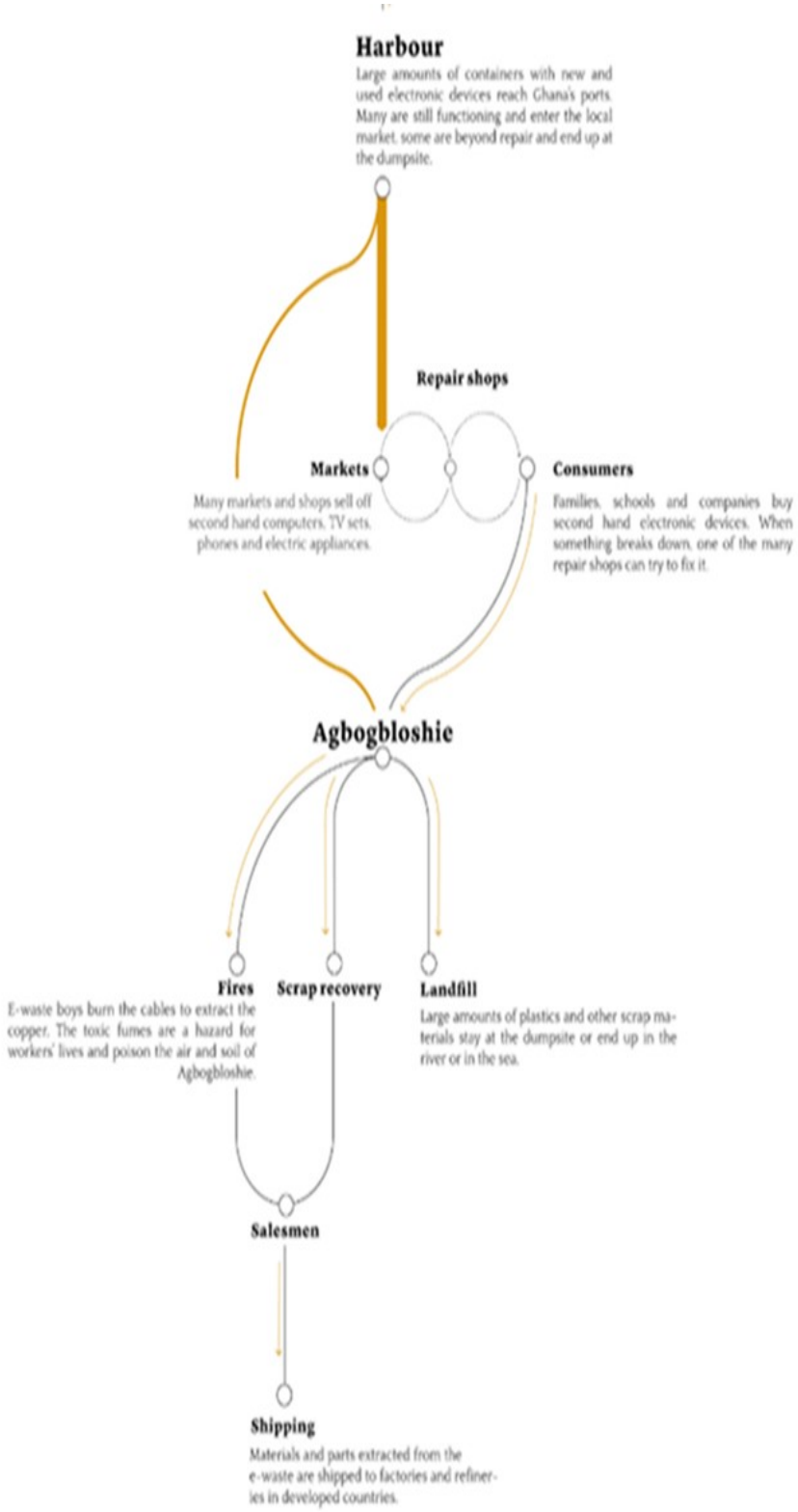


Figure 6. Flow of e-waste (interactive.aljazeera.com)

The Ministry of Education distributed 60,000 pcs to schools across Ghana from 2010-2011 (Oteng Ababio, 2010). The use of pc prompts the use of pc at homes and schools which empowered individuals for convenient learning. Agbogbloshie was known as a staple market for onions and yams. However, it has formed into a ghetto with occupants and workers dealing with a wide range of activities including purchasing and selling old

electrical and electronic items and household e-waste. Huge amounts of e-waste are moved to Agbogbloshie on a consistent schedule, where they are crushed to remove copper and other beneficial metals.

6.3 **Identification of problem**

The importation of second-hand electrical and electronic equipment (EEE) into Ghana is the cause of the e-waste problem but it has also become a productive trade for both formal and informal sectors. The sector patronizes all degrees of used EEE within the nation in view of its moderateness because it is expensive to purchase a brand new one. Thousands of tons of used and obsolete EEE discarded in Europe and North America are brought into the nation. For example, PCs and extras are tax exempt therefore empowering the importation of EEE into the nation.

The importation and sale of used air conditioners, ridges, icebox coolers, and coolers are disallowed by law (LI 1932, 2008); yet e-waste could enter the country under the portrayal of second-hand EEE without restrictions. It is a mind-boggling circumstance to know the amount of EEE that enters Ghana. Business importers import an enormous level of e-waste into the nation for disposal. A large portion of the hardware is offered to make a profit. Procurement of used (EEE) is affordable to numerous individuals yet the life expectancy of these gadgets is beneath three years. Most people and associations store the old (EEE) equipment in their homes and workplaces because of the vulnerability of where to discard. Some portion of it is offered to scavengers, scrap vendors and the rest refuse and dump the rest when there is no additional space for storage. The data and PC innovation act have no reference to how the importation of used PC and PC related things ought to be dealt with after the life expectancy.

These days there is no legitimate management and disposal of e-waste. The (EEE) imports to Ghana are viewed as an appealing decision. Any methodology by legislation to avoid such importations may have a negative effect on ICT advancement in Ghana. For example, restricting the imports of utilized (EEE) with no endowment to make new ones affordable will wind up individuals pirating it over the borders into the country. There is no system set up to teach the laborers on the dangers related to the treatment of e-waste nor any social help for development on the situations where they work. The failure to enforce the law has made it an open paradise for employment creation and as an entry point for immigrants from northern Ghana who have no clue about the hazard in question also children are occupied with these e-waste businesses.

6.4 **Waste Hierarchy**

The ideal of sustainability oversees the common course of waste administration and shapes the premise for the hierarchy of waste management alternatives to the EU approach. The European Commission has set out a clear hierarchy of waste administration alternatives in its enactment. The hierarchy sets up a favoured program needs based on maintainability. To be sustainable, waste administration cannot be fathomed as it were with technical end-of-pipe solutions; as this can be figured out, waste management is entirety moving towards more integrated approaches. The hierarchy was first presented within the Waste Framework Directive (75/442/EEC), and presently could be a component of all waste mandates. Its usage is guided by the consideration of the Finest Practicable Environmental Alternative taking into consideration both social and financial costs. The waste management hierarchy indicates an order of preference for action to reduce and manage waste and is usually presented diagrammatically in the form of a pyramid. The hierarchy captures the progression of a material or product through successive stages of waste management and represents the latter part of the life cycle for each product. Hierarchy of waste management is indicated by Figure 7 below.

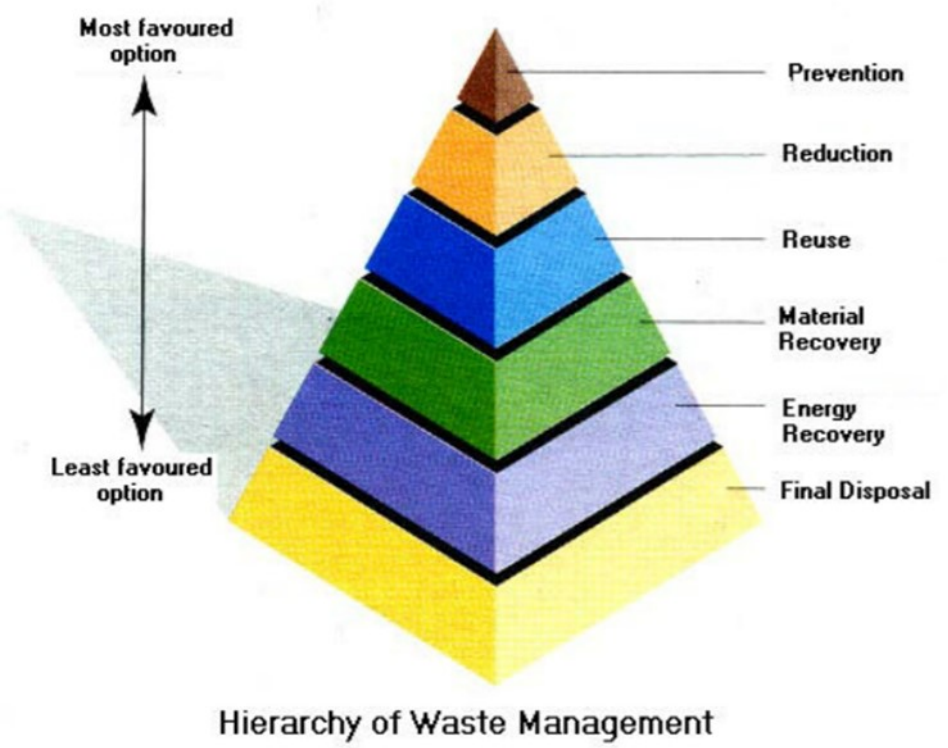


Figure 7 waste hierarchy (EU focus on waste management 1999)

The prevention of waste is the foremost point within the waste hierarchy. Anticipation or reduction minimizes the generation of waste items within the first place. Avoidance, as a rule, comes about within the slightest environmental and financial life cycle costs since it requires no collecting or handling of materials. The re-use of waste is the following most alluring choice. Reuse is utilizing once more of a material without any basic changes in that material. The recovery of waste is divided into categories of recovery of materials and recuperation of energy. Whichever of these two alternatives is superior for the environment and human wellbeing is the favoured one.

The recovery of materials is most frequently the more favoured choice. Recuperation of materials incorporates exercises such as reusing and composting. These exercises, for the most part, require a collection framework as well as a strategy of material processing or transformation into a new item. Recovery of energy, such as incineration is often the less favoured option. Final disposal is continuously a final resort, as it is considered once all other conceivable outcomes have been explored. Before the last disposal, a significant sum of pre-treatment is essential. Pre-treatment incorporates physical, warm, chemical, or natural forms that alter the characteristics of the waste in place to decrease the amount and the harmfulness of the waste.

Landfilling is the last disposal. The Precautionary Principle broadly states that when an action causes danger to human wellbeing or the environment, preparatory measures ought to be taken in case a coordinate cause and impact relationship has not been logically demonstrated. The defenders of the activity, not the public, bear the burden of verification. This Guideline permits a lower level of confirmation of harm to be utilized when making policy in a case holding up for the next level of verification may cause critical or irreversible harm to human wellbeing or the environment. (EEA,2007)

7 E-WASTE MANAGEMENT IN ACCRA

The present e-waste situation in Ghana is problematic. There are no appropriate facilities that supervise such enormous waste that gets into the market each day. A lack of work has additionally pushed many people to set out on the e-waste business making things more complicated than ever. The legislation was passed by parliament, (Act, 917, 2016) but has not yielded results due to the lack of enforcement by the authorities. There are numerous nationalities such as Togolese, Indians, Chinese, Nigerians, and Ghanaians that are into this e-waste business because of the absence of provision by the legislature to safeguard sound e-waste disposal management framework in the country for execution. An estimated of 6300-9600 individuals work at the informal e-waste sector in the nation

with a population of between 121,000-201,600. This pointer tells that the informal sector has assumed total responsibility for e-waste management. There are numerous e-waste dealers across the country; however, the most famous e-waste recycling Centre is in the country's capital Accra called Agbogbloshie scrap yard. The informal e-waste management board practices in the zone consists of four essential divisions specifically recycling, repair, collection, and sale of metals. The procedure for gathering e-waste in the informal sector is called collectors who generally go from door to door collection and purchasing nonfunction or broken EEE from both private associations and establishments for a little fee. (Prakash, Manhart, Amoyaw-Osei et al.,2010)

They convey it to the scrap yard for preparing. In some cases, the collectors do not pay anything for these things as they find them dumped at street corners and at dumpsites by a merchant. Collectors sometimes travel a long distance to visit waste compartments, landfills, and other waste dumping grounds for e-waste. The strategy for handling the e-waste procedure is not the best possible method. Moreover, the e-waste gatherers approach their jobs by dismantling and separating metal recovery by means of burning cables and wires to recover copper available to be purchased. An investigation has uncovered that 90% of e-waste in Ghana is being collected by the informal sector. (Oteng-Ababio, 2011). Figure 8 below shows a picture of scrapyard. (Amoyaw et al.,2011)

Figure 8 map of scrap yard (Googlemap.com)

The repairers turn the non-working equipment to work and simultaneously replace old or broken parts with new ones to make it function. The obligation of the repairers is to make it clean and look attractive to the public. Important metals such as copper, iron, aluminium from the e-waste are dismantled by means of chisels, metal bars and hammers to retrieve precious metals. The non-recoverable items are monitor screens and other non-profitable ones including plastic housings of various types including capacitors and dry batteries which are discarded at a close-by dumpsite and burnt to decrease waste. Chisel and hammer are their main tool for dismantling.

The incomes of the e-waste collectors were between 70 and 140 US dollars. Refurbishes get between 190 to 250 US dollars whilst recyclers make 175 to 285 US dollars. The practicing of leaching of the printed wiring board is not in the Ghanaian e- waste sector. Most of the materials recovered such as ferrous metals, aluminium and copper are sold to private business for export and some industries in Tema. According to researchers, about 171,000 tons of e-waste was collected directly from consumers and repairers in 2009 by the informal sector alone whilst 10,000 to 13,000 metric tons of e- waste was treated annually. (Prakash et.al.,2010)

The mandate of the scrap dealers at Agbogbloshie is to gather and supply various viable waste materials and by moving some of the components from one market to another through their agents called middlemen. Most of the middlemen sold the components to companies and private businesses who in turn ship it to overseas countries for profit. There is an association by the name Greater Accra Scrap Dealers Association which was formed by the scrap dealers making it a complete organization on its own. Middlemen work with both the traders and the scrap dealers which has caused interference in the wake of the business. Studies have demonstrated that the vast majority of individuals engaged with the informal e-waste activities at Agbogbloshie are young men aged 14 to 40 years from the northern part of the nation with working hours from 10 to 12 hours every day, making it 300 to 360 hours out of every month. Financial circumstances have pushed the adolescent to take part in these exercises to profit from the recovery of metals for survival. Despite the various work and income opportunities that have come with e-waste business, the extreme environmental and health issues related to it have not been addressed. The inappropriate procedure of dealing with e-waste exercises by the informal sector has caused poisonous and dangerous substances in our soil air and water bodies which poses serious health dangers to both the laborers and the re
residents living close by. Formal e-waste organizations are not many in Ghana. City Waste Recycling Limited began its e-waste activities in 2010 and Zoom lion Ghana Limited which is also a residential waste management organization, and both have been given a permit from the EPA Ghana to guarantee that the environment is free from any potential harm during their activities. (Amoyaw et al., 2011)

7.1 **Legislation on e-waste in Ghana**

The Environmental Protection Agency (EPA) is the sole responsible for the supervisory of the environment. The parliament of Ghana passed a law on electronic and hazardous waste management act in 2016. (ACT. 2016) to safeguard the handling and processes of electronic waste. Ghana is a signatory to the Basel Convention that came into force in 1992 which provides an outline for the worldwide regulation of e-waste. The relevant national environmental Conservation Act, solid waste Management Act

and other statutory laws and regulations related to the importation and Management of e-waste and solid waste in Ghana include:
Act 462 Solid Waste management Act (1993)
Act 490, Environmental Protection management
Act (1994), Act 503; Import and Export Act (1995),
Act 528; Environmental Assessment Regulations 1999,
LI 1652; Environmental Sanitation Policy of Ghana (1999),
Act 917; Energy efficiency, hazardous and electronic waste management Act (2016)
(L.I. 1812) Ozone depleting substances and products regulation (2005)

7.2 **The Basel Convention**

There are growing worries over the handling and movement of hazardous waste, thus the Basel Convention on control of the transboundary movement of hazardous waste was initiated in 1989. However, it became effective in 1992. The essential target of the convention is decreasing of transboundary shipment of hazardous waste and ecologically sound management for this kind of waste (SBC, 1989). Starting in 2006, 170 states with 63 parties approved to the 1995 amendment to the convention. The trade-in dangerous waste is sensible under a segment of Prior Informed Consent (PIC), which needs parties not to trade dangerous waste except if an importing nation has agreed to it. Infringement by an exporter suggests the exporter country takes the waste back.

7.3 **The Bamako Convention**

A meeting of Africa nations was held in 1998 at Bamako. Mali (called Bamako Convention) where an agreement was reached for the ban on all dangerous waste including e-waste. The convention was to address the waste management problems by the Organization of African Union inside the Basel Convention. The Bamako Convention criminalizes imports into Africa any form of dangerous waste from developed nations into the continent of Africa, perceiving the danger of unsound management on human health and the environment. The continent agreed and obliged member states to observe ecologically sound management and treatment of dangerous waste, like the Basel Convention, the Bamako meeting permit trade in dangerous waste between African states dependent on the instrument of informed consent (Kaminsky, 1992,pp.5-77)

7.4 **Collection and Transportation**

Collection and transportation are done by the youth who are the majority in the field of e-waste business. These folks travel to homes and dumpsites in search of e-waste. They rely on this e-waste business to make a living. There are informal collectors and formal collectors. Informal collectors are individuals who go about looking for e-waste at dumpsites and other

places whereas formal collectors are companies that deal with e-waste. The situation has worsened due to unemployment among the youth in Ghana. A study reveals that a collector must pay between 1 to 2.5 US dollars for discarded PC. Different collectors dismantle and recover metals by open burning of cables and wires. The dynamic of e-waste gathering has changed with the increasing competition. The city is completely exhausted, and collectors must go past their range to get the target of e-waste. Collectors need a big amount of cash to purchase enough e-waste. The transportation and collection of e-waste by informal artisans from one place to another between metropolis is illustrated in figure 9 below

Figure 9. Informal collectors (Prakash et al., 2010)

7.5 **Informal Collection of e-waste**

The Collection of e-waste is done by the informal collectors who gather them at different areas like landfills, dumpsites, and other applicable spots. was estimated that 95% of (WEEE) recorded through the informal sector while 5% end up with the public collection. The household generation of (WEEE) has been named Urban, medium urban and rural. The medium urban represented most (WEEE) with 59,000 tons pursued by the urban 29,000 tons and in conclusion rural with 13,000 kg for every year. The greatest amount of WEEE generated per family per individual is found in urban communities with 31kg/family and 8.8kg/individual and this finish of life products are from buyer to collector. WEE treatment by the conventional method is done on a little scale. City recycling company limited is a privately owned e-waste company that has a license from EPA Ghana to embark on e-waste management in the city. Other private institutions are interested to undertake the e-waste business in the country, but the challenge is about financing. Informal collectors care less about the dangers. Companies and establishments dispose of their obsolete electrical gadgets by instructions from the head of the department while families and individuals decide when to dispose of the item. The choices of some individuals are either adding to family waste,

selling to informal collectors, and giving it away as a gift to relative/school or companion at work. Table 5 shows below (WEEE) flow through communal collection. (tons / year 2009).

Table 6 WEE flow through communal collection. (tons / year 2009)

	WEEE
Communal collection	5'000
To informal treatment	4'800
To official landfill	200

7.6 **Recycling of e-waste**

The approach of recycling and dismantling of e-waste by the informal sector to retrieve valuable materials for sale is becoming an attractive business in Ghana. The primary goal by the informal e-waste workers at Agbogbloshie is by dismantling outdated computers, monitors, televisions and extract metals like Copper and aluminium. Many of these activities carried out by youngsters using primitive tools without safety clothes. Some resources are lost due to the crude practices of recovering materials. The effect of the environmental pollution and health risks remains a major problem, but this e-waste business is a source of income for many poor people especially those youth from the north who are forced to choose between living in poverty or working in perceived poison. Refurbishment and reuse exercise of old electronic gadgets have been a practice in Ghana for a long time which comes along with e-waste management. One of the advantages of reuse and refurbishment gadgets is affordable making it easy for more people to have access to electronic gadgets. The following are the prices for mineral after retrieval, copper 0.22US dollars per half a kilo, plastic 0.01 US dollars per kilo. Conservation of energy and raw materials to produce new ones reduces environmental pollution that comes with energy use and production. A hammer and chisel being used to extract materials as shown in figure 10 below

Figure 10 manual dismantling of e-waste. 7.2019

However, since (WEEE) imported into the country is seldom tested for performance, there is a huge amount of refurbishment and repair which causes plenty of difficulties and is time-consuming, also repairing and refurbishing have become part of e-waste. Transformation of old and nonfunction products into functional and almost new are done by the refurbishes. The refurbishes remove dead and broken parts and fixed new parts to get the item back to functionalities and make it look more attractive to buyers. There is a significant number of e-waste traders and refurbishes who travel to Agbogboshie from all over the nation to buy WEEE due to its well known as the best place to repair their gadgets and obtain any WEEE parts. Ironically, some repair stations have been opened in the northern part of the country for the same purpose. The trade of e-waste is booming and there are not any indications that it will stop soon.

7.7 **Impact on water**

Agbogbloshie e-waste site is situated on the left banks of the Odaw River It is linked to Korle lagoon on its upper side in Accra, at 05°35'N and 00°06'W. The Odaw River covers an area of around 16 km. The town has a population of around 40,000 and lies within tropics. The Odaw and Korle Lagoon streams are adjacent to disposal site which forms some portion of the catchment area in the Accra city and occupy an area of 250 km^2 .The rainfall in Ghana every year is believed to be 1,187mm (FAO ,2005). The precipitation in Accra is about 730mm yearly Accra metropolitan Assembly 2006. There are two rainy seasons around this place and two rainfall peaks in June and in October. This downpour falls with heavy storms on most parts causing flooding which flows through the Odaw and Korle Lagoon into the Atlantic Ocean. Thus, the possibility of water washing contaminants into nearby water bodies is high. (Biney 1998) in his exploration characterized urban run-off as one of the primary types of contamination that reaches Korle lagoon and Odaw catchment. It was later affirmed by (Brigden et al., 2008, pp.1-23). that similar synthetic concoctions found in Korle Lagoon residue were equivalent to the one found close to the site where burning and activities of e-waste take place. Poison from the activities of burning site to surface waters may be the reason for rainfall and flooding. The atmospheric tendency is another instrument of e-waste contaminant to neighbourhood water bodies. Accra district lies in a coastal tropical zone that is dry. This reality in blend with the open burning, activities during e-waste recycling prompts the formation of thick smoke. The smoke particles might be contaminated by surface water close by, either by wet or dry climatic deposition. It was discovered by Caravanos and Otsuka during their soil and ash test at Agbogbloshie e-waste site found high concentrations of toxic metals which was as much as 20 times above ground level. (Otsuka et al. 2012, pp.161-167). Figure 12 below gives the present situation at both lagoons that is near Agbogbloshie e-waste site.

Figure 11 impact on odour river water close to Agbogbloshie. (Oteng Ababio, 2012)

7.8 **The effects of e-waste contaminants in water bodies**

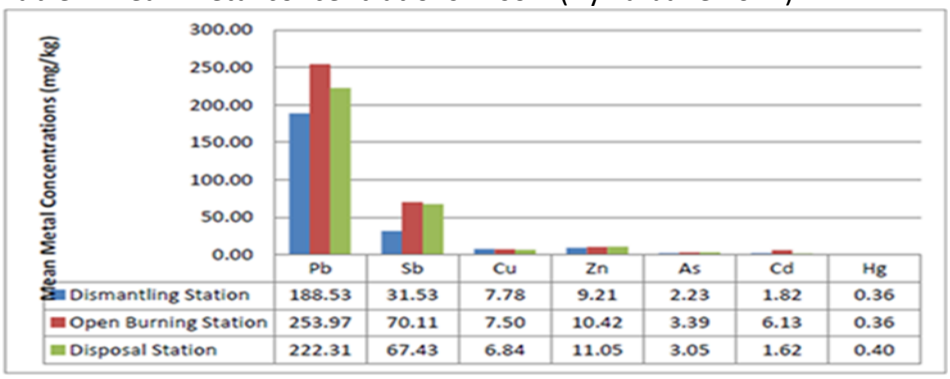
A living thing in Water bodies may retain heavy metal poisons from water or direct way through the food chain. The impacts of e-waste contaminants are disturbing and dangerous. The impacts on our water bodies are of serious concern. The Öko-institut of Applied Ecology in their exploration presumed that the uncontrolled dumping of e-waste and reusing activities seriously affects the nearby Korle Lagoon and Odaw stream. (Prakash & Manhart,2010) A few years prior, the lagoon was used as a fishing ground for the neighbourhood communities but is now contaminated. The Odaw River which serves as a fishing community is dead as a result of huge contamination from the bad strategy used for processing e-waste. It was presumed that the most elevated hazard in the Korle Lagoon dregs assumes to be copper, lead and zinc whose concentrations ran from 20-times higher than the silt concentrations which often combined with a negative impact to benthos (Cu), 15-times higher (Pb), and 5.6-times higher (Zn). The sediment harmfulness edges appeared don't clarify for site-specific effects on the bioavailability of contaminants and just refer to toxicity emerging from the short term (10-30 days) sediment exposures, instead of persistent toxicity and the negative effects emerging from the centralization of contaminants in the oceanic food chains.

7.9 **Impact on soil**

In June 2014, a researcher by the name (Okine Ayikai 2014) made an inspection at the Agbogbloshie e-waste site and the following heavy meal concentration was recorded. , Lead Pb (221.60 mg/kg), Antimony (Sb (56.36 mg/kg) > Zinc Zn (10.23 mg/kg) > Cupper Cu (7.37 mg/kg) > Cadmium Cd (3.19 mg/kg) > Arsenic As (2.89 mg/kg)> Mercury Hg (0.37 mg/kg). However, the most elevated soil Copper (Cu) mean worth recorded for the dismantling station was (7.78 mg/kg) through the open burning station recorded (7.50 mg/kg) trailed by the disposal station with (6.84 mg/kg). The soil heavy metal concentrations between different e-waste inspecting at Agbogbloshie has no huge difference because of the limited quantity of sample size, However, the outcomes show the open

burning of e-waste probably caused more damage by the release of heavy metals in the soil than disassembling activities at Agbogbloshie e-waste site. Prominently, the highest and least mean concentration for different metals examined where four out of seven were seen for the open burning are for dismantling station. (Pb, Cd, As and Sb) while (Pb, CD, As and Zn). Additionally, for the open burning and dismantling stations, a similar mean Mercury Hg addition estimation of (0.36 mg/kg) Zinc, Zn (11.05 mg/kg), and Mercury-Hg (0.40 mg/kg) was recorded.

Table 7 mean metal concentrations in soil. (Ayikai June 2014)



	Pb	Sb	Cu	Zn	As	Cd	Hg
Dismantling Station	188.53	31.53	7.78	9.21	2.23	1.82	0.36
Open Burning Station	253.97	70.11	7.50	10.42	3.39	6.13	0.36
Disposal Station	222.31	67.43	6.84	11.05	3.05	1.62	0.40

7.10 **Landfill and fire**

The record in table 7 above shows that seven metals were assessed. The open burning station had almost the highest mean concentration of these metals particularly Pb (253.97 mg/kg), Sb (70.11 mg/kg), Cd (6.14 mg/kg) and as (3.39 mg/kg), and simultaneously disassembling station recorded minimal concentrations for (4 out of 7) of the metals explored, Especially Pb (188.53 mg/kg), Sb (31.53 mg/kg), As (2.23 mg/kg) and Zn (9.21 mg/kg). Many reports have been published about the outbreak of sickness among those living around that area, but nothing has been done so far to control the dumping of the waste at such vicinity during a research work at the place. Figure 13 below describes the impact informal e-waste practices is having on the soil at the surrounding neighbourhood at Agbogbloshie scrapyard.

Figure 12 Impact on soil field work 7.2019

At Agbogbloshie scrapyard hazardous and non-valuable materials are disposed of at the adjacent dumpsite and the accumulated waste gets burnt to reduce the volume. Open dumping are the main disposal methods used in Agbogbloshie scrapyard. These practices of recovering precious metals from e-waste yard for sale has a serious environmental effect. Initial estimation of total dioxin (PCDD/F) emissions to air from open cable burning in the Greater Accra Region has been recorded as the following; 1000 tons/year burnt cables in Greater Accra Region.38% plastic is amounted to 400 tons/year; 62% copper is amounted to 600 tons a year. A preliminary estimation of total dioxin (PCDD/F) gases from open to air burning in the Greater Accra Region recorded Source Strength of ~5 g/year Compared to European dioxin air emissions stock for 2005 EU15, is equivalent to 0.25 – 0.5 % of total dioxin emission –5 % of dioxin gases from municipal waste incineration. 15 – 25 % of dioxin emissions from modern waste burning. (Quass et al, 2004, pp. 2272-227)

7.11 **Biomedical waste**

A case study concerning biomedical hazards of e- waste at Agbogbloshie was conducted by Environmental Protection Agency (EPA Ghana) with samples from individuals ranging from blood, hair, breast milk, and nail from each single person within the vicinity. The results showed that high levels of electronic waste components were discovered in everyone. In 2009 another study was conducted by the University of Ghana and the results of the blood level of lead exceeding 200 percent in nine different soil sampling areas above EPA acceptable levels were found in places where children often play, increasing the possibility of lead exposure. Medical research has proven that lead poisoning causes an effect in young children which damages the nervous system, delays mental development, epilepsy sensory deficits, and behavioural issues. Researchers from both Ghana and Japan in 2011 predicted a high hazard outcome in mothers at Agbogbloshie for polychlorinated biphenyls (PCBs) and brominated flame retardants (BFRs), both being toxic materials in e-waste using breast milk samples which recorded health risks for their unborn children.

8 **METHODOLOGY**

The strategy utilized for this research was a case study. A case study is based on a subjective approach. The reason for choosing the qualitative approach was that this is an illustrative study. The aim of this study was to come up with the opinions, motivations, and understanding of the forms in order to gain an overall picture of the whole method. It does not contain any numerical examination, but it shapes a theory for future quantitative research. The sources for the qualitative information were the existing

companies' process descriptions that were considered with the assistance of interviews, observations, and a questionnaire. The hypothetical premise was shaped with the assistance of electronic sources, articles, and books. Hypothesis gives a solid establishment for this study without any obstructions with the investigation. The thesis is divided into four parts. Firstly, there is a hypothetical segment that clarifies the principles related to the collection, putting away and reusing methods of WEEE. Furthermore, a description of the current situation of e-waste management in Ghana and Finland is given. Thirdly, different recommendations are given for the present and future in order to gather and handle WEEE proficiently and cost-effectively. Within the final area, a rundown of the response to the research questions is given and the resolute quality of the results has been evaluated.

8.1 **Research Paradigm**

A research paradigm is an established model of interconnected systems of practice which define the nature of inquiry for a given study. The term was first used by Kuhn,1962 to describe the conceptual frameworks guiding the assessment of problems and findings in scientific research. The current research on the Ghana e-waste management will adopt the synthesis alternative of two paradigms: the philosophies of positivism and interpretivism. The positivist paradigm rests on the notion of objectivity, which aims at finding a discrete answer in the form of yes-no or the extent of agreement. In this model, the researcher remains detached from the respondent(s) by distance to maintain a neutral emotion and thus make a more definite distinction between reason and perception. The researcher can differentiate between facts and values and maintains objectivity and a consistent logical approach.

A cross-sectional examination includes the gathering of information at a point in time on more than a disposal case. The information is then inspected to detect examples of the relationship on the varieties. This is different from a longitudinal report in which the information is gathered at repeated intervals. Characterizing the use of a cross-sectional research plan in this examination involves a determination of a whole or a subset of an area from which the intended information is gathered from people associated with e-waste disposal. The advantage of using a cross-sectional research configuration is that the researcher can look at different factors at a point in time. However, the design does not give a positive purpose behind the connection between the causes and the resultant effects. (Rindfleisch et al., 2008, pp. 261-2779)

8.2 **Research method**

Owing to the adoption of a cross-sectional research design, the study used mixed research techniques. The approach gives a hybrid of results that are

flexible and adaptable. Other reviews refer to the technique as a data triangulation method due to its ability to converge the traditional methods of Quantitative and Qualitative approaches. The quantitative research method is associated with the positivist paradigm which emphasizes that real-life-events can be observed empirically and analysed logically. This realistic approach helps in collecting empirical data and building relationships between two or more variables. The rationale for using a qualitative approach for collecting data from e-waste workers is to get a better insight into the e-waste disposal mechanism in Ghana and being able to propose solutions for its improvement. The pros of deploying the mixed data collection techniques give a basics for qualitative and quantitative data comparison. (Creswell et.al2014, pp51-65)

8.3 **Data collection and sample size**

This study depended basically on direct information from the intended interest group, which has been gathered from the two discrete sources of e-waste system, clients (who either sell or get e-waste through the private waste management system and metropolitan assemblies. A random sampling approach was use gather information from e-waste disposal clients. Individuals were reached by visiting the e-waste disposal site at Agbogbloshie. A total of 10 e-waste workers were contacted one on one approach, which brought about every one of the 10 legitimate responses, which were recorded for analysis. The qualitative information from the e-wasters, a 'purposive-inspecting approach' was utilized to contact e-waste workers who have a working knowledge of e-waste disposal for over three years.

8.4 **Data Analysis**

Illustrative measurable data investigation was used to analyse the clients' questionnaire responses (quantitative) and the derivations used to generate tables and diagrams, exhibiting scores for every client survey. Thematic measurement analysis was then used for descriptive qualitative information. The researcher goes through information decrease process, deleting interview parts, which are not significant to the present inquiry. The data is then perused line-by-line to personality watchwords, which are then combined to frame significant topics. The advantage of shaping significant subjects is that they involve gathering keywords, which cannot be assessed in isolation. By consolidating keywords into a significant theme, the researcher can make the importance of every joined reaction and propose a decisive outcome. (Knox , 2012).

8.5 **Questionnaire Development**

The study begins with questions regarding whether the members have attempted different techniques for e-waste disposal or retrieval. This will

give a general thought of the popularity of the e-waste in Ghana, other accessible institutions and foundations used for disposal. The survey is made shortened, acquainting specific questions related to members' involvement with e-waste disposal. Ten e-waste laborers were interviewed at the site.

A stream of questions and issues were addressed in other to improve the integrity of the information. The interview questions are as follows.

1.After dismantling where do you keep the unwanted materials and why?
2. How old are you?
3. Who introduced you to this work?
4. Do you use safety gloves when handling materials?
5. How much money do you make in a day?
6.What do you do when you are sick?
7.What are your future goals?
8.Where do you live?
9.How many years have you been doing this work?
10.Do you like this work?

Information collected after the interview shows that lack of employment prompted them to embark on this e-waste business. They are between 17-35 years of age. This business is their only source of income: If they had a better job they will quit. they also live in the ghettos around the Agbogbloshie. Headaches are common among them and rampant sickness is also common. Medicines are purchased by themselves. Life here is very tough because sometimes they do not buy anything, and one goes home empty- handed. The unwanted materials are dumped at any available place. (7.2019)

8.6 **Ethical Consideration**

Surrounding the criticality and discussions on the subject, it is significant that fundamental actions have been taken during the data collecting process. The significant examination of Finnish e-waste compared with Ghana e-waste makes the procedure of data accumulation less difficult and advantageous for this investigation. To guarantee members secrecy, private data like name, email locations, or telephone numbers, were not gathered during the data collection process. With the negative discernments about e-waste collection procedure in Ghana and the negative perception about the system, the researcher explained and assured the e-waste workers that the aim and objectives of the questions are for academic purposes only in other for them to feel comfortable while giving responses. Following the British Educational Research Association system of the agreed venture, all members were educated about their cooperation as being wilful and they reserved the option to decline to react to any question or stop the meeting whenever the right of assent. Also, hand-notes were used as an account material and no sound recording gadget was used. The utilization of sound recorders regularly makes members awkward and they start being suspicious about the interview and the questioner. (BERA 2011, p. 87).

9 ORGANISATIONAL AND FINANCIAL ASPECTS

A law governing the management and handling of electronic waste in Ghana was passed in 2016 which makes manufactures of e-waste producers responsible for handling and recycling of e-waste. The new e-waste law in Ghana requires makers and merchants of (EEE) to register with the Environmental Protection Agency and pay taxes that would be used for the management of e-waste. This model is designed that the financial obligation is given to producers. However, the organizing role remains with the government. The effectiveness of this process relies on the location of the EEE manufacturer.

The operation of e-waste is dominated by the informal sector where a large portion of the groups is not registered as a business entity. It is evaluated that 40% to 60% of e-waste is produced locally and 95% is recycled by the informal sector. Ghana depends on donations of EEE, and many of the donors do not check the functionality of the gadget before giving it away. The most challenging aspect is replacing the informal sector with the formal sector when it comes to models regarding financing.

The legislature cannot provide the resources for the e-waste management alone, thus public-private participation (PPP) can organize resources, lessens hazards, contribute, and improve service delivery. The PPP would work better if there is an institutional structure that fuses a business idea that will yield returns for private investors. It was expressed in the 2015 UN report that the worldwide generation of WEEE will add up to 50 million metric tons in 2018. Private Partnership is a type of joint venture, mergers as a vital alliance on account of the huge investment needed to finance e-waste business. PPP and strategic alliance coalition are not a common practice in Ghana.

The bank of Ghana expanded the minimum capital requirement from 60 million cedi's to 120 million cedi’s in 2009. In 2014, the small and medium-sized waste management organizations went into a strategic alliance, taking the opportunity to raise the capital required for
e-waste management. Figure 13 shows the strategies in e-waste funding in Ghana.

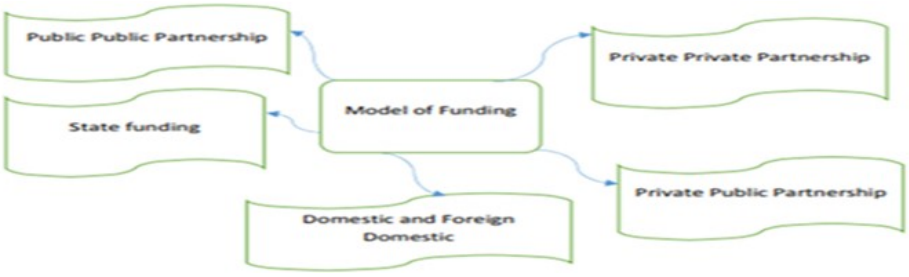


Figure 13 alternative (source) of funding e-waste in Ghana

The German economic corporation and development (BMZ)have emerged as a sponsor on many projects in Ghana including e-waste management. There are also other sponsors such as the Netherlands Directorate-General for International Cooperation (DGIS) and the Danish International Development Agency (DANIDA) on similar projects within the country. The idea for state and public funding has not yielded any success. Both domestic and foreign sources of funding would be critical in financing e-waste activities in the country.

9.1 **Initiative towards implementation of e-waste management in Accra, Ghana**

The initiative of the government in Ghana is to improve the Policy on e-waste management by supporting and assessing the establishment of ecological sound collection and recycling systems in the nation by connecting local recycling enterprise with international markets for explicit recycle fractions, improve the recovery of important metals from the end of life in an ecological manner. In March 2017, the German government decided to support the establishment of structures for the effective collection and recycling of e-waste which had become a threat to health and environment in the country for decades. The support which amount to 25 million euros will be used for funding a pilot program that seeks to reduce the environmental impact of electronic waste in Ghana for at least three years.

Figure 13 signing of pact by Germany and Ghana (graphic online, Mar,29 2017.

In 2012, (SRI) Sustainable Recycled Industries was started by Switzerland SECO) Secretariat of Economic Affairs of Switzerland and the Swiss Federal Laboratories for Material Sciences and Technology (Empa) called the SRI in which Ghana was among the selected countries to participate in the program. The SRI program introduced three systems namely conformity assessment, technology partnership, and business opportunities and all these three were fundamental for effective e-waste management in the country.

10 E-WASTE MAAGEMENT IN FINLAND

Finland is one of the EU member Countries, therefore, the same EU legislation is being applied in Finland for the execution of e-waste management in the country. Three producer cooperatives were formed to facilitate the e-waste management. They are SER-Tuottajayhteisö Ry (SERTY), Elker Oy ERP Finland Ry and ERP Finland Ry, which deal with the producer responsibility commitments for collection and recycling of WEEE material for its members. There are 450 collecting points. Other retail shops also collect e-waste. Producers and other co-agents such as (SELT RY), ICT Producer Co-operation (ICT-tuottajaosuuskunta) and Finnish Lamp Importers (FLIP Ry) also collect e-waste. WEEE incorporates numerous stages. collection, transportation, sorting, dismantling, and selling reusable items. Finland has three regulatory components and three approaches for effective e- waste management. Collection framework, collective framework and clearing house framework are all regulations whereas municipal takeback, retail take back and producer take back are approaches that safeguard the collection, transportation, recycling, and landfilling of e-waste. There are several collection organizations working within the e-waste environment making sure the effectiveness of the e-waste management is attained. These organizations are Mustankorkea Oy, Vaentupa Oy, Sammakkokangas Oy, Lassila and Tikanoja, Kuusakoski Oy and TKV Finland Oy which collect different sorts of waste including e-waste. The fundamental phases of collection of WEEE in Finland are exhibited in figure 14 below

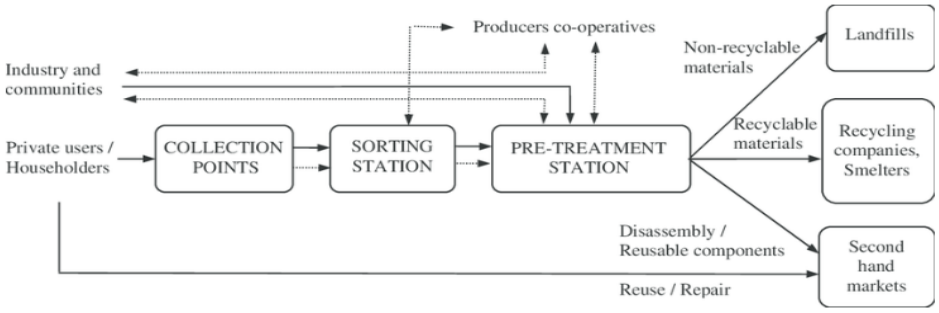


Figure 14(WEEE) in Finland (Lehtinen & Poikela, 2006)

During our school visit to (Fortum waste solutions) waste recycling company located at Riihimäki, in 2017, most of the technologies discussed below were being used for the waste treatment. The e-waste technologies used in Finland focus on material flow. The procedures used are mechanical separation, thermal treatment, hydrometallurgical treatment, and electrochemical treatment. In this process, there are also initial level treatment, the second level treatment and the final level treatment which are also part of the treatment process. The rest of the parts after the whirlpool current separator primarily comprises various metals (particularly valuable metals and their composites) just as various types of

plastics. This part and the light portion from the violent wind separator are offered to the precious metal's recovery unit.

TKV Finland Oy is in the used IT gadgets business, acquired from the previous organization called International Computer Brokers ICB-Finland which worked from 1981 to 1994. TKV Finland acquired a few decent practices that began in the 1980s Its collaborators with another top domestic PC merchant organization by the name Cimos Oy. These two organizations are the local market pioneers for used PC equipment. TKV Finland Oy both purchases and sells used IT equipment on the B-to-B market locally and the organization is a solid player on the international market with huge export/import operations around the world. From an ecological point of view, the used IT- market represents sustainability as reusing PC equipment saves a lot of resources and energy.

TKV Finland Oy gives a full report about the information deleted from hard drives and other stockpiling gadgets. TKV Finland Oy gives upgrade services and recycles old hardware. The organization recycles everything that is difficult to sell through organizations which are experts in e-waste disposal. Finland Oy is predominantly a used IT hardware representative, which is an association component in a chain of first users and re-users of equipment. The organization gets equipment either from recycled markets or directly from private clients or organizations. TKV Finland Oy offers conveyance services inside the southern Finland district, Finland. The end-client data in all the equipment must be erased to conform to the security agreement. TKV Finland Oy uses the most developed information deletion technology, which toward the end gives to the previous client a thorough report to demonstrate successful information eradication and after successful information deletion, the hardware goes to the quality control department for evaluations and condition of the gadget.

10.1 **Legislation in Finland**

During the study observation from Finland, the following was noted. Finland's e-waste legislation is as follows and it is very effective. Government Decree on landfills (331/2013, in Finnish, Finlex) Government Decree on waste incineration (151/2013, Finlex) General waste legislation -Waste Act (646/2011), Waste Decree (179/2012) Regulation (EC) No 1013/2006 (EUR-lex) of the European Parliament and of the Council on shipments of waste Act (as amended by 626/2017 in Finnish, Finlex) Environmental Protection Act (as amended by 627/2017, in Finnish, Finlex), Council Regulation (EC) No 1420/1999 (EUR-Lex) Commission Regulation (EC) No 1418/2007 (EUR-Lex). Trans frontier shipments of waste (ymparisto.fi source. www.ym.fi/en-us/)waste legislation.

10.2 **Reality**

The reality at Agbogbloshie e-waste scrapyard reveals that none of the informal laborers wore protective clothing while working. Their working conditions were destitute. However, a few of the workers had boot-like footwear or running shoes, whereas, others wore slippers. Their working environment was very noisy and there is a chance of walking on sharp objects and getting harmed. The place was littered with pieces of crashed electronics. There were other hazards such as flying objects due to the methods used. There is a potential for flying objects from the hammering of e-waste to injure workers. There was also some debris within the air, particularly when the wind blew intensify. In addition, they grow vegetables and rear animals at the scrapyard. A few other cattle and sheep I saw were eating from a garbage dump near to some informal laborers who were burning wires, etc. The nearby waters seemed heavily polluted. Other people were selling food and drinks to the e-waste workers.

However, the technics used in the handling of e-waste in Ghana was observed and noted as follow

1. There was not any proper technics in dealing with the e -waste management.
2.Collection of EEE is done by young guys between the ages from 16- 40 years old who goes from door to door to ask for these items. Others walk a long distance to search from abandoned containers and road sites which are left by importers.
3. Transportation is done by the same guys, some carry it to the scrap yard, some also hire a pick-up truck to carry it. Others also hire a small local made truck for transporting.
4. Dismantling are done by using chisel and hammer and any other tools available without any safety clothes.
5. copper is retrieved by means of open burning which eventually pollute the air.
6. Reuse are done by some self-trained guys who repair the best that can be repaired and sell it out to customers who might not be able to afford to purchase a new one.
7 Disposal: Open dumping, open burning, and land filling are the main disposal method used without any proper technics. They dispose of the computer casings near Odaw river Korle lagoon banks and at any place which they find it appropriate.

The Health hazards associated with e-waste handling in Ghana was also observed and recorded as follows:

Data analysis

1.Chronic illness
2. Respiratory illness
3.High rate morbidity
4. High rate mortality
5. Cancer

6. Damage to nervous system
The exposure of leads to children causes damage to their nervous system. The activities of e-waste at Agbogbloshie scrapyard have cause water bodies such as korle lagoon and Odaw river polluted causing serious health hazards mentioned above on the inhabitants and the workers themselves.

Technics and comprehensive e-waste management and administration framework used in Finland during the research were observed as follows:

E-waste treatment technologies have three levels and these levels focus on the material flow and four procedures that are also used for e-waste recycling. Procedures used for metal recycling are
Mechanical separation,
Thermal treatment
Hydrometallurgical treatment
Electrochemical treatment.
A comprehensive e waste management administration framework namely.
Collection framework
Collective framework
Clearing House framework
Legal regulation (EEE directive 852,2004)
System Coverage,
System financing,
Extended Producer responsibility (ERP) and (OECD)
Ensuring Compliance, (Widmer et al., 2005). Municipal take back
Retailer take back
Producer take back.
municipal take back
(UNEP E-waste manual vol. 2, 2007) P25
Finland has 448 collection points.

Established companies for e-waste treatment are
Fortum waste solutions Oy.
Mustankorkea Oy
Vaentupa oy
Sammakkokangas oy
Lassila and Tikanoja oy
Kuusankoski oy
Tkv oy
SER-Tuottajayhteiso ry (SERTY)
ELKer Oy
This approach by the Finnish government has made it one of the best wastes and e-waste management countries in Europe.

Finally getting back to the research questions these answers were found in Agbogbloshie e- waste in Accra
What are the e-waste management practices and disposal methods used in Accra Ghana?

The e-waste practices and disposal methods used in Agbogbloshie such as handling, reuse, recycle and disposal methods were unprofessional and unsafe.

What are the health and environmental dangers associated with e-waste handling in Accra?

The health risks and environmental dangers were Chronic illness, Respiratory illness, High rate morbidity, High rate mortality, cancer, and Damage to nervous system

What can Ghana learn from (EU)Finland e-waste management?

Adapting the Finnish e-waste management approach would enhance proper control and handling of e- waste in Ghana thereby reducing health risks and environmental pollution.

11 COMPARISON BETWEEN FINLAND AND GHANA

Finland has everything that it takes to make e-waste management efficient base on the research. It has 450 collection points and Companies that take care of e-waste. A comprehensive system approach and many more other systems for the management of waste and e-waste has been introduced by Finns.

Throughout the research, it has revealed that e-waste handling in Ghana is unsafe, and it is not the best as compared to Finland. There are no mechanisms in place thereby e-waste management in Ghana is a catastrophic issue. lack of infrastructure and resources. This practice has caused environmental pollution and health issues within the community and the general public.

Comparing Finland to Ghana, the institutions, infrastructure, technology, and mechanisms that are being implemented by the Finns, none of those are being practiced in Ghana. It will be difficult for Ghana to come out of e-waste problems unless Ghana adopts most of the Finnish approach.

12 SOLUTION

Adapting the Finnish e-waste management approach would enhance the proper control and handling of e -waste in Ghana. E-waste companies must be established with the help of the Government. More collecting points should be created. Grassroots Education on e-waste must be implemented Materials such as bins etc. must be provided by the state. Environmental laws must be enforced.

13 CONCLUSION

The results of the thesis and literature review show that e-waste management in Ghana requires plenty of work from the government if they want to turn the challenges into opportunities. Lessening negative ecological and health impacts and improving the material recovery from (WEEE) requires government to adopt the Finland e-waste management approach that would enhance the proper control and treatment of e-waste in Ghana. There is a need for the state to ensure the neglect obligations by organizations like the Standards Board, Customs Excise and Preventive Service. EPA must do their work effectively without compromising. The government of Ghana should strengthen the Metropolitans, municipalities, and district assemblies (MMDAs)with logistics and money to help manage e-waste in a proper manner.

Finally, the government ought to base on specific policy-level implementation and capacity building and increment in public awareness such that it can change over the challenges of e-waste into job creation.

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