Article

E-waste management status worldwide: Major challenges and solutions

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Abstract
The e-waste stream has been intensified considerably over the recent decade causing its management to be a significant challenge to our world. This research aimed to investigate and assess the status quo of e-waste management in different countries. We systematically searched Embase, PubMed, Scopus, PubMed Central (PMC), Google Scholar databases, as well as medRxiv using the following key-words: waste electronics, waste electrical and electronic equipment (WEEE), medical waste, material flow analysis, e-waste recycling, waste management, disposal, e-waste per-capita generation. A total of 48 eligible articles were identified. E-waste management practices are examined for 15 countries, including China, US, Malaysia, Botswana, Australia, Korea, Brazil, Finland, Sweden, Taiwan, Sri Lanka, Jordan, India, Tanzania, and Iran. The systems for e-waste management in these countries vary considerably. The highest (30 kg/capita-year) and the lowest (0.8 kg/capita-year) rate of generation was found in the US and Tanzania, respectively. The rate of e-waste generation (kg/capita-year) was positively correlated with gross domestic product (GDP) per capita (USD) in various countries. About 73% of countries used landfill, while approximately 87% of countries used recycling (safe/ unsafe) for all e-waste. E-waste components include various hazardous materials like e.g., halogenated substances, heavy metals, radioactive compounds and micro and nano-size particles all of which need appropriate handling during the segregation, collection, storage, recycling, disposal and treatment phases.

Keywords e-waste; gross domestic product (GDP); management; challenges; recycling.

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1 Introduction

E-Waste covers various kinds of electrical and electronic equipment (EEE) and its components that have been disposed of without the purpose to be reused. E-waste includes waste of desktop PC, laptop PC, monitor, cell phone, DVD player, phone, headset, television, computer, refrigerator, washing machine, air conditioner, radio, microwaves, cameras, vacuum cleaners, battery, Printer, video projector, and photocopier (Thiébaud et al., 2017; Heacock et al., 2018). As an important tool in e-waste management, material flow analysis (MFA) term is used in the analysis of flow of matter (compounds, chemical constituents, commodities) that is supported by material equilibrium representing the material conservation rule (Fadaei, 2014; Islam and Huda, 2018). The highest amount of e-waste in 2019 was produced by Asia (24.9 metric tons (Mt)), the United States (13.1 Mt), Europe (12 Mt), Africa (2.9 Mt) and Oceania (0.7 Mt), respectively (Forti et al., 2020a). Waste electrical and electronic equipment (WEEE or e-waste) disposal by the European Union (EU) is predicted to be 6.5 million tons annually. This volume of WEEE is equal to 8% of all municipal waste (Alavi et al., 2015). A variety of diseases such as cancers, psychological and neurodevelopment disorders, thyroid disorders, and decline in physical function (DNA injury and gene's expression changes) occur due to the human body exposure to e-waste (Song and Li, 2014). In the under-development and transitional countries, the amount of e-waste equals 1–2% of the whole solid waste on average, which is even anticipated to further increase in the near future (Alavi et al., 2015; Sadeghi et al., 2020). The e-waste recycling chain occurs in three main stages: waste collection, segregation, and pre-processing (i.e. arranging, dismantling, treatment using mechanical techniques, and end-processing i.e., treatment and disposal) (Méndez-Fajardo et al., 2020).

In several developing nations, especially those with low or middle income, a considerable amount of e-waste disposed of in uncontrolled dump sites. Likewise, illegal recycling of e-waste is extensively done (Méndez-Fajardo et al., 2020; Jalili et al., 2021). The chemical, physical, and biological waste treatment techniques are three public treatment methods that have been extensively used. As the most perfect method, chemical technique is of two types: pyro-metallurgy and hydro-metallurgy chemical methods. Physical technique is a mechanical method that refers to the segregation of various constituents from the e-waste on the basis of their various physical properties. The most important methods are dismantling, powdering and magnetic separation. The aim of biological technique is the extraction of heavy metals via microbial leakage. Nevertheless, this technique is in its infancy and does not have a wide application (Islam and Huda, 2018). The population lifestyle changes, technological change, and inexpensive access to electronic gadgets have caused an increase in the use of electronic products. E-waste is an increasing environmental challenge and further attention should be paid to its management in the community. Additionally, scant research has been conducted on this topic given the academic literature.

Unfortunately, unsafe e-waste management methods still dominate a large number of the transitional and developing nations. E-waste management in a safe manner is currently a major problem to governments because it contains hazardous toxic metals, but it can also be popular and trade opening due to the presence of precious metals. Nowadays, approximately 70% of the above mentioned poisonous and hazardous chemicals in the environment originate from e-waste (Abalansa et al., 2021). The present research aimed to investigate and assess the status quo of e-waste management in different countries. The findings of this study should be useful to increase communal knowledge of e-waste.

2 Material and Methods

In this study, a multidisciplinary reviewing framework was used to search quantitative and qualitative articles on air pollution. To achieve this goal we systematically searched PubMed (Medline), Science Direct, Scopus bibliographic, and Google Scholar databases, as well as the Texas A&M University Library databases using various combinations of 14 keywords: “Material Flow Analysis” or “material flow analysis (MFA)”; the search was refined using the following keywords, “electronic waste” OR “E-waste” OR “waste electrical and electronic equipment (WEEE)” OR “End of life electronics” OR “waste electronics”, “E-waste recycling”, “collection”, “treatment”, “waste management”, “disposal”, “IT equipment”, and “e-scrap”. In Fig. 1, a total of 115 peer reviewed publications are accessed based on the relevance of titles to the research. These were further screened to 60 after reading through their abstracts. Following screening the full text of the articles, 28 were used for this review study. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) references were excluded from the study (Moher et al., 2009).

Information on the authors' name, implementation country, materials recovered, waste disposal and treatment, most challenges, generation rate, and components of e–waste and outcomes were collected. Correlations were calculated between quantities of medical waste produced (stated in kg/capita-year) versus gross domestic product (GDP) (US $/capita) per capita. The GDP per capita is changed to dollars using buy power equality rates. A nation's GDP per capita is the gross level of all goods and services generated per year, measured in a general tender and then distributed by the people of the nation. E-waste management practices are examined for 15 countries, including China, US, Malaysia, Botswana, Australia, Korea, Brazil, Finland, Swedish, Taiwan, Sri Lanka, Jordan, India, Tanzania, and Iran.

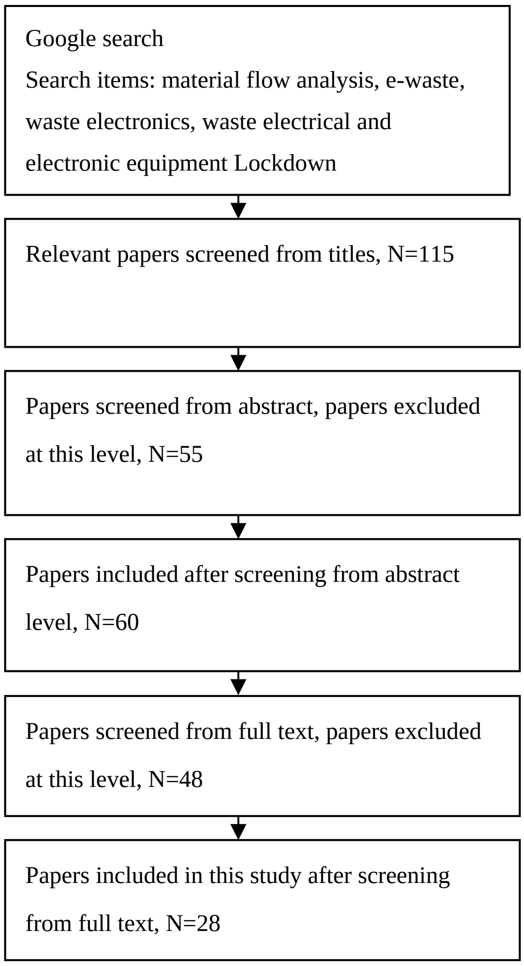

Fig. 1 Chart presentation of the review process.

3 Results and Discussion

This study investigates 8 variables (i.e. implementation country, materials recovered, waste disposal and treatment, major challenges, generation rate, and components of e–waste and outcomes, and GDP) in the management of e-waste across 15 countries.

3.1 Generation rate

The results from this study demonstrated that the generated e-waste range from 0.8 to 30 kg per capita. The highest level calculated is 30 kg per capita/y in the US which is 38 times greater than Tanzania's per capita e-waste generation rate (0.8) or 15 times greater than that of a resident from Botswana (Table 1).

The amount of waste has been increasingly rising worldwide at different rates in different countries. Additionally, a considerable difference is observed in per capita e-waste generation rate between high income and low income nations. For example the appraised quantity of e-waste generated by the US in 2014 was 22.1 kg/ca-year vs the global waste generation rate of 5.4 kg/ca-year (Tansel, 2017). The globe generated on average a considerable amount of e-waste which is equivalent to 7.3 kg per capita (Forti et al., 2020b). The reports demonstrated that in 2019, the continents such as Europe, Oceania, and Americas produced 16.2, 16.1, and 13.3 kg e-waste per capita, respectively. While Asia generated 5.6 kg and Africa produced only 2.5 kg e-waste per capita (Forti et al., 2020b). Another study revealed the e-waste generation per capita to be 22 kg in Austria, 21.4 in Belgium, 10.7 in Bulgaria, 22.1 in France, 21.6 in Germany, 15.1 in Greece, 17.6 in Italy, and 22.2 in Sweden(Salhofer, 2017). The total e-waste produced by different countries, such as Asia, Europe, north America, Africa, and Oceania, was reported to be 38%, 28%, 9%, 5%, and 1%, respectively (Magalini et al., 2015).

The cell phones, laptops/tablets, and flat screen TVs are among tools that generate the highest per capita per habitation in-active-use products in Australia(Golev et al., 2016).

The assessment of e-waste composition in Australia indicated that e-waste contains metals, plastics, glass, and PCBs by 51%, 30%, 6%, and 4%, respectively (Golev et al., 2016). The material composition of e-waste in India showed that e-waste mainly contains metals (60%) and plastics (30%), and the hazardous pollutants comprise only about 2.70% of the e-waste (Rajput, 2013).

A positive correlation was observed between e-waste generation rate (kg/per capita per year) and GDP per capita (USD) in different countries (Fig. 2). There is also a correlation between the sale amount of electric and electronic equipment (EEE) and the national per capita GDP. One study reported that the e-waste generation rate basically depends on GDP per capita (Gaidajis et al., 2010). In another study, Awasthi et al. (2018) found that an increase of $1000 in the GDP in a nation will result in generation of 7.7 kg of e-waste per person (Awasthi et al., 2018a). Abalansa et al. (2021) found that there is a correlation between the use of EEE and e-waste generation rate. For instance, e-waste generation rate is high in Australia, US, China, Japan, and nations in Europe where the use of EEE is high making up around 8% of the solid waste streams in these nations (Abalansa et al., 2021).

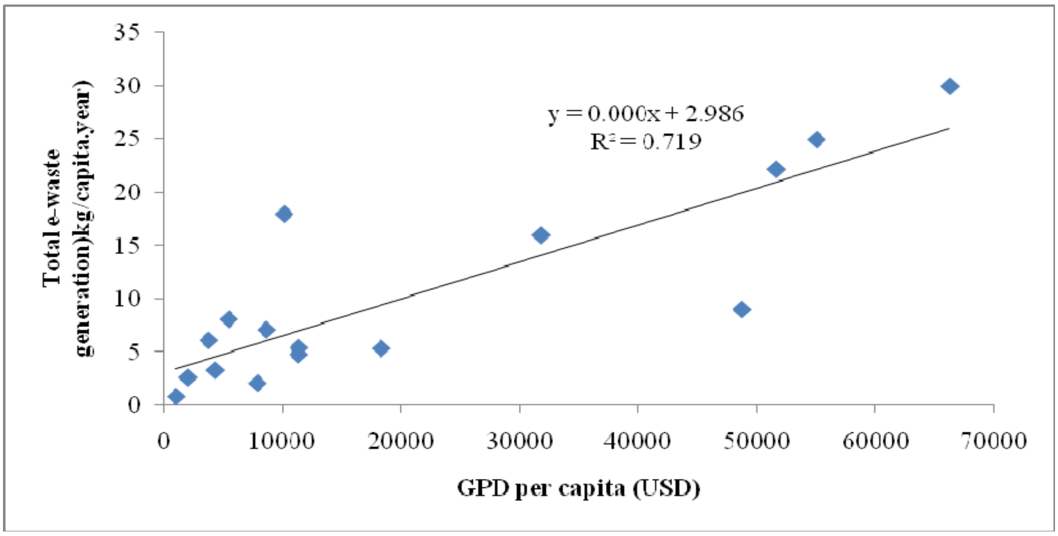

Fig. 2 Correlation between total e-waste generation and GDP per capita.

3.2 Recycling

According to the findings of this research, about 87% of countries use recycling (formal/informal) for all e-waste (Table 1). Only about 17.4% (9.3 Mt) of global e-waste generated across the world was formally recycled in the first year of the 2020s (Withanage and Habib, 2021). In developing nations, recycling is performed under uncontrolled situations resulting in strict environmental contamination (Cesaro et al., 2019). A study by Li and Achal demonstrated that about 20-25% of the globally produced e-waste is legally recycled in under-development nations (Liao and Yang, 2020). United Nations Environmental Programme (UNEP) states that, nowadays, only 10% of the globally produced e-waste undergoes recycling in high income countries, and the remaining 90% is sent to low income countries across the world (Abalansa et al., 2021).

Recycling has five major advantages: conservation of natural resources; prevention and control of water pollution*;* reduction of solid waste transfer and management costs; reduction of area required for landfills and decrease of greenhouse gas releases(Mmereki et al., 2018).

The results from this research show that the main recyclable parts of e-waste include metals (e.g., iron, aluminum, copper, silver, gold and palladium, lead, mercury, cadmium, hexavalent chromium, zinc), plastics, and glass (Table 1). In Malaysia, the recycled materials were reported to be gold, iron (ferrous) and iron free (non-ferrous) metal, and plastic (Shumon et al., 2014). A study found that Europe has the highest collection and recycling rate (42.5%) (Forti et al., 2020b). In Finland, at least 9 kg/inhab of e-waste is gathered per year (Ylä-Mella et al., 2015). A study by Garlapati demonstrated that e-waste is a mixture composed of iron and steel (50%), plastics (21%), iron free metals (13%), etc (Garlapati, 2016). Results of another study showed that e-waste constituents such as iron (50%) and iron free metals (13%), plastics (21%) and mercury, arsenic, cadmium, selenium, lead, hexavalent chromium, and flame retardants (Joon et al., 2017). E-waste processing and recycling is mostly done through illegal businesses in Asian countries, such as China, India, Pakistan, the Philippines, Sri Lanka, Thailand and Vietnam (Ádám et al., 2021). Some countries like e.g., Europe, Switzerland, Norway, and Sweden used the most advanced techniques for managing e-waste. The recycling rate in these countries was 49% which was the highest rate worldwide (Ádám et al., 2021). Other countries like e.g., Chile, Ghana, Nigeria, Uruguay, Vietnam, Colombia, Peru and Ecuador lacked the fully developed foundation and recycling management methods for dealing with e-waste (Abalansa et al., 2021). Legal e-waste activities are costly and capital centralized, thus leading to a lower number of safe recycling units in the e-waste sector (Perkins et al., 2014).

An improvement in the recycling rate may effectively amend the source effectiveness and decrease the environmental effect even further (Guo and Yan, 2017). A large part of e-waste (particularly generated by the family) combines with municipal solid waste at landfill sites, causing considerable environmental and health problems (Ádám et al., 2021). One study stated that about 60-75% of e-waste collected in the European countries is transferred to the Asian and African countries to be recycled or disposed of (Cruz-Sotelo et al., 2016).

The environmental effects of illegal e-waste recycling include public exposure (e.g., via food, water, air), occupational exposure (e.g., *inhalation* of smoke generated through burning wires and cooker circuit boards), exposure of fetus (e.g., pregnant women who works as recyclers), children exposure (e.g., ingestion of polluted particle on surfaces, playing with dismantled electronics collection, dismantling, and recycling), and environmental pollution (e.g., pollutants that enter the water and food system by chattels, fish, and agricultural products, particle pollution, dioxins, furans caused by dismantling electronics, materials leakage from *dumping* ground or cumulative electronics, dumping acid utilized for gold removal into rivers (Forti et al., 2020a). The mass percentage of each e-waste is displayed in Table 2.

3.3 Waste disposal and treatment

The e-waste treatment process commonly includes dismantling, processing and end processing. As the first step, during dismantling hazardous and precious parts are separated from each other.

Based on the findings of this research, there are various e-waste disposal and treatment techniques, such as incineration, mechanical-physical, and chemical separation, landfilling, open dumping and hybrid methods (Table 1). Additionally, the results from this study show that about 73% of countries use landfill (safe/ unsafe) for all e-waste.

Only five countries (Brazil, Finland, Sweden, Sri Lanka, and Iran) use two techniques simultaneously for e-waste disposal and treatment, such as recycling and landfill, while two countries (US, and China) use three techniques of incineration, recycling, landfill or open dumping simultaneously for e-waste disposal and treatment.

The majority of e-waste is led to sanitary landfill places (Gaidajis et al., 2010). Recycling methods have minimum environmental effect when mixed with the proper technology (Gaidajis et al., 2010). A study demonstrated that around 80–85 % of end-of-life (EoL) electronic products dispose of in US landfills (Shumon et al., 2014). Metals, such as Cu, Pb, Zn, etc., can be successfully isolated using vacuum *metallurgy*. In optimal conditions, Cu and Pb are respectively recovered at a rate of about 84.2% and 89.4% in a single step wet oxidation process like i.e., supercritical water oxidation (SCWO) in combination with electrokinetic (EK) (Zhang and Xu, 2016).

Environmentally sound management (ESM) of e-waste needs establishing collection sites, and transporting, treating, storing, recovering and disposing of e-waste nationwide (Garlapati, 2016). In a study, Kumar and Dixit reported more than 95% of e-waste treatment to be done through illegal methods and eventually discarded in the uncontrolled dumping sites (Kumar and Dixit, 2018). The African countries' (e.g., Nigeria, Egypt, South Africa, and Kenya) e-waste management strategy is landfilling (Bimir, 2020). One study reported that landfilling and incineration of disposed e-waste are widespread activities in under-development nations like Nigeria and Ghana (Abalansa et al., 2021). A study found the absence of valid data and statistics on the amounts of e-waste being produced to be one of the most critical gaps linked with e-waste management (Withanage and Habib, 2021).

3.4 Most challenges and solutions

Based on the findings of this research, the major challenges lying ahead of e-waste management include:

1-Lack of foundation for e-waste collection and segregation that causes e-waste to be collected mixed with the other wastes produced in most countries;

2-The absence of accounting mechanisms for e-waste cross-border transportation*;*

3-Lack of knowledge and practice to handle and process e-waste in a secure way during materials recovery in informal recycling processes;

4-Lack of adequate rules and regulations;

5-Presence of toxic materials;

6-The growing volume of the present challenges together with e-waste requires practical strategic programs for e-waste management to control the amount of the global potential effects;

7-E-waste separation is commonly done in an irregular and non-industrial way, sometimes using technology at a low level;

8-Uncontrolled dump and incineration of hazardous e-waste mixed with other hazardous and non-hazardous solid wastes cause the highly toxic gases, such as dioxins and furans to be released and pose severe risks to human health and environment;

9-E-waste recycling requires related technical experience, management, facilities, and equipment;

10- Failure to identify reuse as a technique for e-waste management;
11-Inadequate infrastructure, electronic equipment with bad designs, and shortage of finances to recycle e-waste.

According to this study, nine recommendations for e-waste management improvement are as follows:
1-Applying MFA tool to identify different flows within the management method in all countries;
2-Road map must be produced to develop a sustainable system for e-waste recycling across the world;
3-Studyng the quality and the generation rate of e-waste for provision of the necessary foundations to separate, collect, recycle, and manage e-waste;
4-Using high technologies like e.g., ultrasound, biometallurgical, supercritical, mechanochemical technologies combined with pyrometallurgy, and hydrometallurgy technology for recycling metals from e-waste;
5-Using reduce, reuse, recycle, and recover approach in e-waste management;
6-The extended producer responsibility (EPR) program represents a proper candidate policy for e-waste management worldwide. Among EPR advantages are source reduction, product recycling, an increase in recycled substances usage, reduction of natural resource use, internalization of environmental costs, and recovering energy when incineration is regarded suitable;
7-Increasing public awareness on the impacts of exposure to e-waste recycling, and taking more effective techniques for risk minimization, and making further efforts to increase knowledge of e-waste consumers, businesses and policymakers;
8-Cultivating environmental awareness in schools and universities on e-waste reduction, separation, collection and health effects;
9-Environmental challenges related to e-waste management directly affect the community, especially the human health. Thus, having essential technological capacity is of paramount importance for e-waste management systems to appropriately manage waste. Moreover, using proper traceability methods is important to ensure health protection and environmental sustainability in e-waste management processes, including e-waste collecting, transporting, treating and disposing;
10-In a few nations, e-waste-related activities are not carried out under an admissible standard that protects the health and safety of those exposed. We therefore persist with the international community, UN agencies, national policymakers and regulatory authorities, industry and NGO_s to collaboratively develop and demonstrate protective methods to limit undesirable health e-waste from direct and indirect exposure to materials resulting from unsafe management of e-waste practices.

Table 1 Most important specifications of reviewed articles.

Country	**Materials recovered**	**Waste disposal and treatment**	**Major challenges**	**Generation rate (kg/capita.y)**	**Ref**
China (seven provinces)	Iron, Aluminum, Plastic, Powdered ink	Mechanical recycling	No united effort; each legislation only addresses a specific perspective of e-waste management	16–18	(Lu et al., 2015)
China (Dalian)	Iron, Aluminum, Plastic	Incineration, acid baths, and open air dumping, channels	Unclear responsibilities for stakeholders and insufficient supporting infrastructure	1.11	(Qu et al., 2013)

Worldwide	Copper, Lead, Zinc, Argentum,	Mechanical-physical separation	Informal recycling, lack of recycling legislations	5.4	(Zhang and Xu, 2016)
Iran (Tehran and Tabriz)	Metals and Plastics	Recycling legally or illegally, land fill	E-waste mismanagement	8.08	(Taghipour et al., 2012)
Iran (Ahvaz)	Metals and Plastics	Landfill	E-waste mismanagement(e-waste and other wastes are collected mixed with each other; informal recycling	9.95	(Alavi et al., 2015)
Malaysia	Metals, Plastics, Glass, PCB	Illegal dumping and landfilling	E-waste scavengers, lack of appropriate infrastructure, informal recycling, disposal in river)	4.78	(Shumon et al., 2014)
BOTSWANA (Gaborone)	-	Landfill, illegal channel	informal recycling, lack of e-waste management policy	2.07	(Mmereki et al., 2018)
Australia	Iron/Steel, Copper, and Gold	Landfill	Inappropriate e-waste management practices and regulation	25	(Golev et al., 2016)
Worldwide (10 countries)	Metals, Plastics, Glass, and Rare earth elements	Recycling	Deficient substructure for e-waste collecting and separating; faulty accounting mechanisms for e-waste cross boundary transportation; and deficiency in knowledge and training of personnel	5.4	(Tansel, 2017)
US	Plastics, Iron/Steel, Copper, Glass, Lead	Landfill, Recycling, incineration	Lack of recycling, unsafe workers	30	(Seeberger et al., 2016)
Korea	Plastics, Copper, Aluminum	Recycling	Deficiency in consumer knowledge of possible hazards	16	(Jang, 2010; Seeberger et al., 2016; Mihai et al., 2019)
Brazil	Plastics, Copper, Aluminum, Iron	Landfill, Informal recycling	Illegal recycling, lack of proper facilities to extract precious metals	7.1	(Torres et al., 2016; Dias et al., 2018; de Oliveira Neto et al., 2019)
Finland	Plastics, Copper, Aluminum, Iron	Landfill, recycling	Physical spaces of collection cages are limited	9	(Ylä-Mella et al., 2014; Ylä-Mella et al., 2015)
Sweden	Plastics, Copper, Aluminum, Iron	Landfill, recycling, dumping	Dumping of e-waste in basements, no source-separated, challenges in management of transportation of reverse logistics	22.2	(Bernstad et al., 2011)
Taiwan	Lead, Mercury, Cadmium, Hexavalent	Recycling	Illegal recycling	5.34	(Tsai, 2020)

	Chromium, Plastics				
Sri Lanka	Lead, Iron, Plastics	Recycling, landfill	Informal sector management, illegal recycling	6.1	(Ranasinghe and Athapattu, 2020)
Jordan	Lead, Iron, Plastics, Lead, Mercury, Cadmium	Open dumps, informal Recycling	Unsuitable separation, storage, collection, transportation and disposal, informal Recycling	3.28	(Fraige et al., 2012)
India	Iron And Steel, Plastics, Copper, Aluminium, Gold, Palladium, Platinum	Informal recycling, landfill	Unsound management	2.6	(Awasthi et al., 2018b; Forti et al., 2020b)
Tanzania	Copper, Aluminum, and Iron	Open burning, informal recycling, open dumping	Unsound management(temporary storage of e-waste in unsuitable	0.8	(Asiimwe and Åke, 2012; Forti et al., 2020b)

Table 2 Component of e-waste in various countries.

Country	Component of E –waste	Ref
China (seven provinces)	Television 40%, Refrigerator 11%, Washing machine 17%, Air conditioner 2%, and Computer 30%	(Lu et al., 2015)
China (Dalian)	Television 8%, Refrigerator 15%, Washing machine 13%, Air conditioner 9%, enterprises and institutions 9% and Others from households 46%	(Qu et al., 2013)
Iran (Tehran and Tabriz)	Television 42.42%, Computer 32.66%, Mobile telephone 0.5%, Photocopier 3.05%, Printer 1.14%, Radio 19.52%, Video projector 0.28%, and Laptop or notebook 0.44%	(Taghipour et al., 2012)
Worldwide (17 countries)	Television 18%, Computer20%, Refrigerator 9%, Washing machine 9%, Air conditioner 8%	(Islam and Huda, 2019)
	Mobile telephone 10%, Photocopier 3.05%, Printer 2%, Radio 19.52%, DVD player 2%,Camera 1%, Monitor 6%,Battery 2%, Audio system 3%, Freezer 2%, Microwave oven 1%, hoovers 2%, and Laptop 7%	
Australia	Cooling and freezing 14%, Screens and monitors 17.4%, Lamps 1.7%, Large equipment (e.g. , washing machines, cooking equipment, dishwashers…etc) 24.5%, Small tool (e.g., radio, microwaves, cameras, vacuum cleaners…etc) 33.4%, Small IT (e. g, Mobile phones, desktops, telephones, etc) 8.9%	(Golev et al., 2016)
Jordan	washing machines 28.4%,TV 24.9%, PC 11.7%,air conditioners 5.3%, refrigerators 1.6%, Mobile phones 1.1%, microwaves 1.1%, electronic games 1.1%, and Other e-waste 3.3%	(Fraige et al., 2012)
India	Computer 70%, telecommunication 12%, electrical 8%, medical equipment 7% and household sector waste 3%.	(Joon et al., 2017)

Table 3 Quantity of e- waste production to GDP in various nations.

Country	E-waste generation rate (kg/capita-year)	*GDP per capita (USD, 2019)
China	18	10216.6
Australia	25	55057.2
Botswana	2.7	7961.3
US	30	66297.5
India	2.6	2099.6
Brazil	7.1	8717.2
Tanzania	0.8	1122.1
Korea	16	31846.2
Finland	9	48771.4
Jordan	3.28	4405.5
Sweden	22.2	51648.5
Taiwan	5.34	18381.1
Sri Lanka	6.1	3853.1
Tanzania	0.8	1122.1
Iran	8.08	5550.1
World average	5.4	11433.2

*https://data.worldbank.org/indicator/NY.GDP.PCAP.CD.2019

4 Conclusions

The present research presents the e-waste management condition in various countries. Unfortunately, unsafe systems of e-waste management are still considered superior in a large number of the transitional and developing nations. The problem of e-waste is reaching alarming proportions in most countries. E-waste is among the most complex flows of specific waste. Findings of this study illustrated that e-waste generated in different countries is between 0.8 and 30 kg/capita-year. About 87% of countries use recycling (formal/ informal) for all e-waste. Moreover, approximately 73% of countries use landfill (safe/ unsafe) for all e-waste. A positive correlation was observed between e-waste generation rate (kg/capita-year) and GDP per capita (USD) in various countries. All the findings can hopefully improve e-waste management for all countries, and need much consideration in managing it within the community.

5 Abbreviations

WEEE: Waste electronics, waste electrical and electronic equipment; GDP: Gross domestic product; EEE: Electrical and electronic equipment; MFA: Material flow analysis.

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