Review Article

E-WASTE-AN EMERGING PUBLIC HEALTH THREAT: BANGLADESH PERSPECTIVE

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ABSTRACT

Electronic waste or e-waste is emerging as a major public health threat worldwide including Bangladesh because of rapid advances in technology leading to the generation of large amount of wastes and a lack of knowledge in handling of these wastes. The present review discusses the existing e-waste problem in Bangladesh, as a public health concern, and necessary recommendations to have effective e-waste management. This is a traditional review study. The burden of e-waste, regulations and its impact on health at the global and country level were identified using various search engines such as PubMed, Google Scholar, Scopus and ScienceDirect. Books, case studies, legislation documents, reports, original articles and other documents from international organizations and specific governmental agency websites were retrieved. Out of more than 100 research articles on e-waste and health impact in total, 45 original articles, reports, case studies and documents were used for this review. About 400,000 tonnes of electronic waste have been generated across the country in 2018 and that the amount grows by 20% every year**.** The generation of e-waste rate in Bangladesh has surpassed 72 million tons, which is a 33% increase over the previous decade. According to a study report by Bangladesh University of Engineering and Technology (BUET), e-waste volumes in Bangladesh will rise to 4,62 million tonnes by 2035. Harmful contents of e-waste mainly include lead, cadmium, mercury, chromium, copper, nickel, lithium, Beryllium long term exposure of which may cause health effects like damage to brain, kidney, liver, nervous systems, blood systems, endocrine system, reproductive system and produce stomach cramps, allergic dermatitis, asthma, bronchitis and also develop life threatening disease like cancer. The current review shows that the e-waste poses a serious public health threat leading to significant environmental and health risks. Most of the developing countries including Bangladesh were found to be lagging behind in the implementation of environmentally sound formal recycling processes. Hence, a better life cycle assessment model which have been successfully implemented in other developing countries should be introduced in Bangladesh.

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INTRODUCTION

Electronic waste (E-waste) generally refers to the electronic waste produced from the disposed electronic gadgets and equipment such as mobile phone sets, televisions, refrigerators, air conditioners, computers and so on that are used in household and various industries.[1] Outdated and non-functioning electronic devices are disposed. Among many sources, televisions, computers, electric vehicles, mobile phones and mercury bulbs, and medical waste are the most common in E-waste generation of Bangladesh.[2,3] Electronic waste (e-waste) is one of the fastest-growing pollution problems worldwide given the presence of a variety of toxic substances which can contaminate the environment and threaten human health, if disposal protocols are not meticulously managed.[4] Electronic wastes are one of the fastest-growing waste streams globally. Over the last decade, Bangladesh has made remarkable progress in digitalizing the public and private sectors. This resulted in having various electronic amenities in industrial use and those at the household level, such as television, freezer, and small home appliances. In particular, mobile phone users in Bangladesh number about 60 million, ranking Bangladesh among the top 10 countries globally. This is certainly an outstanding achievement for Bangladesh to make its way to developed countries. However, this poses a new challenge ahead of dealing with E-waste.[5] The tendency to throw away old electrical products due to temptation from the

new ones has led to rapid e-waste in Bangladesh and around the world.[6]

About 400,000 tonnes of electronic waste are said to have been generated across the country in 2018 and that the amount grows by 20 per cent every year.[7] Another report says that the generation of e-waste rate in Bangladesh has surpassed 72 million tons, which is a 33 percent increase over the previous decade.[8] According to a BUET study report, e-waste volumes in Bangladesh will rise to 4,62 million tonnes by 2035.[9]

E-wastes are classified into six categories: Cooling and freezing equipment like refrigerators and freezers, and other equipment such as televisions, monitors, laptops, notebooks, and tablets.[5] There are some 32 separate heavy metals including lead, chromium, cadmium and copper and plastic additives that are found in e-waste, and 18 of them can directly enter the human body through the food chain and people can develop diseases like cancer.[10]

METHODS

E-waste comprises of wastes generated from used electronic devices and house hold appliances which are not fit for their original intended use and are destined for recovery, recycling or disposal. The study included observational, randomized and non-randomized studies. Different electronic websites, databases and journals including Web of Science, The Lancet, International Journal of Sciences, PubMed, Google Scholar, BBC News Online, Int J Innov Sci Res Technol**,** Elsevier, GSC Advanced Research and Reviews, Environment and Social Development Organization (ESDO) were searched to detect published articles on category, types, source, characteristics, constituents, legislation, policy and health effects of e-waste. The study used the following heading as search terms: E-waste, environment and human health, hazardous effect of e-waste on health, E-waste management strategy, E-waste management policy and legislation, electronic waste recycling, observational study, etc. Total 45 studies were reviewed in this article.

FINDINGS (BASED ON LITERATURE REVIEW)

The study found more than 100 research articles on e-waste and its health impact by using different se arch items. From the search articles 45 studies were included. E-waste is hazardous, complex and mostly discarded in the general waste stream, especially in developing countries. The unprecedented growth of e-waste is not only contributed by developed countries but also developing countries like Bangladesh. In case of Bangladesh, wide range of factors, including globalisation, urbanisation, increased access to modern technology and purchasing power, substantial reduction in new development cycle, increased frequency of offering new products are contributing towards the generation of a huge amount of electronic waste stream.[11] Improper e-waste management in Bangladesh is posing a threat to the environment, causing soil degradation and water contamination with heavy and toxic base metals and ultimately causing serious harm to human health.[10]

Electronic equipment contains many hazardous metallic contaminants such as lead, cadmium, and beryllium and brominated flame-retardants. The fraction including iron, copper, aluminum, gold, and other metals in e-waste is over 60%, while plastics account for about 30% and the hazardous pollutants comprise only about 2.70%.[12,13] Of many toxic heavy metals, lead is the most widely used in electronic devices for various purposes, resulting in a variety of health hazards due to environmental contamination.[2,14]

According to a World Economic Forum research, E-waste is now the world's fastest-growing trash stream, with an estimated waste stream of 48.5 million metric tons in 2018. Comparing that to previous trends, it appears that by 2023, there may be an estimated 61 million metric tons generated.[15] The global e-waste monitor estimated that in 2019 the quantities of e-waste was 53.6 million metric tons (Mt). This is projected to grow to 74.7 Mt by 2030. Asia generated the highest quantity of e-waste in 2019 at 24.9 Mt, followed by the Americas (13.1 Mt), Europe (12 Mt), Africa (2.9 Mt), and Oceania (0.7 Mt).[16] Humans who are living and working near e-waste recycling sites can be exposed through inhalation, ingestion, and dermal absorption if they come into physical contact with contaminated soil, dust, air, water, and food sources. Exposure to e-waste poses serious health threats, especially for vulnerable populations such as pregnant women and newborns.[17] A study conducted by Khan and Saadat showed ten categories of E-waste in Bangladesh (Table-I).[18]

Table 1. Categories of E-waste[18]

Category (C)	Characteristic	Example
C01	Bulky house hold appliance	Microwaves, refrigerators, washing machines, electric cooking stoves, dishwashers and electric fans, and air conditioners.
C02	Small house hold appliance	Coffee machines, toasters, vacuum cleaners, grinders, drying and shaving.
C03	ICT and telecommunication equipment	Computers, notebooks, laptops, printers, telephones, cell phones and IP phone.
C04	Consumer equipment and photovoltaic panels	Video recorders, video cameras, radios, televisions, musical instruments etc.
C05	Lighting equipment	Straight and compact fluorescent lamps and high intensity discharge lamps, LED, solar panel.
C06	Electrical and electronic tools	Drills, saws, sewing machines, irons, equipment for grinding, drilling, folding, bending of wood and metal.
C07	Toys, leisure and sports equipment	Toys, leisure equipment, and sporting goods: electric trains or car sets, video games etc.
C08	Medical device	Ventilators, craniological device, nuclear analyzers, radiotherapy equipment, all types of dialysis equipment.
C09	Monitoring and control instruments	Smoke detectors and thermostats, heating regulators etc.
C10	Automatic dispensers	Solid products, food and drinks related electrical device, all electronics device that mechanically deliver various products, cold or hot bottles.

It is very popularly known as Bangladesh is one of the major e-waste import countries. Apart from this, the country also produces about 2.81 million metric ton e-waste annually (Table-II).[4,19] Sources of various e-waste, their constituents and health impacts are shown in Table-III.[20]

Table 2. Amount of e-waste produced from different electrical and electronic equipment in Bangladesh[19]

Sources of e-waste	Amount of e-waste (Million metric ton/year)
Electric charged vehicle	2.5
Television	0.17
Computer	0.035
Mobile phone	0.005
CFL bulb	0.0005
Mercury bulb	0.0001
Thermometer	0.009
Other medical and dental wastes	0.09
Total	2.81

Table 3. Various e-waste sources, their constituents and health impacts[20]

E-waste sources	Constituents	Health effects
Solder in printed circuit boards, glass panels, and gaskets in computer monitors	Lead	Damage to central and peripheral nervous systems, blood systems, and kidney
Chip resistors and semi-conductors	Cadmium	Toxic irreversible effects on human health, Accumulates in kidney and liver, Causes neural damage
Relays and switches, and printed circuit boards	Mercury	Damage to brain, kidney, liver
Galvanized steel plates and decorator or hardener for steel housing	Chromium	Causes bronchitis
Cabling and computer housing	Plastics and PVC	Burning produces dioxin that causes reproductive and developmental problems
Electronic equipment and circuit boards	Brominated flame-retardants	Disrupt endocrine system functions
Copper wires, Printed circuit board tracks	Copper	Stomach cramps, nausea, liver damage, or Wilson's disease
Nickel–cadmium rechargeable batteries	Nickel	Allergic dermatitis, asthma
Lithium-ion battery	Lithium	Nausea, vomiting, muscle weakness, tremor
Motherboard	Beryllium	Carcinogenic (lung cancer)

The fast growth in e-waste and fast product outdated nature has realized the significant issues of e-waste on human wellbeing, animals, and ecology.[21] The measure of cadmium in one cell phone can taint up to 600 cubic meters of water placing human health and livestock at risk.[22] According to Perkins et al, the problem of concern is the rate at which e-waste develops.[23] Schwarzer et al assert that e-waste grows at a rate of 3% to 5% annually and development rate of e-waste is around three times more than any own waste in the solid waste segment.[24] In the United States over 300,000 mobile phones are improperly disposed of every day.[25] Literature also suggests that the accumulating e-waste is due to the absence of knowledge about its harmful effects on humans and ecology.[26]

Mobile phones rapid rise and their relatively short lifespan are posing disposal management challenges at the height when mobile phones are the fastest growing stream of e-waste.[27] According to Babatunde et al, most people consider this gadget obsolete in little over a year, even though they are still in right working conditions.[28,29] When mobile phones are considered e-waste by their owners, they threw them along with municipality solid waste from dustbins. According to Rowley throwing away mobile phones with municipal rubbish should be avoided, this tendency could make e-waste lend into or onto landfill.[30,31]

At present, Bangladesh has no particular environmental policy or act or guidelines to directly manage the e-waste problem. Nevertheless, a draft regulation on 'E-waste management rules' was refined and amended in 2011 and 2017 respectively under the Environment Conservation Act, 1995 but no development in rules acceptance and implementation has been visible till today. Currently, there are some Legislation regarding E-Waste Management in our country. These are: National Environment Policy-1992, Bangladesh Environment Conservation Act, 1995, The Environmental Court Act, 2000, The Environmental Conservation Rules, 1997, Medical Waste Management Rules, 2008, E-Waste Policy 2017 (Draft).[32] On June 10, 2021, Bangladesh's Department of Environment (DOE) published the Hazardous Waste (e-waste) Management Rules, 2021 under the Bangladesh Environmental Protection Act, 1995.[33] 14th October

of every year is celebrated as the International E-Waste Day.[17]

DISCUSSION

The study was conducted to find out the health impacts of e-waste. Total 45 articles from different web sites and journals were included for the present study. All those articles were studied and reviewed thoroughly to know the exact health impacts of e-waste which are commonly seen.

A study conducted by Meem RA et al showed that apart from environmental impacts of e-waste such as air pollution, soil pollution, water pollution, and degradation of the beach e-waste also creates lots of health problems. Humans can be exposed to e-waste contaminants by the inhalation, dietary intake, dust ingestion, and dermic contact. These contaminants e-waste fluxes from producers to receivers and ultimately to humans.[34]

E-waste enters into new born baby's body through the food consumption from mother. It has been calculated that 6-month-old breastfed infants who live near e-waste recycling sites are consumed e-waste associated with Polybrominated diphenyl ethers (PBDEs) about 57 times higher than the infants who live in control areas due to high maternal exposures level.[35] Inhalation is another important route of intake to e-waste for the new born babies. As body functional system (i.e. central nervous, immune, reproductive, and digestive system) are still developing so exposure to contaminants substances may hamper further development causing unchangeable damage.[36] In north eastern part of Bangladesh, about 36.3% women who lives near recycling sites experienced the death of a baby.[4]

There are about 50,000 children in Bangladesh are working in the e-waste collection and recycling process. Of them, 40% (i.e. 20,000) children are working in ship breaking yards.[37] In our country about 15% child laborers die because of e-waste mismanagement practice. Moreover, 83% child laborers of this sector are affected by long term health problem.[36,38] Children those who are living near the e-waste recycling sites likely to become more affected by the contaminants through inhalation during their outdoor play time.[39] Again, children those who are living near the e-waste recycling sites also appear to have poorer neonatal behavioral neurological assessment scores, poorer temperament scores, and lower intelligence quotient (IQ) because of lead levels are increasing in the blood.[40] Due to improper management of e-waste nearly 30 million children, women, and non-formal workers are exposed to heavy metals, for example, lead, mercury, cadmium, zinc and chromium, PCB, dioxin, and furan.[41]

After new born babies and children pregnant women are more vulnerable to e-waste contaminants. Pregnant women may face spontaneous abortions, premature birth, fetal loss, thyroid development, abnormal thyroid function, neurobehavioral disturbances, gene toxicity, low birth weight, and congenital malformations due to their exposure to various POPs (e.g. PBDEs, PCBs, PFOA), and PAHs.[36,41,42] Higher contaminant levels in fetal tissues are found in pregnant women those who are living near the e-waste recycling sites or involved in e-waste recycling activities during their pregnancy. Again, pregnant women may exposure from family members who are working in the e-waste collection or recycling sectors.[40]

There are about 120,000 Bhangaries (E-waste recycling workers) who may be exposed to e-waste contaminants more seriously.[43] When original e-waste elements are degraded hazardous compounds e.g. dioxins are formed resulting severe health problems of the workers.[44] Sometimes skin and blood of workers are infected by e-waste or by infected wounds. Contact with sharp objects resulting wounds. During metal separation from landfill and incineration operations different types of chemicals are coming out. These chemicals are responsible for eye and respiratory infections.[36] Incineration operators may exposure to chronic respiratory diseases include cancers. Apart from open incineration, improper dismantling techniques for recovering metals followed by copper, aluminum, and iron also creates great risks to the workers. Likely, breaking of CRT monitors using stones, hammers, heavy metal rods and chisels for recovering copper, steel and plastic casings may result in the inhalation of hazardous cadmium dust and other pollutants by the workers. Handling of heavy containers causing bone and muscle disorders. Moreover, occupational accidents e.g. burns occur at the waste disposal sites or from chemicals explosions.[36]

E-waste is the major source of several heavy metals (e.g. mercury, lead, cadmium, chromium, zinc etc.) When these heavy metals are kept unprocessed and open to the environment causing numerous human diseases including cancer, nerves breakdown, asthma, hearing problem, infant mortality, visual problem, kidney, disable baby birth, brain disorder, liver and lung damage as well.[36]

There are few E-waste management rules in Bangladesh. In case of violation of the provisions of

these rules, the offender shall be liable to imprisonment for a maximum period of two years or to a fine of up to two hundred thousand taka, or to both, in accordance with Section 15(1) of the Bangladesh Environmental Protection Act, 1995. In case of repetition, offenders shall be punished with imprisonment for a term ranging from two to ten years or a fine ranging from Taka 200,000 to Taka 1,000,000 or both.[45]

CONCLUSION

The hazardous nature of e-waste is one of the rapidly growing environmental and health problems of the world and Bangladesh also proceeding in the same pace. The ever-increasing amount of e-waste associated with the lack of awareness and appropriate skill is deepening the problem. A large number of e-waste recycling workers specially children and women are involved in crude dismantling of these electronic items for their livelihood and their health is at risk; therefore, there is an urgent need to plan a preventive strategy in relation to health hazards of e-waste handling among these workers and other persons who are directly involved in handling of e-waste. There is significant research gap in developing country regarding impact of e-waste on health and environment. Bangladesh is not an exception. It is necessary to review the public health risks and strategies to combat this growing menace. The current practices of e-waste management in Bangladesh suffer from a number of drawbacks like the difficulty in inventorisation, unhealthy conditions of informal recycling, inadequate legislation and policy, poor awareness and reluctance on part of the corporate to address the critical issues. The government and the authorities concerned must also draw up a comprehensive plan to address the issue before it gets out of control.

REFERENCES

1. Rode S. “E-waste management in Mumbai metropolitan region: Constraints and opportunities”, Theoretical and Empirical Researches in Urban Management 2012; 7(2): 89-103. Available from http://um.ase.ro/no72/5.pdf (Accessed on 21 Sep 2022).
2. Jungst RG (2001). “Recycling of electric vehicle batteries”, Industrial chemistry library, 10:295327, Elsevier. Available from: http://um.ase.ro/no72/5.pdf (Accessed on 25 Sep 2022).
3. Awasthi AK, Zeng X and Li J. "Comparative Examining and Analysis of E-waste Recycling in Typical Developing and Developed Countries," Procedia Environmental Sciences 2016; 35 (July).
4. Alam M, Bahauddin KM. Electronic Waste in Bangladesh: Evaluating the Situation, Legislation and Policy and Way Forward with Strategy and Approach. Present Environ Sustain Dev 2015; 9(1): 81–101.
5. Haque R and Rahman N (9 Feb 2022). E-waste management in Bangladesh. Available from https://thefinancialexpress.com.bd/views/e-waste-management-in-bangladesh-1644420768 (Accessed on 26 Aug 22).
6. Rapid e-waste pileup ongoing. Bangladesh post. Available from https://bangladeshpost.net/posts/rapid-e-waste-pileup-ongoing-80762 (Accessed on16 Sep 22). Published: 02 Mar 2022.
7. Govt must make e-waste management a priority (28 June 2021).
1. Available from https://www.newagebd.net/article/142133/govt-must-make-e-waste-management-a-priority (Accessed on 27 Aug 22).
8. Namias J (2013). “The future of electronic waste recycling in the United States: obstacles and domestic solutions”, Columbia University. Available from http://um.ase.ro/no72/5.pdf (Accessed on 21 Sep 2022).
9. Centre for Environmental and Resource Management (CERM), Bangladesh University of Engineering and Technology (2018), “Assessment of Generation of E-Waste, Its Impacts on Environment and Resource Recovery Potential in Bangladesh,” Dhaka, Bangladesh. Available from http://um.ase.ro/no72/5.pdf (Accessed on 21 Sep 2022).
10. Sakib SMN (2022). Bangladesh’s environment at risk from improper e-waste management. Available from https://www.aa.com.tr/en/asia-pacific/bangladeshs-environment-at-risk-from-improper-e-waste-management/2655584 (Accessed on 27 Aug 2022).
11. Akter N, Hossain MI. Time to formalize informal e-waste in Bangladesh. Daily star, 27 August 2022.

12. E-Waste Management: As a Challenge to Public Health in India Indian J Community Med. 2010 Jul; 35(3): 382–385.

13. Widmer R, Oswald HK, Sinha DK, Schnellmann M, Heinz B. Global perspectives on e-waste. Environ Impact Assess Rev 2004; 25:436–58. [Google Scholar]

14. Jang YC, Townsend TG. Leaching of lead from computer printed wire boards and cathode ray tubes by municipal solid waste landfill leachates. Environ Sci Technol. 2003; 37:4778–4. [PubMed] [Google Scholar]

15. Responsible e-waste: The Importance of Proper Electronic Trash Recycling. Available from https://dedicatednetworksinc.com/responsible-e-waste-disposal-the-importance-of-proper-electronic-trash recycling/?gclid=EAIaIQobChMI8tnow8yYgIVmZJmAh3MyAE7EAAYASAAEgIjCPD_BwE (Accessed on 16 Sep 2022).

16. Roy H, Rahman TU, Suhan MBK, Al Mamun AR, Haque S, Islam MS(2022). A comprehensive review on hazardous aspects and management strategies of electronic waste: Bangladesh perspective. Heliyon, 8, e09802.

17. E-waste: A threat to the environment and human health-icddr,b. Available from https://www.icddrb.org/news-and-events/news?id=882 (Accessed on 16 Sep 2022).

18. Khan MAR, Saadat AHM. Status of Electronic Waste Generation in Bangladesh: Int J Innov Sci Res Technol 2019; 4(8): 918–26.

19. Awasthi AK, Zeng X, Li J. Comparative Examining and Analysis of E-waste Recycling in Typical Developing and Developed Countries. Procedia Environ Sci 2016; 35: 676–80.

20. Puckett J, Byster L, Westervelt S etal. Exporting Harm: The high-tech Trashing of Asia. Seattle: Basal Action Network; Available from http://www.ban.org (Accessed on 10 Oct 2022) [Google Scholar].

21. Park JK, Hoerning L, Watry S, Burgett T and Matthias S. "Effects of Electronic Waste on Developing Countries." Advances in Recycling & Waste Management 2017; 2(2): 1-6.

22. Song Q and Li J. "A systematic review of the human body burden of e-waste exposure in China," Environ Int 2014; 68: 82-9.

23. Perkins DN, Drisse M and Nxele T. "E-Waste: A Global Hazard." Annals of Global Health 2014; 80(4): 286-295.

24. Schwarzer S, Bono AD, Peduzzi P, Giuliani G, and Kluser S. "E-waste, the hidden side of IT equipment's manufacturing and use UNEP Early Warning on Emerging Environmental Threats 2005; 5.

25. Anderson M, "What an E-Waste," IEEE Spectrum 2010; 47(9):72.

26. Kitila AW. "Electronic Waste Management in Educational Institutions of Ambo Town, Ethiopia, East Africa," International Journal of Sciences: Basic Applied Research 2015; 24: 319-331.

27. Speake J and Yangke LN. ""What do I do with my old mobile phone? I just put them in a drawer": Attitudes and perspectives towards the disposal of mobile phones in Liverpool, UK." Human Geographies- Journal of Studies and Research in Human Geography 2015; 9(2): 242-259.

28. Gelenbe E and Caseau Y. "The Impact of Information Technology on Energy Consumption and Carbon Emissions." Ubiquity 2015; 1:1-15.

29. 29. Ongondo FO and Williams I. "'Greening Academia: Use and disposal of mobile phones among university students'," Waste Management 2011; 31:1617-1634.

30. Rowley J. (2006, October), "Mobile Phone Lifecycles Use, Takeback, Reuse and Recycle," Available from: https://docplayer.net/3629152-Mobile-phone-lifecycles.html (Accessed on 15 Oct 2022).

31. Moletsane R and Zuva T. Managing Electronic Waste Generated from Mobile Phones: A Review of African Countries. Proceedings of the World Congress on Engineering and Computer Science 2018;1.

32. Shovon KMA. Electronic waste Management in Bangladesh: Challenges of Environmental Law. Available from: http://lawyersclubbangladesh.com/en/2021/04/07/electronic-waste-management-in-bangladesh-challenges-of-environmental-law/ (Accessed on 27 Aug 2022).

33. Bangladesh publishes E-waste Management Rule. Available from: https://enviliance.com/regions/south-asia/bd/report_2900 (Accessed on 27 Aug 2022).

34. Ahmed A, Hossain MS and Khan RA. A Review on the environmental and health impacts due to electronic waste disposal in Bangladesh. GSC Advanced Research and Reviews, 2021, 08(02), 116–125.

35. Leung AOW, Chan JKY, Xing GH, Xu Y, Wu SC, Wong CKC, et al. Body burdens of polybrominated diphenyl ethers in childbearing-aged women at an intensive electronic-waste recycling site in China. Env Sci Pollut Res 2010; 17: 1300–13.

36. ESDO. Magnitude of the Flow of E-waste in Bangladesh 2014; 1–40.

37. Islam MN. E-waste Management of Bangladesh. Int J Innov Hum Ecol Nat Stud 2016; 4(2): 1–12.

38. Masud MH, Akram W, Ahmed A, Ananno AA, Mourshed M, Hasan M, et al. Towards the effective E-waste management in Bangladesh: a review. Environ Sci Pollut Res 2019; 26(2): 1250–76.

39. Song Q, Li J. A systematic review of the human body burden of e-waste exposure in China. Environ Int [Internet] 2014; 68: 82–93.

40. Aich N, Kordas K, Ahmed SI, Sabo-Attwood T. The Hidden Risks of E-Waste: Perspectives from Environmental Engineering, Epidemiology, Environmental Health, and Human–Computer Interaction. In Transforming Global Health 2020; 161-178.

41. ESDO. E-waste: The Bangladesh Situation 2010; 1–36.

42. Wu K, Xu X, Peng L, Liu J, Guo Y, Huo X. Association between maternal exposure to perfluorooctanoic acid (PFOA) from electronic waste recycling and neonatal health outcomes. Environ Int [Internet] 2012; 48: 1–8.

43. Ahmed FRS. E-Waste Management Scenario in Bangladesh, Department of Environment, Government of Bangladesh [Internet] 2011.

44. Brigden K, Labunska I, Santillo D, Johnston, P. Chemical contamination at e-waste recycling and disposal sites in Accra and Korforidua, Ghana. Greenpeace International, Amsterdam. 2008.

45. Shovon KMA. Electronic waste Management in Bangladesh: Challenges of Environmental Law. Available from http://lawyersclubbangladesh.com/en/2021/04/07/electronic-waste-management-in-bangladesh-challenges-of-environmental-law/.(Accessed on 27 Aug 2022).