e-ISSN: 2548-060X

International Journal of Energy Applications and Technologies

journal homepage: https://dergipark.org.tr/en/pub/ijeat

Original Research Article

Electrical and electronic wastes in the world and Türkiye: policies and practices in Türkiye and some recommendations

Ali Özhan Akyüz [1]*, Kazım Kumaş [2]

[1] *Electronics and Automation Department, Burdur Mehmet Akif Ersoy University, Bucak Emin Gulmez Techn. Sci. Voc. School, Burdur, Türkiye*
[2] *Electric and Energy Department, Burdur Mehmet Akif Ersoy University, Bucak Emin Gulmez Techn. Sci. Voc.School, Burdur, Türkiye*

ARTICLE INFO

Received June 22, 2022
Accepted August 23, 2022

Published by Editorial Board Members of IJEAT

* Corresponding author
aakyuz@mehmetakif.edu.tr

doi: 10.31593/ijeat.1134468

ABSTRACT

All of the electrical and electronic products that no longer work, are unwanted, or have expired are called electronic waste or e-waste. Computers, televisions, mobile phones, fax machines, and printers make up the majority of this waste. So why are these wastes harmful? The recycling of end-of-life products is not only an ecologically necessary issue supported by regulations but also economically interesting because of the use of raw materials and reduced costs. Therefore, electronic waste (e-waste) is now seen as a serious raw material source rather than waste, as it includes materials that have a chance of secondary use as well as recyclable materials. The problem of electronic waste in the world is not separate from the problem of electronic waste in Türkiye. The global electronic waste problem is a whole made up of parts. E-waste is a subject that needs to be read and analyzed from a holistic perspective in Türkiye and the world.
In this study, what has been done about e-waste in the world and Türkiye, numerical information is given in detail. Various solution proposals have been tried to be proposed in terms of the e-waste problem in Türkiye.

Keywords: E-waste; Environmental problems; Pollution

1. Introduction

Today, the diversity of technological products is in a state of continuous increase. Every year, new smartphone models come into our lives, and there are big differences between the computers of two years ago and those offered for sale today. This rapid production of technological products also shortens their useful life. Don't we always say that? Old refrigerators and washing machines were hard to break. The continuous emergence of new products and the shortening of their useful life add another environmental problem. With the developing technology, consumption habits are changing rapidly, and accordingly, new types of waste are emerging. One of them is electrical and electronic waste (E-Waste). Thanks to today's trends that constantly market themselves as faster, more efficient, more stylish, and more economical, the electronic devices we use become "inoperative" or "more expensive to repair than to buy a new one" within 1 to 6 years, depending on their intended use. In this case, our electronic goods, which we once bought by paying high sums, either go to the garbage or to scrap dealers for 3-5 cents. This is how the type of waste called e-waste has emerged. E-waste covers all electrical and electronic wastes that are disposed of without the intention of being reused by the user [1-3]. Waste in this scope includes all electronic products that work with an electrical circuit, power system, or battery. Therefore, when it comes to electronic waste, only laptops and smartphones should not come to mind. The subject is much more detailed than one might think. There is hardly a chance that the problems related to the environment and nature will not be felt on a global scale. Globally, all people are exposed to the effects of issues such as environmental pollution and greenhouse gas emissions. Although the main share in the depletion of the ozone layer is the large industrial countries, all of humanity is responsible for this situation and everyone

pays the bill for the negative aspects of climate change, whether they realize it or not [4-7].

All of the electrical and electronic products that no longer work, are unwanted, or have expired are called E-Waste or, in other words, WEEE (Waste Electrical and Electronic Equipment). Computers, televisions, mobile phones, fax machines, and printers make up the majority of this waste. So why are these wastes harmful? [8,9]

The vast majority of electronic wastes contain substances such as brominated flame retardant, chlorinated solvents, PVC, harmful metals, lead, mercury, beryllium, and cadmium. The dispersal of these substances in the environment as waste causes serious pollution and disrupts natural habitats. But beyond these, it also threatens human health [10,11].

Electronic waste also contains pollutants that are harmful to the environment and human health. The Basel Convention, which aims to keep the deportation movements of wastes with toxic content under control, has and this agreement entered into force in 2010 with the signature of 186 countries. Therefore, the Basel Agreement had to design a separate process for the protection of human and environmental health, for toxic wastes not to circulate freely like commercial products, and for deportation, movements to be subject to approval. This agreement entered into force in 2010 with the signature of 186 countries. Therefore, the Basel Agreement had to design a separate process for the protection of human and environmental health, for toxic wastes not to circulate freely like commercial products, and for deportation, movements to be subject to approval. However, the Basel Agreement also covered the principle of reuse, which is a condition for producing less electronic waste for electronic devices sent abroad. By increasing the functionality of electronic equipment, we also reduce the rate of recycling or waste, even temporarily, while protecting natural resources. However, whether something should be wasted or reused was a long-standing topic under the Basel Agreement. No final consensus was reached under COP 13. According to the Waste Electrical and Electronic Equipment Control Regulation published by the Ministry of Environment and Urbanization in Türkiye in 2012; electrical and electronic equipment, goods designed for use not exceeding 1000 Volts with alternating current and 1500 Volts with direct current, which are dependent on electric current or electromagnetic field for their proper functioning, and the production, transfer of these currents and fields and items used for measurement [12-16].

2. E-waste Content

E-Waste as a general expression; broken, damaged, seen as irreparable or expired, can be given in the form of electrical and electronic goods that pollute nature when thrown away. E-Waste is the fastest-growing segment of the domestic and industrial waste stream and most of the e-waste is classified as hazardous waste. It is a growing problem for the world day by day due to the large volume and substances harmful to health, and the increasing use of technology in every field. Since electrical and electronic goods have a wide range of products and different uses, they are grouped under 10 main headings in the Waste Electrical and Electronic Equipment Control Regulation. This grouping is important for manufacturers. Because, according to the regulation, producers are held responsible for the collection, recycling, and recovery of e-waste. On the other hand, it would be more correct to base the grouping on 6 in terms of the simplicity and ease of organizing the collection organized by the municipalities. According to the Waste Electrical and Electronic Equipment Regulation, the categories of electrical and electronic goods are listed in Figure 1 [17, 18]. The collection and processing costs of goods-type wastes such as refrigerators, coolers, and air conditioners are high. The material sales revenue is moderate, while the environmental benefit of recycling is high. Collection-processing costs and material sales revenue for large white goods excluding refrigerators, coolers, and air conditioners are moderate, and the environmental benefit of recycling is also moderate. The collection and processing costs of domestic waste such as televisions and monitors are high. The material sales revenue is moderate, while the environmental benefit of recycling is moderate. The collection-processing costs of IT telecommunications and consumer equipment, excluding televisions and monitors, are moderate, while the revenue from material sales and the environmental benefit of recycling is high. Lighting equipment collection and processing costs are high, and material sales revenue and the environmental benefit of recycling are moderate. The collection and processing costs of small domestic appliances, hand tools, toys, sports, and entertainment equipment, and monitoring and control tools are low, while the revenue from material sales and the environmental benefit of recycling are high. Assessment of separate collection schemes in the 28 capitals of the EU [7, 19-21].

There are many sources of e-waste, including government agencies and private sectors, research organizations, manufacturing, and households. The number of electronic materials that have become unusable in all these institutions, organizations, and sectors is increasing day by day. Although government agencies and some private sectors are obliged to dispose of their wastes in certain places, household e-waste is improperly collected and disposed of inappropriately.

In 2016, it was reported that 44.7 million metric tonnes of e-waste were produced all over the world. This number is about the same size as 4500 Eiffel Towers. According to 2016 data, 37% of the e-waste amount is small household items, 20% large household items, 17% heaters, 15% computer and

International Journal of Energy Applications and Technologies, Year 2022, Vol. 9, No. 3, pp. 71-80

television monitors, 9% mobile phones, tablets, and 2%. It consists of lighting elements. The global e-waste amount in 2019 accounted for the highest percentage with 17.4 Mt of small household appliances, followed by 13.1 Mt of large equipment and 10.8 Mt of air conditioners. According to the worldwide statistics for 2020, 37% of e-waste consists of small household appliances such as irons, kettles, toasters, and vacuum cleaners, 22% of large white goods such as freezers, refrigerators, washing machines, and dryers, and 17%. heaters, air conditioning systems, thermostats, 14% screens (TV, PC screens, etc.), and 9% mobile phones, laptop computers, and 1% lamps [22-24].

Fig. 1. The categories of electrical and electronic goods [17, 18]

There may be several reasons for the out-of-use period of electronic devices and equipment. The rapid technological development, the compatibility of the models used with the software that is updated very quickly, and the marketing strategies of the companies can be counted for these reasons. In addition, repair options for many electronic devices are limited today. Also, in the new age, electronic device designs do not allow repair, or repair costs are very high. The type of electronic products is very important at the stage of use and waste. The damage they cause to the environment and their contribution to the economy in recycling vary according to the types of devices and equipment [17]. In Figure 2, the lifetimes obtained from various references of different devices are given. In the report prepared by the EPA regarding the duration of use of other goods, some predictions were made, and information was given about consumption habits. In the report, it is stated that the usage period of desktop computers, printers, and monitors is 7 years in the USA, the average usage period of laptop computers is 6 years, and CRT televisions are used for an average of 11 years. According to the report, while 75% of tube black and white TVs are used by consumers for a long time, such as 17 years, it is seen that 100% of LCD-LED televisions become e-waste in an average of 8.5 years. As a result of studies on consumer habits, 20% of mobile phones are included in the e-waste management chain after 2 years of use and 70% after 5 years. The remaining 10% of mobile phones are included in the e-waste management chain within 10 years in total, remaining in stock that cannot be sold [23, 25, 26].

Electronic devices contain metals, elements, and a wide variety of compounds. Among the most basic metals are iron, aluminum, nickel, zinc, selenium, indium, and gallium. It can also be divided into copper, palladium or gold, and silver. Therefore, the electronic waste contains this element and various chemicals reported that when electrical and electronic devices are compared in terms of metal content, large electrical devices contain fewer potential contaminants than small ones. Mercury, beryllium, lead, arsenic, cadmium,

doi: 10.31593/ijeat.1134468

International Journal of Energy Applications and Technologies, Year 2022, Vol. 9, No. 3, pp. 71-80

antimony, and plastics, glass, and ceramic components can be quite dangerous for both the environment and human health. Factors such as the type of electronic device, duration of use, and manufacturer are important for the content of the waste component. Figure 3 shows the selected material composition for five different types of electronic device waste. In the graph on the left, iron, aluminum, copper, andplastic contents are given as percentages. The graph on the right shows the contents of precious elements (silver, gold, palladium) in ppm. According to Figure 3, plastic and ferrous contents are the dominant components for TV and computer boards and DVD and mobile phones. In addition, these electronic types (<0.5%) also contain precious metals [23, 27, 28].

In a study in 2018, more detailed information was given. The percentages of nickel, lead, aluminum, copper, and iron in the printed circuit board, PC mainboard, calculator, DVD player, portable music player, phone, computer, and TV units are given in the left graph in Figure 4. The abundance of iron use is striking. In the same study, the values of valuable elements in ppm were also included. The figure is given in the graph on the right [29, 30].

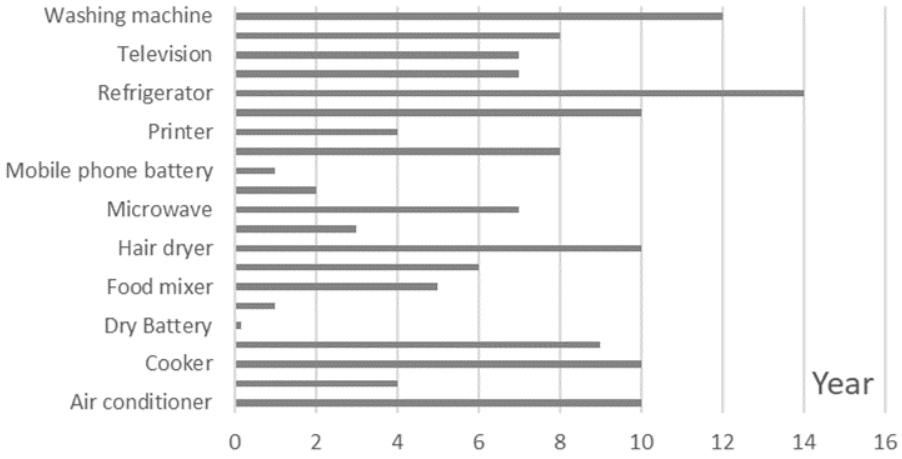

Fig. 2. The lifespan of some devices and equipment containing electronics

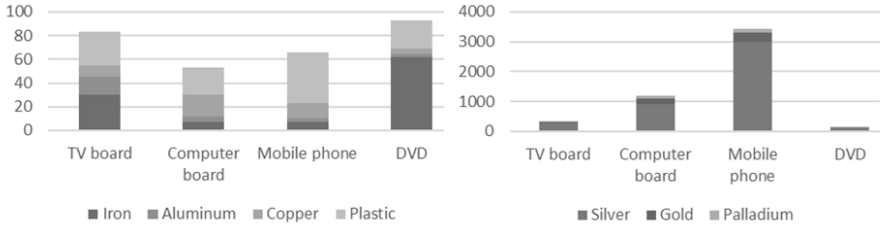

Fig. 3. Selected material contents for some electronic devices

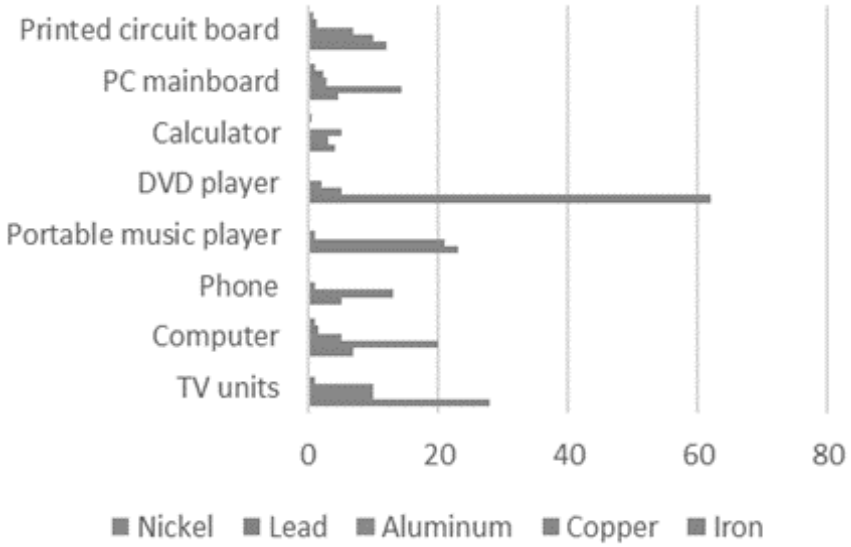

Fig. 4. Some material contents for electronic devices

doi: 10.31593/ijeat.1134468

International Journal of Energy Applications and Technologies, Year 2022, Vol. 9, No. 3, pp. 71-80

An older model PC with Cathode Ray tube monitors contains approximately 43.7% metal, 17.3% electronic components, 15% glass material, and 23.3% plastic. Refrigerators and washing machines often contain steel and small amounts of environmental pollutants, while computers, laptops, and mobile phones contain higher amounts of heavy metals. Wastes from cooling and freezing devices have an important share in e-waste. Especially the environmental effects are important. The percentages by weight of the substances constituting a refrigerator waste are given in Figure 5. Steel has the highest share of refrigerator e-waste. Then plastic and polyurethane foam make up the biggest share [31, 32].

When considering the washing machine, steel (37%) and plastic (21%) have the highest share. There are also precious and platinum metals silver, gold, and palladium. (Figure 6) Dishwashers have become indispensable appliances in homes in the last 10 years. For example, dishwashers used in Türkiye are of very high quality and energy standards. The materials contained in a dishwasher are given in Figure 7. It has been reported that there are approximately 2 billion air conditioners in the world in 2020, mostly in the United States, China, Japan, and South Korea. The percentage appearances of the materials in the air conditioner are given in Figure 8 [33-37].

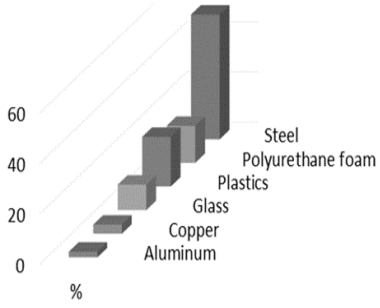

Fig. 5. Contents of a domestic refrigerator

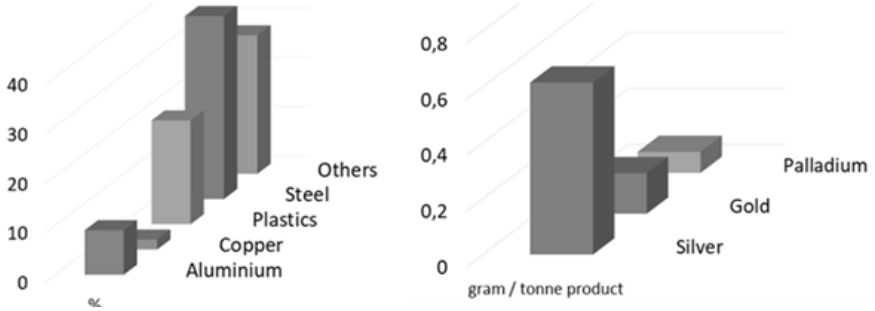

Fig. 6. Materials in the washing machine

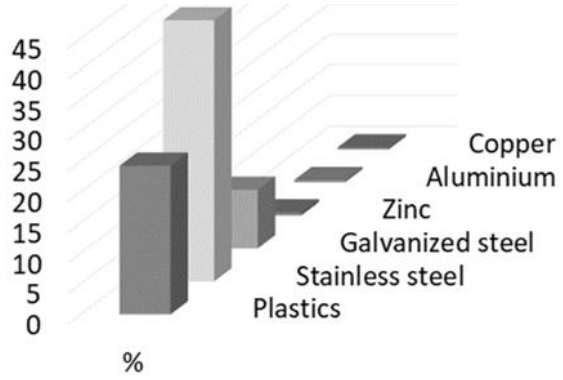

Fig.7. Materials in the washing machine

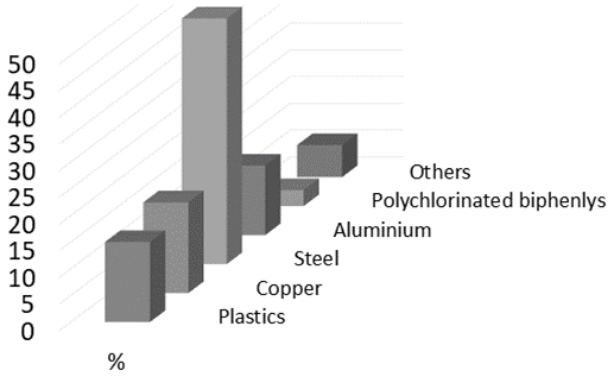

Fig. 8. Materials in the air conditioners

Electronic devices and thus their waste; Along with the ones mentioned above, there are also materials such as arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), lead (Pb), phosphorus (P), brominated flame retarders. The mixing of these materials with that soil, water, and air causes serious pollution and threatens the health of living things as well as disrupts their natural habitats. In a study conducted in and around e-waste enterprises in Buriram, Thailand, the most common heavy metal measurements on the soil surface were copper, followed by arsenic, cadmium, and lead, respectively. In deeper soil measurements, it was stated that cadmium was the most, followed by copper, arsenic, and lead, respectively [38].

In a study conducted in Agbogbloshie, Ghana (a region close to the center of Accra, thought to be the world's largest e-waste site), arsenic and its derivatives were found to be well above the tolerable level in the urine samples of 84 e-waste workers [39].

Ribeiro et al (2022) stated in their review of the effects of e-waste on human health that there were nearly 500 articles on e-waste pollutants between 2010 and 2020. In general, the effects of some materials found in e-waste on human health are given in Table 1 [40, 41].

Table 1. Effects of some materials on human health

As	Skin and Lung Cancer
Ba	Brain Swelling, Muscle Weakness, Heart and Liver Diseases
Be	Lung Cancer, Skin Diseases
Cd	Kidney Diseases, Lung Damage, and Bone Diseases
Cr	Heart Diseases, Allergic Reactions, Kidney-Liver Damage
Hg	Nervous and Digestive System Damage, Liver and Kidney Damage, Skin Diseases, etc.
Pb	Anemia, digestive and excretory system, and brain diseases

doi: 10.31593/ijeat.1134468

The collection and recycling of e-waste are valuable in terms of its great importance in terms of the environment and human health, as well as making great contributions to countries in terms of economy. It is clear that with the recycling of e-waste, resources will be provided to the secondary raw material and commercial market. Thus, it is clear that it will contribute to the circular economy. The materials that can be obtained from the e-waste mentioned above require less energy than extracting raw materials from mines. For example, it has been reported that 1 ton of smartphones contains approximately one hundred times more gold than 1 tonne of gold mines. According to the United Nations, 53.6 million tons of e-waste were produced in the world in 2019. Less than 20 percent of this waste is recycled, which is equivalent to about $57 billion [42].

3. Statistical Information on the Amount of E-Waste

In 2016, approximately 45 million tons of e-waste (approximately 6 kg per person) were generated in the world. In 2016, European Union (EU) countries and the USA and the European Union are responsible for about half of this amount. While approximately 20 kg of e-waste is generated per person per year in the USA and Canada, this figure is 18 kg in the EU. On the African continent with a population of 1.2 billion, only 1.9 kg of e-waste per person is generated [43]. The amount of e-waste for 2019 is categorized and given in Figure 9 in Mt units. The amount of e-waste according to the population for 2020 has been reported as 7.3 kg/person. In 2019, 53.6 million tons of e-waste were generated and according to the Global E-Waste Monitoring Report, approximately 18% of this waste was recycled. Compared to the numbers in 2014, the biggest increase was in temperature exchange equipment with seven percent annually, followed by large equipment with an increase of five percent, and lamps and small equipment with four percent (Figure 9) [22].

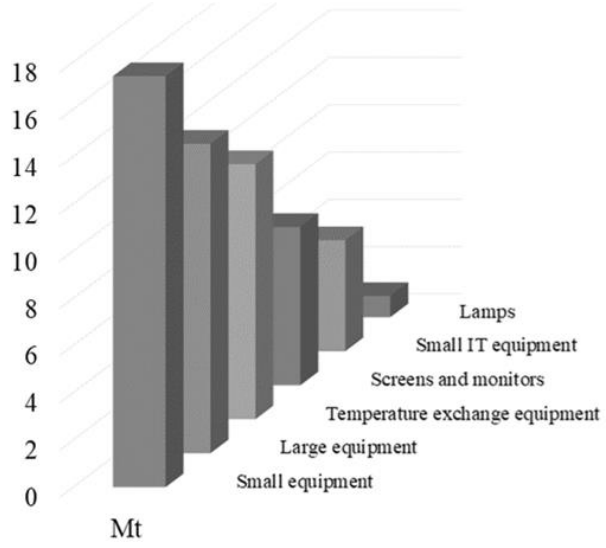

Fig. 9. Types and amounts of e-waste in the world in 2019

According to the same report, as of the end of 2019, there are legislation and regulations regarding e-waste in 78 countries in the world. However, in many countries these regulations are not legally binding, just included in the programs. In 2019, the European continent ranked first with approximately 17 kg of e-waste per capita. In addition, Europe ranks first in e-waste recycling. In total, the Asian continent ranks second in the amount of e-waste with approximately 25 Mt. According to 2019 statistics, the Americas produced about ten percent of the total amount of e-waste in the world, while Oceania produced nine percent (Figure 10) [22]. E-waste is estimated to be around 75 Mt by 2030. According to the report, only 17.5% of e-waste is officially collected and recycled. The country with the highest e-waste recycling rate is Sweden with 62.6%. This rate is 14% in the USA, 21% in China, and 23% in Japan. The target of increasing e-waste recycling to 30 percent by 2023 has been set [22].

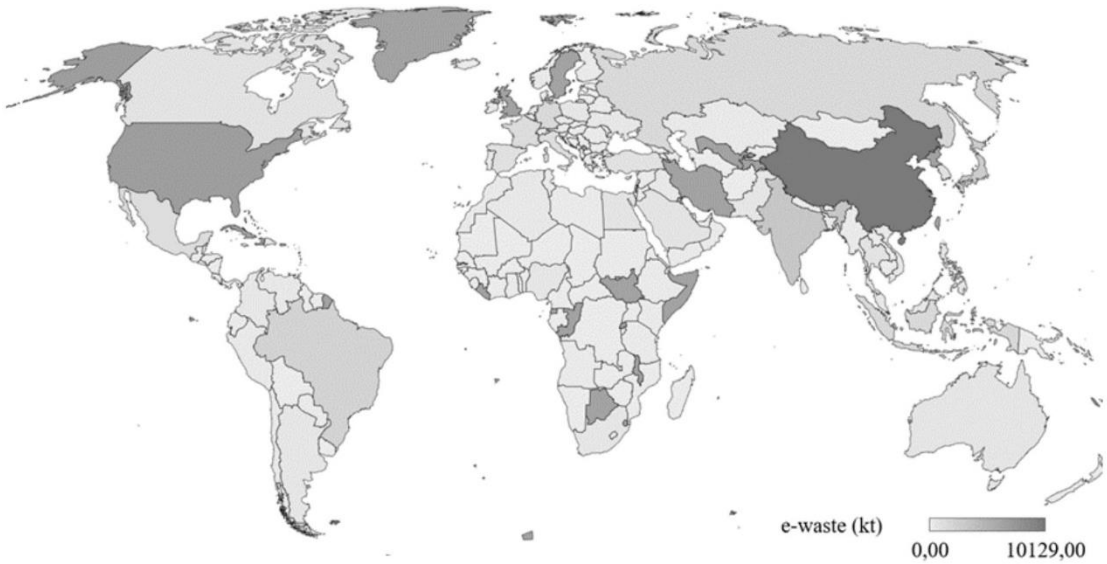

Fig. 10. E-waste (kiloton) of 180 countries in the world for 2019

International Journal of Energy Applications and Technologies, Year 2022, Vol. 9, No. 3, pp. 71-80

4. E-Waste Policies-Practices and Statistical Information for Türkiye

The concept of e-waste in Türkiye is legally encountered for the first time with the addition made in 2002 to the Solid Waste Control Regulation published in 1991. The first study on the management of electrical and electronic waste in Türkiye was carried out with the Dutch Government in 2004 within the scope of the Matra Project. In the process of Türkiye's European Union membership candidacy, the e-waste management regulation studies, which came into force in the European Union in 2003, started in 2005, and the Environmental Law No. 2872, "Regulation for Control of Waste Electrical and Electronic Equipment" dated 22/5/2012 and numbered 28300" published by the Ministry of Environment and Urbanization on 22 May 2012. It entered into force in June 2013 [44].

Table 2. Laws, regulations, and communiqués on e-waste in Türkiye

Date and issue / Official Gazette of the Republic of Türkiye	Laws, Regulations, and Communiques
11 August 1983/18132	Environmental Law
05 July 2008/26927	Waste Management Regulation
21 November 2008/ 27061	Environmental Audit Regulation
22 May 2012/28300	Waste Electrical and Electronic Equipment Control Regulation
31 December 2014/ 29222	Waste Collection Center Communiqué
7 April 2016 / 29677	Personal Data Protection Law
04 May 2016/28300	Authorization Procedures and Principles
28 December 2017/30284	Communiqué on Administrative Fines
23 March 2017/ 30016	Regulation on Making Changes in Waste Management Regulation
10 December 2018/30621	The Law on the Amendment of the Environmental Law and Some Laws
04 April 2019/30735	General Communiqué on Recycling Contribution Share Declaration (No 1)
12 July 2019/30829	Zero Waste Regulation
31 December 2019/30995	Regulation on Recycling Contribution Share
05 February2020/31030	General Communiqué on the Recycling Contribution Share Declaration (No 2)
22 March 2020/31076	General Communiqué on the Recycling Contribution Share Declaration (No 3)

In the regulation published in the Official Gazette (30.05.2008/ 26891) by the Ministry of Environment and Forestry as "Regulation on the Limitation of the Use of Certain Harmful Substances in Electrical and Electronic Equipment" in Türkiye, electrical and electronic goods are specified in ten classes. In the regulation, devices that are designed for use not exceeding 1000 Volts with alternating current and 1500 Volts with direct current and that are dependent on electric current or electromagnetic field, and goods that generate electricity, that is used for electricity transfer and measurement, are electrical and electronic goods.

With the issuance of this regulation by Türkiye, it was ensured that the European Union's WEEE and RoHS Directives were harmonized with the national legislation. Table 2 shows the laws, regulations, and communiqués made in Türkiye on e-waste management [44].

In the light of developments and improvements, a draft regulation was prepared in 2015-2016, with new updates, and it was revised and opened to view on the website of the ministry. The 16th article of the regulation that came into force in 2013, it is stated at what rate companies should meet the recycling amounts. When the 2017 data is analyzed, it is seen that the total amount of electrical and electronic goods put on the market in Türkiye is 777 thousand tons, while the average for 2014, 2015, and 2016 is 750 thousand tons [45].

In Figure 11, e-waste collection targets published in the Official Gazette, (24.11.2015/ 139115 are given as a percentage for various electronic product ranges for 2013, 2014, 2015, 2016, and 2018 (no target has been determined for 2017) [44]. In addition, the Ministry of Environment and Urbanization gave the amounts of e-waste collection in the statistics and reports published in 2017 and 2019 as in Figure 12. [46, 47].

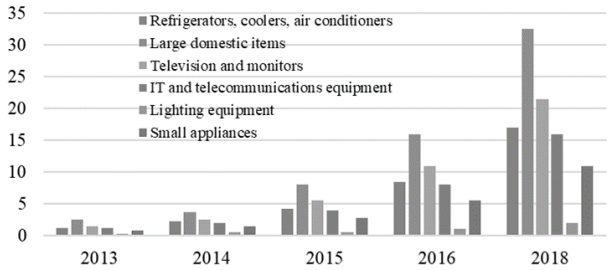

Fig. 11. E-waste collection targets Türkiye

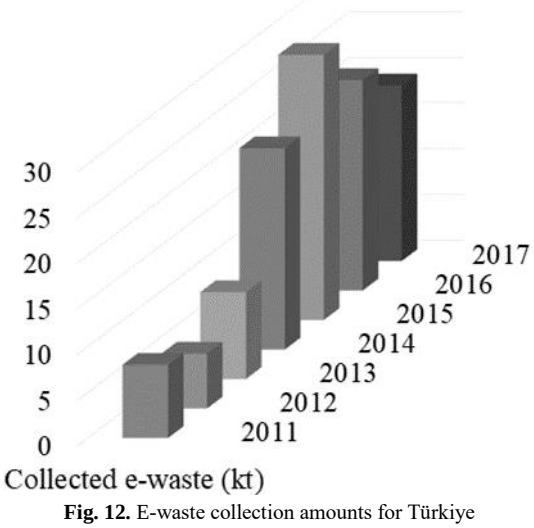

Fig. 12. E-waste collection amounts for Türkiye

doi: 10.31593/ijeat.1134468

International Journal of Energy Applications and Technologies, Year 2022, Vol. 9, No. 3, pp. 71-80

The total amount of e-waste generated in Türkiye was reported as 542 thousand tons for the next two years in the estimation created by the European Commission in 2014 (EC, 2014). Global E-waste Monitor, on the other hand, estimated 623 thousand tons (7-8 kg per person) in 2016 and the forecast for the next three years is 672 thousand tons [45]. Türkiye's total e-waste and put on the market e-waste (in kT unit) and per capita data of the Global E-waste Monitor for the years 2015-2019 are given in Figure 13 [22].

There are three associations in Türkiye that have been licensed by the Ministry of Environment and Urbanization for the production of electrical and electronic devices. These are the Electrical and Electronics Recycling and Waste Management Association (ELDAY), the Lighting Equipment Manufacturers Association (AGID), and the Information Industry Association (TÜBİSAD). For example, TÜBİSAD was appointed by the ministry in 2015 as the authorized institution for the collection of TV - monitors and information telecommunication and consumer equipment wastes. In this context, this organization continues to carry out various training, consultancy, and campaigns. The website of the organization contains the addresses of 294 e-waste collection centers. While provincial and district municipalities are also working on e-waste collection, citizens can also get information and guidance on e-waste by calling the ministry's ALO 181 call center [48].

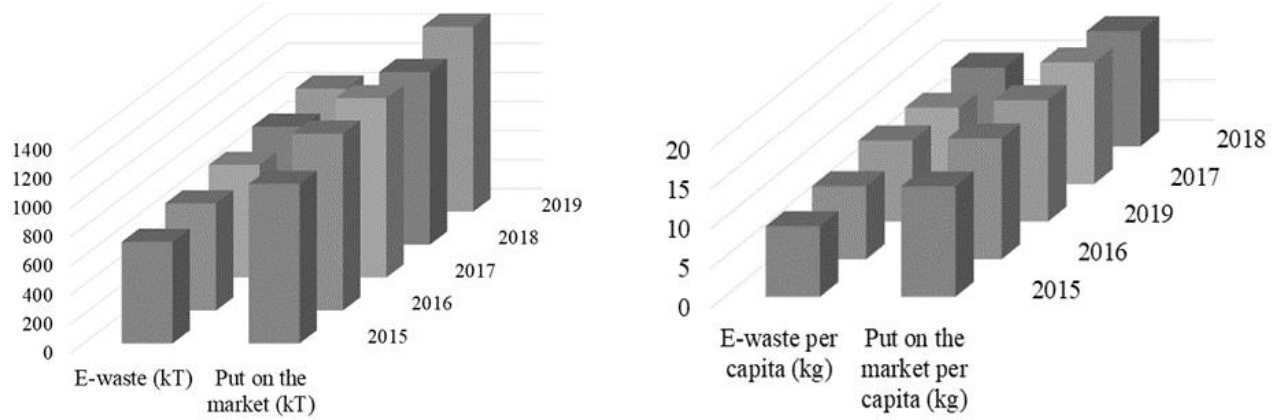

Fig. 13. Total e-waste and put on the market e-waste and per capita data for 2015-2019

5. Conclusion and Recommendations

The amount of e-waste in Türkiye is increasing rapidly thanks to the rapidly developing technology. In the European Union member countries, non-used products are collected separately by certain rules. Again, these wastes, which are collected following certain rules and regulations, are subjected to different processes instead of being thrown away with other wastes. Again, these wastes, which are collected per certain rules and regulations, are subjected to different processes instead of being thrown away with other wastes. As mentioned above, studies on e-waste in Türkiye since the 2010s have only just begun to take shape, although regulations have been made. Since the separate collection system is not widespread in many regions in Türkiye, there are various problems.

Considering Türkiye's foreign dependency on energy, not only e-waste but also recycling of all kinds of waste is a necessity both in terms of a clean world and a healthy environment and in terms of bringing it into the economy. We have explained in detail above what the metals and precious metal ratios in hand-waste are. When the recovery process is evaluated professionally, these metals and precious metals will be very beneficial economically and environmentally.

Accurately knowing the number of users of electrical and electronic products produced and imported in Türkiye is important for estimating the total amount of e-waste and determining methods and regulations based on these estimations. Professionally and in compliance with the regulations in all steps of the e-waste collection and recycling process contributes economically and helps prevent environmental problems. It helps to reduce the harm to human health. The number of recycling activities of e-waste, which can create ecological problems, which are not in compliance with regulations, and are carried out under dangerous conditions, is increasing.

To prevent such negativities, producers, consumers, associations, and government institutions should be sensitive about e-waste collection and recycling, and they should fulfill their responsibilities for the effective and sustainable management of these wastes.

Continuous public service announcements about e-waste content and harms on TV and social media can attract the attention of consumers. It is also important for municipalities to place e-waste collection points at certain points. However, the main thing is that they need to be coordinated properly.

Establishing and following up a database and system in which all data on e-waste will be collected by the relevant

doi: 10.31593/ijeat.1134468

ministries and appointing professional persons will ensure coordination between municipalities and associations. The contents and percentages of metals and precious metals in the content of all electronic products are attached to large white goods and used in other types of products, such as user manuals. may raise awareness of consumers in this regard. Giving more informative seminars on this subject in vocational high schools, vocational schools, and faculties related to electricity and electronics, and when necessary, students studying at such schools on e-waste work in terms of internships, etc. can increase the sensitivity.

Authorship contribution statement for Contributor Roles Taxonomy

Ali Özhan Akyüz: Writing - original draft, Investigation, Supervision, Conceptualization.
Kazım Kumaş: Investigation, Supervision, Writing.

Conflict of interest

The author(s) declares that he has no conflict of interest.

References

[1] https://www.step-initiative.org/e-waste-challenge.html. (08 June 2022)
[2] Parajuly, K., Kuehr, R., Awasthi, A. K., Fitzpatrick, C., Lepawsky, J., Smith E., Widmer, R. and Zeng, X. 2019. Future E-waste Scenarios.
[3] Kumara, A., Holuszkoa, M. and Espinosab, D.C.R. 2017. E-waste: An overview on generation,collection, legislation and recycling practices. Resources, Conservation and Recycling, 122, 32-42.
[4] Choudhary, K. 2017. Electronic waste: a growing concern in today's environment. Surya-The Energy Management Research Journal, 3(4), 36-49.
[5] https://www.iberdrola.com/sustainability/what-is-e-waste (17 May 2022)
[6] Chakraborty, M., Kettle, J. and Dahiya, R. 2022. Electronic waste reduction through devices and printed circuit boards designed for circularity. IEEE Journal on Flexible Electronics, 1(1), 4-23.
[7] Nithya, R., Sivasankari, C. and Thirunavukkarasu, A. 2021. Electronic waste generation, regulation and metal recovery: A review. Environmental Chemistry Letters, 19(2), 1347-1368.
[8] Zhang, L. and Xu, Z. 2016. A review of current progress of recycling technologies for metals from waste electrical and electronic equipment. Journal of Cleaner Production, 127, 19-36.
[9] Wang, R. and Xu, Z. 2014. Recycling of non-metallic fractions from waste electrical and electronic equipment (WEEE): A review. Waste Management, 34(8), 1455-1469.
[10] Ankit, Saha, L., Kumar, V., Tiwari, J., Rawat, S., Singh, J. and Bauddh, K. 2021. Electronic waste and their leachates impact on human health and environment: Global ecological threat and management. Environmental Technology & Innovation, 24, 102049,1-28.
[11] Rajesh, R., Kanakadhurga, D. and Prabaharan, N. 2022. Electronic waste: A critical assessment on the unimaginable growing pollutant, legislations and environmental impacts. Environmental Challenges, 7, 100507,1-15.
[12] Ogunseitan, O. A. 2013. The basel convention and e-waste: translation of scientific uncertainty to protective policy. The Lancet Global Health, 1(6), e313-e314.
[13] Khan, S. A. 2016. E-products, e-waste and the basel convention: regulatory challenges and impossibilities of international environmental law. Review of European, Comparative & International Environmental Law, 25(2), 248-260.
[14] Suraweera, I. 2016. E-waste issues in sri lanka and the basel convention. Reviews on Environmental Health, 31(1), 141-144.
[15] Öztürk, T. 2015. Generation and management of electrical-electronic waste (e-waste) in Turkey. Journal of Material Cycles and Waste Management, 17, 411-421.
[16] İzmirlioğlu, A. 2017. Han insight view into e-waste legislation in Turkey and EU. Journal of Yedıtepe Unıversıty Faculty of Law, XIV (2), 293-304.
[17] Goodship, V., Stevels, A., & Huisman, J. (Eds.). Waste electrical and electronic equipment (WEEE) handbook. Second Edition, Woodhead Publishing, Elsevier, 2019.
[18] Andeobu, L., Wibowo, S. and Grandhi, S. 2021. An assessment of e-waste generation and environmental management of selected countries in Africa, Europe and North America: A systematic review. Science of The Total Environment, 792, 148078, 1-15.
[19] Balde, C. P., Kuehr, R., Blumenthal, K., Fondeur Gill, S., Kern, M., Micheli, P., Magpantay, E., and Huisman, J. 2015. E-waste statistics-guidelines on classification, reporting and indicators, United Nations University, IAS-SCYCLE, Bonn (Germany) 2015.
[20] http://ec.europa.eu/environment/waste/studies/pdf/Separate%20collection_Final%20Report.pdf. (20March 2022).
[21] Rene, E. R., Sethurajan, M., Ponnusamy, V. K., Kumar, G., Dung, T. N. B., Brindhadevi, K. and Pugazhendhi, A. 2021. Electronic waste generation, recycling and resource recovery: technological perspectives and trends. Journal of Hazardous Materials, 416, 125664,1-11.

[22] Forti, V., Balde, C. P., Kuehr, R. and Bel, G. The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential. SCYCLE Books, United Nations University/United Nations Institute for Training and Research, International Telecommunication Union, and International Solid Waste Association, Bonn, Geneva and Rotterdam, 2020.

[23] https://www.bbc.com/news/business-51385344 (23 March 2022).

[24] Hischier, R. and Böni, H. W. 2021. Combining environmental and economic factors to evaluate the reuse of electrical and electronic equipment – a Swiss case study. Resources, Conservation and Recycling, 166, 105307, 1-8.

[25] Duan, H., Miller, T. R., Gregory, J., Kirchain, R. and Linnell, J. 2013. Quantitative characterization of domestic and transboundary flows of used electronics: Analysis of generation, collection, and export in the United States. Official Document of Environmental Protection Agency (EPA), under the umbrella of Solviong the e-waste problem (STEP) Dec, 121.

[26] https://quantumlifecycle.com/blog/whats-the-average-lifespan-of-your-electronics/ (10 April 2022).

[27] Hashmi, M. Z. and Varma, A. (Eds). Electronic Waste Pollution. Springer, Switzerland, 2019.

[28] Fornalczyk, A., Willner, J., Francuz, K. and Cebulski, J. (2013). E-waste as a source of valuable metals. Archives of Materials Science and Engineering 63(2), 87-92.

[29] Ghosh, M., Basu, S., Sur, D. and Banerjee, P.S. 2020. Metallic Materials from E-Waste. Encyclopedia of Renewable and Sustainable Materials, 1, 438-455.

[30] https://www.elektriktesisatportali.com/elektronik-atiklarin-geri-donusturulmesinin-milli-ekonomiye-olan-katkilarinin-incelenmesi.html

[31] Berkhout, F. and Hertin, J. 2004. De-materialising and re-materialising: digital technologies and the environment. Futures, 36(8), 903-920.

[32] Baxter, J. 2019. Systematic environmental assessment of end-of-life pathways for domestic refrigerators. Journal of Cleaner Production, 208, 612-620.

[33] Schaik, A.V., Reuter, M. A. Shredding, sorting and recovery of metals from WEEE: linking design to resource efficiency, in Goodship,V., Stevels, A. Waste electrical and electronic equipment (WEEE) handbook, Woodhead Publishing, 2012.

[34] Porras, G.Y., Keoleian, G.A., Lewis, G. M. and Seeba, N. 2020. A guide to household manual and machine dishwashing through a life cycle perspective. Environmental Research Communications, 2(2), 1-15.

[35] https://www.reportlinker.com/market-report/HVAC/7959/Air-Conditioning (23 March 2022).

[36] http://eco3e.eu/products/air-conditioner(15 June 2022).

[37] Eduljee, G. H. and Harrison, R. M. (Eds.). Electronic Waste Management. Royal Society of Chemistry, Second Edition, Royal Society of Chemistry, US, 2019.

[38] Amphalop, N., Suwantarat, N., Prueksasit, T., Yachusri., C. and Srithongouthai, S. 2020. Ecological risk assessment of arsenic, cadmium, copper, and lead contamination in soil in e-waste separating household area, Buriram province, Thailand. Environmental Science and Pollution Research, 27, 44396–44411.

[39] Yang, J., Bertram, J., Schettgen, T., Heitland, P., Fischer, D., Seidu, F., Felten, M., Kraus, T., Fobil, J.N. and Kaifie, A. 2020. Arsenic burden in e-waste recycling workers - A cross-sectional study at the Agbogbloshie e-waste recycling site, Chemosphere, Ghana. 261.

[40] Ribeiro, J. N., Barbosa, A. F. M., Ribeiro, A. V. F. N., Pereira, M. G., Oliveira, J. P., Zordan, A.B. and Silva, A. R. 2022. E-waste and its consequence for environment and public health: Perspectives in covid-19 pandemic times. Global Journal of Health Science, 14(3), 54-76.

[41] Vidyadhar, A. A Review of Technology of Metal Recovery from Electronic Waste, in: Mihai, F-C., E-Waste in Transition-From Pollution to Resource. Intech Open, Croatia, 2016, 121-158.

[42] WEF, 2019. A New Circular Vision for Electronics, The Platform for Accelerating the Circular Economy, http://www3.weforum.org/docs/WEF_A_New_Circular_Vision_for_Electronics.pdf.

[43] Baldé, C. P., Forti, V., Gray, V., Kuehr, R. and Stegmann, P. 2017. The global e-waste monitor 2017: Quantities, flows and resources. United Nations University, International Telecommunication Union, and International Solid Waste Association, 102syf.

[44] T.C. Cumhurbaşkanlığı Resmi Gazete, https://www.resmigazete.gov.tr/

[45] EC, 2014. Study on collection rates of waste electrical and electronic equipment (WEEE), European Commission, https://ec.europa.eu/environment/waste/

[46] ÇŞB 2017, Ulusal atık yönetimi eylem planı (2016-2023).

[47] ÇŞB, 2019. Tehlikeli Atık İstatistikleri Bülteni 2017, Çevre ve Şehircilik Bakanlığı.

[48] https://www.tyk.org.tr/tr/aeee-nereye/ (15 June 2022).