ITJ | The International Tax Journal

# Waste from the electronics industry and environmental pollution

**Julio Cesar Guamán-Segarra**
Universidad Técnica de Manabí, Facultad de Ingeniería y Ciencias Aplicadas, Carrera de Ingeniería Eléctrica, Portoviejo, Manabí, Ecuador
Email: julio.guaman@utm.edu.ec

**Dolores Vanessa Maza-Vivanco**
Gobierno Autónomo Decentralizado, Montecristi, Manabí, Ecuador
Email: vanessa94mv@gmail.com

**Beatriz Irene Caballero-Giler**
Universidad Técnica de Manabí, Facultad de Ingeniería y Ciencias Aplicadas, Carrera de Ingeniería Civil, Portoviejo, Manabí, Ecuador
Email: beatriz.caballero@utm.edu.ec

**Maria Shirlendy Guerrero-Alcivar**
Universidad Técnica de Manabí, Facultad de Ingeniería y Ciencias Aplicadas, Carrera de Ingeniería Civil, Portoviejo, Manabí, Ecuador
Email: maria.guerrero@utm.edu.ec

**Olinda Elizabeth Caicedo Arevalo**
Universidad Técnica de Manabí, Facultad de Ingeniería y Ciencias Aplicadas, Carrera de Ingeniería Civil, Portoviejo, Manabí, Ecuador
Email: olinda.caicedo@utm.edu.ec

**Abstract---**One of the current problems that hits technological development the hardest is environmental pollution caused by waste. The development of electronics is advancing every day and with this, waste problems become a problem that affects health and the environment. Therefore, it is necessary to draw up strategies to mitigate them. The objective of the research is to know the main pollutants and propose solutions for their mitigation. The methodology used was the bibliographic search, the inductive and

**How to Cite**:
Guamán-Segarra, J. C., Maza-Vivanco, D. V., Caballero-Giler, B. I., Guerrero-Alcivar, M. S., & Caicedo Arevalo, O. E. (2024). Waste from the electronics industry and environmental pollution. *The International Tax Journal*, *51*(1), 1–8. Retrieved from https://internationaltaxjournal.online/index.php/itj/article/view/1

The International tax journal ISSN: 0097-7314 E-ISSN: 3066-2370 © 2024
ITJ is open access and licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.
Submitted: 9 Jan 2024 | Revised: 18 Feb 2024 | Accepted: 27 March 2024

deductive method, and the proposal of some strategies to mitigate them mitigate the polluting effects of waste electrical industry where one of the aspects considered most relevant is education and awareness of the people who produce, use and manage these pollutants.

**Keywords---**pollution, technology, strategies, SDGs, heavy metals.

## Introduction

The electronics industry has experienced exponential growth in recent decades, driving technological innovation and making everyday life easier. However, this progress has been accompanied by significant environmental impacts. The production, use and disposal of electronic devices generate a variety of pollutants that affect air, water and soil, contributing considerably to environmental pollution.

One of the main problems associated with the electronics industry is the use of toxic materials such as lead, mercury and cadmium, which are common components in many electronic devices. During the manufacturing and disposal of these products, these materials can be released into the environment, causing damage to ecosystems and risks to human health (Smith et al., 2018). Furthermore, the production process of electronic devices consumes large amounts of energy and natural resources, contributing to resource depletion and greenhouse gas emissions (Williams et al., 2013).

Another critical aspect is the management of electronic waste, known as e-waste. Millions of tons of e-waste are generated globally every year, and much of this waste is not managed properly, ending up in landfills or being informally recycled in developing countries. These unregulated recycling processes can release dangerous pollutants into the environment, affecting both public health and air and water quality (Widmer et al., 2005).

The electronics industry provides significant benefits, it also presents considerable environmental challenges. It is necessary to implement sustainable practices and improve waste management to mitigate negative impacts and promote more ecological and responsible development.

At a global level, strategies have been drawn up to mitigate environmental problems due to the growing concern about these damages caused by the electronics industry, these range from the design of more sustainable products to the improvement in electronic waste management.

One of the main strategies to reduce the environmental impact of electronic products is ecological design, also known as ecodesign. This approach focuses on minimizing the use of toxic materials and increasing energy efficiency during the design and production phase of electronic devices. For example, incorporating recyclable materials and reducing energy consumption in manufacturing are key practices in eco-design (Kuehr & Williams, 2020).

In some cases, work has been done on adequate management of electronic waste, or e-waste, which is essential in the processes of mitigating the environmental impacts of electronics in this context, including formal collection and recycling, as well as the promotion of circular economy, which seeks to reuse and recycle electronic components to reduce the need for new raw materials (Forti et al., 2020). There are other initiatives that promote the collection of obsolete electronic devices through manufacturer-sponsored take-back and recycling programs.

One of the actions that must be clear are government provisions, some international organizations have implemented regulations to control and reduce the environmental impacts of the electronics industry. The European Union's Waste Electrical and Electronic Equipment (WEEE) Directive is a leading

example of legislation that sets standards for the collection, treatment and recycling of e-waste (European Commission, 2023), these policies encourage extended consumer responsibility producer, forcing manufacturers to take charge of the entire life cycle of their products. Another action that has been developed is the adoption of innovative technologies that play an important role in mitigating environmental impacts. The development of advanced recycling techniques and the creation of biodegradable electronic materials are examples of how innovation can contribute to a more sustainable electronics industry (Garlapati et al., 2021). The use of renewable energy sources in the production of electronic devices can significantly reduce the carbon footprint of the industry. This should be a key example of the future development of these energies, knowing that the energy future is directed towards these renewable sources.

Education and awareness about the environmental impacts of electronic products and the importance of their recycling are essential to promote more sustainable practices among consumers, awareness campaigns and educational programs can motivate users to actively participate in the collection and recycling of electronic products. -waste (Baldé et al., 2017).

**Materials and methods**

For the research, the qualitative and inductive-deductive method was applied, which allowed us to know the behavior of environmental pollution in the electronics industry, in addition to the literature review to be clear about the possible areas that have been affected and propose a strategy that Help mitigate these environmental problems.

**Analysis and discussion of the results**

The electronics industry, currently a fundamental axis of the global economy and technological advancement, faces significant challenges related to environmental pollution. From production to disposal of electronic devices, each stage of the life cycle of these products involves considerable environmental risks.

The manufacturing of electronic components, such as chips and printed circuits, uses a wide range of toxic chemicals and heavy metals, including lead, mercury and cadmium, which can be released into the environment if not properly managed (Baldé et al., 2020).

The production of electronic devices requires a substantial amount of energy, generally coming from non-renewable sources, which contributes significantly to greenhouse gas emissions (Williams et al., 2013), all of which should be a challenge for companies in look for alternatives to the use of non-polluting sources in technological processes.

Another difficulty occurs when devices reach the end of their useful life, the inadequate management of electronic waste, it is estimated that only 20% of global electronic waste is formally recycled, while the rest ends up in landfills or is recycled. drives informally, often in conditions that do not meet environmental and health standards, which can lead to the release of hazardous substances (Forti et al., 2020).

The growing demand for electronic products and the rapid pace of technological obsolescence have intensified these problems, making the implementation of mitigation strategies and sustainable management of electronic waste urgent. These strategies include eco-friendly product design, promoting the circular economy, and adopting stricter policies on waste management (Kuehr & Williams, 2020). As the electronics industry continues to expand, it is critical to address challenges to minimize its environmental impact and promote more sustainable practices. Figure 1 shows some environmental impacts caused by these materials.

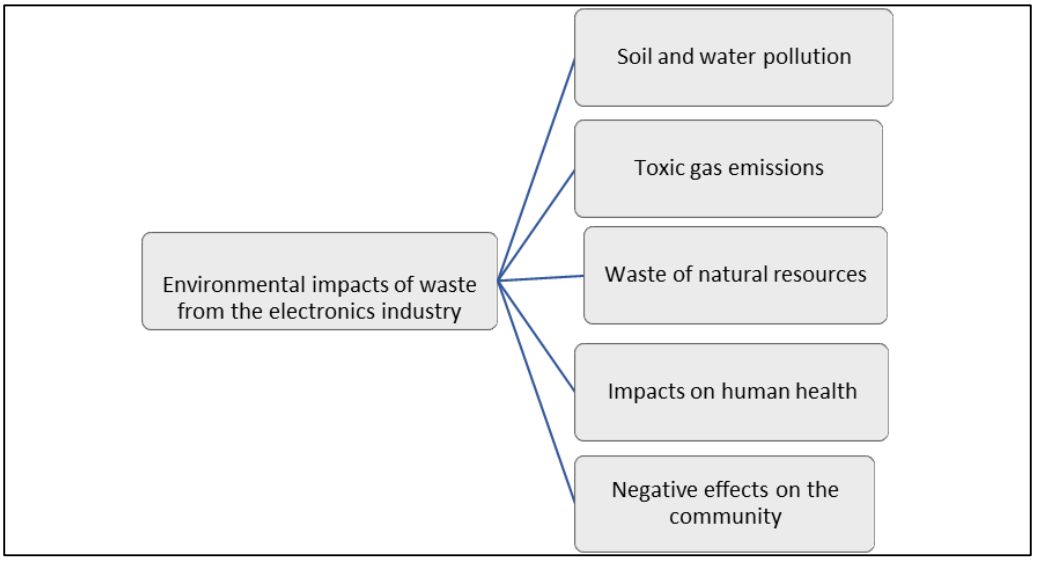



Figure 1. Some environmental impacts caused by these materials
Fuente: (Leung, Cai, & Wong, 2006), (Robinson, 2009), (Huisman et al., 2015).

Waste is often disposed of improperly, ending up in landfills or being burned; when it decomposes, heavy metals and toxic chemicals leach into the soil and water sources, contaminating the environment. This not only affects soil and water quality, but can also enter the food chain, affecting plants, animals and, eventually, humans (Leung, Cai, & Wong, 2006).

Another difficulty is the burning of electronic waste is the emission of toxic gases and particles into the air, contributing to atmospheric pollution, these gases include dioxins and furans, which are highly toxic and can cause serious health problems, such as cancer and disorders of the immune system (Robinson, 2009).

The manufacture of many electronic devices requires the extraction of valuable natural resources, such as precious metals and rare earths, when these are not recycled properly, they are wasted. The recovery of these materials through recycling can help reduce the need for new extractions, thus conserving natural resources and reducing the environmental impact of mining (Huisman et al., 2015).

An example of inadequate recycling of these materials that affected human health has occurred in China in the city of Guiyu. Here, the extremely high levels of soil and water contamination have been studied, which has found lead in the blood of local children. , as well as a high incidence of respiratory and dermatological diseases (Leung, Cai, & Wong, 2006). Another problem is the improper burning of cables and electronic components, these release toxins into the air, and non-recyclable waste often ends up in illegal landfills, contaminating soil and water (Caravanos et al., 2011).

**Classification of Electronic Waste**

Electronic waste can be classified into different categories, each with its own management challenges in information and telecommunications equipment, consumer appliances, white goods, lighting equipment such as fluorescent lamps, Led bulbs, electrical and electronic tools, toys and equipment. electronic sports: Video game consoles, electronic toys, fitness equipment among others.

There are resources to mitigate electronic pollution by improving recycling infrastructure, this includes implementing appropriate facilities, promoting safe and efficient recycling practices, and creating waste

collection and separation systems. Policies must be established that encourage manufacturers to take responsibility for managing the waste of their products throughout their life cycle; but training is essential for producers and consumers (Kiddee, Naidu, & Wong, 2013).

The circular economy must be disseminated and approaches that can help reduce the generation of electronic waste must be adopted, products must be designed that are more durable, repairable and recyclable, and the reuse and reconditioning of electronic devices that can prolong their useful life must be encouraged and reduce the demand for new products (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017).

Training and public awareness are essential to address e-pollution in this context. Consumers must be guided about the environmental and health impacts of e-waste; In addition, promoting responsible consumption practices can help reduce the amount of garbage generated in this sense. Awareness campaigns can motivate people to recycle their electronic devices appropriately (Ongondo, Williams, & Cherrett, 2011).

The implementation of strict regulations and appropriate legislation is necessary to manage electronic waste effectively, which includes establishing standards for the safe handling of these types of garbage, imposing restrictions on the export of hazardous electronic waste to developing countries and promoting the extended producer responsibility to ensure that manufacturers are responsible for the proper disposal of their products (Widmer, Oswald-Krapf, Sinha-Khetriwal, Schnellmann, & Böni, 2005).

Exposure to heavy metals affects people involved in the informal recycling of electronic waste, especially in developing countries, they face significant risks to their health. Neurological damage can also be caused by exposure to lead and mercury, especially in children. , this can cause cognitive development, and in adults they can cause infertility and other reproductive problems, chronic respiratory diseases, such as asthma and bronchitis. (Londoño, Londoño and Muñoz, 2016).

**Solutions for mitigation**

Strategies must be drawn up to reduce pollution; when implemented jointly, they can contribute significantly to the mitigation of the effects caused by electronic waste, promoting more responsible and sustainable management of this waste.

There are different strategies to mitigate polluting waste from the electronics industry. Figure 2 shows some of them.

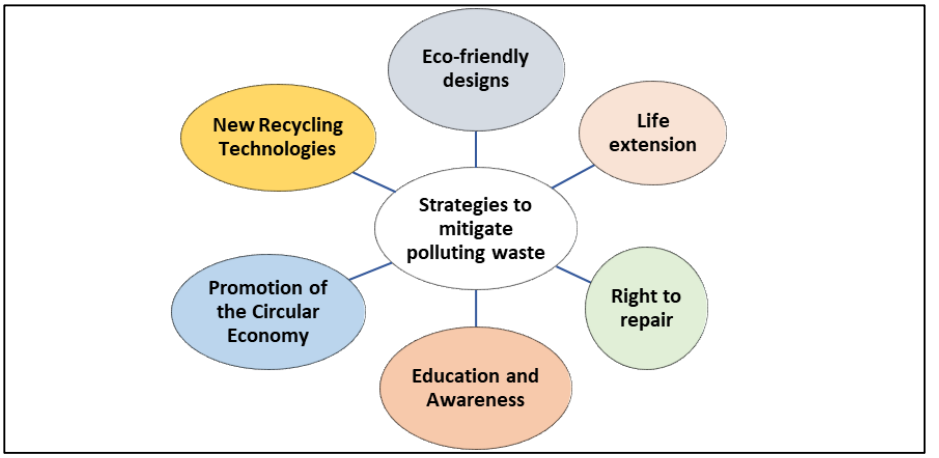



Figure 2. Some strategies to mitigate polluting waste

As can be seen, we must work on ecological designs that promote electronic products that are easier to recycle, repair and reuse. This includes the use of recyclable materials, the reduction of toxic substances, and the simplification of components to facilitate disassembly (Zambrano, Macías, & Medina, 2022). Some manufacturers are adopting "modular design," which allows specific device components to be replaced or upgraded without needing to scrap the entire product.

Work should also be done to extend the useful life of products, promoting practices that extend the useful life of electronic devices. This includes awareness campaigns about proper maintenance, accessible repair programs, and the reuse of equipment through second-hand markets (Arroyo, Villanueva, Gaytán, & García, 2014).

Another form of recycling is the right to repair. This form is gaining popularity, and manufacturers are being pressured to provide repair manuals and spare parts for consumers and independent workshops (Delva, 2022).

Responsible collection and recycling allow us to establish effective collection and recycling systems to manage electronic waste appropriately. This includes creating accessible collection points and investing in recycling infrastructure that meets environmental standards. Some countries have implemented extended producer responsibility (EPR) systems, where manufacturers are responsible for the collection and recycling of products at the end of their useful life (Ruiz, 2024).

Education and social awareness is one of the aspects that must be taken into account by Implementing educational programs that inform the public about the environmental and health risks associated with electronic waste, and the appropriate ways to dispose of it, for example campaigns such as how to recycle electronic objects that do not work, they teach consumers about the available collection points and the importance of not throwing electronic waste in the common trash (Gordillo & Sierralta, 2023).
New recycling technologies must be implemented by investing in research and development of advanced technologies to recycle materials that are difficult to extract from e-waste, such as precious metals and rare earths, these can be innovations such as hydrometallurgical recycling, which uses less chemical solutions. toxic to extract metals, are being explored to improve the efficiency and safety of recycling (Trelles & De-Valladolid, 2023).

Environmental regulations that govern the management of electronic waste must be strengthened and compliance guaranteed through inspections and sanctions. It is crucial that governments implement and enforce strict regulations on the production, collection, and recycling of electronic devices, for example,

the European Union has implemented the Directive on Waste Electrical and Electronic Equipment (WEEE) (Europea, 2012), which establishes specific requirements for garbage collection and recycling.

The promotion of the circular economy, where electronic products are designed, used, repaired and recycled in a way that minimizes the generation of waste and maximizes the reuse of materials, "take-back" or product return programs, where Consumers can return their old devices to manufacturers for recycling or reuse, they are a way to implement the circular economy in the electronics industry (Da Costa & Clayson, 2022).

The recycling of electronic materials is necessary due to the environmental impact that they cause, in addition to the loss of valuable resources that their improper disposal implies, these devices contain metals and other toxic materials that can contaminate the soil and water when they are not managed. correctly. Recycling these materials allows for the recovery of valuable components, reduces the need to extract new natural resources, and reduces the amount of hazardous waste in landfills. Additionally, recycling electronics helps reduce greenhouse gas emissions associated with the manufacturing of new products, thus contributing to a more sustainable approach to technological production and consumption.

Now with the changes in the energy matrix and the use of accumulation systems for energy storage (Sánchez, et al., 2024) in distributed generation, awareness must be taken of the recycling of materials that come from accumulation systems. Being able to recycle electronic waste reduces environmental pollution, achieving environmental protection, resource conservation, and the promotion of a more sustainable circular economy.

**Conclusions**

E-pollution is a significant environmental and health challenge that requires concerted action at a global level. By improving recycling infrastructure, promoting the circular economy, educating the public and establishing appropriate regulations, we can mitigate the negative impacts of e-waste and move towards a more sustainable future. It is the responsibility of everyone, from governments to consumers, to take action to reduce electronic pollution and protect the environment and health.

**References**

Barrón, A. R., & Ramírez, M. H. (2023). Universal learning design in physics teaching: an application proposal. *Scientific magazine, 47*(2), 71-86. https://doi.org/10.14483/23448350.20105

Da Costa, P., & Clayson, C. (2022). The Circular Economy as an axis of development of Latin American countries. *Economy and Politics Magazine* (35), 1-18. Obtained from http://scielo.senescyt.gob.ec/scielo.p

European, D. O. (2012). Obtained from DIRECTIVE 2012/19/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL.

Gordillo, W. R., & Sierralta, S. B. (2023). Environmental education and solid waste management at the José Faustino Sánchez Carrión Trujillo Educational Institution. *Mendive. Education Magazine, 21*(4). Obtained from http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1815-76962023000400017&lng=es&tlng=es.

Influencer, R. (2024). *8 methodologies that every teacher of the 21st century should know*. Obtained from https://www.realinfluencers.es/2018/09/09/8-metodologias-profesor-siglo-xxi-deberia-conocer/

Molina, E., Cedeño, N. J., Rodriguez, M., & Saltos, W. M. (2024). Community service: Artificial intelligence in employment and the reconfiguration. *Tennessee Community Service International of Empowerment, 1*(2), 9–15. doi: https://doi.org/10.53730/tcsie.v1n2.8

Mora, A. M. (2018). Conceptions about language and its relationship with higher cognitive processes, in I Cycle teachers. *Education Magazine, 42*(1). doi: https://dx.doi.org/10.15517/revedu.v42i1.19908

Mora, E., & Rodríguez, M. (2018). Conceptions about language and its relationship with higher cognitive processes, in I Cycle teachers. *Education magazine*.

Ruiz, H.,. (2024). Solid waste management and its relationship with public investment in municipalities of Peru. *Alfa Journal of Research in Agronomic and Veterinary Sciences, 8*(22), 220-231. https://doi.org/10.33996/revistaalpha.v8i22.260

Sailema, T. A., Lucero, M. F., Aguirre, M. B., & Escobar, M. C. (2023). Active methodologies for teaching-learning physics in high school. *Latin Science Multidisciplinary Scientific Magazine, 7*(1), 9446-9477. https://doi.org/10.37811/cl_rcm.v7i1.5069

Sánchez, J. J., Rodriguez, M., Cuenca, L. A., Saltos, W. M., Nuñez, J. R., & Vázquez, A. (2024). Energy storage system for increasing electrical-power stability. *International Journal of Power Electronics and Drive Systems (IJPEDS), 15*(4), 2517-2525. https://doi.org/10.11591/ijpeds.v15.i4.pp2517-2525

Trelles, V. M., & De-Valladolid, J. (2023). Solid waste management to develop investment projects. *Interdisciplinary Arbitrated Journal Koinonia, 8*(16), 204-219. https://doi.org/10.35381/r.k.v8i16.2544