Electronic waste, the national solid waste policy and the 2030 Agenda

Resíduos eletroeletrônicos, a política nacional dos resíduos sólidos e a agenda 2030

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Emanoelen Bitencourt and Bitencourt
Master Student in Environmental Sciences
Institution: Universidade do Estado do Pará (UEPA)
Address: Tv. Dr. Enéas Pinheiro, 2626, Marco, Belém – PA, CEP: 66095-015
E-mail: bitencourtemanoelen@gmail.com

Silvane Gonçalves and Gonçalves
Doctorate Student in Natural Resources Engineering of the Amazon
Institution: Universidade Federal do Pará (UFPA)
Address: R. Augusto Corrêa, 01, Guamá, Belém – PA, CEP: 66075-110
E-mail: silvane goncalves87@gmail.com

Marcos Vinicius Afonso Cabral
Master Student in Environmental Sciences
Institution: Universidade do Estado do Pará (UEPA)
Address: Tv. Dr. Enéas Pinheiro, 2626, Marco, Belém – PA, CEP: 66095-015
E-mail: marcos.vacabral@aluno.uepa.br

Antônio Pereira Júnior
Doctorate Student in Environmental Sciences
Institution: Universidade do Estado do Pará (UEPA)
Address: Tv. Dr. Enéas Pinheiro, 2626, Marco, Belém – PA, CEP: 66095-015
E-mail: antonio.junior@uepa.br

Gundisalvo Piratoba Morales
Doctor in Geochemistry from the Universidade Federal do Pará
Institution: Universidade do Estado do Pará (UEPA)
Address: Tv. Dr. Enéas Pinheiro, 2626, Marco, Belém – PA, CEP: 66095-015
E-mail: gundymorales@yahoo.com.br

ABSTRACT
Electrical and electronic equipment is obsolescent and is therefore discarded incorrectly, causing significant adverse effects on the environment. Faced with this issue, the objectives of this work were the identification of the environmental and
socioeconomic aspects related to electroelectronic waste, the way of managing this waste in Brazil, and whether or not it was in line with the goals set in the National Policy on Solid Waste (PNRS) and the Sustainable Development Goals (SDGs – Agenda 2030). The methodology used was the bibliographic review, since in the data previously used in articles, theses, dissertations, books and electronic links, evidence was sought about the disposal and the problems that electronic waste causes to the environment. The data obtained and analyzed indicated that there is a divergence between the PNRS and the targets set in the SDGs. Finally, the gap identified with regard to electroelectronic waste has shown that the efficient management of this waste requires the participation of all actors involved, from producers, consumers, recyclers, to the public authorities, scientific institutions and civil society.

Keywords: environment, recycling, agenda 2030, solid waste.

1 INTRODUCTION

The advancement of industrial technology, the shortening of the life cycle of portable and non-portable electrical and electronic equipment (EEE), has led to an increase in residual quantity that currently lacks a correct destination and final disposition and generates, on average, 44.7 million tons (Baldé et al., 2017; Oliveira; Miranda, 2019). One of the alternatives, in the developed countries, is to export this waste to those considered "poor" for recycling. However, this
measure is accompanied by increased vulnerability and health risk for communities that will act on the segregation of metals contained in this waste (Farias, 2019).

In the European context, two countries, Sweden and Germany, stand out for applying a more viable alternative: reverse logistics, from residual segregation as occurs in China and the United States (Lucas et al., 2021). In Latin America, among the countries that produce this type of waste, Brazil, four years ago, 2019, was the largest generator, with average value per capita equivalent to 10.2 kg of electronic waste (Forti et al., 2020), and it should be noted that this country is still considered developing.

In Brazil, electro-electronic devices are defined by the Brazilian Standard (NBR) of No. 16.156, item 3.12, as equipment whose functioning depends on electric and electromagnetic currents (Brazil, 2012). Already the Brazilian Association of Industrial Development (ABDI, 2013), identifies them from four categories, whose guideline involves the use: 1) Blue line (e.g. mixers); 2) White line (e.g. washing machines); 3) Brown line (e.g. printer).

Although electro-electronic devices are generally regarded as "durable consumer goods", the advancement of the technological field has created the "programmed obsolescence" of some of these devices (e.g. mobile phones), the inadequate disposal of which is causing the increase of waste globally, and consequent adverse effects on the environment (Peiter; Ferreira, 2021). Such a practice, in the context of consumer law, is already analyzed as an irreversible harm to him, because it becomes an abusive mechanism of consumption (Oliveira; Dutra, 2021).

It can be seen that the planned obsolescence generates numerous challenges to be overcome, among which is identified the inadequate disposal of waste electrical and electronic equipment (WEEE), which involves: 1) the effectiveness and efficiency of the recycling system as reverse logistics – LR (Cardoso et al., 2019); 2) the incentive for a more effective participation of cooperatives of waste recyclers (Araújo; Xavier, 2021). These challenges are aligned with Article 3, Section XII, of the National Policy on Solid Waste – PNRS (Brazil, 2010), regarding the implementation of the RL, which could become a
mitigating factor of adverse effects caused to the environment due to inappropriate disposal.

Another challenge evidenced to be overcome is in the extraction of inputs for the production of EEE, from electrically conductive minerals such as Lithium (Li), present in rechargeable batteries. In order to obtain this material, it is necessary to access pegmatitic rocks such as amblygonite, spodumenium (where Li is found), among others (Pinto; Braga, 2019). However, obtaining a mineral contributes to global warming, increasing waste generation, as well as increasing acidification and water eutrophication (the recovery process of this mineral consumes a large amount of fresh water) and soil upheaval, as it is extracted in underground plowing (Freitas; Marchesini, 2022).

Other metals (Lead – Pb; Cadmium – Cd; Mercury – Hg; Lithium – Li) occurring in the battery composition of portable electronics such as notebooks, tablets and mobile phones, are subject to national legislation. Among them, there is the Resolution of the National Council for the Environment – CONAMA, No. 424 (Brazil, 2010). In Brazil, the University of the State of São Paulo (UNESP) and the company Energy Source have a technology for recovering these metals. However, it is not yet in the public domain (Jorge, 2021).

As regards the opportunity offered by WEEE, they are not yet effectively used, although they are already included in the PNRS, in the form of a social and solidarity-based economy and are associated with the Sustainable Development Goals (SDGs). This association can use tools as appropriate training for recycling from correct disassembly, as well as the correct destination of what is actually identified as "electronic waste" (Álvarez et al., 2020). Therefore, LR is an opportunity for the generation of both work and decent income in communities where economic hyposufficiency is present (Pessoa et al., 2022).

Therefore, the social and environmental problems that REEs cause, are the justifications for carrying out this study and increase the relevance of this study as to the relationship between them, the PNRS and the SDGs. Therefore, the objective was to analyze the gaps between the situation of REEs in Brazil and their relationship with environmental and economic sustainability, in the light of
the National Solid Waste Policy and the Sustainable Development Goals of the 2030 Agenda.

2 METHODOLOGY

For the preparation of this study, a qualitative methodology was used in conjunction with the investigative methods of bibliographic and documentary research. The main objective was to present theoretical knowledge from secondary data such as scientific articles, books, official government documents/reports, relevant to the subject in question. The focus of the research was to explore concepts and data related to REEs, PNRS and SDGs, and to establish connections between these themes.

According to Pereira and Galvão (2014), the use of bibliographic research emerges as a crucial methodology for academic advancement, offering a solid basis and theoretical grounding for the research themes to be explored. Thus, this research has explanatory and descriptive qualities, since it aimed to explore real-life phenomena and collect information on the subject investigated, exploring the link between the life cycle of WEEE and its correlation with PNRS and SDGs.

The study started with extensive research for a comprehensive understanding of the concepts and national context that involves WEEE LR. This involved consulting various sources such as websites, government documents, books and scientific journal articles, consulted in the Scientific Electronic Library Online (SciELO) virtual libraries, the Periodicals Portal of the Coordination for the Training of Personnel with Higher Education (CAPES), Science direct and others. In order to present current and consistent data, the priority was to use publications from the last five years, although some are older, due to the relevance of the content.

In addition, the search covered terms in Portuguese and English, specifically "waste electrical and electronic equipment" in Portuguese and "electronic waste" in English. The search was conducted from August to December 2023. After a thorough review of the literature, objectives 2, 3, 6, 8, 10, 12 and 13 of the 17 SDGs were selected as they were closely aligned with the proposed discussion. These targets particularly addressed solid waste
management and quality of life. Subsequently, a bibliographic analysis was carried out to examine the national adherence to the SDGs in relation to the WEEE destination paradigms and how the country has been working to achieve the SDGs under the NSRP.

3 RESULTS AND DISCUSSION

3.1 REE’S – BRAZIL

The data obtained and analyzed indicated that one of the most frequent REEs in the national territory, comes from the sale and disposal of mobile phones and computers which, between 2017 and 2021, was equivalent to 250 million and 32 million, respectively (ABINEE, 2022), whose life cycle is exhausted between two and five years (ABDI, 2013). In this way, it can be observed that the presence of precious metals, including Au, Ag, Cu, Pt and Pd, as well as large quantities of Fe and Al, and various types of recyclable plastics, add significant commercial values to the materials recovered in the WEEE recycling processes.

As to the relation of the disposal of these devices or the application of LR, whose term is defined in the PNRS Law No. 12.305 (Brazil, 2010), Chapter II, Article 3, Section XII, it is not complied with! Therefore, it is not the legislative force that will fill the gap between the residual generation and obedience to this law. The determination as to collection, transportation and final destination are still unknown by manufacturers, importers, distributors, traders and consumers (Paixão; Oliveira, 2023).

From the lack of knowledge of LR, PNRS, it appears that the gap tends to suffer greater distancing as far as Goal 3 of the ODS-Agenda 2030 is concerned, because there will be no healthy life if the metals contained in cellular devices (e.g. Ni) are discarded inadequately into the environment and promote the release of toxic metals that jeopardize the health of the community where this occurred. For Santos and Stange (2020), one of the compromising ways for human health is in the production and release of methane gas (CH4), one of the effective components of the increase in the temperature in the greenhouse effect, which does not meet the 13th objective of the SDGs.
There is a prospect of reusing EEE components, through LR, such as plastics, ceramics, metallic and non-metallic minerals (Copper – Cu, Aluminum – Al, Iron – Fe), noble metals (Gold – Au; Silver – Ag) and rare earths (Gallium, Tantalum and Platinum) (Rautela et al., 2021; Roy et al., 2022). When this happens, Nascimento and Barreto (2019) state that there will be a new economic spindle in action: urban mining. It is tied to the circular economy, where the advent of the three errors is present: reuse, recovery and recycling.

According to the authors, the effectiveness of the recycling of these EEE inputs will meet the requirements contained in Goal 12 (sustainable development) and, consequently, there will be applicability of Goals 12.1, 12.2 and 12.4, i.e. global and local actions, efficient use of natural resources and appropriate handling of chemical waste, respectively. Currently, these gaps between these targets are still extensive. These facts also widen the gap in poverty eradication (Goal 1 – SDG – Agenda 2030), from segregation of residual EEE components.

4 INFLUENCES ON THE ENVIRONMENT

4.1 NEGATIVE IMPACTS

Analysis of the data obtained indicated that REEs are currently recycled in two ways, and one of them tends to cause these types of impacts, especially on the health and quality of life of recyclers and waste pickers. In this context, Huang et al. (2018), in the study conducted in Qingyuan City (Guangdong Province, South China), used primitive and low-tech techniques in family workshops, resulting in the extensive and severe release of persistent organic pollutants (POPs) and halogenated flame retardants (HFRs).

For this type of influence, the analysis of the data obtained indicated that some types of flame retardants present in electro-electronics and other types of devices were added to the list of Persistent Organic Pollutants – POPs (UNEP, 2019), which have characteristics such as persistence, bioaccumulation and toxicity. Because of this, Poma et al. (2019) state that certain types of brominated flame retardants have been replaced by others with the same function: organophosphates.
However, the data obtained also indicated that the quantities of potentially toxic chemical components present in EEE are high because they are above the permitted level of resolution 401 (Brazil, 2008). This was confirmed in the account by Wagner et al. (2022). They stated that only in the year 2019 it was estimated that the electroelectronic waste discarded by 13 Latin American countries contained at least: 2.2 t of Hg, 0.6 t Cd, 4.4 t of Pb and 4 t of brominated flame retardants. After the inappropriate disposal of WEEE, it is spread in the environment and contributes to the propagation and potentialization of soil, flora, fauna and water sources contamination.

According to Garcia and Azevedo (2019), Hg, due to its molecular weight being 13 times higher than that of water, is deposited in the sediment. Cd also bioaccumulates in aquatic plants, invertebrates, fish, and mammals, and can cause mortality and food poisoning in humans when exposed to high concentrations of this metal. Ávila-Campos (2020) considers this metal to be an environmental micro-contaminant, which is present in NiCd-type batteries, and contributes to environmental pollution and loss of water potability, besides having a biological average life, in the environment, between 10 and 30 years.

When this occurs, gaps in the objectives of Nos 2 (zero hunger and sustainable agriculture), 3 (health and wellbeing) and 6 (drinking water) are expanded, as the damage to the quality of life of aquatic communities and fish consumers is evident. Such statements are similar to the one described by Franzoni, Souza e Silva (2020), regarding the components for "sustainability": the social, the environmental and the economic. So two of them are already affected by the inadequate disposal of WEEE in Brazil.

Another two negative impacts on the national territory are associated with: 1) informal and low technology recycling; 2) partnerships between the productive sector and the cooperatives of residual recyclers. On recycling, Giese, Lins and Xavier (2021), explain that it is currently called "Urban Mining", whose reception sites are known as "urban mines", and that the recycling carried out in this type of mining is still incipient, because the recovery techniques applied are not adequate.
With regard to partnerships, the data contained in the Recycling Yearbook published by Pragma (2021) were analyzed to better identify partnerships. These data indicated that the numbers of existing partnerships between cooperatives and EEA retailers are still rare. In addition, the remuneration for the collection of WEEE becomes a ‘donation’ of the material to be recycled. In this case, the economic bias is not in line with Goal 8 (Decent work and economic growth) and Goal 10 (Reduction of inequalities) of the 2030 Agenda. While the application of the provisions of the PNRS, Article 33 has been made.

Still in the socioeconomic context and the SDGs – Agenda 2030, about the gap caused by inadequate remuneration to waste pickers of WEEE, in Brazil, a portion of them, which according to Pragma (2023) currently amount to 86,878 workers, fix residences in the very places where the urban mines were established. But, according to Bouvier and Dias (2022), there are those who do not live in these areas, but in urban roads like streets and avenues, and the "average salary/month", in Pará, corresponds to R$ 850.00.

In the case of pregnant women and women living in urban mines, the negative impact can be even more serious, in view of the exposure and counted directly on the Pb. In two studies conducted on women in this state, by the World Health Organization (WHO, 2021) and Ankit et al. (2021), they concluded that fetuses and newborns of these pregnant women may present Attention Deficit Hyperactivity Disorder (ADHD), behavioral and child temperament changes, problems with sensory integration, and low cognitive and linguistic scores.

4.2 POSITIVE IMPACTS

During the data collection, it was identified that one of the positive impacts as an alternative to avoid and minimize environmental pollution is the recycling of WEEE. In Brazil, this waste is the object of reverse logistics – LR, as established by art. 33, of the National Policy of Solid Waste:

Art. 33. Manufacturers, importers, distributors and traders of:
From an evolutionary point of view, especially for the state of Rio de Janeiro, half the number of cooperatives that handle the components of WEEE act exclusively with this type of residual material. In this context, Araujo, Ottoni and Xavier (2020) conducted research on such cooperatives in Rio de Janeiro – RJ, and concluded that due to the monthly volume having relative frequency, this results in a fixed gain to the cooperatives. In addition, Freire and Xavier (2021) state that, urban mining is one of the most effective methods to prevent and mitigate adverse environmental effects, such as greenhouse gas (GHG) emissions.

Another positive impact was the growth of both the number of waste collectors and the cooperatives with which they are associated. Data contained in the annual reports of Pragma (2017-2018), state that this activity, through Decree n. 7.405 (Brazil, 2010), is active in the five Brazilian regions, with higher labor concentration in the southeast region (53%), and in 2022 (Pragma, 2022), these cooperatives reached 1.996 units in 1.032 of the 5.570 Brazilian municipalities.

The data for the residual quantity of EEE produced at the national level are disclosed by the Brazilian Association of Public Cleaning and Special Residues Companies (ABRELPE), which publishes annually the Panorama of Solid Residues in Brazil. According to the studies, Green Electron collected and correctly disposed of 342.9, 88.7 and 715.8 tons of electronic waste for the years 2019, 2020 and 2021 (Table 1).

Table 1 – Data about the management of electronic waste in Brazil between 2020 and 2021.

<table>
<thead>
<tr>
<th>Waste</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous and non-ferrous metals</td>
<td>100</td>
<td>34</td>
<td>327</td>
</tr>
<tr>
<td>Plastic</td>
<td>47.5*</td>
<td>22.3*</td>
<td>121</td>
</tr>
</tbody>
</table>

**NUMBER OF UNITS**

<table>
<thead>
<tr>
<th>Voluntary Delivery Points (ENPs)</th>
<th>104</th>
<th>731</th>
<th>811</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of municipalities; states concerned</td>
<td>188; 12 and the Federal District</td>
<td>225; 14 and the Federal District</td>
<td></td>
</tr>
</tbody>
</table>

*2019, there was 69 t less CO₂ released; 2020, the decrease reached 195 t.

Source: ABRELPE/GREEN ELECTRON.
Table 1 shows that the efficiency of WEEE management in terms of consumer cooperation from ENPs has been positive in terms of municipal quantity since 2019. About this evolution, ABRELPE (2022), reported that the number of ENPs, increased, from 811, in 2021, to 3,417 (+40%), in 1,224 municipalities (22.9%) of the 5,570 component municipalities of the national territory, besides the Federal District. The quantity of WEEE collected and destined in an environmentally sound manner for recycling in 2021 was equivalent to 1,245 tons.

Besides the recovery of WEEE, the data obtained indicated that there was a recovery of the packaging of the appliances (paper and cardboard) of 22,336.65 t and 8,194.43 t post-consumption. According to Parreira, Oliveira and Lima (2009), despite the efforts to expand the recycling of this waste, it is important to highlight that the PEVs installed in the country generally collect mobile phones, batteries and other small equipment. In the municipality of Belém-PA alone there are 42 collection points for batteries, under the responsibility of the GM&C recycler (2023).

5 FINAL CONSIDERATIONS

The present study addressed the issue of electronic waste in Brazil, emphasizing the challenges and opportunities presented to the country in the search for sustainable development.

A bibliographic review on the environmental and socioeconomic aspects related to electroelectronic waste was carried out, as well as an analysis on the management of such waste in Brazil, considering the National Policy on Solid Waste and the Sustainable Development Goals of the 2030 Agenda.

The study concluded that the efficient management of electronic waste requires the participation of all actors involved, from producers, consumers, recyclers, to the public authorities, scientific institutions and civil society. Furthermore, the importance of recycling was highlighted as a way to reduce environmental impacts and generate economic value from electronic waste.

Finally, it was pointed out that Brazil has the potential to become an example of sustainability in the management of electronic waste, provided that it commits itself to the implementation of the current legislation and to the fulfillment of the goals of the 2030 Agenda.
REFERENCES


