THE DISPOSAL OF ELECTRONIC WASTE AND ITS ENVIRONMENTAL IMPACTS - AN EXTENSION ACTIVITY OF THE PET-CHEMISTRY OF UFCG

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ABSTRACT

The disposal of electronic waste and its environmental impacts, addressing the importance of awareness and education on the subject, was the subject of a lecture given by academics from the Federal University of Campina Grande to high school students, with the aim of sensitizing them about the damage caused by the improper disposal of electronics and encouraging recycling practices. The study highlights the risks associated with e-waste, which contains toxic substances such as mercury and lead, which are hazardous to the environment and public health. The methodology included an expository lecture, questionnaires applied before and after the event to assess the students' knowledge, and discussions on the importance of proper environmental management. The results suggest that despite an initial awareness among students, there is still a significant need for ongoing education and improvements in e-waste collection infrastructure. The conclusion emphasizes the importance of educational campaigns and greater community engagement to promote sustainable disposal practices.

Keywords: High School, Contextualization, Environmental Education.

INTRODUCTION

The means of communication began to expand with scientific advancement, gaining prominence and being driven by trade in goods and services. From the twentieth century, with the advance of globalization, countries such as Brazil began to import electronic products. The internet, which originated in the U.S. in 1969 with the development of the Cold War Arpanet, has constantly evolved, allowing for the immediate distribution of a vast array of products and services globally. The current capitalist economic model favors rapid technological innovations, influencing social behaviors and excessive consumption habits, which often results in waste of natural resources. Given that many economic, social, and especially environmental challenges arise from this dynamic, the issue of sustainability has

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become a priority, attracting the attention of companies, governments, and academic institutions (Lunardi et al., 2014; Salles et al., 2016).

Each Brazilian disposes of approximately 0.5 kilograms of electronic waste per year. Some of this waste is repurposed, with some people selling scrap metal, especially copper, for extra income (Celinski et al., 2011). Electronic waste (WEEE) is classified as a special solid waste that requires mandatory collection, representing a serious problem for the environment and health. This waste, from its manufacture to disposal, contains materials with highly toxic heavy metals, called "silent villains", such as mercury, cadmium, beryllium and lead, as illustrated in chart 1. WEEE production can affect both workers in factories and communities near electronics industries. In addition, this waste is often disposed of in landfills, contributing to environmental pollution by seeping into the soil and groundwater. Garbage collectors, who survive from the sale of materials collected in landfills, are also exposed to risks of contamination (Siqueira; Moraes, 2009; Silva, 2010). Due to the large amount of this waste, it is essential to implement effective environmental management to reduce its environmental and social impacts, promoting cooperation between consumers and manufacturers (Bachi, 2013).

There are three main approaches to e-waste management. The first is the reuse of equipment that is still functional, which can be used in community digital inclusion projects. The second approach involves disposing of obsolete components, which can be recycled and repurposed. The third approach focuses on raising awareness among the population through educational campaigns and collection points, emphasizing the importance of recycling for the sustainability of the consumption cycle.

The proper and controlled disposal of electronic waste is essential due to the presence of substances that are harmful to health and the environment. In this context, extension plays a crucial role in managing the improper disposal of electronic waste, connecting technical knowledge with the community and promoting awareness about the correct management of this waste. Similar to the extension focused on the safe management of chemical products, this approach can involve the population through lectures, workshops and educational campaigns that address the causes, effects and strategies for the proper disposal of electronic waste. These educational activities are essential to sensitize the community about the importance of correct disposal practices, such as recycling electronic equipment, reducing waste generation, and supporting public policies aimed at more efficient waste management. In addition to disseminating information, the extension actions enable the community to adopt practices that minimize the production of electronic waste and to actively participate in collection and recycling

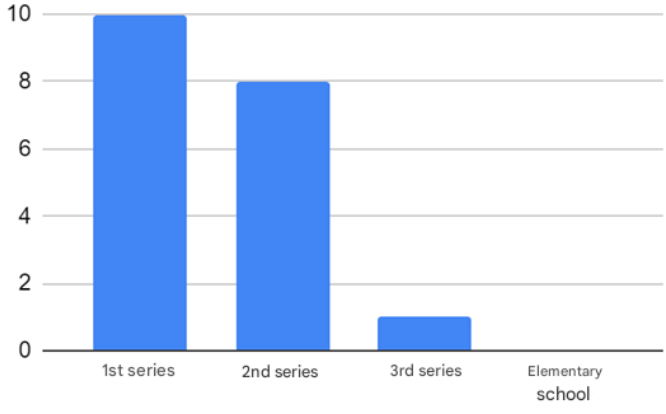
initiatives. In this way, the extension contributes significantly to improving the quality of life and general well-being of the population, promoting a cleaner and more sustainable environment.

In this scenario, the extension activity was aimed at students from the 1st to the 3rd grade of high school at the José Rolderick de Oliveira Integral Citizen School, located in Nova Floresta - PB. The objective was to make students aware of the impacts of improper disposal of electronic waste and enable them to adopt sustainable practices in their daily lives. Through educational activities, such as lectures and workshops, the initiative aimed to engage students and motivate them to become agents of change in the correct management of electronic waste, promoting a positive transformation in the school community and beyond. This study aims to evaluate the effectiveness of these educational activities in raising students' awareness and promoting appropriate disposal practices. Through the application of questionnaires and the analysis of the data collected, we sought to measure the impact of lectures and workshops on students' understanding of electronic waste and its consequences. The expected results may provide valuable information to improve educational practices and guide strategies and measures aimed at the responsible management of electronic waste.

METHODOLOGY

The extension activity consisted of a lecture developed by academics who are part of the Tutorial Education Program (PET-Chemistry) of the Federal University of Campina Grande (UFCG), Cuité campus. The lecture dealt with the theme "disposal of electronic waste in the environment" for students from the 1st to the 3rd grade of high school at the José Rolderick de Oliveira Integral Citizen School, in the city of Nova Floresta - PB (Figure 1). The event was attended by students from the integral school, with varying ages.

Figure 1. Distribution of research participants by series.



Source: Survey data, 2024.

Most of the students who participated in the survey are in the 1st grade, followed by the 2nd grade, with a smaller number in the 3rd grade. The concentration of responses in grades 1 and 2 may also suggest that students in these grades are more engaged or available to participate in surveys of this type.

The disclosure was made through social networks, such as Instagram, WhatsApp, facebook and tiktok. To increase the reach of the event, a specific publication (Figure 2) was shared on Pet-Química's profile, using digital platforms to expand online interaction and reach a larger audience.

The main objective of the lecture was to promote students' awareness of the incorrect disposal of electronic waste and the associated environmental damage, aiming to promote greater environmental responsibility on the part of students. The lecture was conducted under a dialogued expository approach through the use of slides and the direct participation of the target audience in the debate. During the lecture, the types of waste, their definition and classification, those responsible for managing this waste and the environmental impacts caused by incorrect disposal were presented.

Figure 2. Card referring to the post on social networks.

Source: The Authors, 2024.

At the end of the lecture, a questionnaire with 20 closed questions was made available to ascertain the knowledge and practices of students about the disposal of electronic waste, and we distributed a folder and also a souvenir as a form of thanks.

RESULTS AND DISCUSSION

Holding lectures focused on environmental issues in schools plays an essential role in making students aware of their individual responsibility and promoting practices that

cause less environmental impact. These lectures also aim to strengthen individuals' sense of belonging to their territory and community, while also highlighting the direct connection between human beings and the environment in which they live. When discussing environmental issues, people often associate them with events far from their daily lives, such as the extinction of species, deforestation, the melting of the polar ice caps, desertification, and other similar problems. This view may be related to a limited perception of what constitutes the environment and the way in which the media have addressed these issues in recent decades. Often, the media tends to focus on isolated events, disconnecting them from the complexity and underlying causes of environmental problems (Pereira; Curi, 2012).

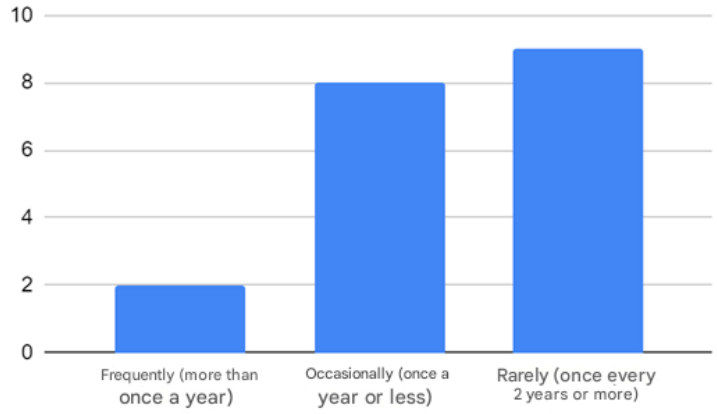
In this context, it becomes crucial to promote a fundamental change in the way people perceive and respond to environmental challenges. As highlighted by Sorrentino (2002), it is essential to awaken in each individual a sense of "belonging", participation and responsibility in the search for solutions at local and global levels, according to the concept of sustainable development. This process aims to transform each person from a passive observer of environmental reality into an active agent, effectively contributing to the preservation of the environment.

Two questionnaires were used, developed to be applied at the beginning and at the end of the lecture. The purpose of these questionnaires was to evaluate the students' previous perceptions regarding the management of electronic waste and to collect important information about their practices of separation of this type of waste, aiming to promote adequate management. Finally, the second questionnaire had the purpose of verifying the students' level of understanding after the detailed presentation of the content covered during the lecture.

When asked about their knowledge regarding electronic waste, the distribution of the answers reveals that all answered "yes", which suggests that all the participants of the research have knowledge about the subject. This result points to a complete awareness among the participants on the topic of electronic waste, which can be seen as a positive indicator in terms of environmental education and level of information on sustainability issues. However, it is important to consider the limitations of the research, such as the limited number of participants, which may not be representative of a larger population. In addition, additional information about the context is missing, such as the profile of the participants or the region where the research was conducted. While the results may suggest that e-waste awareness efforts are proving effective among participants, larger studies would be needed to confirm this trend in a larger population.

The graph presented in Figure 3 addresses the frequency with which survey participants discard electronic devices, such as cell phones, computers, and batteries. The analysis of the responses is divided into three categories: those who discard frequently (more than once a year), representing a smaller number of participants (approximately 2); those who discard occasionally (once a year or less), with about 8 participants; and those who discard rarely (once every 2 years or so), being the largest group, with about 10 people.

Figure 3. Frequency of disposal of electronic devices.

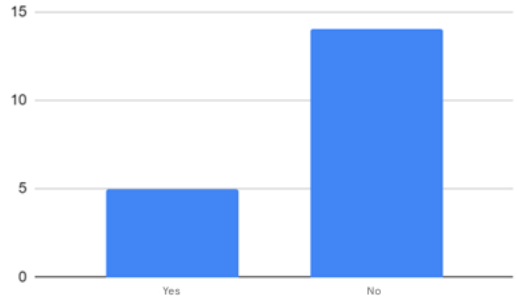


Source: Survey data, 2024.

The graph above suggests that most participants (the sum of those who dispose occasionally and rarely) do not dispose of electronic devices very often. This may indicate that participants prefer to keep their devices for longer periods of time before disposing of them, possibly due to the high cost of electronics, environmental concerns, or lack of knowledge about proper disposal locations.

When asked about the participants' habit of separating electronic waste from common waste, the answers reveal that a little more than half of the participants (55%) stated that they usually perform this separation, while a smaller number do not. This result suggests that, although there is significant awareness about the importance of separating electronic waste, there is still a considerable portion of individuals who do not adopt this practice. Separating electronic waste is crucial, as these materials contain toxic substances that can cause harm to the environment if disposed of improperly. Therefore, this practice should be more widely disseminated and encouraged. Regarding the knowledge about collection points for these types of waste in the city, Figure 4 illustrates the results.

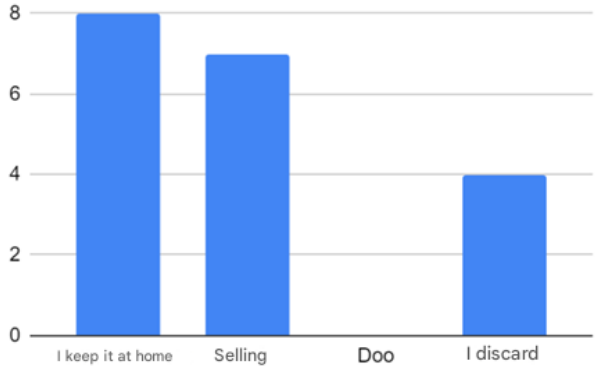
Figure 4. Knowledge of the specific collection points for the disposal of electronic waste in the city.



Source: Survey data, 2024.

The chart illustrated in Figure 5 explores the actions people take toward electronic devices that still work but no longer use, with options such as "I keep it at home," "I sell," "I donate," and "I discard." The most common option is "I keep it at home", chosen by 8 people, which may indicate a resistance to disposal or the intention to use these items in the future. About 6 people choose to sell their electronics, suggesting an appreciation of these items and a preference for recovering part of the investment made. Donation is the least frequent, with almost no one choosing this alternative, which may reflect a lack of knowledge about where to donate or a lack of confidence in the proper use of donated items. Three people discard their electronics, indicating that while this is a less common practice, there is a growing awareness of the environmental impact of improper disposal or difficulties in disposing of them correctly. Figure 6 illustrates where the materials are discarded.

Figure 5. Destination of electronic devices that still work, but no longer use.



Source: Survey data, 2024.

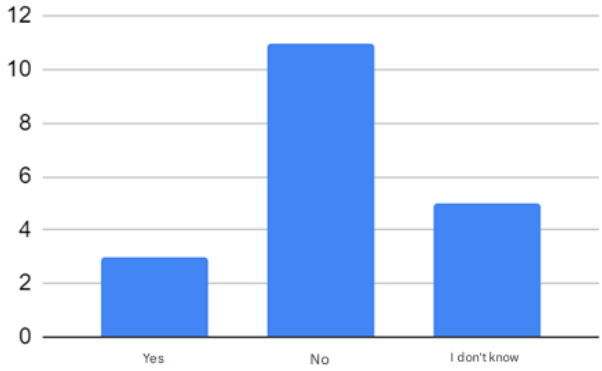
Figure 6. How do you usually dispose of your e-waste?

Source: Survey data, 2024.

The graphs above reflect a trend of accumulating or trying to monetize disused electronics, with fewer people opting for donation or disposal, suggesting that awareness campaigns could focus on promoting donation and proper disposal, educating the population about the benefits and importance of these practices.

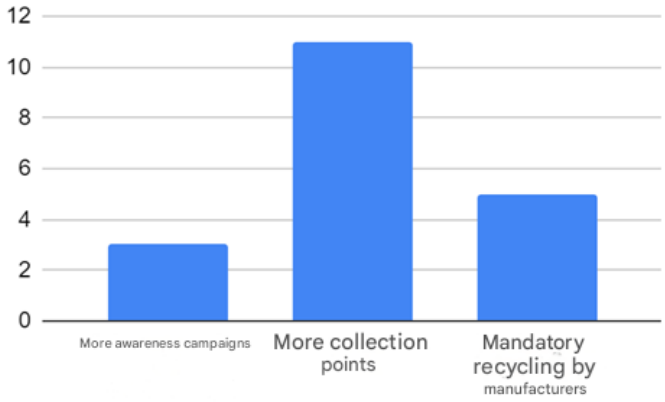
The graph shown in Figure 7 shows the answers to the question, "Do you believe that improper disposal of electronic waste can cause harm to the environment?" The results indicate that most participants do not believe that improper disposal of electronic waste causes harm to the environment, as observed by the higher number of responses in the "No" option. Next, there is a considerable group of people who answered "I don't know", demonstrating uncertainty or lack of knowledge on the subject. Finally, the lowest number of answers was for the "Yes" option, indicating that few people are aware of the possible environmental damage caused by the improper disposal of electronic waste. These data suggest the need for greater awareness and education about the environmental impacts related to electronic waste. The graph presented in Figure 8 addresses the participants' opinions on what would be the most important measure to improve the disposal of electronic waste. According to the data, most people believe that the creation of "More collection points" is the most relevant action, being this the option with the highest number of votes. This indicates that the participants consider accessibility to suitable places for disposal as a crucial factor for the improvement of this process. Secondly, "Mandatory recycling by manufacturers" appears as a significant option, suggesting that a portion of respondents see manufacturer accountability as an important measure to ensure proper disposal. Finally, "More awareness campaigns" received the fewest votes, which may indicate that while awareness is important, participants believe that practical actions, such as creating collection points, have a more immediate and effective impact on solving the problem.

Figure 7. Do you believe that improper disposal of electronic waste can cause damage to the environment?



Source: Survey data, 2024.

Figure 8. In your opinion, what is most important to improve the disposal of electronic waste?

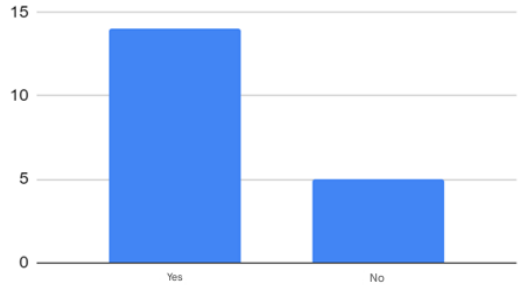


Source: Survey data, 2024.

These results highlight the need for more accessible infrastructures for e-waste disposal and suggest that consumers are willing to collaborate, provided they have the proper means to do so.

The graph in Figure 9 presents the results of the question "Have you ever reused or donated an electronic device that you no longer use?". Most participants answered "Yes," indicating that the practice of reusing or donating electronics is common among respondents. This data suggests a growing awareness of the importance of extending the useful life of electronic devices, either through their continued use by other people or through other forms of reuse. On the other hand, a smaller portion of respondents answered "No", which may indicate that there are still barriers or lack of motivation to adopt this practice. The reasons can range from ignorance about how or where to donate, to simple lack of habit.

Figure 9. Have you ever reused or donated an electronic device that you no longer use?

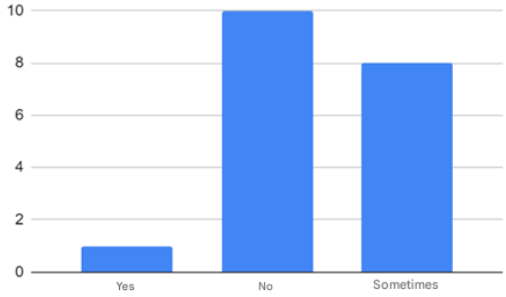


Source: Survey data, 2024.

Overall, the chart points to a positive trend towards the reuse and donation of electronics, but it also highlights the need to further encourage these practices, perhaps through information campaigns or the creation of facilities that allow individuals to participate more actively in these processes.

The graph in Figure 10 shows the habits of disposing of electronic waste in homes, with the following categories: A relatively low number of people say that there is a habit of correctly separating and disposing of electronic waste ("Yes"), while the majority admit that there is no such habit ("No"). An intermediate number sometimes practices correct disposal ("Sometimes"). The fact that most people are not in the habit of correctly disposing of electronic waste is concerning, as improper disposal can cause significant environmental damage.

Figure 10. Habit of separating and correctly disposing of electronic waste.



Source: Survey data, 2024.

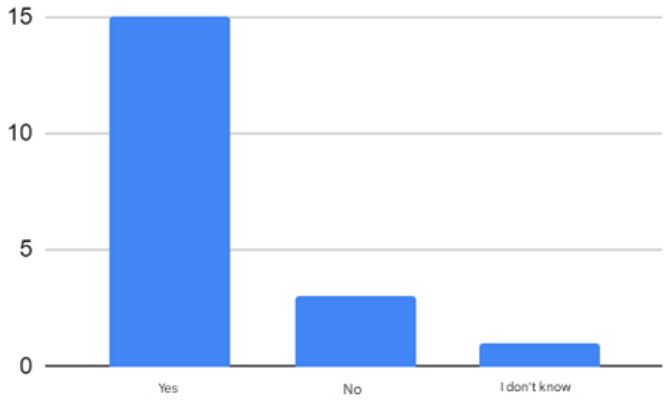
These data indicate an urgent need for educational campaigns that encourage correct electronics disposal practices. The group that "sometimes" practices correct disposal suggests that there is potential to improve these habits with proper education. While there is a recognition of the importance of proper disposal, practical implementation is still limited, necessitating additional efforts to raise awareness and sustainable practices.

When asked the question "in your opinion, does the improper disposal of electronics affect public health?", all said no. This unanimity indicates a possible lack of awareness, as electronic waste, when disposed of improperly, can release toxic substances, such as heavy metals, which contaminate soil and water, directly affecting public health. The result suggests an urgent need for education and awareness campaigns to inform the population about the dangers that electronic components pose to human and environmental health when they are not disposed of correctly. The lack of perception of public health impacts can perpetuate inappropriate practices, aggravating environmental and health problems over time. Therefore, in addition to raising awareness, it is necessary to implement disposal and recycling policies that are effective and easily accessible. This analysis highlights the importance of increasing public perception of the environmental and health risks associated with electronic waste, seeking a change in attitude towards the disposal of these materials.

A question that addresses people's knowledge of the presence of hazardous chemical components such as lead, mercury, and cadmium in electronic devices was asked. According to the survey data, all respondents answered "no", indicating that they did not know this information. These results suggest a lack of awareness about the risks associated with toxic components in electronic devices, which can have significant implications for both human health and the environment. Lack of knowledge about these hazardous materials can lead to improper disposal and exposure to harmful substances, highlighting the need for education and awareness campaigns on the correct and safe handling of electronic waste.

The graph in Figure 11 investigates participants' knowledge of the environmental impact of improper disposal of e-waste, specifically whether they knew that such waste can release toxic chemicals into soil and water. The 2024 survey data reveals that the majority of respondents answered "Yes", demonstrating that they are aware that improper disposal of electronic waste can release hazardous substances into the environment. A smaller portion answered "No", indicating ignorance about this issue, while only 1 person answered "I don't know", showing uncertainty about the environmental impact of this waste.

Figure 11. Did you know that e-waste can release toxic chemicals into soil and water if disposed of improperly?

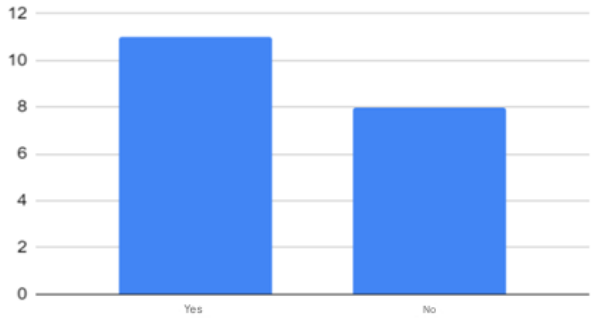


Source: Survey data, 2024.

These results suggest that, unlike the previous graph on knowledge of chemical components in electronic devices, there is a higher level of awareness of the environmental risks of improper disposal. However, the existence of negative responses and uncertainty points to the need for more education and public awareness about environmental impacts and the importance of correct disposal of electronic waste to avoid soil and water contamination with toxic substances.

The graph in Figure 11 presents the answer to the question: "Have you ever heard that improper disposal of batteries can release substances such as sulfuric acid and nickel?". It turns out that most respondents have heard about the dangers of improper battery disposal, while a smaller number are not aware of these risks. This situation indicates a partial awareness: although most participants have some knowledge about the risks associated with improper disposal of batteries, which is a positive sign, there is still a significant group that is unaware of these dangers. This suggests that information on environmental and health risks is not being disseminated in a sufficiently comprehensive manner. Batteries contain hazardous substances, such as sulfuric acid and nickel, which, if released into the environment, can contaminate soil and water, as well as cause harm to human health. The fact that some respondents are not aware of these risks reflects the need to intensify environmental education.

Figure 11. Have you ever heard that improper disposal of batteries can release substances such as sulfuric acid and nickel?

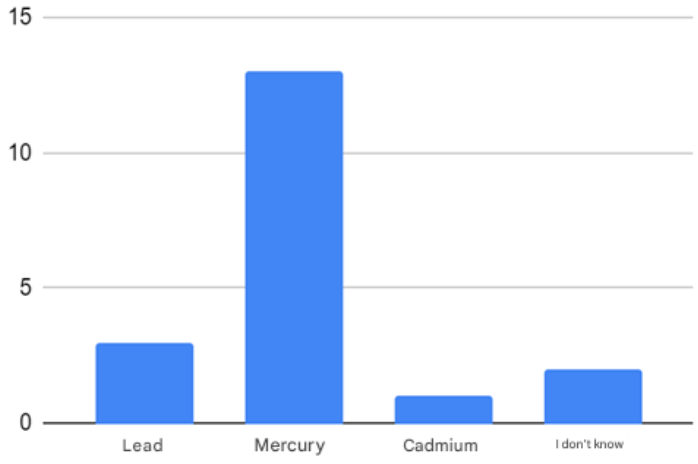


Source: Survey data, 2024.

This data reinforces the importance of educational campaigns that not only inform about the specific risks of batteries, but also promote safe disposal practices. These campaigns should reach all segments of the population, ensuring that everyone has access to this vital information. In summary, the analysis of this chart suggests that while there is a level of awareness about the dangers of improper battery disposal, there is still much work to be done to ensure that information reaches everyone and that the practice of correct disposal is widely adopted.

The graph presented in Figure 12 shows the opinion of respondents on which is the most hazardous component of electronic waste. The options are "Lead," "Mercury," "Cadmium," and "I don't know."

Figure 12. Conception about the most hazardous component of electronic waste.

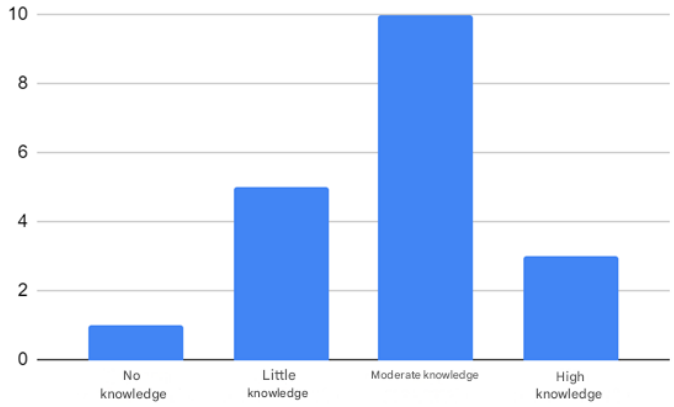


Source: Survey data, 2024.

A significant majority of respondents consider mercury to be the most dangerous component. Then the lead and the "I don't know" option have a similar number of responses. Finally, cadmium is considered the least dangerous or least recognized. This graph highlights the perception of the dangers associated with mercury, possibly due to its

widespread recognition as a highly toxic substance. On the other hand, the low number of responses to cadmium and the considerable number of people who do not know how to point out the most dangerous component indicate a possible lack of knowledge or awareness about the risks associated with other materials present in electronic waste, as can also be seen in Figure 13.

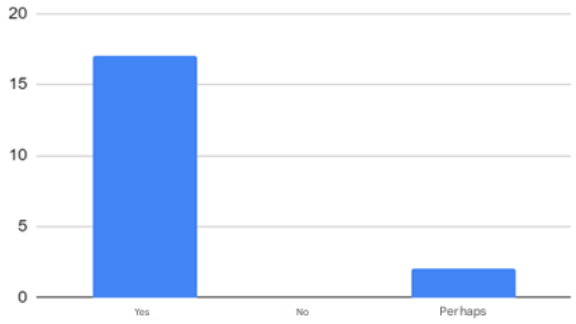
Figure 13. What is your level of knowledge about the impact of electronic waste on the environment?



Source: Survey data, 2024.

These results reflect a heightened perception of the risks associated with mercury, possibly due to its notoriety for being highly toxic. On the other hand, the fact that a significant portion of respondents do not know which metal is the most dangerous may point to a gap in public awareness of the dangers of other toxic components found in electronic waste. One of the solutions would be the insertion of themes like these in Chemistry classes. The graph in Figure 14 illustrates the participants' opinions on the importance of the presence of chemistry in discussions about solutions for the disposal of electronic waste. The possible answers were "Yes," "No," and "Maybe." Most respondents believe that chemistry should be more present in these discussions, which reflects a recognition of the relevance of the field of chemistry in solving complex environmental problems, such as the management of electronic waste. This result highlights the awareness of the need to apply scientific, specifically chemical, knowledge to address the challenges associated with electronic waste and minimize its negative impacts on the environment and human health.

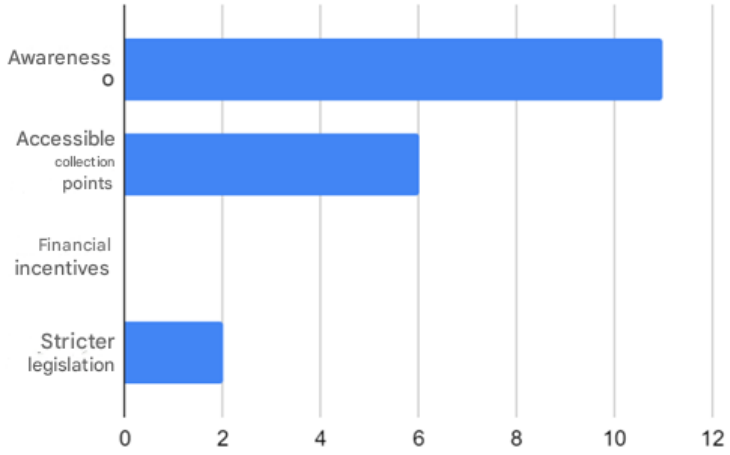
Figure 14. In your opinion, should chemistry be more present in discussions about solutions for the disposal of electronic waste?



Source: Survey data, 2024.

The graph illustrated in Figure 15 presents the answers to the question "What do you think is missing for the disposal of electronic waste to be done more correctly?". The most voted option, with a significant margin, was "Awareness", indicating that the majority of respondents believe that education and sensitization of the population about the importance and correct methods of disposing of electronic waste are crucial to improve this practice.

Figure 15. What do you think is missing for the disposal of electronic waste to be done more correctly?



Source: Survey data, 2024.

Secondly, there is the need for "Accessible Collection Points", which suggests that many consider the ease of access to places where they can dispose of their electronics appropriately as an essential factor. The third position is occupied by "Financial incentives", which indicates that some people see the need for economic benefits, such as discounts or rewards, to encourage correct disposal. Finally, "Stricter legislation" was the least selected option, suggesting that most participants believe that, while important, simply implementing stricter laws is not as crucial as awareness and accessibility of collection points.

CONCLUSION

The management of incorrect disposal of electronic waste in Brazil and other countries is currently facing significant challenges. Therefore, it is essential to direct more resources to the dissemination of information and technological development. Making knowledge about the recyclability of materials more accessible, along with education on proper packaging disposal practices, is an essential measure. Additionally, it is crucial to invest in research and development to create technologies that make materials more recyclable, while also being environmentally safe and inert, while preserving the environment.

It is concluded that the lecture on the proper way of electronic waste was an event of great importance, providing clarity on the awareness and relevance of this crucial topic for society and the environment. First, it was clear that a significant part of the participants already had some level of awareness about electronic waste management before the lecture. This suggests that concern with the environmental issue is widespread, but also indicates the need to improve the public's knowledge and understanding of this topic. It is therefore necessary to provide additional clarification on the disposal of hazardous waste, such as safe handling and the identification of suitable places for its disposal.

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