Environmental Impacts of Inadequate Disposal of Heavy Metals in Soil, Water, and Air

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The improper disposal of electronic waste poses significant risks to human health through soil contamination and subsequent water pollution. This text aims to shed light on the detrimental effects of such actions. The primary objective is to identify the impacts of irresponsible disposal of electronic waste and batteries on soil and, by extension, water sources. Specific objectives include exploring how heavy metals from these waste products can be correctly disposed of to prevent harm to animals and humans. Additionally, the text seeks to underscore the necessity of discussing existing public policies for proper waste disposal. A comprehensive literature review was conducted to gather insights from experts in the field. Researchers have proposed various approaches to address this issue, emphasizing the urgency of adopting sustainable practices for electronic waste disposal. In conclusion, there is an urgent need to reconsider current practices and implement sustainable methods for discarding electronic devices. By doing so, we can mitigate water, soil, and air contamination, thereby reducing the risk of disease transmission to humans.
Keywords: Heavy Metals. Environmental Impacts. Batteries.

Introduction

Dealing with waste has long been a challenge, particularly in societies entrenched in a disposable culture, which has only been exacerbated by the Industrial Revolution. The pervasive presence of computers, cell phones, and other electronic devices in our lives has led to increasingly shorter lifespans for these products.

Given the significant contamination potential of electronic waste, educating the population and policymakers alike is imperative. Simultaneously, research efforts must be intensified to develop alternatives to address the inevitable consequence of technological advancement and its associated products, as our modern world is inseparable from their functionality.

The overarching objective of this article is to elucidate how the rapid disposal of electronic waste can result in significant environmental impacts. It is disconcerting to note that neither the general populace nor governmental authorities have given due attention to the severity of waste accumulation in vacant lots, landfills, rivers, or even backyard settings. This prompts essential questions: how can heavy metals from electronic waste be disposed of safely to mitigate harm to animals and humans? There is a pressing need for a discourse on existing policies governing proper disposal methods. The article also provides a brief historical overview of electronic waste management before delving into the health risks of water contamination from these devices.

While technological progress and educational efforts must go hand in hand, it is crucial to craft robust environmental policies to ensure the proper disposal of electronic waste, thereby preventing the release of harmful substances into groundwater. In failing to do so, the blessings of modernity may unwittingly yield to the curse of illness inflicted by high technology on those who seek its benefits. In essence, we must reckon with the consequences of our production and disposal practices. Failure to do so compromises the quality of the water we consume and undermines our aspirations to be a civilized society.

Historical Route: Construction of Inadequate Waste Disposal Since the Beginning

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Historically, waste accumulation became noticeable as humans settled into permanent homes and established communities, leading to initial damage to cities and the environment. While waste was generated before, the accumulation issue was less prominent. In prehistoric times, waste primarily consisted of biodegradable materials such as bones and stone objects, which were quickly absorbed by nature and did not cause significant environmental damage [1].

Today, the discussion revolves around technological waste as a pressing global challenge driven by rapid industrial and technological evolution, exacerbated consumerism, and contemporary capitalism. Most electronic devices are intentionally designed with shorter lifespans, coupled with high repair costs, prompting consumers to opt for new purchases rather than repairs. Consequently, there needs to be more concern about the final disposal of these products.

The 20th century witnessed unprecedented industrial, scientific, and technological development alongside issues such as irregular urban growth, resource extraction, deforestation, soil, water, and air pollution, climate change, and waste management challenges. Technological progress has created a consumer society focused on economic efficiency and constantly creating new technologies, leading to various environmental risks.

This acceleration of technological progress has inevitably generated diverse environmental risks, including waste management challenges. As society increasingly relies on technology, addressing the proper disposal and management of technological waste has become a critical issue for environmental sustainability.

In this context, the emergence of the capitalist model characterized by high consumption has led to the proliferation of a disposable culture [2,3]. Consequently, various social organizations have explored alternative approaches to minimize the environmental impact of this reality.

Legal institutions and social bodies have recognized the existence of technological waste, also referred to as electronic waste or e-waste. These solid waste materials are no longer used or desired by their generators but retain value and potential utility. Therefore, addressing the proper disposal or reuse of such waste is imperative to prevent environmental damage and safeguard human health.

Furthermore, the significance of addressing environmental concerns gained momentum in the 1970s when the detrimental effects of pollution and the finite nature of natural resources became widely acknowledged. This era sparked international debates and led to the formation of prominent non-governmental organizations (NGOs) focused on environmental advocacy. Notable examples include Greenpeace, the World Wide Fund for Nature (WWF), and Conservation International (CI), which have since gained national and international recognition, forming extensive environmental networks.

In addition to these networks, the Rio 92 conference [4], also known as the United Nations Conference on Environment and Development, held significant importance. This conference was signed in 1992 and ratified by Congress in 1994, followed by confirmation by the Brazilian government in the same year. In 1998, its provisions were enacted through Law 2,519/98, which mandated the implementation of its content. Furthermore, this conference laid the groundwork for Law 4,339/02, establishing the principles and guidelines for implementing the National Biodiversity Policy. Notably, Brazil has had environmental legislation in place since 1981, with the enactment of Law 6,938/81 [5]. This legislation established the National Environmental Policy, which articulates principles to ensure sustainable development, preserve human life, and safeguard national security. Among these principles, as highlighted in Article 2, are:

"*I - governmental action in maintaining ecological balance, considering the environment as a public asset to be necessarily secured and protected, with a view to collective use; II - rationalization of the use of soil, subsoil, water, and air; (...) VII - monitoring the state of environmental quality; (...)X - environmental education at all levels of education, including community education, aiming to enable them to participate in the defense of the environment actively.*"

Changes in attitude toward environmental conservation are a complex interplay of political and educational factors. However, until such changes are ingrained in societal behavior, they must be enforced through legislation.

Disposal of Electronic Waste: Appropriate Ways to Carry Out the Procedure

According to Ferreira [6], garbage encompasses "everything useless and thrown away; dirt; filth; worthless, old, worthless thing or things." However, in contemporary times, adhering solely to this definition perpetuates misinformation about waste management, as we now emphasize concepts such as recycling, reusing, and redefining products that no longer serve their original purpose. In Brazil, data from the Brazilian Association of the Electrical and Electronic Industry (ABINEE) indicates that approximately 1.2 billion batteries are sold annually. Unfortunately, only a tiny fraction of these batteries are disposed of and recycled correctly, with the majority ending up in common household waste, ultimately contributing to significant environmental issues [7].

Despite their seemingly innocuous nature, batteries are classified as toxic waste due to their composition, which includes heavy metals such as mercury (Hg), cadmium (Cd), manganese (Mn), zinc (Zn), lead (Pb), and nickel (Ni). Improper disposal of batteries leads to substantial environmental and socio-environmental impacts, primarily through the bioaccumulation of heavy metals [8]. Thus, there is an urgent need to incentivize the recycling of these waste products. However, this initiative faces numerous challenges and needs more adequate support.

These challenges include the limited number of collection points for toxic waste, the low economic viability of recycling processes, inadequate support from public policies that fail to address pollution issues adequately, and the importance of proper waste handling and disposal.Consequently, companies responsible for waste production incur high waste management costs.

Damage Caused by Improper Disposal of Electronic Waste

It is crucial to underscore that environmental issues stemming from computers extend beyond their mere usage and disposal. The problems begin during their production phase, particularly with silicon processing. Silicon, the second most abundant substance on Earth after oxygen, is a natural semiconductor widely used in the electronics industry to construct boards, circuits, and chips. However, its industrialization poses significant environmental challenges, as processing just one kilogram of this material generates approximately five kilograms of electronic waste [9].

Furthermore, any improper disposal of waste, regardless of its type, exacerbates environmental degradation by increasing pollution and the risk of soil and water contamination. Electronic waste, in particular, compounds this issue due to toxic substances such as lead, mercury, and beryllium. This waste category encompasses discarded or dysfunctional electronic products like laptops, televisions, cell phones, stereos, and copiers. The most pressing concern arises with the final disposal of these products. Without specific legislation, electronic devices are often discarded as ordinary waste, posing risks to waste collection employees and the general population. If deposited in landfills, these devices can contaminate soil and water sources with heavy metals [9].

The improper disposal of these substances can lead to severe environmental contamination, posing significant public health risks. Additionally, electronic devices are constructed from materials that decompose slowly, such as glass and plastic. Compounding the issue is the problem of electronic waste, as many devices are discarded despite being in good condition. Implementing alternative forms of reuse could mitigate the detrimental environmental impacts. However, the lack of an effective recycling program, insufficient collection efforts, or the disposal of these devices in improper locations contribute to soil and aquifer contamination, hastening the depletion of natural resources.

It is crucial to note that indiscriminate disposal, including landfilling, releases toxic substances within electronic equipment directly into the soil and surface and underground water sources. This contamination of natural resources, particularly water, can be a vector for diseases if polluted by toxic waste.

For instance, when electronic devices are disposed of in common trash (Figures 1 and 2), the chemical substances found in their components, including mercury, cadmium, arsenic, copper, lead, and aluminum, seep into the soil and groundwater. This contamination affects plants and animals through water, posing risks to human health if consumed.

Additionally, heavy metals like lead and barium in unused televisions, monitors, and cameras can leach into the soil and contaminate groundwater.

It is well-documented that elements such as mercury, cadmium, and brominated dioxin, found in printed circuit boards, emit pollutants into the air and rivers. Moreover, chips and gold-plated components contain substances such as hydrocarbons, contributing to river acidification. Burning equipment containing hydrocarbons, such as copper wires used in computer machines, releases acidic gases that can reach water and soil. Similarly, when this equipment is crushed for reuse, it generates emissions of brominated dioxins, hydrocarbons, and toxic heavy metals.

According to Antônio Guaritá, a chemist at the Environmental Analytical Chemistry Laboratory at the University of Brasília (UnB), these emissions can lead to health complications ranging from headaches and vomiting to severe issues like nervous system disorders and cancer [10].

In line with this perspective, Gonçalves [11] identifies lead, a component of e-waste, as particularly harmful to water quality and human health:

"Lead can cause damage to the central and peripheral nervous system, blood system, and kidneys in humans. Effects on the endocrine system have also been observed, and its serious negative effect on children's brain development has been well documented. Lead accumulates in the environment and has acute and chronic toxic effects on plants, animals, and microorganisms. The main concern about lead found in landfills is the possibility of it leaking and contaminating drinking water systems."

Figure 1. Incorrect disposal on vacant land 1.

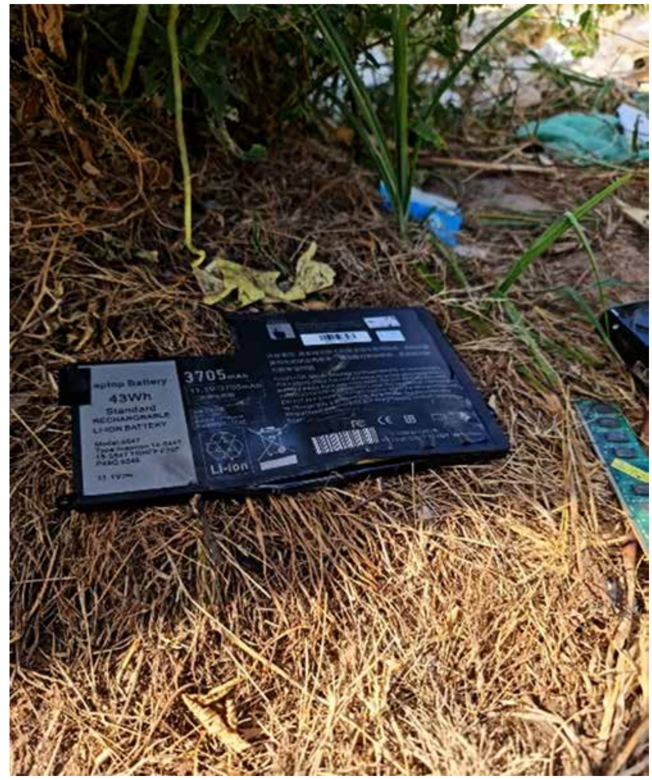
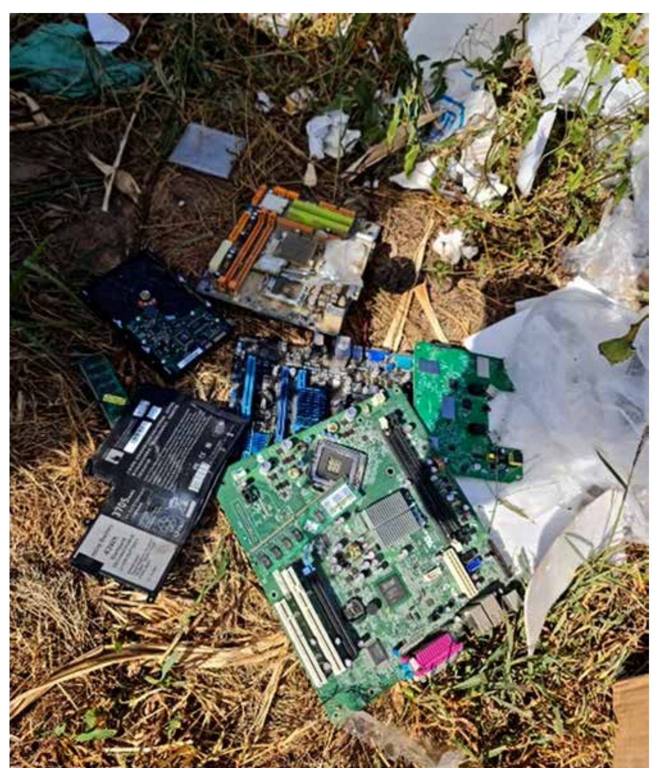


Figure 2. Incorrect disposal on vacant land 2.



It is important to emphasize that the risks posed to the environment, biodiversity, and human health entail significant costs [12-15]. These costs, coupled with the loss of raw materials from discarded electronic equipment, also result in economic losses. This underscores the fact that environmental concerns extend beyond ecological factors alone. This understanding stems from sustainability and its three pillars, encompassing environmental, social, and economic dimensions.

Final Considerations

The quest for knowledge on minimizing the damage caused by electronic waste, which is discarded daily in large cities, will be a crucial path for current and future generations to pursue. Promoting sustainable practices and disseminating information are vital drivers for effecting change in this environmental degradation scenario, particularly concerning soil contamination and its impact on water quality [16-19].

It is no longer feasible to consider technological progress without acknowledging the environmental impacts caused by the devices designed to enhance modern life. For technological advancement to be sustainable, it must prioritize the preservation of nature and its vital resources, including water, land, biodiversity, and air quality.Electronic waste deposited in the ground poses a silent threat as it contaminates groundwater, posing health risks to communities [20].

Therefore, it is imperative to rethink societal norms regarding consumption and prioritize intelligent and sustainable practices. Addressing the issue of electronic waste disposal is not only urgent but also fundamental for ensuring our continued existence on this planet.

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