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E-Waste Management: A Study of Residential and Commercial Practices

Shubhada Deshmukh[1], Pawan Gaikwad[2], Deepak Shendage[3], Vivek Sutar[4], Ajay Padvi[5], Chinmay Tulaskar[6]
Lecturer, Department of Civil Engineering[1]
Students, Department of Civil Engineering[2-6]
Bharati Vidyapeeth Institute of Technology, Navi Mumbai, India
shubhadakd95@gmail.com, pavangaikwad737@gmail.com, deepakshendage78@gmail.com
sutarcamping@gmail.com, apadvi801@gmail.com, chinmaytulaskar@gmail.com

Abstract: *The increasing use of electronic devices has led to a significant rise in electronic waste (e-waste), posing environmental and health challenges worldwide. Improper disposal and inadequate recycling methods result in the release of toxic substances, contaminating soil, water, and air. This paper examines the current trends in e-waste generation, the environmental and human health impacts, and the effectiveness of existing management strategies. It explores sustainable solutions such as improved recycling technologies, circular economy approaches, and extended producer responsibility (EPR) policies. Furthermore, the study emphasizes the role of legislation, industry participation, and public awareness in mitigating e-waste issues. By analyzing global best practices, this research aims to highlight practical and innovative strategies for efficient e-waste management, promoting sustainability and resource conservation.*

Keywords: Commercial E-waste, Electronic Waste, Environmental Awareness, E-waste Management, Recycling Behavior, Residential E-waste, Survey-Based Study, Sustainable Waste Solutions, Urban Waste Management, Waste Disposal Practices

I. INTRODUCTION

In the modern era of technological advancements, electronic devices have become an integral part of daily life. From smartphones and laptops to household appliances and industrial equipment, the global dependency on electronic gadgets continues to grow. However, with this rapid technological evolution comes a significant environmental challenge—electronic waste, commonly known as e-waste. E-waste refers to discarded electrical and electronic equipment (EEE) that has reached the end of its useful life. The improper disposal of such waste poses severe risks to the environment and human health due to the presence of toxic materials such as lead, mercury, cadmium, and brominated flame retardants.

The increasing volume of e-waste is a matter of concern worldwide. According to recent studies, millions of metric tons of electronic waste are generated annually, with only a fraction being recycled through proper channels. The rest ends up in landfills, incinerators, or is illegally exported to developing countries, where inadequate disposal practices lead to pollution and severe health hazards. The informal e-waste recycling sector, prevalent in many developing nations, often involves manual dismantling and chemical processing without protective measures, exposing workers to hazardous substances and contaminating soil, air, and water sources.

Addressing the growing challenge of e-waste requires comprehensive management strategies that involve government policies, corporate responsibility, and public awareness. Efficient e-waste management includes practices such as recycling, refurbishment, and sustainable disposal methods to minimize environmental impact.Many countries have introduced regulations and extended producer responsibility (EPR) programs, holding manufacturers accountable for the entire lifecycle of their products. Additionally, innovations in recycling technology, such as automated sorting systems and eco-friendly material recovery processes, are playing a vital role in improving e-waste handling.

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This research paper aims to explore the significance of e-waste management, its environmental and health impacts, and potential solutions to mitigate its adverse effects. By understanding the importance of sustainable e-waste practices, individuals, businesses, and policymakers can contribute to a cleaner and more sustainable future. Addressing e-waste responsibly is not only an environmental necessity but also a crucial step toward a circular economy that promotes resource efficiency and sustainable development.

II. LITERATURE REVIEW ON E-WASTE MANAGEMENT

1. Kumar, S., Holuszko, M., & Espinosa, D. C. R. (2017)

Title: "E-waste: An overview on generation, collection, legislation, and recycling practices"

Summary: This study provides a global perspective on e-waste generation and the challenges of collection, legislation, and recycling. It highlights the increasing volume of e-waste due to rapid technological advancements and short product life cycles. The authors emphasize the importance of extended producer responsibility (EPR) policies to ensure proper disposal and recycling. They also discuss the limitations of current recycling methods and the need for innovative solutions to manage hazardous materials effectively.

2. Baldé, C. P., Forti, V., Gray, V., Kuehr, R., & Stegmann, P. (2019)

Title: "The Global E-waste Monitor 2019"

Summary: This report presents comprehensive data on global e-waste trends, revealing that approximately 53.6 million metric tons of e-waste were generated in 2019, with only 17.4% properly recycled. The study highlights the disparity in e-waste management practices between developed and developing nations, with wealthier countries having better infrastructure for collection and recycling. It also warns that without urgent policy interventions and improved recycling technologies, e-waste could reach unsustainable levels, further harming the environment and public health.

3. Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M., & Böni, H. (2005)

Title: "Global perspectives on e-waste"

Summary: This paper explores the environmental and socio-economic challenges of e-waste across different regions. The authors examine how developing nations are disproportionately affected due to the illegal dumping of e-waste from developed countries. They highlight the role of informal recycling sectors, which use crude methods such as open burning and acid leaching, leading to severe pollution and health risks. The study calls for international cooperation to establish ethical e-waste trade policies and promote sustainable recycling practices.

4. Li, J., Lu, H., Guo, J., Xu, Z., & Zhou, Y. (2015)

Title: "Recycling and disposal of electronic waste: Health hazards and environmental impacts"

Summary: This research focuses on the toxic materials present in e-waste, such as lead, mercury, cadmium, and brominated flame retardants, and their potential health impacts. The authors discuss how improper disposal methods, including informal dismantling and incineration, release hazardous chemicals into the environment, leading to air, soil, and water contamination. They emphasize the importance of establishing strict disposal regulations and promoting eco-friendly recycling technologies to minimize health risks and environmental degradation.

5. Parajuly, K., Fitzpatrick, C., Muldoon, O., & Kuehr, R. (2019)

Title: "Behavioral change for the circular economy: A review with focus on electronic waste management"

Summary: This study investigates how consumer behavior influences e-waste management. The authors explore factors such as lack of awareness, limited recycling options, and consumer reluctance to recycle old electronics. The study suggests that behavioral change strategies, such as financial incentives, awareness campaigns, and convenient recycling programs, can encourage individuals and businesses to adopt responsible e-waste disposal habits. It also emphasizes the role of circular economy principles in extending the life cycle of electronic products through reuse and refurbishment.

6. Wang, F., Huisman, J., Meskers, C. E., & Stevels, A. (2012)

Title: "The Best-of-2-Worlds approach: Connecting high-tech and developing countries for e-waste recycling"

Summary: This paper proposes an innovative model combining the strengths of high-tech recycling in developed nations with labor-intensive recycling in developing countries. The authors argue that this approach can enhance material recovery while ensuring worker safety and environmental protection. They highlight case studies where

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advanced recycling facilities handle hazardous materials, while labor-intensive processes are used for disassembling components that require minimal risk exposure. This method aims to improve global e-waste recycling efficiency while supporting sustainable economic development in low-income regions.

7. Lepawsky, J. (2018)

Title: "Reassembling Rubbish: Worlding Electronic Waste"

Summary: In this book, the author challenges the conventional narrative of e-waste management, emphasizing the global movement of electronic waste and its socio-economic implications. He argues that e-waste should not be viewed merely as an environmental hazard but as part of a complex global system that involves trade, labor, and resource extraction. The book discusses how e-waste regulations often fail to address the root causes of waste production and suggests that global cooperation and innovative policy approaches are needed to tackle the issue effectively.

8. Ibanescu, D., Cailean, D., Teodosiu, C., & Fiore, S. (2018)

Title: "An overview of decision support systems for waste management: Identifying gaps and opportunities"

Summary: This study examines the role of decision-support systems (DSS) in optimizing e-waste management. The authors explore how data-driven approaches, such as artificial intelligence and machine learning, can improve waste collection, sorting, and recycling processes. They identify key challenges, including a lack of real-time data integration and limited adoption of DSS in developing nations. The study recommends enhancing digital infrastructure and investing in smart waste management technologies to improve efficiency and sustainability.

9. Kiddee, P., Naidu, R., & Wong, M. H. (2013)

Title: "Electronic waste management approaches: An overview"

Summary: This research categorizes different e-waste treatment methods, including mechanical recycling, incineration, and emerging biotechnological approaches. The authors discuss the advantages and limitations of each method, highlighting the need for sustainable alternatives. They advocate for the development of bio-recycling techniques using microorganisms to extract valuable metals from e-waste in an environmentally friendly manner. The study calls for further research and investment in green technologies to make e-waste recycling more sustainable.

10. Nnorom, I. C., & Osibanjo, O. (2008)

Title: "Electronic waste (e-waste): Material flows and management practices in Nigeria"

Summary: This study focuses on Nigeria's e-waste crisis, emphasizing the role of the informal recycling sector in handling discarded electronics. The authors analyze how hazardous processing methods, such as open-air burning and acid baths, contribute to severe environmental and health issues. The study highlights the lack of regulatory enforcement and calls for the establishment of formal recycling centers, stricter policies, and public awareness campaigns to improve e-waste management in Nigeria and other developing countries.

III. AIM OF THE RESEARCH

This research aims to reduce e-waste generation, promote responsible disposal, and encourage conservation efforts through awareness and action.

IV. OBJECTIVES OF THE RESEARCH

- To Reduce E-Waste Generation.
- To Spread Awareness on E-Waste Disposal.
- To Encourage Conservation and Recycling.
- To Organize Awareness Campaigns and Policy Advocacy.

V. METHODOLOGY

To study e-waste generation, disposal practices, and awareness levels, this research employed a mixed-method approach, combining both online and offline data collection methods. The aim was to gather insights from both residential and commercial sectors regarding the usage lifespan of electronic gadgets, disposal methods, and awareness

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of e-waste management. By analyzing data from households and commercial buildings, this study provides a holistic view of e-waste handling practices and highlights areas for improvement in sustainable disposal methods.

1. Data Collection Methods

A. Online Survey for Residential Data

A structured online survey was conducted using Google Forms to collect responses from 100 households. The questionnaire was designed to capture consumer behavior regarding e-waste disposal, focusing on common household electronic devices such as televisions (TVs), mobile phones, refrigerators, air conditioners (ACs), washing machines, laptops, and personal computers (PCs).

The survey consisted of multiple-choice, ranking, and open-ended questions covering the following aspects:

Ownership and Usage Duration: Participants were asked to list the electronic gadgets they own and specify how many years they use them before replacement or disposal.

Disposal Methods: Respondents indicated how they dispose of old electronics—whether by selling, recycling, donating, dumping, or storing them at home.

E-Waste Awareness: The survey assessed knowledge of proper e-waste disposal practices and awareness of government recycling programs, take-back schemes, or local recycling facilities.

Barriers to Proper Disposal: Questions were included to understand challenges faced in recycling, such as lack of facilities and convenience.

The online mode allowed for easy data collection from a diverse range of households, ensuring a broad understanding of residential e-waste management habits.

B. Offline Data Collection from Commercial Areas

To assess e-waste management in business environments, physical visits were conducted at five commercial buildings, including office complexes and retail spaces. Data was gathered through direct observation and structured interviews with office managers, IT administrators, and facility maintenance staff.

The on-site study focused on:

Types of Electronic Devices Used: A record was made of commonly used office electronics, including desktop computers, laptops, printers, photocopiers, servers, televisions, and other electronic appliances.

Lifespan and Replacement Frequency: Information was gathered on how long electronic devices were used before being replaced, repurposed, or discarded.

E-Waste Disposal Practices: Businesses were asked about their existing disposal methods—whether they resold, recycled, stored, or discarded electronic waste informally. The study also investigated whether companies followed any e-waste disposal regulations or partnered with professional recycling firms.

Awareness and Compliance: Interviews explored whether businesses were aware of government policies, extended producer responsibility (EPR) programs, or corporate sustainability initiatives related to e-waste.

The offline visits provided practical insights into large-scale electronic waste disposal trends and highlighted gaps in formal recycling practices within commercial sectors.

2. Data Analysis

Once the data was collected, it was systematically categorized and analyzed to identify key trends in e-waste generation, disposal behavior, and awareness levels.

Quantitative Analysis 1: The survey responses from 100 households were compiled and analyzed using statistical tools to determine average gadget lifespan, most common disposal methods, and levels of awareness. Graphs and charts were used to illustrate patterns in residential e-waste management.

Qualitative Analysis 2: Observations and interviews from commercial site visits were reviewed to identify prevalent e-waste disposal practices, challenges, and potential areas for improvement. The data was compared with existing e-waste policies to assess compliance levels and highlight gaps in corporate e-waste management.

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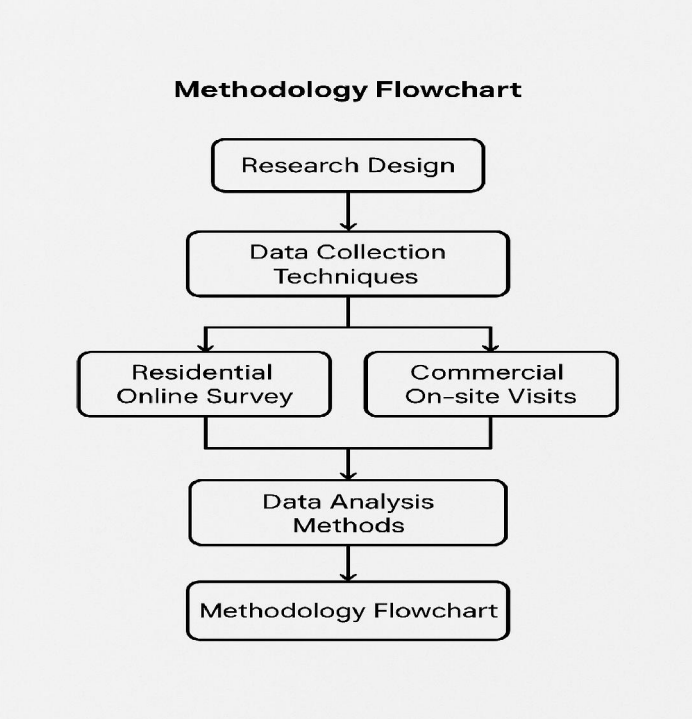
By integrating both online and offline data collection methods, this research ensures a well-rounded understanding of e-waste disposal behaviors, challenges, and potential solutions. The findings aim to contribute to the development of better e-waste management policies, increased awareness, and the promotion of sustainable electronic waste handling practices in both residential and commercial sectors.

3. Flowchart representing Methodology



VI. RESULT

The results of this study provide insights into respondents' perspectives on e-waste management, their demographic details, and gadget usage patterns. The survey responses include data on participants' age groups, their city of residence, and the number of electronic devices they have used over time. Additionally, the study examines whether respondents have opted for refurbished gadgets, highlighting their awareness and attitudes toward sustainable electronic consumption. These findings help in understanding e-waste generation trends and the potential for promoting responsible disposal and recycling practices.

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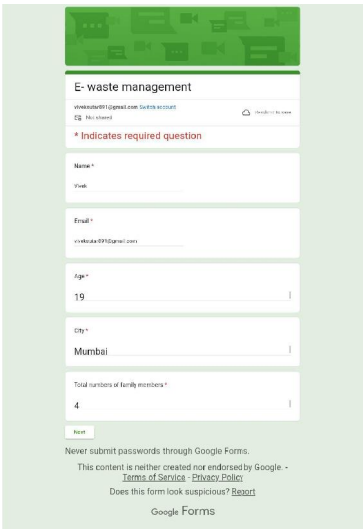
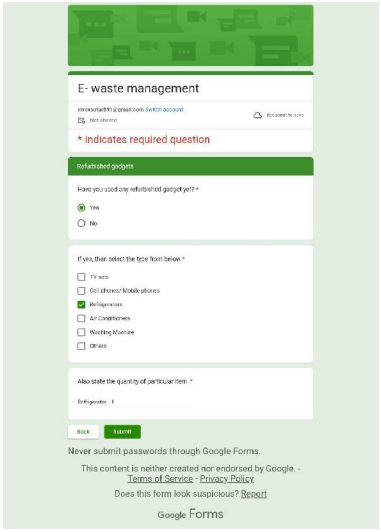
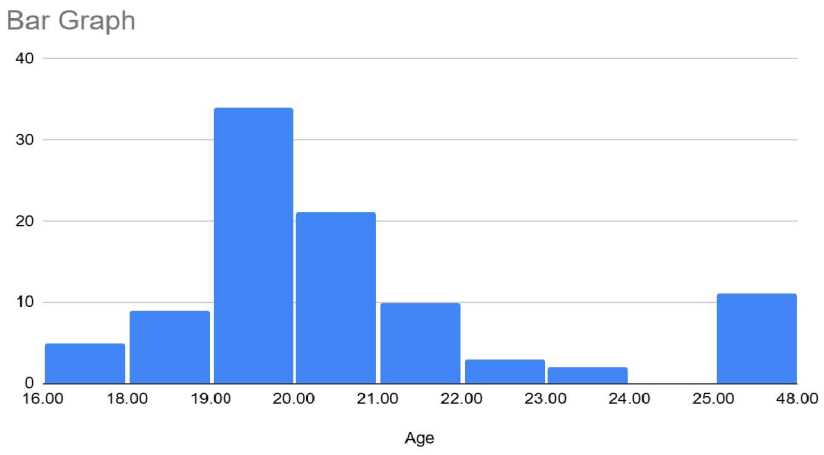
1. Online Survey (Google Form) - 100 Residentials





A. Responders' age (Bar graphical representation)



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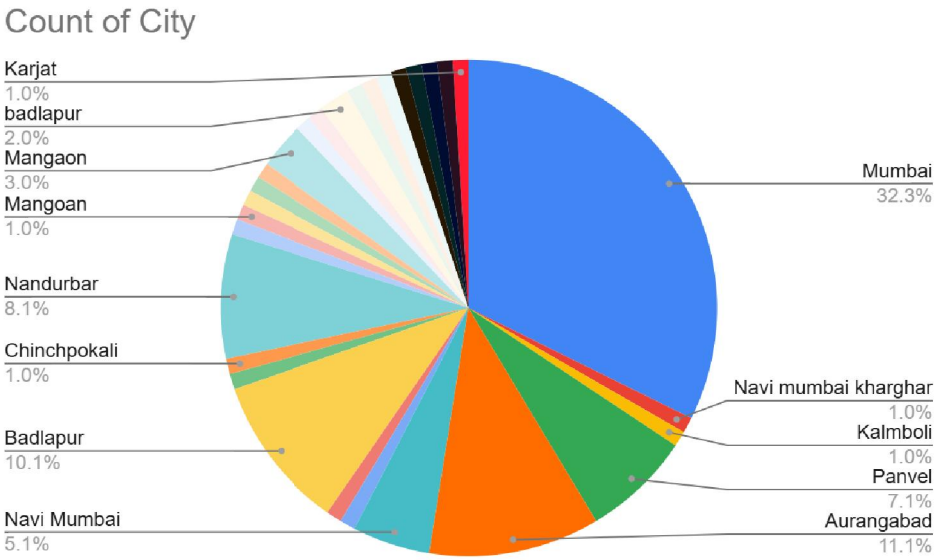
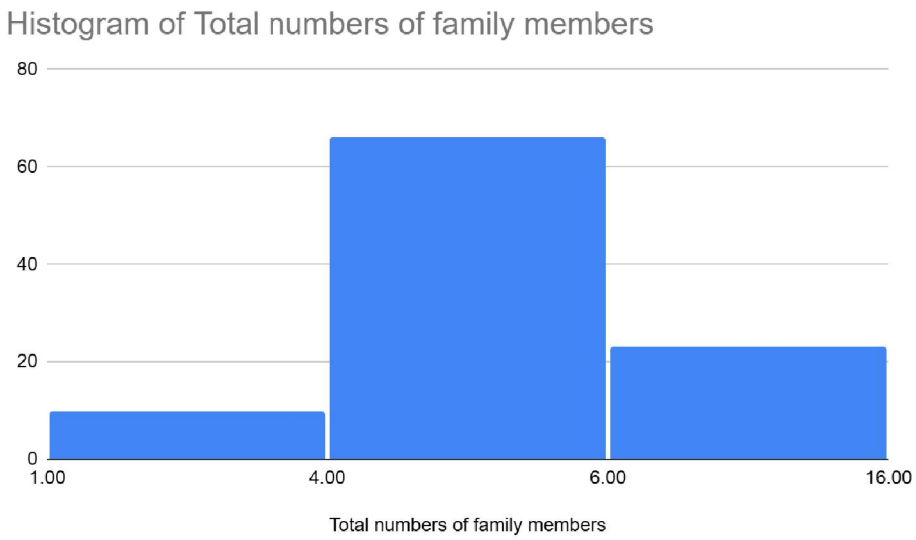
B. Responders' City (Region)



C. Responders' total no. of family members (Bar graphical representation)



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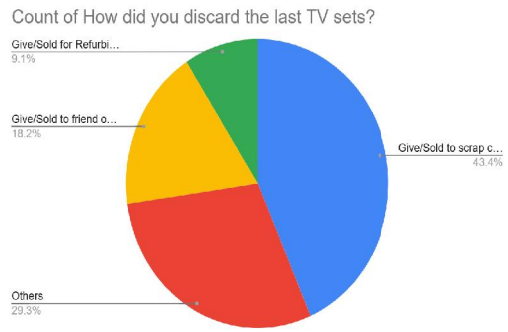
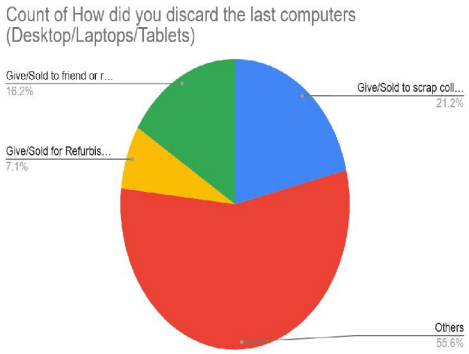
D. Discarding of devices by responders

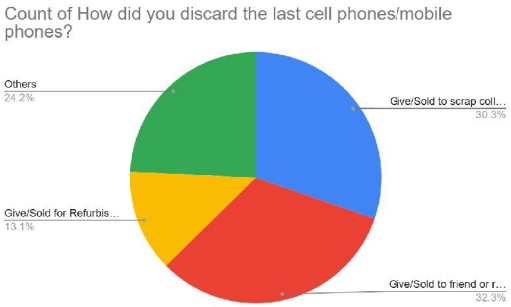
1.Televisions



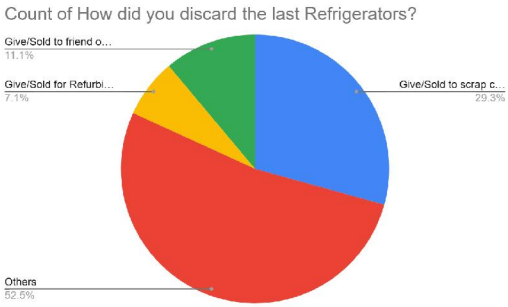
2.Computers (Desktops/Laptops/Tablet)



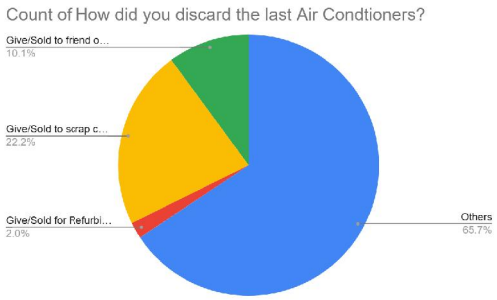
3.Cell Phones/ Mobile Phones



4.Referigerators



5.Air Conditioners



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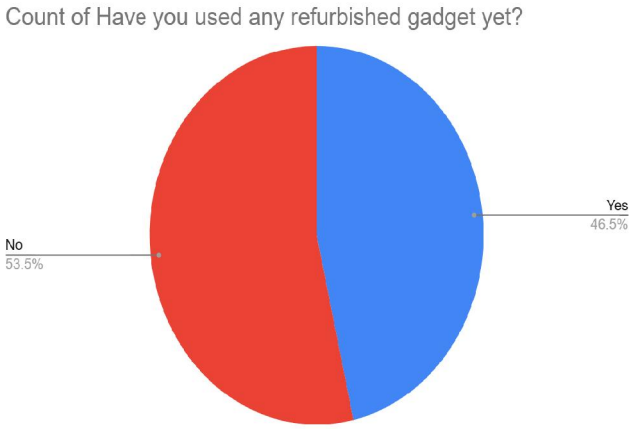
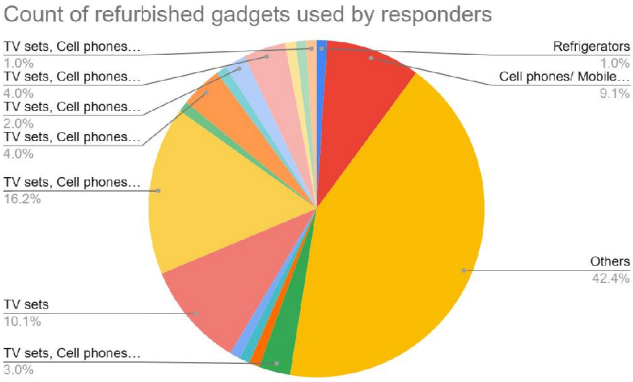
E. Responders' view about Refurbishment

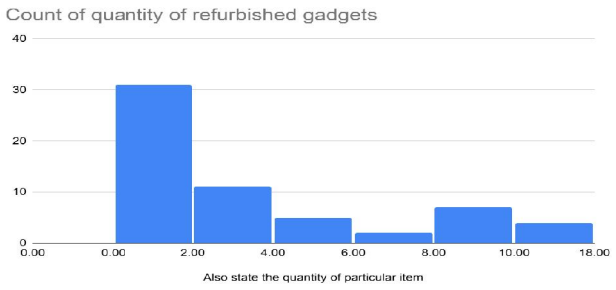
1. Have you used any refurbished gadgets yet?



2.Type of refurbished gadgets used by responders



3.Quantity of refurbished gadgets used by responders



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2. **Offline Survey (Visiting Physically) - 5 Commercial Buildings.**

A. Survey Data: E-Waste Installed and Discarded in Commercial Buildings in the last 5 years.

1.Bharati Vidyapeeth College of Engineering

Device	Installed	Discarded
Computers	200	80
Keyboards	250	90
CPUs	200	80
Tube Lights	400	150
Projectors	20	8
Microphones	15	5

2. Bharati Vidyapeeth Institute of Technology

Device	Installed	Discarded
Computers	180	70
Keyboards	220	85
CPUs	180	70
Tube Lights	350	130
Projectors	18	7
Microphones	12	4

3.Bharati Vidyapeeth Institute of Architecture

Device	Installed	Discarded
Computers	150	60
Keyboards	180	75
CPUs	150	60
Tube Lights	300	110
Projectors	15	6
Microphones	10	3

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4. Bharati Vidyapeeth Institute of Nursing

Device	Installed	Discarded
Computers	120	50
Keyboards	150	60
CPUs	120	50
Tube Lights	250	90
Projectors	12	5
Microphones	8	2

5..Bharati Vidyapeeth Institute of Dental

Device	Installed	Discarded
Computers	140	55
Keyboards	170	70
CPUs	140	55
Tube Lights	280	100
Projectors	14	6
Microphones	9	3

VII. CONCLUSION

Our study, based on an online survey of 100 residential respondents and an offline survey of 5 commercial establishments, highlights a concerning trend in e-waste management. A vast majority of respondents either discard electronic devices improperly or store them unused, with only a small fraction utilizing recycling programs. Furthermore, the adoption of refurbished gadgets remains low, indicating a missed opportunity for reducing e-waste.

To mitigate the environmental impact of e-waste, it is crucial to adopt sustainable disposal practices. Consumers should prioritize proper recycling by depositing old electronics at authorized e-waste collection centers. Manufacturers must take responsibility by implementing take-back programs and designing products with extended lifespans. Government regulations should enforce stricter guidelines on e-waste disposal and incentivize formal recycling facilities. Additionally, raising public awareness about the hazards of improper e-waste management and the benefits of using refurbished electronics can encourage more responsible consumer behavior.

Protecting our environment and conserving natural resources require collective efforts. By embracing responsible e-waste disposal, promoting a circular economy, and minimizing electronic waste through reuse and recycling, we can significantly reduce the ecological footprint of our digital consumption. It is imperative that individuals, businesses, and policymakers work together to safeguard our planet from the hazards of e-waste and contribute to a more sustainable future.

ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to all those who supported us throughout the journey of completing this research paper on “E-Waste Management: A Study of Residential and Commercial Practices.”

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encouragement, and insightful suggestions throughout the research process. Her expertise and patience played a crucial role in shaping this study.

We also extend our sincere thanks to the faculty members of our department for their support and motivation. A special appreciation goes to all the participants of our online and offline surveys, whose responses formed the foundation of this research.

Finally, we thank our families, friends, and peers for their continuous encouragement, understanding, and moral support during this project.This research would not have been possible without the collective efforts and cooperation of everyone mentioned above.

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