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E-Waste Management in Uttarakhand: Insights from Srinagar Garhwal/Chauras and Evaluation of Authorized Units

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ABSTRACT
As the world braces for an impending tsunami of e-waste, this study evaluates Uttarakhand's preparedness for environmentally sound e-waste management. Focusing on the hill state's Srinagar and Chauras regions, a survey was conducted to assess the population's awareness of e-waste issues. The results revealed a significant lack of knowledge, with only 5% of residents being aware of e-waste. An awareness campaign initiated by the author led to a notable impact, resulting in the collection of 70 kg of e-waste within a one-month drive. In the second phase, the study examined the performance of authorized e-waste collection and recycling units in Uttarakhand from 2017 to 2022, during which 101,401.23 metric tons of e-waste were processed. However, only 3-4 units demonstrated serious and effective recycling operations, predominantly handling ferrous and non-ferrous materials, plastics, aluminum, and hazardous materials. The study projects future challenges and recommends strategies to address the growing e-waste issue, including increasing the number of recycling units, improving their geographical distribution, and enhancing public awareness. These efforts are critical for promoting sustainable practices and mitigating the environmental impacts of e-waste in the region.

Keywords: e-Waste Management • Uttarakhand • Recycling Units • Public Awareness • Sustainable Practices • Environmental Impact

Introduction

E waste is a global problem associated with the digitalization, technological advancement and global economic development. The Electrical and electronics equipment (EEE) are Becoming more and more advanced with shorter life span and hence contributing to the huge e-waste generation. As the world is already facing the problem of household and industrial waste the problem of e-waste is a huge cost to development. The segregation of e-waste from household / normal waste is a challenging task with health and environmental hazards associated with it. If not segregated from the normal waste, the e-waste renders the normal waste most hazardous and no recyclable (Sengupta et al. 2023, Semalty & Agrawal, 2024a).

The current status of e-waste globally is concerning, with 53.6 million tonnes generated in 2019 and projected to reach 74.7 million tonnes by 2030, growing at a rate of 3-5% annually (Sarvaiya et al. 2023). In a recent study, the top ten immersive technologies were studied. Interestingly out of 10 technologies 08 technologies are based on electronics which in turn are going increase the global burden of e-waste (Semalty & Agrawal, 2024b). E-waste contains hazardous substances like lead and mercury, posing environmental and health risks if not managed properly (Agarwal et al. 2024). In India, e-waste generation ranges from 0.77 to 3.2 million tonnes, with informal recycling practices, inadequate regulations and lack of awareness hindering sustainable management (Sarvaiya et al. 2023).

Challenges in India include illegal imports, insufficient policies, and improper implementation of existing rules (Taksali & Rathore 2024). Effective strategies such as legislation, recycling, and awareness campaigns are crucial for mitigating the e-waste problem and promoting sustainable practices globally (Agarwal et al 2024). Awareness campaigns through various media channels play a vital role in educating the public about e-waste management (Solanki & Rathore 2024).

As per the NITI Aayog's SDG India Index 2023-24, India's overall Sustainable Development Goal (SDG) score increased from 66 in 2020–21to 71 in 2023–24. Overall scores have improved in every state. This improvement is due to significant progress in areas such as poverty elimination, decent work, economic growth, climate action, and life on land.

After ranking ninth in 2019, Uttarakhand, a state in the Himalayas, made considerable strides to tie for first place with Kerala. Kerala and Uttarakhand earned 79, while the average national score was 71 (SDG 2024). The generation of e-waste is a critical environmental issue globally, exacerbated by the rapid growth in technology consumption and disposal, leading to adverse health effects and environmental contamination (Agarwal et al 2024).

This case study explores e-waste awareness and management in Uttarakhand, focusing on the formal sector's compliance with regulations. Data gathered from both primary and secondary sources were critically analyzed, highlighting the key factors influencing the current status and projecting future trends.

Material and Methods

In the study, the e-waste awareness survey was conducted before and after the e-waste awareness campaign in and around the local population of Srinagar Garhwal and Chauras area of Uttarakhand. The selected area is an education hub consisting of various higher educational centres including HNB Garhwal University (A Central University), National Institute of Technology, Medical College, and Nursing College apart from 14-15 senior secondary schools. Srinagar Garhwal is a sub divisional head quarter and located at 130 Km from Dehradun airport, midway to Srinagar-Badrinath Highway.

In the awareness campaign individual schools were approached and survey was conducted with the questionnaire. After the brief introduction to concept of e-waste, students and staff members were motivated to bring the e-waste from the household and submit to the designated place in an e-waste dustbin. The type of e-waste collected, and impact of e-waste collection drive was observed critically.

As the second part of the study, the authentic secondary data (by State Central Pollution Control Board, Uttarakhand) of e-waste collection by formal sector were collected, organized and studied to draw important trends in e-waste collection from 2017 to 2022. The data was analysed, and results were presented so as to present the trend in e-waste management.

Results and Discussion

In the present study the e-waste awareness status was studied in the local population before and after the awareness campaign. The study also focused on the e-waste management practice in the state by government authorized e-waste collectors from 2017-22.

E-waste survey in local population

A survey conducted in Srinagar and Chauras revealed that while 70% of the local population is familiar with the term e-waste, only 5% truly understand what it encompasses. Most residents lack knowledge about the types of equipment classified as e-waste, including electrical items. The area lacks a dedicated e-waste segregation system, and in some cases, even regular household waste disposal systems are absent. Recently, Chauras introduced bi-

weekly waste disposal after decades. Currently, e-waste disposal is handled primarily by local scrap dealers and is limited to larger electronic and electrical items.

The awareness program and E-waste collection drive

The awareness program was conducted in various schools and the information was disseminated through the local newspapers. This created a significant awareness among the local population. The post awareness campaign survey showed an increased awareness for e-waste and its sound disposal. But the challenge remains the availability of disposal mechanism in the subject area. A total of 70 Kg e-waste was collected in one month collection drive. The e-waste collected comprises of 20 % cables/ USB cables, 25 % audio devices (head phone/ear phone/speaker etc.) and auxiliary equipment, 10 % mobile phones, 35 % computer/ laptop/monitor screen/ tablet/mouse/ remote/keyboard etc., 10 % miscellaneous

E-waste management by formal sector

As per the state Pollution control board website there are only 8 authorized E-waste collector/ recycler units in Uttarakhand. All units are in Roorkee. Haridwar and Udham Singh Nagar and no single authorized dealer is listedfrom Dehradun (state capital). However, 32 units have been mentioned as e-waste collector/recycler in annual report of e-waste collection/recycling during 2021-22. As per Uttarakhand Pollution Control Board, wWith approved capacity point of view there are only 4 units with huge capacity (UPCB, 2024). The Attero Recycling (P) Ltd has the highest capacity of 12000 metric ton per month (MT/M) followed by Root Recycling (240 MT/M), Resource E-waste Solution Pvt Ltd. (2343.06 MT/A), Anmol Paryavaran Sanrakshan Samiti/ Nayak Enterprises (1200 MT/A); and Scarto Metal Recycling Plant (86.33 MT/M).

But out of these 8 only 5 unit have contributed data and systematic record of e-waste collected/recycled in the annual reports. These seriously working units are Attero Recycling (P) Ltd, Resource E-waste Solution Pvt Ltd., Bharat Oil & Waste Management Ltd (BOWM), Anmol Paryavaran Sanrakshan Samiti, Scarto Metal Recycling Plant. There is no significant increase in the number of authorized units in Uttarakhand from the year 2017-22. Though there are some new entrants in authorized units in 2021-22 but their contribution in collection and recycling is insignificant. There is an urgent need of increasing the number of authorized e-waste collection and recycling units in Uttarakhand.

Table 1. Authorized Recyclers / Dismantler / Refurbishers Units in Uttarakhand (UPCB, 2024)

S. No.	Recyclers / Dismantlers / Refurbishers	Capacity
1	Resource E-waste Solution Pvt Ltd., F-97, F9, Bhadrabad Industrial Area, Distt. - Haridwar.	2343.06 MT/A
2	M/s BOWM, Mukimpur, Roorkee-LaksarRoad, UKJ	325 MT/A
3	Anmol Paryavaran Sanrakshan Samiti kh no. - 85/2, 87/1, Daulatpur Hazaratpur Urf, Budhwasahid, Daulatpur.	1200 MT/A
4	Attero Recycling (P) Ltd., 173 Village Bhagwanpur, Raipur Industrial Area, Roorkee,Haridwar	12000 MT/M

5	Scarto Metal Recycling Plant, kh- No- 314 Kh, Mehwar Khurd Urf Nagal, Roorkee	86.33 MT/M
6	Nayak Enterprises, Vill. Dabhora, Kashipur,US Nagar	1200 MT/A
7	Root Recycling, Khasra No.- 911, Village Padli Gurjar, Roorkee, Haridwar	240 MT/M
8	M/s Asha Enterprises, Khasra No. 438/1, Rawli Mehdood, Phase - 2, gangotri Enclave,Haridwar	10 MT/M

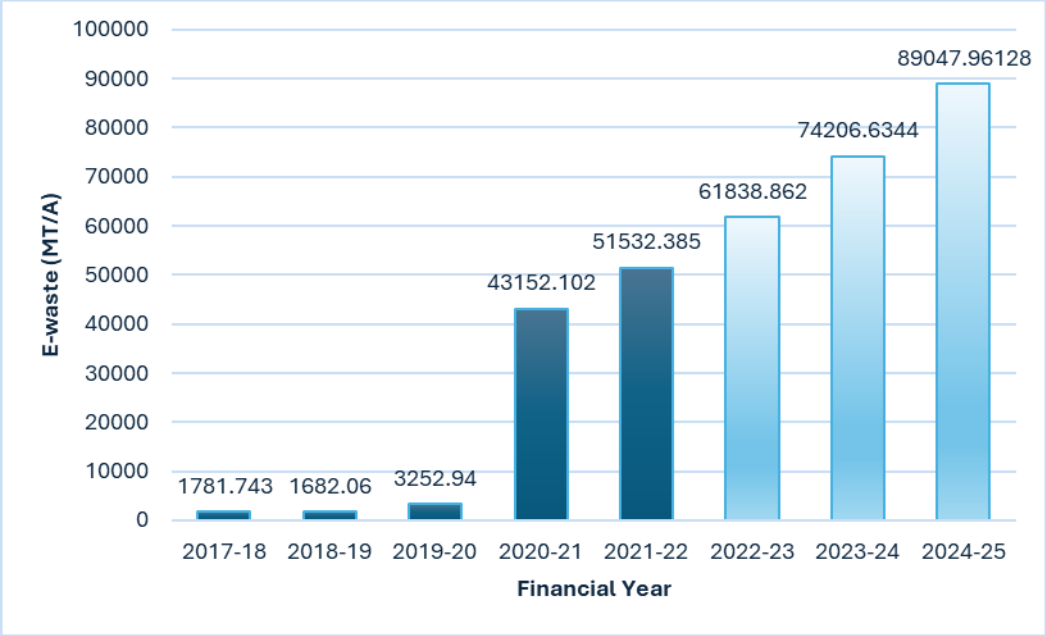

Fig. 1. E-Waste collected/recycled by authorized units from 2017-22 and projection for 2022-25
**Data of 2017-22 has been collected from official source: E Waste reports of Uttarakhand Pollution Control Board, (UPCB, 2024).*

The annual reports (from 2017 to 2022; 05 financial years) of the e waste management by these units were collected and studied (UPCB, 2024). An amount of 101401.23 Metric tons (MT) of e-waste was reported to be collected by the authorized units from 2017 to 2022 (Fig. 1).

The data showed that there was a dip in e-waste collected/recycled in 2018-19 as compared to 2017-18. But after 2018-19 there has been a boom in collection/recycling and the projected figures for 2022-23 2023-24 and 2024-25 (which are not available in the official records) are 61838.86, 74206.63 and 89047.96 MT/A, respectively. The projections are just on the basis of current capacity. Moreover, it is interesting to note that only 4 major players (Attero Recycling (P) Ltd, Resource E-waste Solution Pvt Ltd., Bharat Oil & Waste Management Ltd (BOWM), and Scarto Metal Recycling Plant) are contributing to this increase out of which “Attero” and “Resource” are outperformers as compared to others. If capacity is increased the e-waste collection /recycling will increase by multi-fold. The data showed that the e-waste recycling/collection is capacity limited. If the capacity is increased with increase in number of authorized units in

different geographical areas, the e-waste collection/recycling will exhibit the exponential increase.

When the types of material recovered from recycling of E-waste was compared the interesting results were obtained (Table 2).

Table 2. Types and amount of recycled e-waste by authorized units in Uttarakhand from 2017-2022

Type of recycled E-waste	Recycled Amount (MT/A)				
	2017-18	2018-19	2019-20	2020-21	2021-22
Ferrous Metals	109.9749	954.066	4637.73	14642.99	18487.75
Non-Ferrous Metals	15.19335	195.976	615.93	644	2179.397
Plastic/PVC	24.472	45.894	615.93	430.625	235.725
Hazardous	-	-	1.29	16.81	54.33
Aluminium	1.4601	56.872	131.79	111.402	86.777
Glass	3.4382	9.705	756.81	9.18	114.3
IT & Other Component	13.87623	0.512	0.58	0.44	2.004
Rubber	-	-	-	-	22.308
Mix metals	11.04	-	-	-	-
CFL	-	2.836	62.16	9.6	8.544
Misc.	36.053	-	3158.01	26018.28	27563.2

***Data has been processed from official source: E Waste reports of Uttarakhand Pollution Control Board, (UPCB, 2024).*

Major classes of recycled material were Ferrous and nonferrous material followed by plastic, aluminium and hazardous material (Fig. 2).

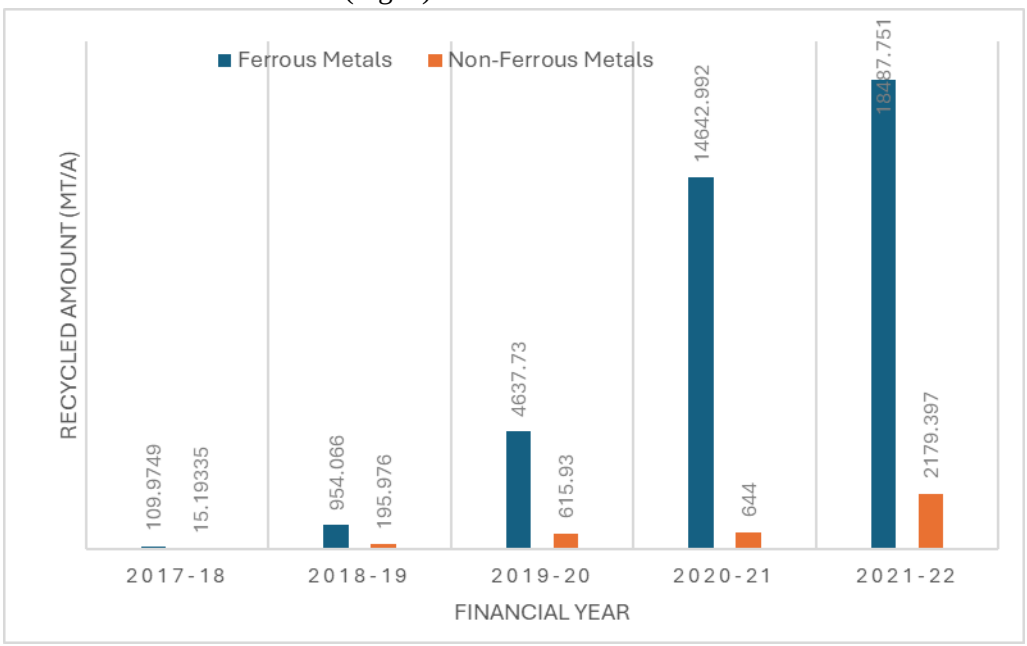

Fig. 2: Recycling of Ferrous and nonferrous material (the major class of recycled material) from 2017-22 by authorized units in Uttarakhand

Strategies to cope with the Tsunami of E-Waste

The key challenges in e-waste management include the widening gap between production

and recycling, rapid technological advancements, increased consumption, limited repair options, design flaws, expanding digital/ICT infrastructure, and inadequate management systems. In response to these challenges, this study proposes the following strategies to address the impending surge of e-waste.

Increasing collecting/ recycling units for environmentally sound management of e-waste

In 2019, India was third largest country generating e-waste (3.2 million metric tons) after China and US (Forti et al 2020). But the amount of e-waste generated per person in India is one-third that of the world, whereas in the USA, it is three times higher than the global average (Forti et al., 2020, GEM 2024). Europe led in e-waste generation, with 17.6 kg per capita in 2022. But at the same time, it also collects and recycles the generated e-waste at the highest rate (42.8%). Additionally, the amount of e-waste produced per person has climbed from 6.4 kg in 2014 to 7.3 kg in 2019 and is predicted to reach 9 kg by 2030 (SDG Report 2021, G12). The serious efforts are needed to boost the e-waste collection and recycling by the formal sector. The E-waste (Management) Rules, 2011, 2016 followed by its amendments in 2018 and 2022 (Ministry of Environment, Forest and Climate Change, 2011, 2016, 2022) emphasizes on the environmentally sound management of e-waste. "Environmentally sound management of e-waste" refers to undertaking all necessary efforts to guarantee that e-waste is managed in a way that shall protect health and the environment against any harmful impacts of e-waste.

In India the number of CPCB authorized dismantlers/ recyclers of e-waste in India have increased from 312 (installed capacity of 782080.62 metric tons per annum) in 2019 to 569 (with installed capacity of 1790348.27 metric tons per annum) in 2023 (CPCB 2023). But still the number is too low to cater the need.

Geographical distribution of recycling units

It was observed that the authorized units are located only in two-three cities. And there is no unit in the hill region of this hill state. This requires urgent attention. The facilitation of establishment of the units must be prioritized and supported in the different geographical regions.

Community awareness campaigns and training programs

The community awareness drives must be undertaken in the entire area. Rather the schools and colleges should be prioritized for the campaign. The debate, poster, quiz, rally like activities should be conducted in the school and colleges to spread the awareness. E-waste management in Uttarakhand, (even in the capital Dehradun) faces challenges due to low awareness levels among communities as highlighted in a previous study conducted in the region (Dimri et al 2002). The district administration should take the responsibility with the support of volunteers. The study showed a good impact of awareness program in the local population of Srinagar and Chauras.

Establishing public E-waste collection system

Until the facility is provided to public for disposal of e-waste the awareness programwill not yield a positive outcome. The school/college and public administration must provide the e-waste dustbins and ensure their proper collection regularly. The retail shops of electric and electronic equipment should provide the e-waste recycling bins. Moreover, the customized systems may be planned for catering the needs of tough geographical terrain like Hill area of Uttarakhand.

Supporting startups and entrepreneurs for EEE sector

With the aim of infusing circular economy (a model of production and consumption that ensures long-term growth) the startups and

entrepreneurs should be supported to work in the e-waste sector. To increase the lifespan of electronic devices, Extended Product Responsibility (EPR) principles should be implemented to ensure that manufacturers take responsibility for their products throughout their lifecycle.

Implementing and promoting relevant government schemes

For extension of life span of e devices apart from EPR, the innovations triggering the reuse of e-waste and converting these into useful products is being supported by Indian Government under the umbrella of various schemes like Swachhta Saarthi Fellowship and Inspire MANAK Award. Reuse of old Lithium-ion batteries and waste UV LEDs of water purifiers for preparing rechargeable tooth sanitizer like innovative studies are contributing to EPR programs (Semalty & Agrawal 2023)

Conclusion

The study concluded that e-waste management in hill region of Uttarakhand is at its nascent stage with lack of awareness in the local population. However, the study demonstrated the positive impact of awareness campaign. The e-waste management in the formal sector through approved collection/recycling units showed a continuous growth in e-waste management as well as recycling of various types of materials during the study period. It also presented the positive future projections. To accelerate e-waste management and recycling efforts in the region for promoting sustainable practices and reduce environmental consequences, strategies like increasing recycling units, geographical distribution of units, awareness campaign etc were recommended.

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