E-Waste Crisis in Moradabad Division a Comprehensive Review of Environmental, Health, Socioeconomic, and Policy Dimensions

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***Abstract*—Moradabad Division, historically renowned for its brassware industry, has evolved into a major hub for informal e-waste recycling in India. This review synthesizes environmental data, health studies, socio-economic patterns, and policy frameworks to present a holistic understanding of the region's e-waste crisis. It proposes culturally rooted, community-driven, and institutionally supported interventions to transform this challenge into a model of sustainable development.**

***Index Terms*—Moradabad industry, E-waste, environmental challenges,**

I. INTRODUCTION

The exponential growth of electronic consumption worldwide has triggered an unprecedented surge in electronic waste (e-waste)[1], making it one of the fastest-growing waste streams globally. India, currently among the top five e-waste generators, produced over one million tonnes in FY 2020–21, with an annual growth rate of 32% (Lama et al., 2023)[2]. This crisis is not merely a technological byproduct- it is a complex intersection of environmental degradation, public health vulnerability, socioeconomic entrapment, and policy inertia.

Moradabad Division, historically celebrated for its brassware craftsmanship, has emerged as a critical node in India's informal e-waste recycling network. Moradabad city alone receives approximately 90 tonnes of e-waste daily, including nearly half of the nation's printed circuit boards (PCBs), which are dismantled and processed in unregulated backyard operations (Centre for Science and Environment [CSE], 2023)[1]. These activities, often carried out by entire families without protective gear, release toxic substances such as mercury, lead, and dioxins into the soil, water, and air-posing severe risks to both ecological and human health.

The informal sector sustains over 50,000 livelihoods in the region, yet perpetuates intergenerational cycles of poverty and exposure. Women and children, disproportionately involved in acid-leaching and sorting, face heightened risks of neurological damage, cancer, and developmental disorders (World Health Organization [WHO], 2021)[4]. Despite the existence of the E-Waste Management Rules (2016), enforcement remains weak at the district level, and India still lacks formal soil contamination standards (Ministry of Environment, Forest and Climate Change, 2016)[3].

This review adopts a multidisciplinary lens to examine the e-waste crisis in Moradabad Division, synthesizing environmental data, health studies, socioeconomic patterns, and policy frameworks. It draws comparative insights from global case studies-such as Guiyu in China and Agbogbloshie in Ghana-where structured interventions transformed informal recycling into safer, formalized systems. The paper also highlights the pivotal role of academic institutions in driving citizen science, curriculum innovation, and culturally resonant outreach.

Ultimately, this study positions Moradabad not just as a site of crisis, but as a potential model for ethical and sustainable e-waste management- rooted in tradition, empowered by community, and led by institutions like Guru Jambheshwar University.

II. E-WASTE SOURCES AND RECOVERY MECHANISMS

- Supply Chain: E-waste arrives via trucks from metropolitan cities like Delhi, Mumbai, and

Kolkata. Local kabadiwalas collect discarded electronics from households and industries.[5]

- Family-Based Operations: Entire families, including children, are engaged in dismantling and acid-leaching processes.[6 - 7]
- Informal Dominance: Over 90% of recycling is unregulated, with no protective gear or environmental safeguards.[8 - 9]

III. ENVIRONMENTAL CONTAMINATION

Soil and Water Pollution

Contaminant	Safe Limit (mg/kg or mg/L)	Moradabad Avg	Fold Increase
Zinc	300 mg/kg	4,500 mg/kg	15×
Mercury	0.01 mg/L (BIS)	0.08 mg/L	8×
Lead	0.05 mg/L	0.22 mg/L	4.4×

- Black Powder Residue: Generated during PCB processing, this fine particulate matter contains concentrated heavy metals and is often dumped untreated.
- Airborne Toxins: Burning of plastics and PCBs releases dioxins, furans, and PAHs, contributing to respiratory and carcinogenic risks.

IV. PUBLIC HEALTH IMPACTS

- Neurological Damage: Mercury and lead exposure linked to cognitive decline and developmental delays.
- Cancer Risk: Long-term exposure to arsenic and dioxins increases cancer incidence.
- Women and Children: Vulnerable groups face compounded risks due to prolonged exposure and lack of healthcare access.

V. SOCIOECONOMIC DYNAMICS

- Livelihood Dependency: Informal recycling sustains over 50,000 individuals, many of whom lack alternative employment.
- Intergenerational Entrapment: Children inherit hazardous roles, perpetuating cycles of poverty and exposure.
- Gendered Labor: Women often handle acid-leaching and sorting, facing disproportionate health risks.

VI. POLICY AND GOVERNANCE GAPS

- Regulatory Loopholes: E-Waste Management Rules (2016) mandate authorization, but enforcement is weak at the district level.
- No Soil Standards: India lacks formal benchmarks for heavy metal contamination in soil.
- Inventory Deficit: Absence of reliable e-waste inventories hampers planning and intervention.

VII. COMPARATIVE GLOBAL PERSPECTIVES

- China: Guiyu, once the world's largest e-waste hub, transitioned to formal recycling zones through government intervention.
- Ghana: Agbogbloshie's informal sector was restructured with community-led training and green tech adoption.
- India's Opportunity: Moradabad can become a pilot for ethical e-waste management rooted in cultural and academic leadership.

VIII. ROLE OF ACADEMIC INSTITUTIONS

- Citizen Science: Universities can lead community mapping of contamination zones.
- Curriculum Integration: Embed e-waste awareness in environmental science and vocational programs.
- Research Hubs: Establish interdisciplinary centers focused on circular economy models and green technologies.

IX. RECOMMENDATIONS

Domain	Actionable Steps
Policy	Introduce soil standards, enforce licensing, and incentivize formalization
Health	Mobile clinics, diagnostic camps, and protective gear distribution
Education	School programs, vocational training, and university-led awareness drives
Technology	Pilot green recycling units and low-cost in-situ treatment for black powder
Community	Culturally resonant outreach and participatory governance

X. CONCLUSION

Moradabad Division's e-waste crisis is not just an environmental challenge it is a socio-cultural and institutional opportunity. By blending tradition with innovation, and empowering communities through academic leadership, the region can pioneer a new model of ethical, sustainable development. Guru Jambheshwar University and its allies are uniquely positioned to lead this transformation.

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