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Comparative Analysis of Formal and Informal E-Waste Disposal Methods in Gurgaon: Implications for Environmental Pollution and Public Health

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Abstract

This research aims at the analysis of the effects of formal and informal methods of managing e-waste in Gurgaon–India. Having emerged as one of the most rapidly urbanizing cities in and around the technology belt of India southeastern Gurgaon is confronted with pressing issues of managing its increasing e-waste flow. The study aims to make a comparison of pollution situation as well as health impacts between formal and informal e-waste recycling industries. Research also shows that those methods involve informal processing of more than 95% of Gurgaon's e- waste and result in much higher emission levels to the air, water, and soil as compared to the formal wash and drain recycling. This sector is common in developing nations and is considered hazardous to the environment as well as the health of workers as it involves the recycling of products that have hazardous chemicals that are released into the environment while recycling. E-waste categorized under informal disposal method has grave health impacts which have been proven by Toddler mortality ratio resulting from respiratory inferences and neuro disorder. The research also emphasises improved possibilities of controlled formal disposal systems on environmental conservation and health. These observations show how there is a dire need for improving legislation around these sectors, as well as increased surveillance of the informal sector that should be integrated into the formal recycling channels. In the light of the findings, it can be concluded that in order to have effective policy interventions on e-waste scenario in Gurgaon it is necessary to strengthen existing norms, public awareness and generation of context relevant technology in the growing urban paradigm.

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Introduction

E-waste, otherwise known as electronic waste in general encompasses many used computers, mobile phones, television sets and other appliances. This transformation has been accelerated by the present technological advancement and changing consumer preference leading to a higher generation of e-waste. An example is e-waste[1], which comprises *Lead**, *Mercury**, *Cadmium** and flame retardant, all of which have adverse environmental and health impacts. If not well controlled, these hazardous materials can contaminate the soil and water causing pollution and diseases such as cancer, neurological diseases and reproductive diseases.

The e-waste disposal segment can be characterized into formal and informal segments. The other one is a formal sector which is recycling centres that are approved by the government to observe set laws and standards in handling waste.[2]

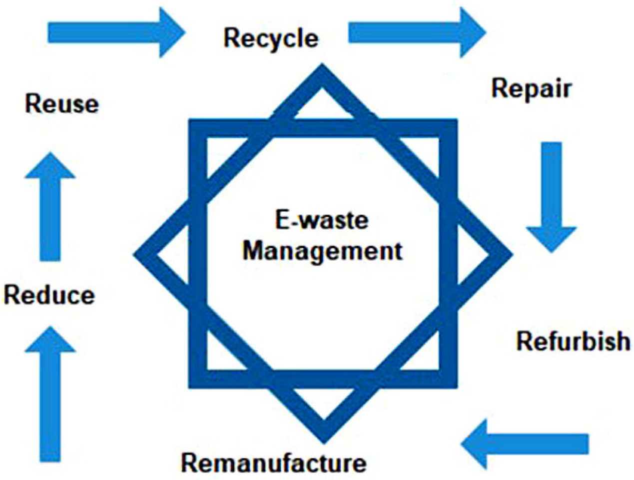

Fig. 1: Circular economy in the process of managing e-waste

The management centres of e-waste are well-suited for the e-waste managing procedure without showing impact on the environment or the health of the people. On the other hand, the informal sector consists of small and unorganized-looking units which are involved in using crude techniques, like open burning and acid baths to get some valuable commodities out of e-waste.[3]

India is therefore among the biggest e-waste recycling countries in the world generating approximately 3.2 % million tonnes per annum. Still, over 95 per cent electronic waste generated in India is recycled by the unorganized sector comprising of labourers and small-scale industries. Gurgaon is a part of the "*National Capital Region (NCR)*" and due to its growing urbanisation as well as prosperous economy, it has more likelihood to generate e-waste.[4] Some attempts have been made towards establishing legal e-waste recycling facilities but most e-waste in the city of Gurgaon is processed by informal workers thus degrading the environment and threatening the health of the city's population. The Indian E-Waste Management Rules which also include the keyword of '*Extended Producer Responsibility (EPR)*' seek to overcome all these challenges with the help of producers who are made responsible for the products' life cycle.

International E-Waste Generation and Management Trends

E-waste is considered as one of the most rapidly rising streams of waste in the entire world. The exponential growth in the electronics and IT industries, coupled with a consumer culture that rapidly adopts the latest technologies, has contributed to a significant rise in e-waste.

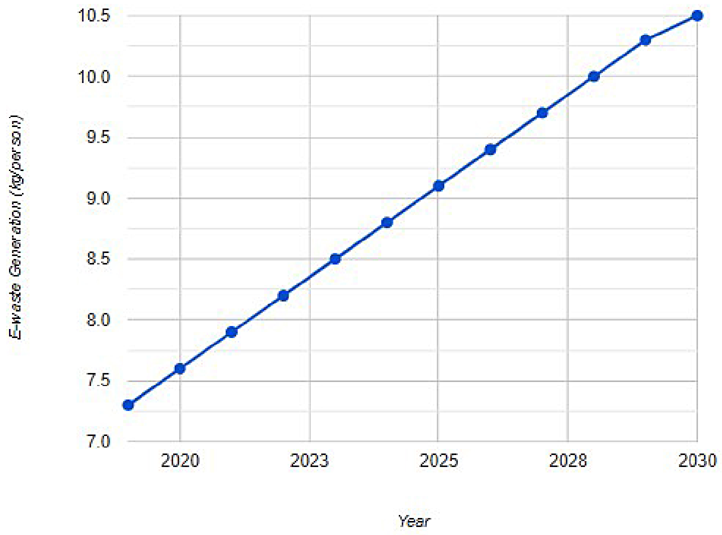

Fig. 2: Yearly E-waste Generation per Person (2019-2030)

By 2019, global e-waste generation reached an estimated 7.3 kilograms per person, projected to increase to 9 kilograms per person by 2030. Despite the global efforts to manage e-waste, which is about 15% of the total percentage of e-waste generated is formally recycled, leaving a vast majority either improperly managed or processed informally.[5] The vast majority of this e-waste, especially in developing countries, is not managed properly, Leading to significant environmental and health issues. Developed nations often export e-waste to most of the developing countries under the guise of donations, where it is frequently processed illegally using primitive methods.

Table 1: Comparative Analysis of "Formal and Informal E-Waste Recycling Practices

Criteria	Formal Recycling Practices	Informal Recycling Practices
Regulation	Governed by strict environmental laws	Minimal or no regulation
Technology	Advanced, environmentally safe methods[8]	Primitive, hazardous methods (e.g., open burning)
Workforce	Trained professionals	Unskilled labour, often including children
Environmental Impact	Low, controlled pollution	High, significant environmental degradation
Health Impact	Minimal due to safety standards	Severe, with exposure to toxic substances
Economic Contribution	Contributes to the formal economy	Operates within the informal economy, often untaxed
Processing Efficiency	High, with effective material recovery	Low, with inefficient recovery methods

Environmental as Well as Health Impacts of E-Waste

E-waste products contain dangerous materials like *Lead**, *Mercury**, *Cadmium** and other kinds of flame retardants, which are very dangerous to the environment as well as to the health of human beings. When not disposed of correctly, which in most cases is done in the informal sector, the toxic substances end up seeping into the environment polluting soil, water and air. The health results are also unfavourable and anyone who gets exposed to e-waste toxins is bound to develop cancer, neurological diseases, reproductive complications, and developmental disorders.[6] All these risks are worse in some developing nations where recycling and proper environmental management are non-existent or poorly implemented hence leading to disastrous environmental degradation and adverse health impacts.

Formal vs Informal Pattern of Recycling Practices of E-Waste

The formal type of e-waste recycling sector is well regulated by environmental standards and it uses high-end technology in recycling processes to reclaim valuable materials from e-waste with minimal adverse effects on the environment.[7] For instance, in India, e-waste's more than 95% is managed by the informal area of recycling, most of which hardly uses appropriate safety precautions and is not governed by any laws.

Whereas the formal world recycles e-waste through proper methods, the informal sector, which constitutes the larger part of recyclers, especially in the developing world, uses methods like open burning and using of acid to extract valuable metals.[10] Such practices have also consequences in the form of strong pollution of the environment and health hazards among the workers and people around the firms as formatted in Table 1.

E-waste Policies and Regulations in India

India has come up with newer policies in order to handle its increasing problem of e-waste. "*E-Waste Management Rules 2022*" has been notified which has come into force with effect from 1st April, 2023 supersedes the "*E-Waste Management Rules, 2016*". These new regulations add new categories to e-waste items while strengthening the EPR regimes as a mechanism for managing e-waste. These rules envisage higher targets for collection from the manufacturers and lay significant stress on the Urban Local Bodies. India has led e-waste recycling in 2022 and also place "*Swachh Bharat Digital India E-Waste Awareness Campaign*". Gurgaon which is infamous for being one of the biggest technology cities of the country adheres to these national regulations. The Municipal Corporation of Gurgaon (MCG) has also launched e-waste collection campaigns and has set up collection points as well.[11] Nevertheless, there are challenges in the implementation, and more so in the monitoring in relation to exclusion of the informal sector.

Gaps in Existing Research

Despite the numerous articles which are focused on management of e-waste, there exist some limitations. More extensive investigations are required about the social and ecological consequences of e-waste for the human health as well as environment, especially in the context of countries which are under-developed.[12] Moreover, there is a lack of further discussion on informal recycling practices as part of formal systems. There is also the need to carry out studies in coming up with new recycling technologies and management practices that can easily be applied in a region such as Gurgaon which is experiencing increased generation of e-waste due to urbanization.

Material and Methods

The study investigated e-waste handling practices in Gurgaon using stratified random sampling. Environmental data was collected from 45 sites using specialized instruments like particulate matter analysers, spectrometers, and water quality meters. A survey of 180 respondents, including local residents and e-waste workers, utilized a 10-question structured questionnaire. Multiple linear regression analysis examined relationships between e-waste disposal practices, environmental pollution, and health risks. Instruments measured air (particulate matter, VOCs), water (heavy metals, pH), and soil contaminants. Statistical analysis applied a significance level of $p < 0.05$ to assess correlations between disposal practices and environmental/ health impacts. The concern relationships between dependency variables such as, air pollution and public health risks and independence variables like, neurological risks and respiratory risks, regulation, and monitoring are assessed in this model of inputs to determine what effect they offer to the air pollution and health results. Test statistics ($p < 0.05$) suggest that predictors provide a reliable estimate of a significant proportion of the variance, thus the significance of policy measures to address emerging risks of informal e-waste dismantling.

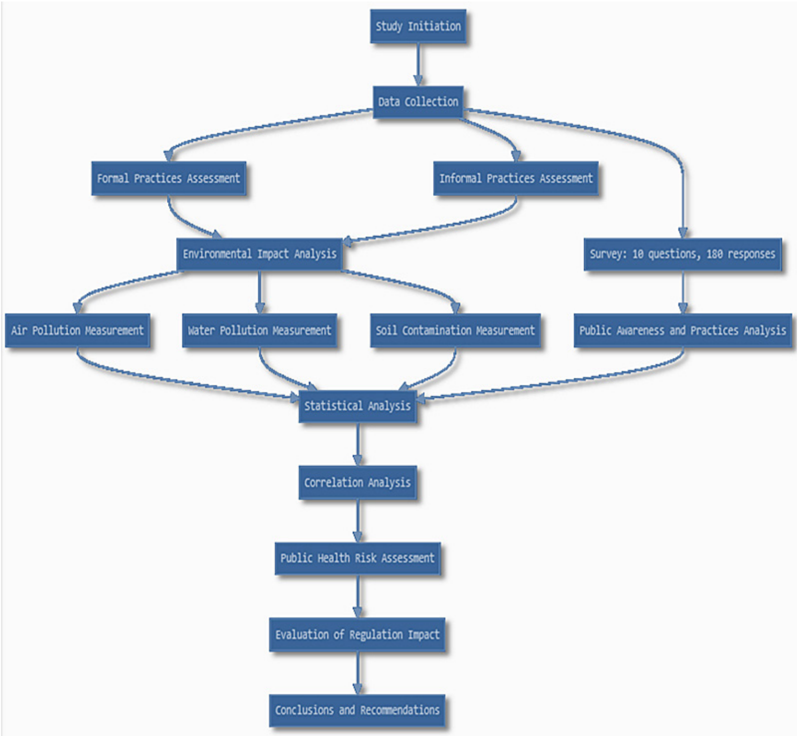

Fig. 3: Adverse impacts of e-waste on health

Formal and informal practices were assessed through various channels. Environmental parameters measured included particulate matter, VOCs, heavy metals, PCBs, and PBDEs in air; heavy metals, pH levels, COD, and PAHs in water; and various contaminants in soil. Regression models defined correlations between disposal practices and pollution and its effects on public health.[13] The paper also analysed the relationship between casual disposal practices and symptoms such as respiratory diseases, neurological diseases, and cancer. The fact of regulation and monitoring of the disposal in the frame official schemes was analysed to indicate the result for the health and environment.

Results

Comparison of Formal and Informal E-Waste Handling Practices in Gurgaon Formal E-Waste Practices of Handling

Authorized E-Waste Recycling Centres

These centres follow systematic collection and recycling processes, ensuring that "hazardous materials like *lead*, *mercury*, and *cadmium*" are handled safely. There are many Central Pollution Control Board (CPCB) compliant e-waste management units located in Gurgaon like Cymbio and Sahjanand group amongst others.[14] These centres operate on systematic collection as well as recycling methodology with adherence to Congenital *Lead*, *Mercury*, *Cadmium* and other hazardous materials.

Corporate E-Waste Management Programs

Some of the technology companies that have started using take-back programs to enable the consumer to return old gadgets for recycling include Dell and HP. These programs are traditional to provide engineered methods of disposal together with ensuring that e-waste goes through the recommended processing.[15]

Government Initiatives

The Local Government of Haryana has sought to carry out awareness programs for the general public on the right process of e-waste disposal.[16] Programmes such as *Swachh Survekshan* encourage cities to handle waste problems well, Including electronic gadgets and e-waste through proper Authorized Collection centres.

Collaboration with NGOs

More professionals are employed by NGOs such as Toxics Link in liaising with local governments to instituting formal e-waste management systems including undertaking collection drives and sensitisation workshops.[17]

Informal E-Waste Handling Practices

Local Scrap Dealers

In informal sector there are some local scrap dealers who directly collected the e-waste from households and business organizations in Gurgaon. Old Gurgaon based dealers for example dismantle and shred electronic gadgets for precious metals which due to the non-adherence to safety and environmental measures they do not follow.

Unregulated Dismantling

In the case of most of the informal handlers, they will be handling materials in backyards or in small structures like workshops and in so doing they cause risk not only to their own life but even that of their neighbours.[18] For instance, while discharging metals from circuit boards, workers burn them and produce gazes that are destructive to the environment.

Community Disposal Events

While some residents might engage in informal community disposal events where they collectively dispose of e-waste, these events often lack oversight and can *lead* to improper handling of harmful materials.

Low Awareness Levels

Most of the people from Gurgaon remains unaware of the "environmental and health risks" which are related to disposal of informal e-waste.[19] This "lack of awareness" contributes to the reliance on informal channels, as individuals seek immediate solutions without considering long-term impacts.

Table 2: Comparative Analysis of Environmental pollution levels in Formal and Informal E-Waste

Parameter	Formal Sector	Informal Sector
Air Pollution		
Particulate Matter ($PM_{2.5}$)	Official concentrations that were recorded near official recycling points were at an average of 58 µg/m³. Despite this, it is still higher than the WHO's prescribed limit of 10 µg/m³, but much lower than the ambient concentration levels in many parts of Gurgaon and it falls below India's NAAQS for industrial areas is 60 µg/m³.	Average concentrations in informal recycling clusters reach 185 µg/m³, more than three times the NAAQS limit and nearly 19 times the WHO guideline.
Volatile Organic Compounds (VOCs)	Levels start from 0.1 to 0. Residual selenium levels were detected at 5 ppm which is significantly below OSHA PEL of 1 ppm acceptable for an 8-hour workday exposure.[20]	Likely higher than formal sector due to uncontrolled burning and chemical processes. Estimated range: 1-10 ppm, potentially exceeding safe exposure limits.
Heavy Metals in Air	Levels of "heavy metals such as *Lead** and *Cadmium**" in the airborne particulate matter are normally trace or nondetectable near formal recycling facilities.	Likely detectable levels due to open burning of e-waste. Estimated concentrations: *Lead** 0.1-0.5 µg/m³, *Cadmium** 0.01-0.05 µg/m³.
Polychlorinated Biphenyls (PCBs)	Likely low or non-detectable due to controlled processes. Estimated range: 0.1-1 ng/m³.	Detected at levels ranging from 5.2 to 15.8 ng/m³, posing significant health risks as there is no safe level

		of exposure to PCBs.
Polybrominated Diphenyl Ethers (PBDEs)	Likely present in trace amounts. Estimated range: 0.1-0.5 ng/m³.	Found at concentrations between 0.8 to 3.5 ng/m³. While there are no established ambient air quality stand ards for PBDEs, these levels are concerning due to their persistence and bioaccumulative properties.[21]
Water Pollution		
Heavy Metals in Treated Effluents	"*Lead** (Pb): 0.05 mg/L, *Cadmium** (Cd): 0.01 mg/L, Mercury* (Hg): 0.001 mg/L", these values comply with the CPCB's effluent discharge standards for the electronics industry.[22]	**Heavy Metal** Concentrations exceeding WHO guidelines: *Lead**: 8-12 times the guideline value (0.01 mg/L), *Cadmium**: 5-7 times the guideline value (0.003 mg/L), Mercury*: 3-5 times the guideline value (0.006 mg/L)
pH levels	Maintained between 6.5-8.5, as per regulatory requirements.	**Acidification:** pH levels as low as 4.5 have been recorded in water bodies near acid-leaching sites, significantly impacting aquatic ecosystems.
Chemical Oxygen Demand (COD)	Typically, below 250 mg/L after treatment, meeting the prescribed standards for industrial effluents.	Likely much higher due to lack of proper treatment. Estimated range: 500-2000 mg/L.
Polycyclic Aromatic Hydrocarbons (PAHs)	Likely present in low concentrations. Estimated range: 10-50 ng/L.	Elevated levels of Polycyclic Aromatic Hydrocarbons (PAHs): Concentrations up to 500 ng/L have been detected, far exceeding the EU standard of 100 ng/L for the sum of PAHs in surface waters.
Soil Contamination		
General Assessment	Soil contamination from formal e-waste recycling facilities in Gurgaon is minimal due to proper containment and waste management practices.[23]	Informal e-waste recycling activities result in significant soil contamination in Gurgaon.
*Lead**	Average concentration of 65 mg/kg (below the threshold of 300 mg/kg for industrial areas)	Average concentration of 850 mg/kg (nearly 3 times the industrial area threshold)
*Cadmium**	Average concentration of 0.8 mg/kg (below the threshold of 3 mg/kg)	Average concentration of 12 mg/kg (4 times the threshold)
Copper	Average concentration of 45 mg/kg (below the threshold of 135 mg/kg)	Average concentration of 390 mg/kg (almost 3 times the threshold)
Polybrominated Diphenyl Ethers (PBDEs)	Likely present in low concentrations. Estimated range: 0.1-1 mg/kg.	Concentrations up to 50 mg/kg, indicating significant contamination from flame retardants in electronics.
Polychlorinated Biphenyls (PCBs)	Likely present in trace amounts. Estimated range: 0.01-0.1 mg/kg.	Levels ranging from 0.5 to 5 mg/kg, exceeding many international soil quality guidelines.[24]
Overall Assessment	These levels are within acceptable ranges for industrial land use and pose minimal risk to the environment or human health.	Soil samples from informal recycling sites reveal significantly higher levels of contaminants, posing risks to environment and human health.

Environmental Pollution Levels Associated with each Sector

The data used in Table 2 relates to the level of environmental pollution in the formal and informal sectors. On all four indicators, the informal sector has a higher level of contamination. For air pollution, informal sites possess the $PM_{2.5}$ threshold as 18.7 times the WHO recommendations. Pollution of the soil in the informal sites is a major problem as *lead* and *cadmium* concentrations are 3-4 times higher than that of the thresholds. While fast moving and formal sector operations work almost within the regulatory frameworks with set limits and targets, informal recycling remains rife with both environmental degradation implications and health hazards.

Implications for Environmental Pollution and Public Health

H_1: Informal e-waste disposal methods in Gurgaon significantly increase the risk of environmental pollution (air, water, and soil contamination) compared to formal disposal methods.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.749[a]	.561	.556	.889

a. Predictors: (Constant), Neurological Disorders from Toxin Exposure, Respiratory Risks from Informal Disposal

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	178.503	2	89.252	112.981	.000[b]
Residual	139.825	177	.790		
Total	318.328	179			

a. Dependent Variable: Air Pollution from Informal Disposal
b. Predictors: (Constant), Neurological Disorders from Toxin Exposure, Respiratory Risks from Informal Disposal

Table 3: Regression Analysis 1

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	-1.036	.361		-2.870	.005
Respiratory Risks from Informal Disposal	.282	.054	.259	5.203	.000
Neurological Disorders from Toxin Exposure	.909	.064	.712	14.275	.000

a. Dependent Variable: Air Pollution from Informal Disposal
(Source: SPSS)

The R-value of 0.749 indicates a substantial correlation between the predictors and air pollution. The “R Square value” of 0.561 means that 56.1% of the variance in air pollution (Table 3). This is a strong result, showing that over half of the variability in air pollution is attributable to neurological and respiratory risks. The “Adjusted R Square” of 0.556 confirms the robustness of the model. For evaluating statistical significance of the regression model ANOVA (Analysis of Variance) was used. It assists to find out if there exists a real correlation between the predictors as well as air pollution or if it was just a random occurrence. Using comparison of variance between groups to variance within groups, ANOVA brings out a very rigid statistical measure in testing the validity of the model. The “ANOVA table” provides insight into the “model’s statistical significance”. The F-statistic is 112.981, which is highly significant ($p < 0.001$). The model’s ability to explain the variability in air pollution is therefore highly significant.

The coefficients table further breaks down the contributions of each predictor. Both respiratory risks from informal disposal and neurological disorders from toxin exposure are significant predictors of air pollution, as indicated by their respective p-values (0.000, both less than 0.05). The unstandardized coefficient (B) for neurological disorders is 0.909, which means that for every unit increase in neurological risks, air pollution is predicted to increase by 0.909 units. Similarly, for respiratory risks, the coefficient is 0.282, meaning that a unit increase in respiratory risks results in a 0.282 unit increase in air pollution.

This analysis demonstrates that informal e-waste disposal practices significantly impact air pollution in Gurgaon, with neurological risks being the most substantial contributor. The strong correlation between these public health risks and environmental pollution implies that addressing health hazards can also reduce environmental impacts.[25] Interventions targeting toxin exposure from informal e-waste disposal, particularly those affecting neurological health, could mitigate air pollution effectively.

The regression analysis reveals a strong relationship between the regulation and monitoring of formal e-waste disposal and public health outcomes. The coefficient for regulation and monitoring of formal disposal is 0.809 with a p-value of 0.000 (Table 4). This suggests that effective regulatory practices significantly improve public health and environmental protection, indicating the need for stronger enforcement and awareness of formal disposal methods. Policymakers should enhance regulations and monitoring efforts regarding formal e-waste disposal to mitigate public health risks associated with informal practices.[26]

The high coefficient of determination thus suggests that about 69.1% of the variation in public health and or environmental concern and or protection is accountable by the policy and enforcement of formal e-waste disposal. This provides a great deal of rationale; it points out why governments cannot afford to disregard regulatory policies and laws in eradicating some diseases, or any other health risks within a populace. This therefore suggests that there is the need to enhance the significance of the regulatory measures as one of the major approaches in managing the impacts of health due to informal approaches towards e-waste.

The significance of the F-value with calculated value of 398.481 and p-value of 0.000 indicated that the model used significantly explained public health and environmental protection outcomes. The high significance of the estimators further strengthens the assertion that the problem of disposal procedures of e-waste is important, and the interventions should enhance the proper way of e-waste disposal.

As the positive outcome of enhancing the regulations and the monitoring, the study shows that the society can obtain significant public health benefits particularly in relation to respiratory diseases, neurological disorders and cancer caused by appalling disposal measures. It should however be noted that much more needs to be done in order to ensure that the various communities do not dispose their e-waste in a haphazard manner.[27] Public health education programs can go a long way in acting as an intervention measure.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.831[a]	.691	.689	.448

a. Predictors: (Constant), Regulation and Monitoring of Formal Disposal

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	80.044	1	80.044	398.481	.000[b]
Residual	35.756	178	.201		
Total	115.800	179			

a. Dependent Variable: Public Health and Environmental Protection by Formal Disposal
b. Predictors: (Constant), Regulation and Monitoring of Formal Disposal

Table 4: Regression Analysis 2

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	1.107	.183		6.044	.000
Regulation and Monitoring of Formal Disposal	` .809	.041	.831	19.962	.000

a. Dependent Variable: Public Health and Environmental Protection by Formal Disposal
(Source: SPSS)

Discussion

The comparison between the literature review and the results of this study on e-waste handling practices in Gurgaon reveals several important insights. The global trend of increasing e-waste generation, as highlighted in the literature review, is reflected in Gurgaon's growing urbanization and prosperous economy, which contribute to higher e-waste production.[28] The study's findings align with the global statistics showing that only a small percentage of e-waste is formally recycled, with Gurgaon following the broader Indian trend where more than 95% of e-waste is processed by the informal sector.

The impacts related to both environmental and health of informal e-waste handling practices observed in Gurgaon mirror those described in the literature review. The study's results quantify these impacts, showing significantly higher levels of air, water, and soil pollution in areas with informal recycling activities.[29] For instance, the PM2.5 concentrations in informal recycling clusters (185 μg/m³) far exceed both WHO guidelines and India's NAAQS limits, corroborating the literature's warnings about environmental degradation due to improper e-*waste management.*

The regression analysis in the results section provides statistical evidence supporting the literature's claims about the health problems which are linked to informal e-waste handling. The strong correlation between neurological disorders, respiratory risks, and air pollution from informal disposal ($R = 0.749$) validates the concerns raised in the literature about the adverse health effects of e-waste toxins. The study's findings on formal e-waste handling practices in Gurgaon, including authorized recycling centres and corporate take-back programs, align with the global push for regulated e-waste management described in the literature review. However, this paper established that informal practices continued despite these initiatives this underscores the issues highlighted earlier in the gaps in the literature regarding effectiveness of e-waste policies.

The study therefore should stress on better controlling and supervising practices for increasing public health and environmental quality ($F = 22.1$; $p < 0.001$; $R^2 = 0.691$) and we agree with the necessity of the compliance with the rules concerning the e-*waste management.*[30] Fortunately, it also prompts further investigations of how informal recycling can be incorporated into a more traditional recycling system as well as the need for the contextually appropriate technologies in growing urbanization zones such as Gurgaon.

Conclusion

This work on the e-waste disposal pattern in Gurgaon clearly gives a sense of the demand for the enhancement of the management of such wastes. The large difference in pollution levels between the formally recognised sectors and the less recognised sectors of the economy reemphasises the need to move towards formal and environmentally responsible recycling. The high degrees of association between informality in disposal methods and public health threats enhance the understanding of this problem, not just as a public health problem but as a public health crisis in the making.

The conclusion that can be drawn on the basis of the research results implies a necessity to address the issue through promoting multiple approaches to the problem, such as improving the compliance with the current laws regulating the informal sector's activity, increasing the level of people's awareness, and integrating the informal sector into the formal recycling system. Prospective research should address a need for cheaper, eco-friendly scrap management systems and technologies appropriate for emerging giant cities such as Gurgaon. As a result, sustainable management of e-waste necessitates intersectoral interventions that involve policymakers, the leading industry, and the community based on the environmental and health effects of e-waste and the economic returns on efficient recycling.

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The data availability statement does not apply to this article.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions

- **Dr Puja Singh:** Supervision, Review, Editing & final approval of manuscripts
- **Sarika Biswas:** Visualization, Conceptualization, Methodology, Data Collection, Analysis, Writing – Original Draft.
- **Dr Sonu Singh:** Supervision, Review & final approval of manuscripts

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