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ANALYZING THE IMPACT OF KNOWLEDGE AND CULTURAL FACTORS ON E-WASTE MANAGEMENT PRACTICES IN INDIA – AN APPROACH TOWARDS SUSTAINABILITY

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Abstract

With the technological advancement and changes in the working and lifestyles of people and industry, the rate of obsolesce of electrical and electronic equipment and gadgets, particularly computers and mobile phones, is high, posing a threat to health and environment creating a threat to sustainability for nations around the globe. Realizing the difficulties of e-waste management, many developed countries have started dumping the e-waste to developing nations that suffer from resources constraints, thus leading to hazardous activities mainly in the informal sector. Therefore, we are motivated to examine whether the awareness of the environment, attitudes, and beliefs, particularly knowledge (constructs), impact practices relating to management of e-waste in India. Analysis of the results of our survey of 180 respondents through SEM model show an insignificant association of these constructs with e-waste management practices. However, we find a significant mediating role of Environmental Knowledge in all these relationships.

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I. Introduction

E-waste is posing a huge threat to the ecological environment and sustainability of nations. The advancement and rapid technology change have resulted in the fast-technological obsolescence of the electronic and electrical equipments and appliances(Awasthi et al., 2018), particularly the category of computers and mobile phones. In common parlance, the obsolescence of electrical and electronic equipment (EEE) which include variety of devices and equipments are titled as e-waste/technological waste/waste from electrical and electronic equipment (WEEE). According to Hossain, Al-Hamadani and Rahman (2015) – "the statistics of United States Environmental Protection Agency (USEPA) indicates spurt in the growth of e-waste as a proportion of global solid waste generation". The likely increase in e-waste between the period 2020 and 2030, according to the report of United Nations University (UNU) is 38% (Pandey, 2020).

The highest e-waste producing country is china, with 10.129kt, and in comparison, India produces 3.230kt. In the South Asian region, India is the country that has emphasized proper e-waste management through legislation (Mittal, 2020a, 2020c). Researchers and analysts have argued that there is a dire need for a global multilateral agreement that can take care of the diverse negative health effects of E-waste coupled with potential eco-toxicological impacts.

Recyclizing of e-waste is a ticklish issue for the sustainable development of a developing country like India. The majority of recycling activity is unauthorized (Borthakur and Govind, 2017). Poor awareness and lack of knowledge of the adverse implications of improper e-waste recycling

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creates a considerable danger to health of humans and our environment (Fowler, 2017). South Asian countries are undergoing rapid transition and transformation in the socio-economic systems and many of these countries, e-waste management is ineffective and its realization is deficient.

E-waste is found to be more hazardous compared to the other types of municipal wastes because of the facts that EEE contain significant mixtures of poisonous and dangerous chemicals that can quickly affect the vital human body systems. The e-waste composition varies according to the type of e-waste. The constituents are classified into hazardous and non-hazardous categories, mainly comprising ferrous and non-ferrous metals. We find the presence of precious metals like platinum, palladium, gold etc. in e-waste and also hazardous metals and substances like cadmium, mercury, lead, arsenic, hexavalent chromium, selenium etc. if their value goes above threshold levels. Needhidasan et al. (2014) has illustrated the important types of toxic metals comprised in E-waste and their consequential impact on human body (Table 1).

Table 1 – Toxic Metals and Health Effects

"Materials	**Weight (%)**	**Recycling (%)**	**Location**	**Effects**
Lead	6.2988	5	Acid battery, CRT	Kidney failure, central and peripheral nervous systems, damage to the reproductive systems
Cadmium	0.0094	0	Battery, CRT, housing	Long term cumulative poison, Bone disease
Mercury	0.0022	0	Batteries, switches, housing	Chronic damage to brain, liver damage, causes damage to the central and peripheral nervous systems as well as the fetus
Chromium VI	0.0063	0	Decorative hardener, corrosion protection	DNA damage, lung cancer

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“Materials	**Weight (%)**	**Recycling (%)**	**Location**	**Effects**
Plastic	22.99	20	Computer mouldings, cablings	Generates dioxins and furans“

The technologies for recycling e-waste are inferior, and there is evidence of illegal export of large quantities of e-waste flowing from the developed countries to developing countries (Needhidasan, Samuel and Chidambaram, 2014). Backyard recycling is a critical activity that carries hazards performed majorly in the informal sectors. The environment distorting activities are highest in Delhi and Mumbai which has conventional been the dump yard of e-waste from OECD countries. As per GTZ-MAIT (2007), 50,000 tonnes of WEEE were imported to India every year. The current figures have skyrocketed to levels more than 50 times and India is becoming a big market for imported E-waste.

The techniques required for processing and extraction of materials and metals from the E-waste that addresses the issue of environment effectively are complex requiring specialised skills and processes. Accordingly, the practices adopted by recyclers are dangerous and threat to environment. These practices are conventional and commonly applied to all types of e-waste.

Extended Producer Responsibility(EPR) embedded in the policy framework makes manufacturers (producers) shoulder responsible from the initiation of manufacturing stage to the end of product life cycle at consumer end(van Rossem, Tojo and Lindhqvist, 2006). In the product life cycle, all the actors share the responsibility in principle, but it is the actor's influence that determines the effectiveness of the EPR. To meet the global challenges of sustainability, low-impact manufacturing and energy efficiency in instruments is of paramount importance(Kumar et al., 2005; Nnorom and Osibanjo, 2008). In developing countries like India, awareness and

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knowledge of suitable e-waste management practices is extremely low(Miner et al., 2020).

Safe disposal of e-waste requires conscious and concerted efforts (Okwesili, Chinyere and Chidi Iroko, 2016). A study conducted by Sari, Masruroh and Asih (2021) shows that "government drivers, facility accessibility, and personal attitudes significantly influence consumer intentions through the behavioural variables". Still, subjective norms and economic drivers exert no influence on consumer intentions. The research questions are – (a) Whether the level of awareness and behavioural factors create any influence on e-waste management practices and (b) Do environmental knowledge play a role in e-waste disposal and recycling practices.

A large number of researches attempt to address this issue and have indicated the importance of awareness of the environment, attitudes, and beliefs of people on management and disposal of e-waste (Nnorom and Osibanjo, 2008; Ong and Musa, 2012; Ali and Batool, 2015; Mishra, Shamanna and Kannan, 2017; Ghazali et al., 2019; Andeobu, Wibowo and Grandhi, 2021). Lack of knowledge and absence of regulation has been cited as important factors affecting management practices of e-waste in developed and developing world. We, in this paper, examine whether the awareness of the environment, attitudes, and beliefs, and, more particularly, knowledge (constructs) impact the e-waste management practices in an Indian context (Mittal, 2020b).

II. Material and Methods

We analyse the impact of knowledge, awareness, and behavioural constructs on e-waste management (recycling) practices. We have used SEM - structural equation modelling to establish the relationship between perceived behaviour and E-waste management practices. Constructs used for analysis and model development are given in Table 2.

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Table 2 - Selected Constructs and Reference Studies

Construct(s)	Reference Studies
A: Environmental Knowledge	
Health(EK1)	Azodo et al., 2017; Bhat & Patil, 2014; Brijesh, 2016; Miner et al., 2020; Mishra et al., 2017; Work & Centres, 2020
Economic(EK2)	
Legal Norms(EK3_	
Experience(EK4)	
B: Environmental Awareness	
Biospheric value Orientation(EAW1)	Ghazali et al., 2019; Han et al., 2017; Lind et al., 2015; Sari et al., 2021; Shin et al., 2017; Verma et al., 2019
Altruistic Values (EAW2)	
Egoistic Values(EAW3)	
C: Perceived Behaviour	
Ease(PEB1)	Mwanza et al., 2017; Ong & Musa, 2012; Turaga et al., 2019; Yuan et al., 2016
Disposal Practice(PEB2)	
Regulatory Pressure(PEB3)	
D: Subjective Norms	
Personal Attitudes (SN1)	Ajzen, 1991; Han et al., 2010; Khan et al., 2019; Sari et al., 2021; Wu & Chen, 2014
Social Pressure(SN2)	
Geographical Area Practices(SN3)	
E: E-waste management Practices	
Recycling(EMP1)	Ali & Batool, 2015; Andeobu et al., 2021; Bimir, 2020; Nnorom & Osibanjo, 2008
Reverse Logistics(EMP2)	
Dumping(EMP3)	
Reuse(EMP4)	

The following Null-hypotheses have been formulated and tested.

H_1: Environmental Awareness has no association with the E-waste management practices

Awareness about the environmental impact/hazards of e-waste creates a significant influence on the management of e-waste(Samar Lahiry, 2019; Nuwematsiko et al., 2021)

H_2: Perceived Behaviour has no association with E-waste management practices

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The attitude and behaviour towards e-waste management influences the management of e-waste (Borthakur & Govind, 2017; Shevchenko et al., 2019)

H_3: Subjective Norms have no association with E-waste management practices

H_4: Environmental Knowledge has a mediating role between indicators of Environmental Awareness, Perceived Behaviour, Subjective Norms, and E-waste management practices

We have administered structured questionnaires through the google platform to 180 respondents using the snowball sampling technique. Respondents are adults (>18 years) who are dealing in or directly involved in e-waste recycling in Delhi-NCR, the national capital region of India. Out of 180, we received 172 valid responses with a success rate of 95.5%. The sample size is adequate as per KLEIN (2005) who suggest that for relaibility of structural equation models, the respondents between 100-150 are sufficient. The questions in the survey instrument uses Likert scale [1=Strongly Disagree, 2= Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree]. To run SEM, we have checked the construct validity and reliability as given in Table 3.

Table 3 – Test for Reliability and Convergent Validity

Construct	Loadings	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
A: Environmental Knowledge				
EK1	0.591	0.682	0.808	0.515
EK2	0.746			
EK3	0.776			
EK4	0.743			
B: Environmental Awareness				
EAW1	0.903	0.635	0.792	0.565
EAW2	0.689			
EAW3	0.635			
C: Perceived Behaviour				
PEB1	0.465	0.637	0.756	0526

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PEB2	0.932			
PEB3	0.701			
D: Subjective Norms				
SN1	0.807			
SN2	0.477	0.542	0.750	0.512
SN3	0.811			
E: E-waste management Practices				
EMP1	0.976			
EMP2	**0.760**	0.941	0.960	0.858
EMP3	**0.977**			
EMP4	**0.972**			

The factor loadings of all the items for their respective latent variables are greater than 0.6 and the average variance extraction values > 0.5 (Fornell and Larcker, 1981). The results confirm the evidence of convergent validity. All constructs show a composite reliability ≥ 0.75, implicating high internal consistency (Hair et al., 2010). We have used the Fornell and Larcker criteria for assessing the discriminant validity. The diagonal values of the discriminant matrix present the average variance extraction of all constructs and is greater than then non-diagonal values imply the presence of discriminant validity criterial proposed by Fornell and Larcker(1981) and Hair et al.(2010).

Table 4 shows the results of the correlation test for the discriminant validity of constructs.

Table 4 – Observed Correlation Matrix[for Discriminant Validity]

Constructs	Environmental knowledge	Environmental awareness	Perceived behavior	Subjective norms	E-waste management practices
Environmental knowledge	**0.718**				
Environmental awareness	0.401	**0.752**			
Perceived behaviour	0.325	0.391	**0.725**		
Subjective norms	0.318	0.241	0.084	**0.716**	
E-waste management practices	0.457	0.152	0.071	0.255	**0.926**

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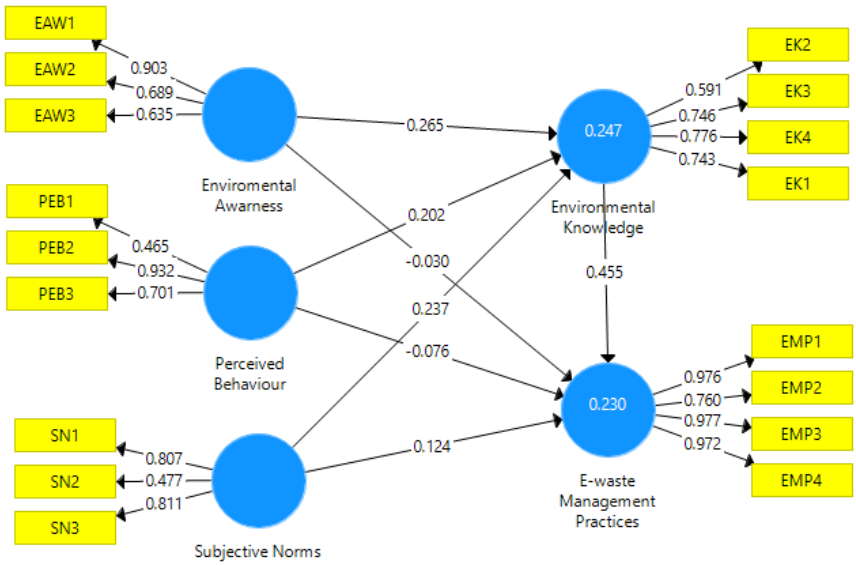
III. Results

We have used the path analysis(based on Partial Least Squares regression) for developing the SEM model that examines the impact of indicators on management practices of e-waste in India. We derive SEM model as follows (Figure 1).

Figure 1: Realised SEM Model



Estimated β value (standardised regression weights of the selected indicators on respective constructs are significant and positive(Table 3). Similar findings are observed for "Environmental Knowledge" and "E-waste management practices". The slope coefficients of Environmental awareness, Perceived Behaviour and Subjective norms on E-waste management practices are insignificant(Table 5). Thus, we do not reject Hypothesis H_1, H_2, and H_3.

The awareness of the environment, regulatory framework, social pressure, and cost & convenience factors significantly influence the e-waste management practices (Nguyen et al., 2018), contrary to our findings.

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Akhtar, Masud and Afroz (2014) have established that the knowledge of environmental and risk perception significantly influences the attitude towards e-waste management. Our results differ from studies in other countries like Brazil, where, Echegaray and Hansstein (2017) have established that perceived social acceptance and the viewpoints on recycling together significantly explain the intention to recycle. However, the behaviour of people towards e-waste management practices varies across income groups.

Table 5 – Summarisation and Hypotheses Test Outcomes

Hypothesis	Analysed Path	Slope Coefficient	t Statistics	p-value	Interference
Direct Effects					
H_{01}	Environmental awareness -> E-waste management practices	-0.030	0.204	P>0.10	**Insignificant**
H_{02}	Perceived behaviour -> E-waste management practices	-0.076	0.412	P>0.10	**Insignificant**
H_{03}	Subjective norms -> E-waste management practices	0.124	0.721	P<0.01	**Insignificant**
Indirect Effects: Mediation Model					
H_{04}	Environmental awareness-> Environmental knowledge -> E-waste management practices	0.121	2.286	P<0.05	**Significant (Full Mediation)**
H_{04}	Perceived behaviour-> Environmental knowledge -> E-waste management practices	0.092	1.728	P<0.10	**Significant (full Mediation)**
H_{04}	Subjective norms-> Environmental knowledge -> E-waste management practices	0.108	1.947	P<0.10	**Significant (full Mediation)**

Mediating role of environmental knowledge has been examined in all the relationships, and the indirect effects have been computed from all indicators to e-waste management practices. In all the path(s), environmental knowledge (the mediating variable) is found to be

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significant. We support Hypothesis H4 and infer that environmental knowledge mediates the relationship and is essential for e-waste management practices. Our findings conform to the study of Nuwematsiko et al.(2021), who have established that creating environmental knowledge is pivotal in the effective implementation of e-waste management practices. The need to increase awareness and knowledge creation is necessary to prevent the ill effects of e-waste treatment on health and the environment also indicated by Bimir (2020) and Andeobu, Wibowo and Grandhi (2021).

IV. Conclusion

Protection of the environment is an essential step towards sustainability. Disposal and management of e-waste have created a devastating impact on people's health and well-being, particularly in developing countries. The developed world is inherently shifting the burden of e-waste to relatively poor developing countries. Given the lack of awareness and absence of stringent regulations, the e-waste is disposed of for small gains by the informal sector. We find that in an Indian context, the knowledge of the environment profoundly influences e-waste management, unlike previous works that emphasize awareness and behavioural dimensions. Thus, there is a need to create a culture that can bring healthy e-waste management into action to create a sustainable society.

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