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Statistical Analysis of Factors Affecting Electronic Product Waste Generation in Bangalore City

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Abstract

Environmental sustainability is defined as maintaining global ecosystems and preserving natural resources in particular to promote health and wellbeing, in the face of the electronics industry's rapid technological advancement. Several environmental sustainability standards may be applicable depending on the local economic, social, and environmental situations. Exploring people awareness, practices on waste management for environmental sustainability is essential. There are different types of wastes, among them e-waste is very hazardous and has to be handled carefully. Developing countries like India, especially in Karnataka challenges associated with the generation and management of electronic waste is crucial. In this paper, study regarding the challenges in Karnataka state towards the management policies, disposal methods, harmfulness and consequences of mishandling of e-Waste disposal is carried out. In this paper, a survey has been carried out with a set questionnaire. The questionnaire has been formulated based on the age group, type of e-Waste, disposal methods followed, people community, measures taken by the local bodies, rules existing and most importantly on awareness of harmfulness of e-Waste disposals. As a result, it can be concluded that most interviewees in the urban area are familiar with the disposal procedure, however the rural community requires additional exposure.

Keywords: *Factor analysis, e-waste, statistical methods, harmfulness, recovery.*

1.0 Introduction

Today's civilization is centred around technology, and we are constantly in search of the newest, highest-tech gadgets, which adds to the enormous amount of electrical waste that exists today. Electronic trash, often known as electronic garbage, comes up when an electronic product completes its useful life. Old computers, office electronics, entertainment devices, mobile phones, televisions, and refrigerators are examples of e-Waste. This comprises both secondary scraps as well as reusable electronics that have been discarded and are either intended for using again and selling again; sometimes salvaged and frequently disposed. Since shipments of surplus electronics are frequently jumbled up, including waste from reuse and recycling initiatives, the term "waste" is reserved for leftover or material that is tossed by the buyer rather than being put to use. (good, recyclable, and non-recyclable) (Ashiq *et al*., 2019). The entire amount of generated e-Waste is dumped in landfills, which is very bad for the environment. Finding novel approaches to combat its detrimental effects is crucial. The "fastest-growing source of rubbish in the world" is e-Waste. The term "tsunami of e-Waste" was created by the UN to characterise the predicted 50 million tonnes of electronic garbage reported in 2018.

1.1 Literature review

Literature review has been conducted in the domain of electronic waste management, its components, materials and awareness, by referring to journal papers. Literature reveals

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materials based survey with mercury, lead, beryllium, brominated flame retardants, cadmium, and other substances that are detrimental to both humans and the environment, are among those found in e-Waste. When devices are improperly disposed, these toxins contaminate land, water, and the air. Electronic waste is occasionally illegally exported to countries with no regulations governing its handling and disposal, which makes matters worse (Grant K. *et al*, 2013). Once it gets there, it is dumped. Rarely and under risky operating conditions are valuable resources really extracted. There are several valuable, recoverable materials found in e-Waste, including ferrous metals, polymers, gold, silver, copper, aluminium, and copper. Managing hazardous trash presents a difficult task (Itai. *et al*, 2014). In developing nations, informal e-Waste processing can have a negative impact on the environment and human health. Electronic waste parts like processing units of computers include hazardous chemicals namely lead, brominated flame retardants cadmium, beryllium. The health of not only human beings but also the flora and fauna become detrimental by the recycling and disposal of e-Waste (Kaya *et al*., 2016). Studies showed that India generates between 1,46,000 and 3.3 lakh tonnes of e-Waste annually, and that number is expected to rise to 4.7 lakh tonnes by 2011. India's production of e-Waste is anticipated to rise by about 34% annually. About 90% of the garbage produced is made up of the three forms of waste listed below: Large household appliances make up 42% of the market, while consumer electronics, information, communication related components, and consumer electronics (all together 13.7%) are next in line. To address the e-Waste threat, one should come up with policies dealing with technical interventions for recycling, implementation and also to build required capacity. The policy should also address awareness of e-Waste among general public (kumar S *et al*., 2018).

Literature presents cathode ray tubes which containing hazardous chemicals like copper and lead. The ranges for these chemicals had the range from 730 to 470 mg/kg and 430 to 9900 mg/kg, respectively. In high concentrations, smart phones include nickel, copper, barium, and silver. Recycling of e-Waste are important issues because of its hazardous nature. This is carried out to obtain usable resources from the waste. 82.6 per cent of e-Waste is illegally traded and disposed in landfills and dumps, leaving only 17.4 per cent of it to be legitimately collected and repurposed (Porte *et al*., 2006). e-Waste is frequently imported into developing nations without proper planning or control. Due of this, the majority of these wastes are stored in municipal landfills or by crude recycling businesses. (Lucier et.al, 2019), (Fort *et al*., 2020). To effectively manage e-Waste, it is essential to create eco-designed gadgets, collect e-Waste efficiently, recover and recycle materials safely, dispose of e-Waste properly, forbid the export of used electronic equipment to developing nations, and increase public awareness of the effects of e-Waste. Even if no one tool is sufficient to address this problem, they can be combined to do so. Extended Producer Responsibility, a federal programme, is a successful strategy for addressing the expanding e-Waste issue (Nnorom *et al*., 2020). Electronic equipment can be repaired, refurbished, and reprocessed rather than being disposed of in the environment to preserve normal resources and the efforts required to produce new electronic instrument/equipment from virgin components. The optimal strategies for long-term collecting, sorting, warehousing, transportation, and treatment methods, as well as matching rules and laws, have not yet been developed despite several attempts to manage e-Waste (Leclerc *et al*., 2020), (Kwatra at al., 2014). Due to the accessibility to various unsafe compounds that, if erroneously disposed off, can harm the environment and endanger human health, electronic trash (also known as "e-Waste") is one of the fastest-growing environmental concerns in the world (Sinha *et al*., 2005).

2.0 Research Problem and Objectives

This work provides an overview of the hazardous materials that can be discovered in e-Waste, their potential negative implications on the environment and human and animal health, as well as the current management techniques being employed in a number of countries. In this paper, a survey on e-Waste management and its awareness has been conducted. Aspects of post usage of e-Waste is also taken into consideration like its dumping sites, landfills, recycling, reusing, repurposing, and refurbishing.

The objective of this paper is to conduct survey and further analyse the factors affecting the electronic product waste, and its awareness among people in Bangalore city of Karnataka state. Based on the literature review, survey questionnaire has been formulated and responses have been collected about waste generation of electronic products from residents of Bangalore city. The results of survey have been statistically analysed on the factors that affect the electronics product waste in the green city Bangalore. The survey and the statistical analysis are needed to infer about the people's awareness towards e-Waste.

3.0 Methodology

In Bangalore city, field visits have been conducted to understand how people manages the e-Waste. The benefits of the e-Waste management have been publicized to the people. The following benefits have been familiarized: conservation of natural resources, community support, employment, protects public health and environment. The survey has been conducted in Bangalore region based on the usage of electronic products, type of utilization, consumption and disposal methods. Further the obtained data has been analysed statistically.

Factor analysis, a statistical technique, has been used to explain variability in experimental, variables that are correlated in terms of a probably lesser number of unnoticed variables affecting the e-Waste. The primary goal of the factor analysis is to simplify the understanding of observed data, and it employs several techniques to recognise relationships between the variables. The two distinct types of factor analysis are exploratory factor analysis and confirmatory factor analysis. Exploratory factor analysis is frequently used to investigate the variables' influencing factors and identify the variables' interdependencies. Confirmatory factor analysis, on the other hand, employs structural equation modelling to examine the link between observable and unobserved variables and aids in testing the hypothesis that has been made on the components that are being tested. To modify data, test hypotheses, and perform various data analyses, factor analysis can be employed. Principal component analysis is a multivariate data analysis method that is used to isolate the critical variables and condense a big data set into a manageable size for examination.

4.0 Results and Discussion

The survey has been conducted and over 300 respondents from Bangalore city were asked to rate the variables in the scale of 1 to 5 which indicates not at all, very less, neutral, often and very often respectively. SPSS software is used to analyse the data and the principal component analysis is used for extraction method. The variables are chosen based on the frequent e-Waste items used in the household, consumers' awareness of e-Waste recycling, refurbishing the devices usage of electrical and electronic products, number of electronic products used, shelf life of the electronic products.

For these variables, correlation matrix has been obtained and is shown in Table 1. The correlation matrix reveals the coefficient of correlation between a single variable as well as every variable used in the analysis. A pair of two variables with a value of less than 0.5 can be excluded from the correlation matrix.

Further, the Kaiser Meyer Olkin (KMO) value is determined. It reveals whether the number of responses provided with the sample are adequate. The sample is sufficient for the factor analysis to continue, according to the value of 0.925. The results of Bartlett's test show how

Table 1: Correlation Matrix

	b1	b2	b3	b4	b5	b6	b8	b9	b10	b11	b12	b13	b14	b15	b16	b17	b7
b1	1	-0.066	0.021	-0.077	-0.052	-0.048	-0.057	0.033	0.064	-0.089	0.115	0.132	0.022	0.034	-0.045	0.037	-0.144
b2	-0.006	1	0.223	0.091	0.056	0.083	0.031	0.035	0.024	-0.016	-0.119	-0.097	0.012	0.028	-0.016	-0.021	0.061
b3	0.021	0.223	1	0.476	-0.218	-0.016	0.026	-0.1	-0.259	-0.156	-0.084	-0.008	-0.237	-0.179	-0.217	-0.004	0.094
b4	-0.077	0.091	0.476	1	-0.197	-0.012	-0.011	-0.114	-0.154	-0.015	-0.112	-0.012	-0.097	-0.02	-0.063	-0.02	0.272
b5	-0.052	0.056	-0.218	-0.197	1	0.011	-0.046	0.062	0.115	0.169	-0.01	-0.204	0.072	0.197	0.274	0.018	-0.027
b6	-0.048	0.083	-0.016	-0.012	0.011	1	-0.039	0.101	0.023	-0.041	0.038	0.037	0.033	0.021	0.023	0.082	0.018
b8	-0.057	0.031	0.026	-0.011	-0.046	-0.039	1	0.043	0.111	0.027	0.087	0.027	0.017	-0.029	-0.021	0.028	0.032
b9	0.033	0.035	-0.1	-0.114	0.062	0.101	0.043	1	0.162	0.105	-0.009	0.11	0.11	0.021	0.009	-0.021	0.248
b10	0.064	0.024	-0.259	-0.154	0.115	0.023	0.111	0.162	1	0.253	0.55	0.109	0.825	0.324	0.334	0.14	0.168
b11	-0.089	-0.016	-0.156	-0.015	0.169	-0.041	0.027	0.105	0.253	1	0.101	0.078	0.296	0.346	0.341	0.141	0.048
b12	0.115	-0.119	-0.084	-0.112	-0.01	0.038	0.087	-0.009	0.55	0.101	1	0.121	0.544	0.151	0.17	0.116	0.013
b13	0.132	-0.097	-0.008	-0.012	-0.01	0.038	0.087	-0.009	0.55	0.101	1	0.121	0.544	0.005	-0.025	0.19	-0.007
b14	0.022	0.012	-0.237	-0.97	0.072	0.033	0.017	0.11	0.825	0.296	0.544	0.116	1	0.365	0.341	0.174	0.136
b15	0.034	0.028	-0.179	-0.02	0.197	0.021	-0.029	0.021	0.324	0.346	0.151	0.005	0.365	1	0.74	0.335	-0.047
b16	-0.045	-0.016	-0.217	-0.063	0.274	0.023	-0.021	0.009	0.334	0.341	0.17	-0.025	0.341	0.74	1	0.243	-0.009
b17	0.037	-0.021	-0.004	0.02	0.018	0.082	0.028	-0.021	0.14	0.141	0.116	0.19	0.174	0.335	0.243	1	0.037
b7	-0.144	0.061	0.094	0.272	-0.027	0.018	0.032	0.248	0.0166	0.048	0.013	-0.007	0.136	-0.047	-0.009	0.37	1

strongly the variables are related. It provides a correlation matrix's overall importance of the correlation. It is shown in the Table 2.

Table 2: KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy	0.675
Bartlett's Test of Sphericity Approx. Chi square df sig.	1.210E31360.000

Using Principal Component Analysis (PCA) method communalities are identified and presented in Table 3. It shows the percentage of each variable the underlying factor and factor jointly account for. For further analysis, the total variance is shown in Table 4. According to the values of variances of extraction sum of squared loadings, variable 1 is significant to 61.429 per cent and variable 2 to 13.024 per cent. The remaining variables are all insignificant. For components, scree plot is constructed and shown in Figure 1.

From the Scree plot, it is inferred that from the second factor, the line is relatively flat, indicating that each subsequent element contributes a decreasing percentage of the overall variance. Further, the component matrix, rotated component matric and component transformation are shown in Tables 5 to 7 and Component plot in rotated space is shown in Figure 2.

Table 3: Communalities - PCA

	Initial	Extraction
b1	1	0.146
b2	1	0.187
b3	1	0.573
b4	1	0.634
b5	1	0.395
b6	1	0.011
b8	1	0.051
b9	1	0.066
b10	1	0.764
b11	1	0.332
b12	1	0.551
b13	1	0.237
b14	1	0.753
b15	1	0.679
b16	1	0.702
b17	1	0.188
b7	1	0.345

Table 4: Total Variance - PCA

Component	Initial eigen values			Extraction sums of squared loadings			rotation sum of squared loadings		
	Total	% of variance	cumulative %	Total	% of variance	cumulative %	Total	% of variance	cumulative %
1	3.11	19.479	19.479	3.311	19.479	19.479	2.721	16.003	16.003
2	1.696	9.975	29.454	1.696	9.975	29.454	2.156	12.683	28.687
3	1.608	9.461	38.916	1.608	9.461	38.916	1.739	10.229	38.916
4	1.378	8.106	47.022						
5	1.179	6.933	53.955						
6	1.088	6.4	60.355						
7	1.013	5.957	66.312						
8	0.977	5.748	72.06						
9	0.833	4.9	76.96						
10	0.758	4.461	81.421						
11	0.712	4.189	85.61						
12	0.614	3.612	89.223						
13	0.588	3.457	92.679						
14	0.46	2.707	95.386						
15	0.385	2.264	97.65						
16	0.24	1.414	99.064						
17	0.159	0.936	100						

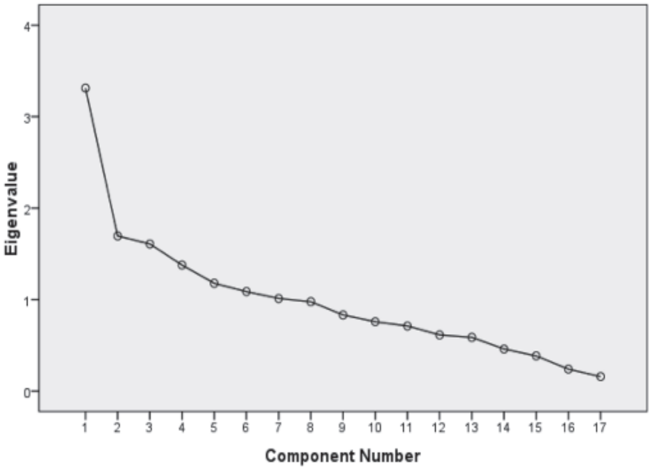

Figure 1: Scree plot

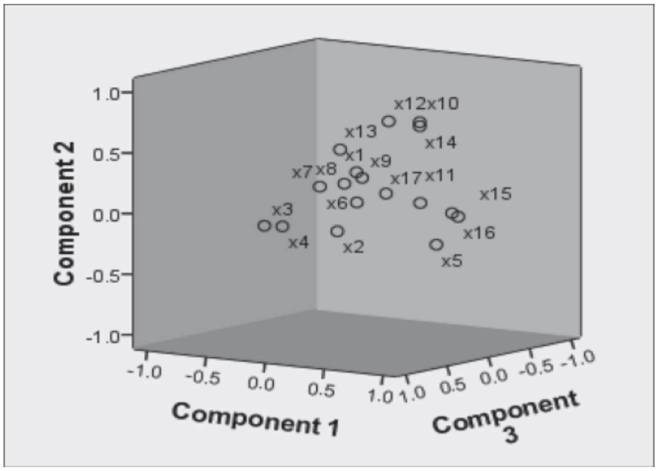

Figure 2: Component plot in rotated space

The correlation between the variable and the factor is revealed by the component matrix. The number of factors on which the variables under consideration have large values obtained is decreased through rotation. It facilitates easier analysis interpretation.

Table 5: Extracted component matrix

	Component		
	1	2	3
b1	0.044	-0.008	-0.379
b2	-0.065	0.21	0.373
b3	-0.436	0.547	0.289
b4	-0.259	0.6	0.455
b5	0.293	-0.475	0.289
b6	0.057	0.082	0.037
b8	0.054	0.195	-0.1
b9	0.177	0.148	-0.114
b10	0.798	0.267	-0.236
b11	0.504	-0.023	0.278
b12	0.556	0.278	-0.406
b13	0.139	0.305	-0.353
b14	0.801	0.281	-0.179
b15	0.682	-0.124	0.445
b16	0.685	-0.189	0.44
b17	0.354	0.159	0.195
b7	0.071	0.55	0.195

Table 6: Rotated Component matrix

	Component		
	1	2	3
b1	-0.173	0.24	-0.241
b2	0.112	-0.126	0.398
b3	-0.303	-0.08	0.689
b4	-0.079	-0.047	0.791
b5	0.493	-0.292	-0.258
b6	0.05	0.059	0.073
b8	-0.052	0.205	0.08
b9	0.049	0.253	0.008
b10	0.458	0.737	-0.105
b11	0.565	0.102	0.04
b12	0.166	0.709	-0.146
b13	-0.146	0.465	-0.004
b14	0.49	0.714	-0.061
b15	0.822	0.043	0.023
b16	0.838	0.006	-0.028
b17	0.361	0.177	0.164
b7	0.054	0.255	0.526

Table 7: Component Transformation matrix

Component	1	2	3
1	0.807	.551	-.214
2	-.204	.600	.774
3	.555	-.581	.596

Extraction: Principal Component Analysis
Rotation: Varimax with Kaiser Normalization

5.0 Conclusion

The study found that residents of Bangalore city know that e-Waste is bad for the environment and people, and that it needs to be properly dealt with in order to maintain environmental sustainability. It is essential to know that metro dwellers prefer to learn about e-Waste from television and social media. Future research on the production and disposal of e-Waste, as well as the creation of technology for the sustainable collection and recycling of e-Waste, can all help create a more sustainable future. In this paper, survey has been conducted, based on the responses collected, principal component analysis is implemented, component correlation and KMO values are identified. The results of the test implicate the adequacy of the responses and the understanding of the waste management disposal among people in Bangalore city is indicated.

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