



Assessing resident awareness on e-waste management in Bangalore, India: a preliminary case study

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Abstract

The generation of e-waste has increased significantly in India, and the informal recycling of e-waste has adverse effects on environment and public health. In this article, the E-waste management is evaluated in accordance from the resident's awareness perspective in Bangalore city, India. The survey data revealed that about 58% male and 42% female responded and 35% of the participants belong to age range between 18 and 25 years. About 60% of respondent's education level was either graduate or post graduate, 27% high school to higher school, 10% higher educated (> post graduate), and 3% primary to middle. Only 30% of the respondents were confident with e-waste rules and regulation, while 39% of the respondents were of very little information. Indian e-waste management has been improving for the last few years and it continues to develop. Therefore, the findings can be valuable for better understanding the resident's awareness for e-waste management and also need to promote the environmentally sound management of e-waste in Bangalore, India.

Keywords E-waste · Environmental awareness · Resident · Informal sector · India

Introduction

With rapid urbanization, continuous population growth, and increasing demands of electronic and electrical equipments (EEEs), the problem of e-waste generation and management has become very serious issue in developing countries (Awasthi et al. 2016a, b; Zlamparet et al. 2017; Chandel et al. 2014; Wang and Xu 2014). In 2014, the estimated quantities of global e-waste quantity was 41.8 Mt (million tons), and this value is expected to reach almost 50 Mt (49.8 Mt) by 2018. In the same time, about 1.7 Mt e-waste was generated in India (Balde et al. 2015). The improper handling of e-waste is one of the cause for environmental pollution and human health issue (Awasthi et al. 2017, 2016a, b; Breivik et al.

2014; Chakraborty et al. 2017, 2016a, b, c; Li et al. 2012; Yu et al. 2014).

India already ratified The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, despite the huge amount (about 80%) of e-waste that shifted from developed country to developing countries (Sthiannopkao and Wong 2013; Zhang et al. 2012). Since the 1st of May, 2012, the e-waste rules known as the E-waste (Management and Handling), Rules 2011, has been enforced (Ghosh et al. 2016). However, this rule has been not implemented very well (Toxic Link 2016). While most of the developed countries has been enforced and implemented strict waste electronic and electrical equipment (WEEE) laws to achieved effective e-waste management system by establishing formal enterprises (Zeng et al. 2016; Sthiannopkao and Wong 2013).

Bangalore is one of the leading telecommunication and technology hubs (India's IT industry) and consumer e-markets in India (Ha et al. 2009), while in the same time, this city is suffering with improper handling of e-waste. It was previously reported that 20,000 thousand tons of e-waste was generated in 2013 at annual growth rate of 20%. The forecast also suggested that the computer waste quantity will increase to about 500% by the end of 2020 (Borromeo 2013). This e-waste mainly belongs to domestic households, official

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generation, and illegal shifting (quantity unknown) from developed countries to developing countries (Jain 2010). The major portion of WEEE is managed by informal sector involved several key players, such as peddler, vendors, scrap dealer, and specialized collector (Keller 2006; Needhidasan et al. 2014). Only 5% of e-waste was treated by formal sector and the remaining 95% reached to either second-hand market or family workshop (informal sector) for recycling (Rajya Sabha 2011).

Therefore, we conducted a preliminary survey on e-waste awareness in Bangalore, India. Firstly, we collected data based on the residents awareness on e-waste management, which mainly included questionnaires about e-waste management in Bangalore, India. Then, we gathered and preliminary analyzed the information to explore the current resident's awareness of e-waste management in the city. Lastly, we provide some suggestions to improve the e-waste management in city.

Material and methods

Brief description of study area, selection of research subject, and design of questionnaire for survey

The Indian city of Bangalore was chosen for this survey study, and the city also known as Silicon Valley of India. The survey was conducted between the 24th of November and 29th of November 2015, (During academic and field visit/survey, including 5th International Conference on Solid Waste Management, 2015) in Bangalore, India. This city is located at 12° 58' N 77° 34' E and 12.97° N 77.56° E in the southern India (Fig. 1). In Bangalore, the major portion of WEEE goes to unorganized sector (Reddy 2013). In order to find out the solution for public awareness on e-waste management, the design questionnaire mainly has three concerns about awareness, such as—socioeconomic condition, environmental and health risk owing to informal management of e-waste, and whether they are aware or not. The survey considered “one person” as a set as the basic research unit in this study.

Methodology used for survey

In order to get survey data, formal direct first-hand information was gathered through face-to-face interview. Through direct interviews, we help the respondents to fill the questionnaire properly and avoid any error or mislaid. Since this survey is preliminary case study, total 200 residents were randomly selected from the city (Including conference participants from the Bangalore city). We used questionnaire with two options for their answers—such as “Yes” or “No.” Further, if the answer was “Yes,” then we also asked what they known about e-waste recycling/management and their views on this particular issue.

Results

Socioeconomic condition of respondents

This survey brings a very brief informative finding, on the other hand, some residents did not respond. The socioeconomic studies included five types of categories, such as gender, age, education, total number of family member, and income (INR/month). We classified the education level in following pattern: (a) primary to middle school, (b) high school to higher secondary school, (c) graduate to post graduate, and (d) higher educated (> post graduate).

In this study, the education level was reported maximum from between graduate and post graduate (60%), although many of them acquired their degree through different education systems, such as distance learning course. 58% and 42% of respondents were male and female, respectively. The monthly income was around 10,000–15,000 (INR/month) for 38% of the respondents, and about 43% of the respondents belonged to four to six family members in a single household. Table 1 presented the descriptive information about respondent resident's socioeconomic condition, however, furthermore, the detail study is still needed for better understanding.

According to some respondents, the refused/obsolete e-products are stored by consumers into their homes or offices or some time sold to those consumers who are economically weak people. The storage duration is possible from several months to years. When obsolete EEE completely becomes un-useable, then they are willing to sell it, at the end expecting at least some return money from informal sector or formal sector. Figure 2 presents the low-level source collection from households, and the different reasons are as follows: environmental awareness (24%), lack of effective formal collection (21%), and ineffective rules and regulation (13%), while some consumers responded with multiple answers, such as environmental awareness and formal collection system (16%), environmental awareness and inappropriate law (9%), and lack of effective formal collection and law (17%). The data revealed that residents have variable information about e-waste management. When we explored their knowledge by questioning, such as how and why informal e-waste management can affect environment and human health, then very few of them have little information and rest of them just replied “No.” Hence, from the conducted survey data, most of the residents believed that the informal sector workers considered this work as decent job.

A number of studies have been conducted on consumer willingness and behavior and attitude toward different aspects of e-waste management (Li et al. 2012). Nevertheless, to effectively solve the informal activities in the local community

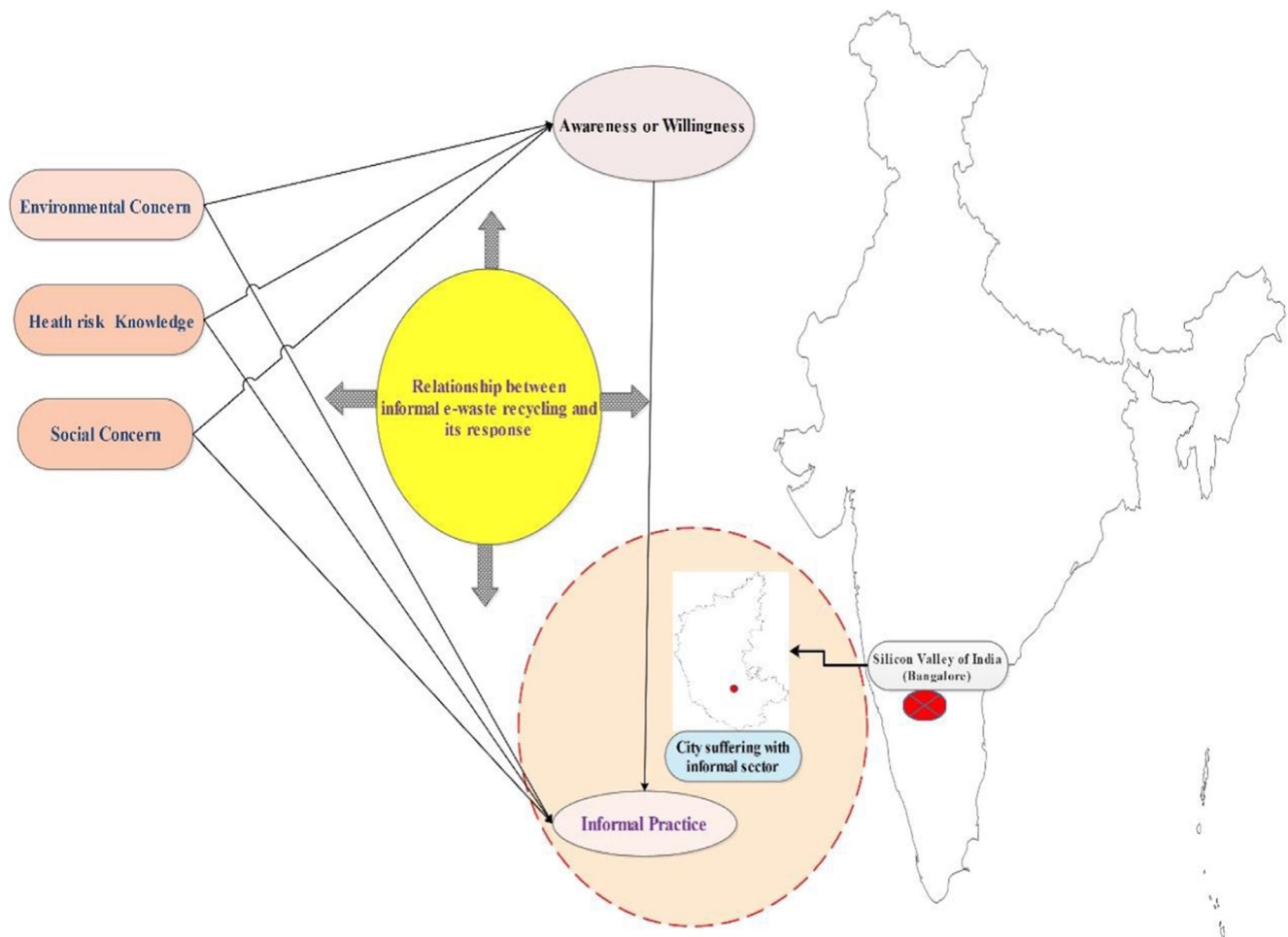


Fig. 1 Systematic indication of informal e-waste activities and related issues in the Bangalore, India

level and to help in communicating governmental policy for e-waste management. Additionally, there is a need to know the ongoing situation on awareness about environment and human health. The survey findings indicate that the local residents are willing to support for environmental mitigation.

E-waste legislation in Bangalore, India

The informal e-waste recycling has been become subject of serious concern among the government/non-government organizations and environmentalist groups/experts. The environmental law has not been effectively implemented in Bangalore city. For instance, many of the respondents were not satisfied with current law for the e-waste issue. On the other hand, 29% and 28% of the residents responded to have moderate and unknown knowledge on e-waste rules and regulation, respectively (Table 2).

The hazardous waste policy initiatives initiated in India, known as the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, were notified on the

24th of September 2008 by the Ministry of Environment and Forest. Furthermore, by considering growing issue of e-waste, the Government of India has taken some initiatives, especially in the inventorization conducted by the State Pollution Control Board (SPCB)/Central Pollution Control Board (CPCB) on the management and handling of e-waste which led to the drafting and the publication of the guidelines for environmentally sound management of e-waste in March 2008 (Table 3).

The guidelines were framed with the aim of providing extensive regulation for identification of different sources of e-waste and the comprehensive approach for both handling and their disposal under environmentally sound manner. These Guidelines consist of information about e-waste composition, recycle potential, identification of potential hazardous materials in e-waste, reuse, recovery possibilities, and disposal alternatives. The current e-waste guidelines are under the umbrella of extended producer responsibility (EPR). The EPR deals with an environment protection approach that makes the producer responsible for the complete life cycle of the e-product particularly, such as take back, recycling and final disposal. The rules also state that EPR is mandatory activity in the legislative framework of EEs life cycle.

Table 1 Details of the residents participated in the study

Population group		Percentage of respondents
Gender	Male	58
	Female	42
Age (year)	18–25	35
	25–34	28
	35–44	25
	45–60	12
Education	Primary to middle school	3
	High school to higher secondary school	27
	Graduate to Post-graduate	60
	Higher educated (> post graduate)	10
No. of family member in a house	< 2	5
	2–4	35
	4–6	43
	> 6	17
Income [(INR)/month]*	Up to 5000	13
	5000–10,000	22
	10,000–15,000	38
	15,000–20,000	19
	More than 20,000	8

* (INR): Indian rupees

The huge quantity e-waste has become the most serious issue for both central and state government, although the Karnataka State Pollution Control Board (KSPCB) enforced and monitored e-waste rules and regulation at state level (Jatindra and Sudhir 2009). There are non-governmental organizations that also done

some activities to improve e-waste situation in Bangalore city. In addition, the government has supported activities on e-waste awareness in the local city. The E-waste (Management and Handling) Rules, 2011, are rules intended to be applied to every producer, consumer/bulk consumer involved in the making of EEEs and their sale or buy or processing as specified under the schedule—I, collection center, dismantler, and recycler of e-waste (KSPCB 2008, 2014).

Environmental damage from informal recycling

According to this preliminary survey, the residents showed awareness on environmental damage and human health risk causes owing to informal recycling of e-waste. The residents believed and said that the majority of e-waste is managed by informal sector in Bangalore city). In this context, earlier, Gupta and Shekar (2009) reported that about 25,000 informal workers engaged in unorganized sector in India. These workers are considering e-waste as the best livelihood option. Only 30% of respondents said “Yes” and 39% of respondents have a very little awareness for e-waste rules and regulation. The results indicate that environmental influences standby, affecting environmental understanding level. However, we can avoid this problem, if we will create more awareness to children. Our data revealed the different reasons for workers why they are participating in informal activities, such as due to economic situation (35%), lack of proper e-waste management system (28%), lack of awareness and public participation (20%), and lack of appropriate rules and regulation (17%) (Table 2). The resident response on present situation of e-waste management is due to several reasons which are shown in Table 2 and Fig. 2.

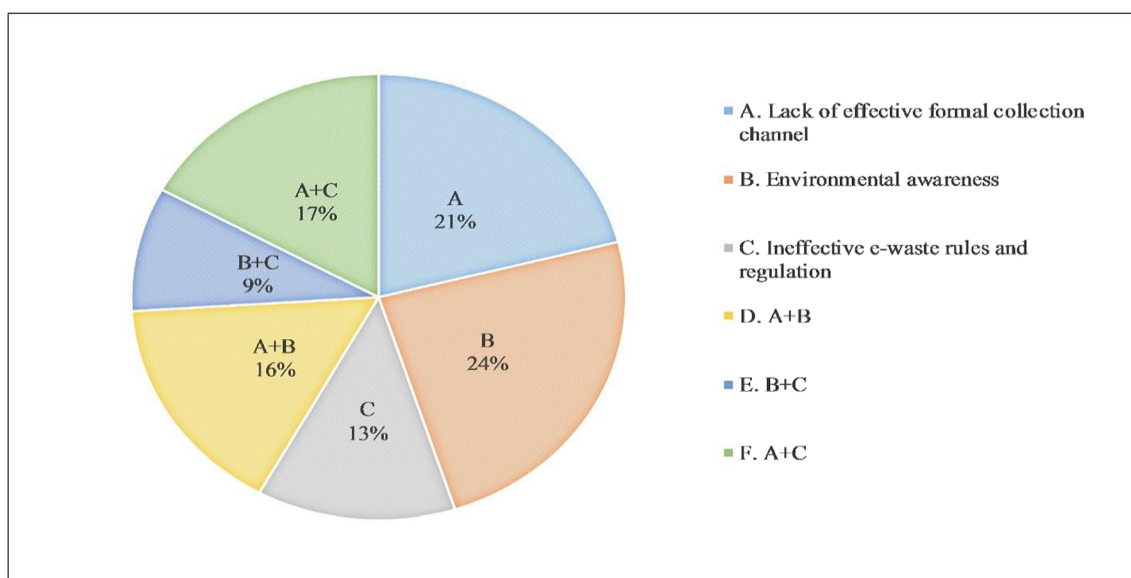


Fig. 2 The main reasons for minimum WEEE collection in Bangalore, India

Table 2 Environmental knowledge of responded population group

Questionnaires	Type of responses	Specific response in percentage (%)			
		1	2	3	4
Whether state/central government is paying satisfactory attention on environmental issues in Bangalore?	(1) Yes, (2) No, (3) Partly	30	42	28	–
How to acquire the relevant information?	(1) Through media (TV and newspaper), (2) Environmental awareness activity, (3) Government propaganda, (4) Family and friends	39	22	32	7
Whether or not often participated in the environmental activities?	(1) Yes, (2) No, (3) Sometimes, (4) Never	61	6	28	5
Whether or not satisfied with the current environmental rules and regulation?	(1) Highly, (2) Low, (3) Moderate, (4) Unknown	27	16	29	28
Do you aware about government e-waste law and regulation?	(1) Yes, (2) No, (3) Very little	30	31	39	–
Source collection could be helpful for maximum e-waste collection by formal recycler?	(1) Yes, (2) No, (3) May be, (4) No response	42	15	28	15
Source segregation can be minimized the e-waste account in landfill disposal site?	(1) Yes, (2) No, (3) May be, (4) No response	44	15	26	15
What is main reason for environmental pollution from informal e-waste?	(1) Lack of awareness and public participation, (2) Lack of appropriate rules and regulation, (3) Economic situation of engaged person, (4) Lack of proper management system	20	17	35	28

Awareness on informal e-waste recycling

The main sources of environmental information to consumer have been received from publicity on hazards and prevention of WEEE pollution from environmental awareness activities (22%), governmental propaganda (32%), TV and newspaper (39%), and family and friend (7%) (Table 2). The data suggested that consumer acquired most information about awareness activities from either print or online media. Although most of the consumer believed that the informal sector is providing very good convenient service (Table 4), within better competitive price than formal sector. In this regard, we received different responses, and the main reasons behind the priority for informal sectors are due to very convenience service (62% and 74%), price competitive (28% and 22%), and dominating

system (10% and 4%), as responded by men and women, respectively (Table 5).

The majority of consumers are willing to give their second-hand or refused EEEs to informal workers known as “Kabadiwala” (Kabadiwala is a local word). In this context, only 9% of the residents identified these workers as illegal group, while 11% of the respondents were completely unknown of them. These findings suggest that resident awareness for informal e-waste activities is not satisfactory. These results were supported by other researcher (Reddy 2013, 2015). For this, the government environmental authorities such as State Pollution Control Board, Central Pollution Control Board, and local municipal corporation should have to focus on regular public awareness camp. Jamshidi et al. (2011) stated that social opposition can reduce the resident awareness and participation in waste recycling. While Kwatra et al. (2014) suggest that the proper use of local media could be one of the best options for increasing the awareness on e-waste activity. For instance, in the morning and evening time, an hour is generally spent by the local people for traveling to office/work place, so this time can be used for online awareness in the city (Kwatra et al. 2014).

Table 3 The summarized form of e-waste rules & regulation in India

S. no.	Rules and regulation	Effective status
1.	Management of e-Waste, Guidelines, 2008	Enforced
2.	State Policy on Electronic Waste, G.O.Ms. No. 18, 2010 [Tamil Nadu (India)]	Enforced
3.	E-waste (Management and Handling) Rules*, 2011	Enforced

Source: http://www.step-initiative.org/Overview_India.html

*Effective rules during the survey time

Awareness on human health risk from informal recycling

The environment and human health can be affected due to informal e-waste recycling. Rebecca and Mamatha (2010) stated that,

Table 4 Residents' awareness toward informal WEEE recycling

Questionnaires	Type of response	Consumer response (%)			
		1	2	3	4
Do you know about informal e-waste recycling?	(1) Yes, (2) No, (3) Partly	34	22	44	–
What do you know about informal recycling?	(1) Management recycling group, (2) Illegal group, (3) Convenient service group, (4) Unknown	17	9	63	11
Is it possible to solve informal recycling in Bangalore city?	(1) Yes, (2) No, (3) Partly, (4) Not at all	27	19	47	7
How it possible to solve the informal e-waste recycling?	(1) By formalizing the more appropriate rules and regulation, (2) Adopting the current rules and regulation by all involved stakeholders/groups, (3) More awareness needed?	54	24	22	–

if we minimize the greenhouse gas emission, it will lower environmental pollution. In this context, the proper understanding level of environmental awareness is very important for environmentalists, educators, and decision makers, for proper planning of sustainable development of socioeconomic condition of residents (Cao et al. 2016). In this context, earlier studies suggested that the informal recycling can be solved by providing proper awareness by conducting extensive capacity building programs that will be helpful to minimizing both the environmental and human health risks (Awasthi et al. 2016a). The awareness is very important and need to initiate the from at the stage of school level for children, and social media could be use for residents awareness. Accordingly, Awasthi et al. (2016b) evaluated the human health consequences of metal exposure pathways and presented the review associated to human body load markers (e.g., breast milk, blood, urine, serum, and hair), due to e-waste/waste in India. In addition, several studies have been conducted on this issue (Chakraborty et al. 2016d, 2013; Eguchi et al. 2013; Huang et al. 2012; Mohmand et al. 2015; Ni et al. 2014). For instance, Cd metal has been reported as human carcinogenic that can cause lung cancer and other types of cancer in humans (Asante et al. 2012). Therefore, these reports directed that the informal e-waste treatment should be switched off by adopting the best available technology, with regular monitoring system and systematic awareness for employees and inhabitants. However, the comprehensive and detail research is essential in this topic.

The main aims were to evaluate the current situation of e-waste awareness residents from Bangalore city, to pinpoint the

related challenges, and to make possible recommendations to resolve e-waste issue. Kaushal and Nema (2013) said that the least generation of e-waste is source separation/collection by formal sector, under the proper environmental and health protection and storage and appropriate recycling system is needed. However, due to a lack of consumer willingness and behavior (Wang et al. 2011), community participation, lack of well-developed infrastructure, competitive price, convenient collection, and low-level environmental awareness about the informal e-waste sector in residents, these are some major concern for e-waste management in India (Wath et al. 2010).

Analysis and discussion

E-waste is one of the fastest-growing waste streams worldwide, owing to innovation, rapid growth in manufacturing, and demand of EEEs. But after EEEs become waste, the proper treatment is a main concern, because it contains various toxic metals like Pb, Hg, and Cd. The informal recycling practice is very common in developing countries, which causes negative impact on environment and human health (Awasthi et al. 2016b). As a consequence, there is need for an eco-friendly and feasible technology for management of e-waste. Furthermore, there is a necessity to create awareness among stakeholders and also a need for active individual participation in e-waste management system.

The e-waste informal collection, handling, and recycling system has been developed impulsively by market forces in India, although there are rules and regulations that are focused on e-waste issue in India. The e-waste management system in the city is shown as in Fig. 3.

Presently, there is a number of challenges in e-waste management India, which need to be properly and carefully solved. In this context, Wath et al. (2010) suggested that eco-friendly recycling or recovery of metals (base metals and precious metals), value addition to recyclables for reuse (glass, plastics, and other recyclables), and final disposal residual waste are challenges in engineering aspect, and the

Table 5 Why first choice is informal collectors than formal ones by consumer

Reason for first choice	Male (%)	Female (%)
Convenience service	62	74
Price competitive	28	22
Dominating system	10	4
Total	100	100

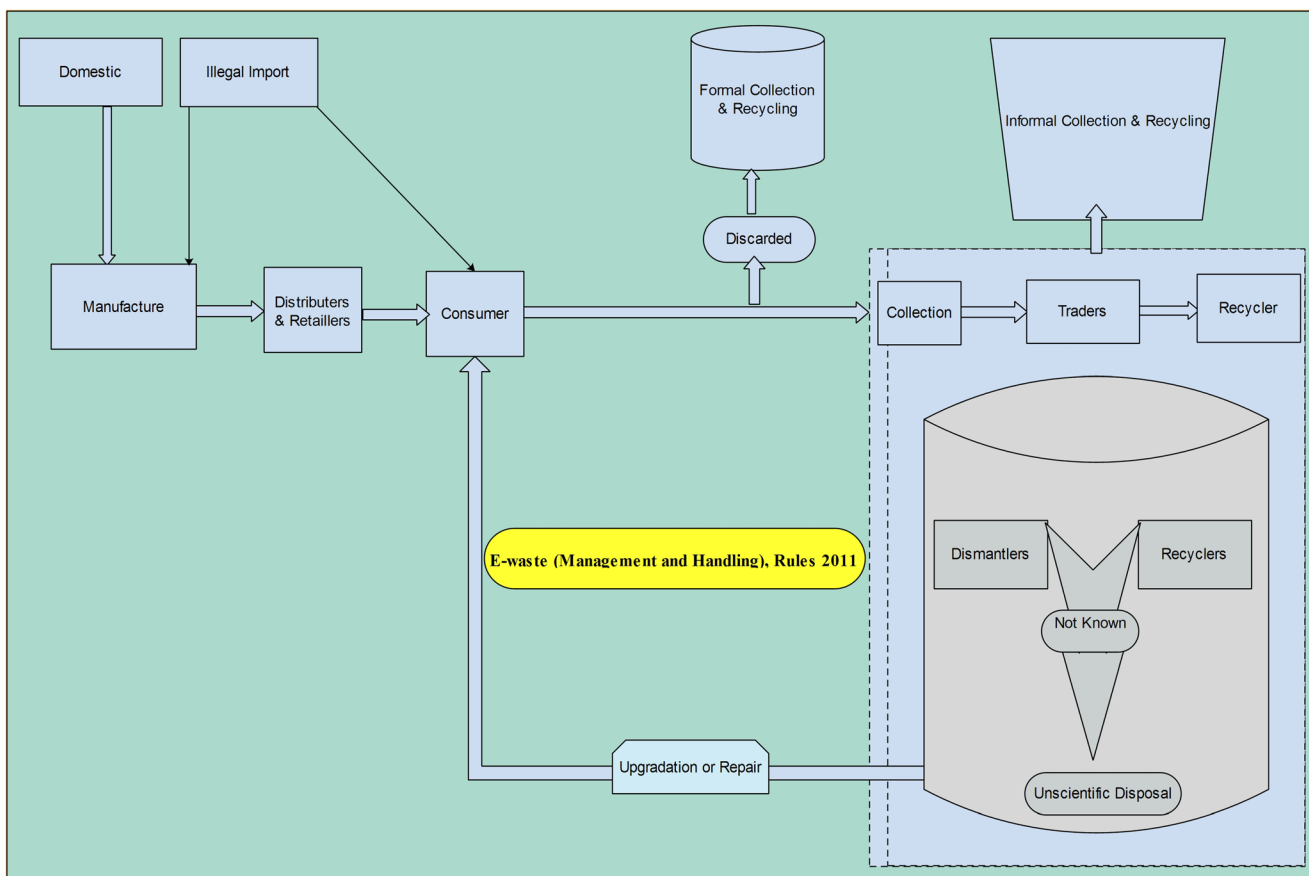


Fig. 3 The illustration of e-waste management in Bangalore city. [E-waste (Management & Handling) Rules, 2011 was effective/enforced during the survey time]

societal changes for better integration among unorganized and organized sectors, with effective participation of non-government organizations (NGOs), are desirable to develop more feasible techno-economical solutions.

On the other hand, the government role and responsibility is also very important for implementing any e-waste management strategy in India. The policy needs to be properly designed and desirable to find out the more appropriate approach to advance the formal recycling sector in India, where mostly untrained/unskilled labor is ample and each individual is worried for their livelihood option. In the meantime, every approach must maintain balance among surrounding environmental and occupational health alongside the sustainable economic expansion (Wath et al. 2011). Therefore, the usage of high number of EEEs makes it important for proper collection, management, and recycling of e-waste, owing to limited resource scarcity, associated environmental pollution, and human health risk. However, due to absence of appropriate strategy and advanced recycling infrastructure, there is a low rate of e-waste collection in India. Therefore, for improvement in better collection of obsolete or discarded e-product, the following suggestion can be considered: (i) The e-waste law needed to be a strictly implement and must apply penalty

system, if any violation occurred; (ii) Target collection system (TCS) is very important; (iii) Tack back system could be a promising way to minimize the informal activities; and (iv) Recycling should be through best available technology.

Since the early 1990s, the information and technology revolution begun in India, while a rule related to e-waste [“E-waste (Management and Handling) Rules, 2011”] was introduced nearly after 20 years, in 2011. The life cycle of EEE from forward logistics to reverse logistics is properly covered by the EPR framework in the India. While developed countries, including those in EU legislation for reverse logistics of EEE, established clearer and very systemic approach of eco-design and integrated policy. For instance, Zeng et al. (2013) stated that more stakeholders are involved in developing country like China, in the law enforcement. In fact, the legislation differences among developing and developed countries are attributed to the diverse cultural and social conditions. In the other hand, the weaker environmental understanding, different governmental organization hierarchies in India lead to the dissimilar frameworks and content from the developed countries. Reddy (2013) mentioned that public involvement is suitably progressively inserted in both international and national environmental policies, as policy makers diagnose that there is requisite to

realize who are affected by the decisions taken earlier and why. Pariatamby and Victor (2013) suggested that WEEE policy making needs to be a specific approach that should be considered as a measure for the national development scheme that take part in green economy investigation and strategic environmental assessment as a measure of national policy planning.

A number of non-government organizations (NGOs) are key in doing work associated to all main features of e-waste, building awareness in public, and contributing strategies nation-wide/worldwide in different countries (Kwatra et al. 2014). Therefore, this kind of proactive approach of NGOs contributes importantly to the e-waste situation. In addition, it is urgent to learn from past experiences and try to develop wide-ranging schemas to handle the e-waste issue. As situation of e-waste in India, it has its specific diversity, such as socio-cultural, lack of advance technology and infrastructure and environmental considerations between its residents that pose severe challenges in conveying single, extensively recognized, and clear e-waste management approach. It appears that consumers' awareness is important to any effective WEEE management involvements; in short, reuse/recycling would be useful and acceptable, and proper pollution mitigation initiatives and policy tools could be adequately implemented.

This preliminary work mainly emphasized and explored on resident's awareness and understanding for e-waste recycling/management. Lack environmental awareness is also one of the concerns in the existing e-waste management system, although India has a regulatory framework to manage e-waste. For the first time, the specific regulation on e-waste was notified in 2011 and came into force from May 2012. This rule was mainly based on EPR that is the main thought in the background, and the rules insist to the producers of EEE to set up an arrangement to collect and afterwards manage the refused EEE. These rules besides specify that e-waste should be treated in environmentally sound manner by registered recycler/dismantler units. Therefore, India can learn from their experiences from the "E-waste (Management and Handling) Rules, 2011" and needs better implementation for effective e-waste management.

Conclusions

Formal e-waste management in India is still in initial stages, and the e-waste has become a serious issue for the environment and human health. Therefore, for developing new strategies, the findings of this study can be useful for better understanding the situation of e-waste issue and residents' awareness of e-waste management. We believe that these findings will help strengthen decision-making step to minimize the informal e-waste recycling activities in Bangalore city. In addition, Bangalore city has an improving condition to manage the e-waste. However, according to survey findings, it suggests that the majority of respondents are willing to improve

the environmental awareness. In addition, the responsible environmental authority should have to take more control measure for e-waste management in city. Furthermore, the detail study is needed in order to make better e-waste management in city.

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