

Contents lists available at [ScienceDirect](#)

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Mobile phone waste management and recycling: Views and trends

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ARTICLE INFO

Article history:

Received 6 July 2015

Revised 7 September 2015

Accepted 8 September 2015

Available online xxxxx

Keywords:

Mobile phone waste

E-waste

Waste management

Review

Recycling

ABSTRACT

There is an enormous growth in mobile phone consumption worldwide which leads to generation of a large volume of mobile phone waste every year. The aim of this review is to give an insight on the articles on mobile phone waste management and recycling, published in scientific journals, major proceedings and books from 1999 to 2015. The major areas of research have been identified and discussed based on available literature in each research topic. It was observed that most of these articles were published during the recent years, with the number of articles increasing yearly. Material recovery and review on management options of waste are found to be the leading topics in this area. Researchers have proved that economically viable refurbishing or recycling of such waste is possible in an environmentally friendly manner. However, the literatures indicate that without proper consumer awareness, a recycling system cannot perform to its maximum efficiency. The methodologies followed and analytical techniques employed by the researchers to attain their objectives have been discussed. The graphical representations of available literature on current topic with respect to year of publication, topics and location have also been explored.

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1. Introduction

Electronic wastes are among the largest and fastest growing waste stream in the world (Goodship and Stevels, 2012; Pariatamby and Victor, 2013; Wang and Xu, 2014). Mobile phones wastes are a part of WEEE (Waste Electrical and Electronic Equipment), a term derived for obsolete electronic devices by European Union Directive on WEEE. Out of the different categories of WEEE mentioned in the EU Directive (2012) mobile phones come under category 3, which includes all kind of IT and Telecom devices.

The number of mobile phone users increased from about 500 million in the year 2000 to about 5000 million in the year 2011, worldwide (Balde et al., 2015; Cadena et al., 2015). Recent data show an almost exponential growth in these values. The International Telecommunication Union's (ITU) latest reports estimates that more than 7 billion mobile phone subscriptions will be there globally by the end of 2015, with a population-wise penetration rate of 97% (ICT Facts and Figures, 2015). The fast advancement in the technology, providing better models regularly forces the consumer to change their phones more frequently. This in turn results in very short service life of mobile phones and thereby generating large amount of waste streams (Seliger et al., 2004; Yammiyavar and Kumar, 2011; Li et al., 2015). The use phase of a mobile phone is less than 3 years in developing countries and less than 2 years in developed countries. Thus, it can be predicted that most of the mobile phones entering into waste streams may still have value (in terms of performance and strength). Hence these can be recovered and reused or recycled if properly sorted and segregated (Soo and Doolan, 2014).

Mobile phones are very complex products when it comes to dismantling and recycling, due to the large variety of materials

present in them such as plastics, metals, glass, and ceramics (Christian et al., 2014). A typical mobile phone consists of several parts such as display unit, battery, front and back cases and printed circuit boards (PCBs). Mobile phones contain about 50% plastics and the rest is formed by the other materials (Palmieri et al., 2014; Dimitrakakis et al., 2009). PCBs alone contain variety of metals such as gold, silver, copper, iron, and platinum (Takahashi et al., 2009). Based on surveys and literatures, about 80% of materials used in mobile phones can be effectively recycled (Moltó et al., 2011). Engineering grade polymers such as Polycarbonate (PC), Acrylonitrile–Butadiene–Styrene (ABS), PC/ABS Blends, and High Impact Polystyrene (HIPS) are mostly used in mobile phones. These polymers can be effectively recycled and may be combined with virgin materials to tailor the high end application needs (Kasper et al., 2011a, 2011b).

By far several reviews have analyzed the trends in e-waste management. Very recently, Perez-Belis et al. (2014) gave a broad literature review on WEEE recycling technologies. Several other reviews also discussed on the concerns and opportunities involved in e-waste management sector (Schlummer et al., 2010; Widmer et al., 2005; Osibanjo and Nnorom, 2007; Tsydenova and Bengtsson, 2011; Chancerel and Rotter, 2009, etc.). However, the aim of this review is to study the contents of articles related to a specific category of e-waste: the mobile phone. Such an analysis becomes vital in the current scenario where sales of mobile phones have crossed that of all other electronic products together (Gupta et al., 2014). If not now, the near future will see the formation of huge amount of mobile phone waste, which has to be managed properly. Researchers have already turned their attention toward this emerging problem, resulting in large number of research articles. The current review analyzes the methods, techniques and

Table 1
Articles published in mobile phone waste generation, management, economics aspects and consumer behavior.

Category	Author(s)	Key points
Generation of waste	Li et al. (2015)	Generation of Waste: Case Study of China
	Rahmani et al. (2014)	Generation of Waste: Case Study of Iran
	Moberg et al. (2014)	LCA (Life Cycle Assessment)
	Babatunde et al. (2014)	Generation of Waste: Case Study of Nigeria
	Polák and Drápalová (2012)	Generation of Waste: Case Study of Czech Republic
Management	Boni et al. (2015)	Mobile Waste Management in Developing Countries in comparison with Industrialized Countries
	Zink et al. (2014)	Comparing Repurposing and Refurbishment
	Sebo and Rosenfelderová (2014)	Sustainable Reuse and Recycling
	Vats and Singh (2014)	Mobile Phone Waste Management: Indian Scenario
	Tanskanen (2013)	Mobile Phone Waste Management
	Paiano et al. (2013)	Energy and Material Consumption of Mobile Phones in Italy
	Miah et al. (2013)	Mobile Phone Waste Management: Case Study of Bangladesh
	Singh et al. (2013)	Government Initiatives for Mobile Waste Management in India
	Sharma et al. (2011)	Mobile Waste Management Policies in India
	Ongondo and Williams (2011a, 2011b)	Generation of Waste and Recycling: Case Study of UK
	Rathore et al. (2011)	Remanufacturing Efficiency In India
	Silveira and Chang (2010)	Mobile phone Recycling Trends in US and Brazil
	Jang and Kim (2010)	Mobile Waste Management Initiatives in Korea
	Liu and Zhang (2008)	Reverse Logistics Network
	Sahu and Srinivasan (2008)	Mobile Waste Management Initiatives in Asia and Pacific
	Tanskanen and Butler (2007)	Mobile Phone Takeback Initiatives: Comparison
	Franke et al. (2006)	Remanufacturing Planning
Paiano et al. (2006)	Material Flows at EoL	
McLaren et al. (1999)	LCE (Life Cycle Energy) Model for Mobile phone Take Back and Recycling	
Consumer behavior	Yin et al. (2014a, 2014b)	Consumer behavior: Case Study of China
	Welfens et al. (2013)	Consumer behavior: Case Study of Germany
	Ongondo and Williams (2011a, 2011b)	Consumer behavior: Among University Students in Europe
	Nnorom et al. (2009)	Consumer behavior: Case Study of Nigeria
Economics	Navazo et al. (2014)	Material Flow and Energy Requirements for material recovery from mobile Phones
	Sebo and Fedorčáková (2013)	Hierarchical end-of-life model for disassembly of mobile phones aiming at economically viable recycling
	Geyer and Blass (2010)	Economic viability of mobile phone reuse vs. recycling
	Yu et al. (2010)	Material and Energy Consumption of Mobile Phones

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