DOI : 10.36347/sjebm.2015.v02i05.009

Scholars Journal of Economics, Business and Management e-ISSN 2348-5302

Wang Z.; Sch J Econ Bus Manag, 2015; 2(5A):495-504 p-ISSN 2348-8875

(An International Publisher for Academic and Scientific Resources)

An overview of waste electrical and electronic equipment governance

Zaifeng Wang[1, 2*]

[1]Center for International Economic Research, School of Public Administration, Southwest Jiaotong University, Chengdu 610031, P. R. China

[2] Center for International Economic Research, Southwest Jiaotong University, Chengdu 610031, P. R. China

*Corresponding Author

Zaifeng Wang

Email: 470163352@qq.com

Abstract: The rapid expansion of waste electronic and electronic equipment (WEEE) not only means a serious waste of resources, but also causes corresponding environmental problems, which has made an enormous negative influence on ecological environment, economy and society development. This paper introduces the situation and experiences of WEEE treatment and utility in some countries and regions, and expounds the effects of WEEE on environment. Furthermore, compared with WEEE management in these countries, this paper has put forward some proposals and countermeasures for China's better improvement.

Keywords: WEEE; WEEE management; environment; recycling system.

INTRODUCTION

Waste electronic and electric equipment (WEEE) is also called as E-wastes or end-of-life electronics, including household appliances, automatic dispensers and IT and so forth [1], and it has been one of the fastest growing wastes. It is reported that, the amount of WEEE has accounted for 8% of municipal waste [2], increasing by 3%-5% every year [3]. In consideration of technological progress in electronics industry, the life time of electronic and electric equipment (EEE) is becoming shorter and shorter, while its waste growth is in a tremendously speed [4]. According to a statistics, 12 million ton of WEEE is generated every year, but about 2.2 million tons of them are treated, only accounting for 18.3%. Therefore, it is necessary to make the WEEE to be re-used, recycled and recovered (called 3R) [5], and it has gotten great attention worldwide about the WEEE, especially in developing countries with a rapid industrialization and urbanization [6].

It is predicted that, old computers would increase about 500% by 2020 in India, and at the same time, it will be about 18 times higher than 2007 level with regard to mobile phones discarded [7]. The WEEE imported illegally to China is about 1.5-3.3 million tons every year [8], and more than 2.3 million tons of WEEE is produced annually with a growing trend all the time [9]. In developed countries, the total quantity of the WEEE is 20 to 50 million tons per year [10]. The quantity of the WEEE produced by the EU is between 8.3 and 9.1 million tons per year in 2005 [11], growing three times more compared to the growth of average municipal waste [12]. The amount of WEEE generated in America is 1.9 million tons in 2000, but it has achieved 3.41 tons in 2011 [13]. Due to lower recycling rate and so large quantity, televisions has become major concern in American and estimated that the amount of junk televisions is about 84.1 million in 2012, indicating every family has 40 pounds of scrap [14].

With the increasing use of electrical and electronic equipment, it has caused a severe pollution problem worldwide [15, 16]. Certainly, on account of the economic benefits and environment protection, it has attracted more and more attention to the recycling of the WEEE for the government and the public in recent years [17]. As we all know, waste electronic and electric equipment contains not only a variety of toxic and hazardous contaminants, but also a large number of valuable materials such as metals, glass, plastics and so on. Therefore, if it is treated in a proper way, a large number of valuable materials will be gained [18]. The most common materials found in E-waste are iron and steel (see Fig. 1), accounting for more than half of the E-waste [19]. With the development of science and technology, a large number of metals are used increasingly due to innovative technologies [20].

As is known from Fig. 1 that, the proportion of metal in the WEEE is 60.20%, and the proportion of plastic is much higher than the others. A statistics shows that the amount of E-waste has increased by 25% from 2007 to 2011, but the proportion for plastics has reached 30% [19] because of the plenty of plastic utility in televisions, refrigerators and washing machines [21, 22, 23].

At present, the recycle of the WEEE has become an important topic [24], as it is necessary for energy recovery and waste treatment as well as the recycling of the valuable materials [4, 25, 26]. In fact, if we do not take any measures to deal with the E-waste based on environment consideration, then it will heavily pollute the environment [27]. Of course, there are still some obstacles in the recycle of the WEEE, including the technology, scheme, policy and so forth [25, 28, 29].

To date, substantial studies on the WEEE treatment in China have mainly focused on its treatment and technology. However, this paper will focus on the situation, effects and governance of the WEEE based on the existing researches, and it is expected that this review will be useful for researchers as well as practitioners and managers of the WEEE.

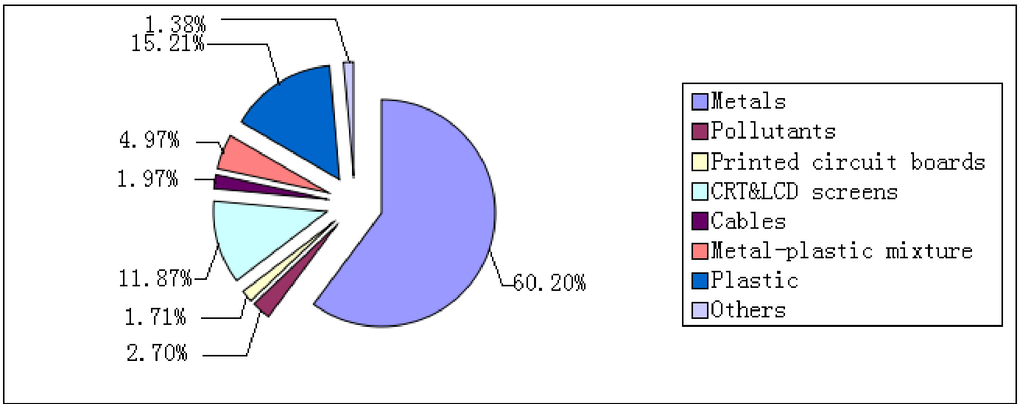


Fig-1: Typical materials in E-waste

WEEE MANAGEMENT SITUATION

E-waste contains a variety of valuable resources such as copper (Cu), gold, aluminium (Al) and so forth. If those valuable resources are not reused, it will not only cost a lot of resources, but also damage environment. Therefore, many countries have made a series of policies and means to recycle the WEEE [19].

WEEE management in Asia

In recent years, more WEEE has been produced in the Asian countries because of rapid economic growth [30]. India has a well-networked informal sector for the WEEE treatment [31], including some key players such as scrap dealers, the vendors and the recyclers [32]. However, India has become one of the major destinations of WEEE coming from OECD countries with approximately 50K tons of WEEE per year, showing an increasing trend [33, 34]. Fig. 2 shows the amount of the PCs sold in India from 2001-2009 [35].

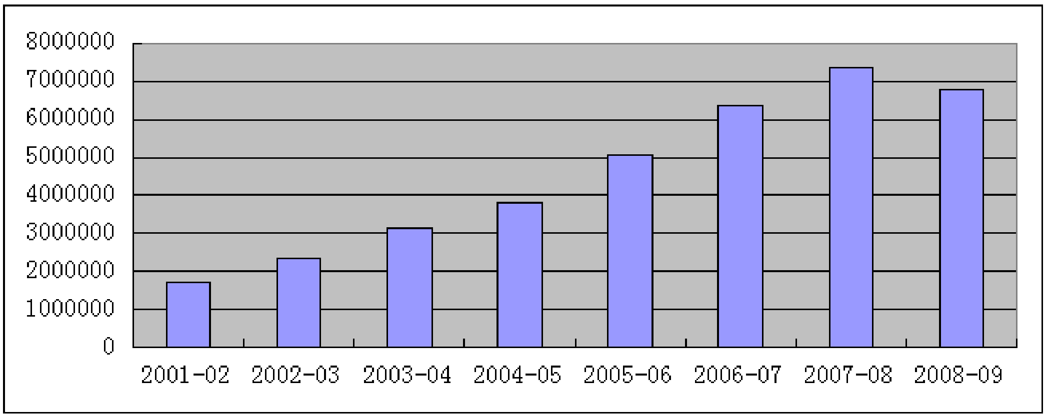


Fig-2: Total PC sales in India from 2001 to 2009

China is a largest consuming and manufacturing country globally [36]. Because of rapid economic growing and urbanization, the consumption of EEE in China has been a rapid growth, resulting in enormous WEEE along with about 2.3 million tons of WEEE generated at home per year [37]. To this end, Chinese government has made recycling policies to encourage proper recycling since the late 1990s [38, 39]. At present, there are four sectors (e.g., supply, marketing cooperatives, manufacturers, individual recyclers, and dismantling companies, etc.) to recycle WEEE [40], and has made a great contribution to reuse and recycle the WEEE for economic and social implications [41]. Approximately 5 million people worked in the WEEE treatment industry in 2005, while people working in such industries have reached 0.7 million in 2007 and 98% of people work in informal recycling sectors (see table 1) [42].

Table-1: Workers in the recycling sectors

Stages	Number of employees per sector		
	Formal	Informal	Total
Collection	-	440000	440000
Disassembly	400	12500	125400
Material recovery	15000	12500	140000
Final disposal	600	-	600
Total	16000	690000	706000

In Japan, more than half of the end of life computers and home appliances maxed out has been transferred to other Asian countries such as China, Afghanistan, Philippines and others, and the WEEE is regarded by them as second-hand goods [43]. The policy about the "Recycling of Specified Kinds of Home Appliances" was issued in 1998 and come into force in April 2001 in Japan. The system of recycling WEEE in Japan is unique. Firstly, it includes a limited number of target appliances. Secondly, the system consists of a recharge fee system that consumers have to pay for the recycling treatment when disposes. The last is a direct recycling obligation for manufacturers (see Table 2) [44].

Table -2: Average recycling fees (2007)

	Washing machine	CRT TV	Air conditioner	Refrigerator
US$	22	25	32	42
Euro(€)	16	18	23	30
Yen	2520	4830	3675	4830

WEEE management in Europe

In 2005, the quantity of WEEE in Europe has reached about 5 million tons, and is estimated to be 12.3 million tons by 2020 [45, 46]. Table 3 shows the kinds of WEEE recycled in Europe.

Table-3: **Types of WEEE recycled in the Europe**

EU WEEE Category	The proportion of WEEE recycling (%)
Large household appliances (washing machines, refrigerators, ovens)	49.07
Consumer equipment (TVs, DVD players)	21.10
Communication tools and IT(cellphone, laptop)	16.27
Small household appliances (toasters, vacuum cleaners)	7.01
Electronic tools and electrical (saws, drills)	3.52
Lighting equipment (lamps)	2.40
Automatic dispensers (money dispenser, drink)	0.18
Medical devices (dialysis)	0.12
Leisure, sports equipment and toys	0.11

The European Union has taken strict recycling quotas for different categories of the E-waste [47]. Because the WEEE contains a mass of plastics, the proportion of plastics quotas is increasing all the time [48, 49]. Under the guidance of WEEE, the countries in European have increased the recycling of WEEE containing all the EEE for consumer and professional use [50]. However, it is reported that, merely 1/3 of the WEEE is collected separately and treated appropriately in Europe in spite of the regulations on recycling and collection, while the rest of the WEEE is possibly transported to landfill or sub-standard treatment places in Europe or outside illegally [51].

WEEE management in America

America has disposed over 1.3 million tons of WEEE per year in the first decade of the 21st century, and has issued relevant laws to manage the WEEE [52]. It is estimated that, 20-24 million wastes of computers and TVs are stored up instead of being recycled or disposed every year in 2002 [18].

THE EFFECTS OF WEEE ON ENVIRONMENT

WEEE has become a global problem, while approximately 1/2-4/5 of the WEEE has been exported to the developing countries (e.g., the Africa and the Asia, etc.) [53, 54, 55]. Therefore, those developing countries are confronted with huge challenges for electronic waste treatment. Hazardous substances in electrical and electronic equipment (EEE) have heavy metals such as gold, iron, copper and others as well as a variety of harmful plastics including flame retardants, polybrominated diphenyl ethers (PBDEs) and other substances, which will pose significant environmental and human health risks if not properly treated (see Table 4) [2, 56].

Table-4: Hazardous substances in the WEEE

Ingredients	Sources	Concerned substances
CRT (Cathode ray tubes)	Old televisions, PC monitors, OSC (oscilloscope)	Pb in cone glass, Ba in electron gun getter, Cd in phosphors
PCB (Printed circuit boards)	Ubiquitous, from beepers to PCs	Pb, Sb in solder, Cd in contacts, Hg in switches, BFRs (Brominated Flame Retardants) in plastics
Cells	portable instrument	Cd in Ni–Cd batteries, Pb in lead acid batteries, Hg in Hg batteries
Gas discharge lamps	Backlights of LCDs	Hg in phosphors
Plastics	Wire insulation, plastic housing, circuit boards	PVC(polyvinyl chloride), BFRs (Brominated Flame Retardants)

If heavy metals in the WEEE are not treated properly, it will be remained in the environment, which will bring about poisoning at low concentrations through bioaccumulation in animals and plants to gather in food chain [57]. It is well known that, the plants can absorb heavy metals through uptaking from soil, while human beings and animals can absorb them through water, air, food, even skin contact [58]. When we eat meat on higher food chain, some heavy metals will be more accumulated in our bodies [59].

The WEEE and environment

The composition of the WEEE is so complex that the type of WEEE is diversity, which will have a serious pollution to environment [60]. The processing site of WEEE is often situated in the fields which are adjacent to land usually used for the purpose of agriculture in China, particularly for the informal recycling of WEEE [61]. The contaminants of WEEE could go into aquatic systems via lixiviating from WEEE dumpsite [62]. The vegetables and crops grown in the land can be polluted by the heavy metals through soil. If people irrigate vegetables and crops with the contaminated water, they will be polluted, too. As is known to all, these metals can be absorbed by the plants through their roots from soil, then enter into plant shoots, and finally accumulated inside plant tissues [63].

The largest city of WEEE recycling is Guiyu with its surrounding towns located in southeast Guangdong province of China [62]. Since 1995, the people in Guiyu have been engaged in the recycling of the WEEE [64]. About 80% people of Guiyu are engaged in the WEEE recycling recently [65]. However, because the techniques of WEEE treatment are simple, it has caused serious environmental pollution [66, 67]. In fact, a large number of sediments with basic physicochemical characteristics have been discovered in Guiyu (see Table 5).

Table -5: **Physical and chemical characteristics of sediments from an acid leaching site in Guiyu**

sediment	PH	TOC(%)	S(%)	N(%)	H(%)	C(%)
Average values	3.97	39.3	0.80	1.42	4.66	40.0
Minimum values	3.68	35.7	0.63	1.21	3.99	37.4
Maximum values	4.35	41.6	1.02	1.78	5.06	44.1
Note: Depth in 0-80 cm and number of samples is 45.						

At the same time, it is found that, the pb concentration in the downstream river is 0.4 mg/L because of waste processing factories located in the upstream in Guiyu. What's worse, the pb concentration in some parts of the river is 8 times higher than local drinking water standard (0.05 mg/L) [68]. 22 PBDE congeners in the air are detected in PM2.5 [69]. Moreover, the levels of heavy metals are also very high in the air, leading to serious biological and environmental problems [70]. WEEE recycling in Guiyu has caused serious environment pollution of heavy metals in dust, too [59, 71].

The WEEE and human health

The WEEE includes more than 1000 materials and most of them are hazardous and toxic, which has caused a lot of serious problems to environment and human health. For example, for a recycling treatment worker on printed circuit board (PCB), the estimated oral daily dose of lead on average is 50 times more than that of the safe standard, indicating that it has adverse health effects [2]. Especially, heavy metals will cause the elevated levels of total suspended particles (TSP) in ambient air, which can increase the risks of mortality and morbidity of people [71].

According to the existing research, the heavy metals of WEEE could get into hair through different ways. For example, when the hair shaft is taking shape, the heavy metals can enter the blood and deep skin [72, 73]. In other words, the hair can be considered as an appropriate indicator to show the people's health exposed to heavy metals of WEEE for a short and long term. Through detection, it may found that the levels of five heavy metals are ranked in the following order in Ni<Cd<Cu<Pb<Zn, while the levels in occupationally exposed workers is the highest [74]. 70.8% of the children in Guiyu have more blood Pb levels than 10 ug/dl, and 20.1% of the children are over 2 ug/L blood Cd levels [75]. In addition, people living in Guiyu have a much higher proportion of diseases than national average level in China, for instance, cutaneous infections, leukemia, and so forth.

THE SOLUTION OF WEEE PROBLEM

Compared with traditional municipal waste, the WEEE is a new kind of waste [76]. As we all know, the WEEE contains a variety of toxic substances, posing a danger to health and environment. As the policies aiming at traditional waste management cannot be applied to WEEE directly, so it is necessary to make a new way [77].

Effective WEEE management system construction

It is better to have an effective regulatory system for monitoring shipments, appropriate labeling and recycling of WEEE [78]. Up to now, although the legislation about WEEE management has issued, there are too many defects in China's WEEE treatment.

Generally, there exist three channels to do with the WEEE in China [79]. The first is that the WEEE is transferred to second-hand markets where the WEEE can be sold for a reasonable price [18]. The second is that the WEEE owners would rather donate their idle home appliances to poor people who live in rural areas rather than selling them in second-hand markets in spite of such behaviors forbidden by national regulations [80]. The last is that the owners of WEEE sell their abandoned WEEE to packmen which will sell WEEE collected to WEEE dealers [1]. In China, the third channel is the main channel for WEEE.

However in Europe, American and Japan, the technologies of WEEE treatment are more mature and the degree of mechanization is higher [81]. According to Masahiro Oguchi et al. (2013), most of the metals contained in WEEE are handled as municipal solid waste. Therefore, the next target for metal recovery in Japan could be the small-grain fraction from the shredding and separation process in terms of both metal amount and content. During the process of recycling WEEE, the innovative separation and beneficiation techniques of different materials have a major improvement [2].

WEEE management policies

China has been aware of the environment and health effects of WEEE for a long time [82]. Therefore, Chinese government formulates relevant policies, laws and professional guidance to manage and control the WEEE recycling and the EEE production. The enterprise needs business licensing to collect, reserve and handle the hazardous waste in WEEE from July 1, 2004. The China WEEE Regulations was issued in August 2008 by the State Council, and it stipulates the implementation of EPR (Extended Producer Responsibility). At the same time, the "3R" indicating reduced, reused and recycled treatment principles has begun to come into force, and the illegal importation of WEEE is banned [83]. Of course, the framework of WEEE management is still imperfect in spite of a large number of laws and regulations in China. Not only is it lack of effective supervision and enforcement, but also is short of profession norm and standard.

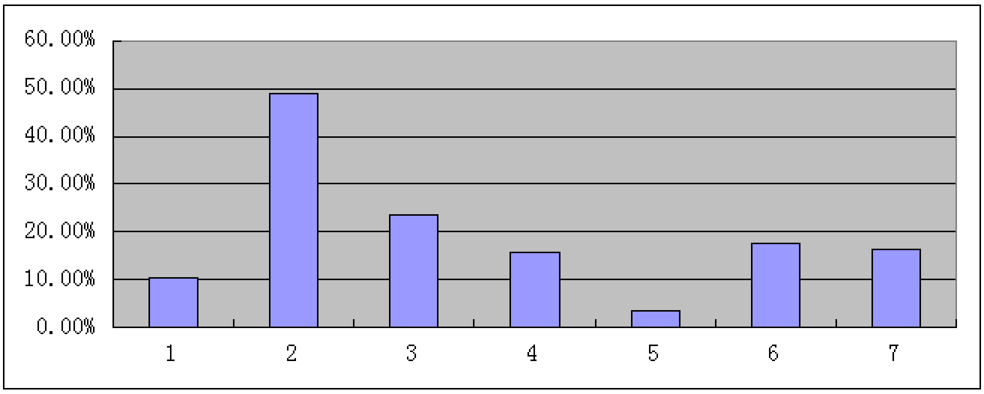
Japan and the EU are the leaders in the WEEE treatment. Since February 2003, the legislation that restricts the use of hazardous substances in EEE in EU has been in force. From then on, many counties have started to issue similar legislation. In European countries, the collection schemes that the people who possess used e-waste can return them for free [52]. The schemes help to recycle or reuse the WEEE greatly. However, it is reported that, only 1/3 of the E-waste is collected separately and treated appropriately in

European in spite of such a regulation about recycling and collection (European Commission).

Since 2001, the recycling laws of home appliance have been issued in Japan, including for CRTs [84]. In Japan, the customers need to pay a recycling fee from 20 to 55 dollar which depends on the type of item and the retail outlets providing collection point. And if the producer is absence of recycling the WEEE, another firm must be designated for the role.

WEEE plastic recycling

The "3Rs" (reduce, reuse, recycle) was put forward by Japan at 2004 G8 summit [84].The representative WEEE contains approximately 10-30wt % of plastic [85]. The important components of WEEE are PWB (Printed Wire Board) and PCB (Printed Circuit Board) with an ever increasing tonnage being generated [86]. Nevertheless, it is lack of the methods of WEEE recycling. The percentage of plastic in different appliances is summarized in Fig. 3 [17].



Note: 1 indicates large cooling appliances, 2 small WEEE, 3 printers, 4 copying equipments, 5 CPUs, 6 CRT monitors, 7 CRT televisions, respectively.

Fig. 3 The percentage of plastic in different appliances

At present, the widely used method of plastic waste recycling is incineration, and plenty energy can be obtained and used for electricity generation [87].Whereas, it will produces a large number of harmful substances that could be dangerous to the environment in the process of incineration, too. The materials, during the process of pyrolysis, are heated to very high temperatures, and will decompose into smaller molecules such as oils, gases and chars for reuse due to lack of oxygen. Therefore, this technology is worthy to be popularized in China [88, 89].

CONCLUSION

In recently years, as the rapidly growing production of EEE has caused a great pressure for environment and issues, so WEEE recycling and management have made a great attention in the world, especially in developing countries [27]. In the near future, with the development of advanced information technology, a large quantity of WEEE will be generated.

The WEEE not only contains a larger number of useful metals such as copper, iron, aluminum and others, but also all kinds of harmful materials. The conventional methods of WEEE recycling have a great effect on environment and people health, which will cause serious environment pollution and complicated disease for people. To deal with the WEEE more efficiently and economically, China must consider a systematic method to solve all the associated problems [86]. Although China has issued a series of laws on WEEE recycling, the situation of WEEE recycling is still worrying. Therefore, how to solve the problem of the WEEE effectively is a long-term and arduous task for China.

REFERENCES

1. Chen YL, Zhang L, Zhong YG; An overview of e-waste management in China. Journal of Material Cycles and Waste Management, 2015; 17: 1-12.
2. Tsydenova O, Bengtsson M; Chemical hazards associated with treatment of waste electrical and electronic equipment. Waste Management, 2011; 31: 45-58.
3. Menikpura SNM, Santo A, Hotta Y; Assessing the climate co-benefits from Waste Electrical and Electronic Equipment (WEEE) recycling in Japan. Journal of Cleaner Production, 2014; 74: 183-190.
4. Kantarelis E, Yang W, Blasiak W, Forsgren C, Zabaniotou A; Thermochemical treatment of E-waste from small household appliances using highly pre-heated nitrogen-thermogravimetric investigation and pyrolysis kinetics. Applied Energy, 2011; 88: 922-929.
5. Menad N, Guignot S, Houwelingen JA; New characterisation method of electrical and electronic equipment wastes (WEEE). Waste Management, 2013; 33: 706-713.

6. Chancerel P, Meskers CE, Hageluken C, Potter VS; Assessment of precious metal flows during preprocessing of waste electrical and electronic equipment. Waste Management, 2009; 13: 791–810.
7. United Nations Environment Programme and United Nations University (UNEP); Recycling-from E-Waste to Resources. Available from http://www.unep. org/pdf/pressreleases/E-waste_publication_screen_finalversion-sml.pdf.
8. Zhou L, Xu ZM; Response to waste electrical and electronic equipment in China: legislation, recycling system, and advanced integrated process. Environmental Science and Technology, 2012; 45: 4713-4724.
9. Chi XC, Wang MYL, Reuter MA; E-waste collection channels and household recycling behaviors in Taizhou of China. Journal of Cleaner Production, 2014; 80: 87-95.
10. Schwarzer S, De Bono A, Giuliani G, Kluser S, Peduzzi P; E-waste, the hidden side of IT equipment's manufacturing and use. UNEP Early Warning on Emerging Environmental Threats No. 5; 2005. Available from http://archive-ouverte.unige.ch/unige:23132.
11. Mostaghel S, Samuelsson C; Metallurgical use of glass fractions from waste electric and electronic equipment (WEEE). Waste Management, 2010; 30: 140-144.
12. Yang XN, Sun LS, Xiang J, Hu S, Su S; (2013) Pyrolysis and dehalogenation of plastics from waste electrical and electronic equipment (WEEE): A review. Waste Management, 2013; 33: 462-473.
13. US EPA Municipal Solid Waste in the US: 2011 Facts and Figures. Available from http://www.epa.gov/osw/nonhaz/municipal/pubs/MSWcharacterization_fnl_060713_2_rpt.pdf.
14. Milovantseva N, Saphores JD; Time bomb or hidden treasure? Characteristics of junk TVs and of the US households who store them. Waste Management, 2013; 33: 519-529.
15. Pérez-Belis, V., Bovea, M.D. and Simó, A. (2015) Consumer behaviour and environmental education in the field of waste electrical and electronic toys: a Spanish case study. Waste Management, 36, 277-288.
16. Panambunan-Ferse M, Breiter A; Assessing the side-effects of ICT development: E-waste production and management : A case study about cell phone end-of-life in Manado, Indonesia. Technology in Society, 2013; 35: 223-231.
17. Wang RX, Xu ZM; Recycling of non-metallic fractions from waste electrical and electronic equipment (WEEE): a review. Waste Management, 2014; 34: 1455-1469.
18. Widmer R, Oswald-Krapf H, Sinha-Khetriwal D, Schnellmann M, Böni H; Global perspectives on e-waste. Environmental Impact Assessment Review, 2005; 25(5): 436-458.
19. Ongondo FO, Williams ID, Cherrett TJ; How are WEEE doing? A global review of the management of electrical and electronic wastes. Waste Management, 2011; 31: 714-730.
20. Oguchi M, Sakanakura H, Terazono A, Takigami H; Fate of metals contained in waste electrical and electronic equipment in a municipal waste treatment process. Waste management, 2012; 32(1): 96-103.
21. Covaci A, Harrad S, Abdallah MAE, Ali N, Law RJ, Herzke D, de Wit CA; Novel brominated flame retardants: a review of their analysis, environmental fate and behaviour. Environment international, 2011; 37(2): 532-556.
22. Convention S; The new POPs under the Stockholm Convention. Available from http://chm.pops.int/Convention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx.
23. Park JE, Kang YY, Kim WI, Jeon TW, Shin SK, Jeong MJ, Kim JG; Emission of polybrominated diphenyl ethers (PBDEs) in use of electric/electronic equipment and recycling of e-waste in Korea. Science of The Total Environment, 2014; 470: 1414-1421.
24. Cui J Forssberg E; Mechanical recycling of waste electric and electronic equipment: a review. Journal of Hazardous Materials, 2003; 99: 243-63.
25. Tsai CK; The construction of a collaborative-design platform to support waste electrical and electronic equipment recycling. Robotics and Computer-Integrated Manufacturing, 2010; 26: 100-108.
26. Santos MC, Nobrega JA, Cadore S; Determination of Cd, Cr, Hg and Pb in plastics from waste electrical and electronic equipment by inductively coupled plasma mass spectrometry with collision–reaction interface technology. Journal of hazardous materials, 2011; 190(1): 833-839.
27. Tsai CK; Waste electronics and electrical equipment disassembly and recycling using Petri net analysis: Considering the economic value and environmental impacts. Computers & Industrial Engineering, 2013; 65(1): 54-64.
28. Manomaivibool P, Vassanadumrongdee S; Buying back household waste electrical and electronic equipment: assessing Thailand's proposed policy in light of past disposal behavior and future Preferences. Resources, Conservation and Recycling, 2012; 68: 117-125.
29. Ylä-Mella J, Poikela K, Lehtinen U, Keiski RL, Pongrácz E; Implementation of waste electrical and electronic equipment directive in Finland: evaluation of the collection network and challenges of the effective WEEE management. Resources, Conservation and Recycling, 2014; 86: 38-46.

30. Terazono A, Murakami S, Abe N, Inanc B, Moriguchi Y, Sakai SI, Williams E; Current status and research on E-waste issues in Asia. Journal of Material Cycles and Waste Management, 2006; 8(1): 1-12.
31. Dwivedy M, Mittal RK; Willingness of residents to participate in e-waste recycling in India. Environmental Development, 2013; 6: 48-68.
32. Sinha S Mahesh P; Into the Future: Managing e-waste for protecting lives and livelihoods. Available from http://toxicslink.org/docs/06171_Into_the_future.pdf
33. Manomaivibool P; Extended producer responsibility in a non-OECD context: the management of waste electrical and electronic equipment in India. Resources, Conservation and Recycling, 2009; 53: 136-144.
34. Li J, Liu L, Zhao N, Yu K, Zheng L; Regional or global WEEE recycling. Where to go?. Waste management, 2013; 33(4): 923-934.
35. Wath SB, Dutt PS Chakrabarti T; (2011) E-waste scenario in India, its management and implications. Environmental Monitoring and Assessment, 2011; 172: 249-262.
36. He W, Li G, Ma X, Wang H, Huang J, Xu M, Huang C; WEEE recovery strategies and the WEEE treatment status in China. Journal of Hazardous Materials, 2006; 136(3): 502-512.
37. Kong SF, Liu H, Zeng H, Liu YS; The status and progress of resource utilization technology of e-waste pollution in China. Procedia Environmental Sciences, 2012; 16: 515-521.
38. Shinkuma T, Managi S; On the effectiveness of a license scheme for E-waste recycling: The challenge of China and India. Environmental Impact Assessment Review, 2010; 30: 262-267.
39. Dou XS; Food waste generation and its recycling recovery: China's governance mode and its assessment. Fresenius Environmental Bulletin, 24, 2015.
40. Li B, Du HZ, Ding HJ, Shi MY; E-Waste Recycling and Related Social Issues in China. Energy Procedia, 2011; 5: 2527-2531.
41. Williams E, Kahhat R, Allenby B, Kavazanjian E, Kim J, Xu M; Environmental, social and economic implications of global reuse and recycling of personal computers. Environmental Science & Technology, 2008; 42: 6446-6454.
42. Yu JL, Williams E, Ju M, Shao CF; Managing e-waste in China: Policies, pilot projects and alternative approaches. Resources, Conservation and Recycling, 2010; 54: 991-999.
43. Yoshida A, Terazono A; Reuse of second-hand TVs exported from Japan to the Philippines. Waste Management, 2010; 30: 1063-1072.
44. Aizawa H, Yoshida H, Sakai S; Current results and future perspectives for Japanese recycling of home electrical appliances. Resources, Conservation and Recycling, 2008; 52: 1399-1410.
45. Kilic HS, Cebeci U, Ayhan MB; Reverse logistics system design for the waste of electrical and electronic equipment (WEEE) in Turkey. Resources, Conservation and Recycling, 2015; 95: 120-132.
46. Huisman J, Magalini F; Where are WEEE now? Lessons from WEEE: will EPR work for the US? Proceedings of the 2007 IEEE International Symposium on Electronics and the Environment, Orlando, USA, 2007; 149-154.
47. Stenvall E, Tostar S, Boldizar A, Foreman MRS, Möller K; An analysis of the composition and metal contamination of plastics from waste electrical and electronic equipment (WEEE). Waste management, 2013; 33(4): 915-922.
48. Dimitrakakis E, Janz A, Bilitewski B, Gidarakos E; Small WEEE: determining recyclables and hazardous substances in plastics. Journal of Hazardous Materials, 2009; 161: 913-919.
49. Wäger, P. A., Hischier, R. and Eugster, M. (2011) Environmental impacts of the swiss collection and recovery systems for waste electrical and electronic equipment (WEEE): a follow-up. Science of the Total Environment, 409, 1746-1756.
50. Oguchi M, Sakanakura H, Terazono A; Toxic metals in WEEE: characterization and substance flow analysis in waste treatment processes. Science of the Total Environment, 2013; 463: 1124-1132.
51. Tanskanen P; Management and recycling of electronic waste. Acta Materialia, 2013; 61: 1001-1011.
52. Lepawsky J; Legal geographies of e-waste legislation in Canada and the US: jurisdiction, responsibility and the taboo of production. Geoforum, 2012; 43: 1194-1206.
53. Leung AOW, Zheng JH, Yu CK, Liu WK, Wong CKC, Cai ZW, Wong MH; Polybrominated diphenyl ethers and polychlorinated dibenzo-p-dioxins and dibenzofurans in surface dust at an E-waste processing site in southeast China. Environment, 2011; 45: 5775-5782.
54. Ma J, Cheng J, Wang WH, Kunisue T, Wu MH, Kannan K; Elevated concentrations of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans and polybrominated diphenyl ethers in hair from workers at an electronic waste recycling facility in Eastern China. Journal of Hazardous Materials, 2011; 186: 1966-1971.
55. Pant D, Joshi D, Upreti MK, Kotnala RK; Chemical and biological extraction of metals present in E waste: a hybrid technology. Waste Management, 2012; 32: 979-990.
56. Grant K, Goldizen FC, Sly PD, Brune MN, Neira

M, van den Berg M, Norman RE; Health consequences of exposure to e-waste: a systematic review. The lancet global health, 2013; 1(6): 350-361.
57. Luo C, Liu C, Wang Y, Liu X, Li F, Zhang G, Li X; Heavy metal contamination in soils and vegetables near an e-waste processing site, south China. Journal of Hazardous Materials, 2011; 186(1): 481-490.
58. Li J, Duan H, Shi P; Heavy metal contamination of surface soil in electronic waste dismantling area: site investigation and source-apportionment analysis. Waste Management Research, 2011; 29: 727-738.
59. Song QB, Li JH; A review on human health consequences of metals exposure to e-waste in China. Environmental Pollution, 2015; 196: 450-461.
60. Qingna K; Research on the policy technology of waste home-appliance in Zhejiang Province. Zhejiang University Master Degree Theses, 2010.
61. Song QB, Li JH; Environmental effects of heavy metals derived from the e-waste recycling activities in China: a systematic review. Waste Management, 2014; 34: 2587-2594.
62. Robinson BH; E-waste: an assessment of global production and environmental impacts. Science of the Total Environment, 2009; 408: 183-191.
63. Li J, Duan H, Shi P; Heavy metal contamination of surface soil in electronic waste dismantling area: site investigation and source-apportionment analysis. Waste Manage. Research Journal of International Solid Wastes Public Cleansing Association, ISWA, 2011; 29: 727-738.
64. Wong CSC, Duzgoren-Aydin NS, Aydin A, Wong MH; Evidence of excessive releases of metals from primitive e-waste processing in Guiyu, China. Environment Pollute, 2007; 148: 62-72.
65. Li Y, Xu XJ, Liu JX, Wu KS, Gu CW, Shao G; The hazard of chromium exposure to neonates in Guiyu of China. Science of the Total Environment, 2008; 403: 99-104.
66. Nie XP, Fan CP, Wang ZH, Su T, Liu XY, An TC; Toxic assessment of the leachates of paddy soils and river sediments from e-waste dismantling sites to microalga, pseudokirchneriella subcapitata. Ecotoxicology and Environmental Safety, 2015; 111: 168-176.
67. Quan SX, Yan B, Lei C, Yang F, Li N, Xiao XM, Fu JM; Distribution of heavy metal pollution in sediments from an acid leaching site of e-waste. Science of the Total Environment, 2014; 499: 349-355.
68. Wang JP, Guo XK; Impact of electronic wastes recycling on environmental quality. Biomed Environment Science, 2006; 19: 137–42.
69. Wong MH, Wu SC, Deng WJ, Yu XZ, Luo Q, Leung AOW, Wong AS; Export of toxic chemicals–a review of the case of uncontrolled electronic-waste recycling. Environmental Pollution, 2007; 149(2): 131-140.
70. Ejiogu AR; E-waste economics: a Nigerian perspective. Management Environment Quality International Journal, 2013; 24: 199-213.
71. Deng WJ, Louie PKK, Liu WK, Bi XH, Fu JM, Wong MH; Atmospheric levels and cytotoxicity of PAHs and heavy metals in TSP and PM2.5 at an electronic waste recycling site in southeast China. Atmos Environment, 2006; 40(36): 6945-6955.
72. Rajarao R, Sahajwalla V, Cayumil R, Park M, Khanna R; Novel Approach for Processing Hazardous Electronic Waste. Procedia Environmental Sciences, 2014; 21: 33-41.
73. Pragst F, Balikova MA; State of the art in hair analysis for detection of drug and alcohol abuse. International Journal of Clinical Chemistry, 2006; 370: 17-49.
74. Zhang Q, Zhou T, Xu X, Guo Y, Zhao Z, Zhu M, Li W, Yi D, Huo X; Downregulation of placental S100P is associated with cadmium exposure in Guiyu, an e-waste recycling town in China. Science of the Total Environment, 2011; 410: 53-58.
75. Zheng L, Wu K, Li Y; Blood lead and cadmium levels and relevant factors among children from an e-waste recycling town in China. Environmental Research, 2008; 108(1): 15-20.
76. Duan HB, Hou K, Li JH, Zhu XD; Examining the technology acceptance for dismantling of waste printed circuit boards in light of recycling and environmental concerns. Journal of Environment Management, 2011; 92: 392-399.
77. Guo Y, Huo X, Li Y, Wu K, Liu J, Huang J, Xu X; Monitoring of lead, cadmium, chromium and nickel in placenta from an e-waste recycling town in China. Science of the total environment, 2010; 408(16): 3113-3117.
78. Lin W, Liu YS; Present status of e-waste disposal and recycling in China. Procedia Environmental Sciences, 2011; 6: 506-514.
79. Wei L, Liu, Y; Present status of e-waste disposal and recycling in China. Procedia Environment Science, 2012; 16: 506-514.
80. Sepulveda A, Schluep M, Renaud FG, Streicher M, Kuehr R, Hageluken C, Gerecke AC; A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: examples from China and India. Environment Impact Assess Review, 2010; 30: 28-41.
81. Li JH, Liu LL, Li BY; Waste Electrical and Electronic Products Management Policies. China Environmental Science Press, Beijing, 2011.
82. Yang J, Lu B, Xu C; WEEE flow and mitigating measures in China. Waste Management, 2008; 28:

1589-1597.

83. The People's Republic of China (PRC), Circular Economy Promotion Law of the People's Republic of China. http://www.lawinfochina.com , 2008.
84. Sthiannopkao S, Wong MH; Handling e-waste in developed and developing countries: Initiatives, practices, and consequences. Science of the Total Environment, 2008; 463:1147-1153.
85. Taurino R, Pozzi P, Zanasi T; Facile characterization of polymer fractions from waste electrical and electronic equipment (WEEE) for mechanical recycling. Waste Management, 2010; 30: 2601-2607.
86. Habib M, Nicholas JM, Hall P; Recovering metallic fractions from waste electrical and electronic equipment by a novel vibration system. Waste Management, 2013; 33: 722-729.
87. Astrup T, Moller J, Fruergaard T; Incineration and co-combustion of waste: accounting of greenhouse gases and global warming contributions. Waste Management Research, 2009; 27: 789-799.
88. Alston SM, Arnold JC; Environmental impact of pyrolysis of mixed WEEE plastics part 2: life cycle assessment. Environment Science and Technology, 2011; 45: 9386- 9392.
89. Alston SM, Clark AD, Arnold JC, Stein BK; Environmental impact of pyrolysis of mixed WEEE plastics part 1: experimental pyrolysis data. Environment Science and Technology, 2011; 45: 9380-9385.