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Review

Current situation of used household batteries in Iran and appropriate management policies

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Abstract

Used household batteries are considered as hazardous wastes in many countries due to the potential environmental and human health risks associated with the heavy metals present in batteries. This article presents the current situation of waste household batteries and policies in Iran. Iran with more than 70 million people is a developing country where latest technologies like cell phones and laptops are in widespread use and battery consumption increases accordingly. The household battery demand in Iran has rapidly grown since 2001 and it is expected to increase more quickly in next years, due to increasing technological development. Based on the available data, more than 9800 metric tons of household batteries were imported into Iran in recent decade, with the market value of about US$ 42.6 million. At present, there is no program available in Iran regarding to collection, separation, recycling or safe disposal of used batteries. Therefore, almost all of the spent household are discarded into municipal solid waste (MSW) and sent to sanitary landfills. Appropriate policies to meet safe disposal of household batteries in Iran is also discussed in this investigation.

Contents

1. Introduction

The disposal of used household batteries into municipal solid wastes (MSW) has potential human and environmental health hazards. Batteries contain a variety of heavy metals that may become toxic contaminants in landfill leachate, incinerator emissions, incinerator ash and compost (Tchobanoglous and Kreith, 2002). Typical household-type batteries are used in consumer items such as cordless telephones and cell phones, flashlights, radios, watches, calculators, hearing aids and so on (Bernardes et al., 2004). Based on 1989 statistics, household batteries accounted for more than 88% and 50% of the mercury and cadmium, respectively, in MSW in USA (U.S. EPA, 1989; Tchobanoglous and Kreith, 2002).

From the sustainable development viewpoint, a battery must be considered as recyclable material due to

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its high metal content; it should not be dumped directly in landfills both for environmental and economic reasons, because natural resources will be lost and therefore new material must be imported (Pietrelli et al., 2005). In the other word, landfilling of batteries is no longer a sustainable option for battery disposal. More than 9.5 million tons of municipal solid wastes are disposed in municipal landfills of Iran every year (Abduli, 2005). Iran is a developing country where latest technologies like computer equipment, cell phones, digital cameras and other small electrical appliance are in widespread use and battery consumption increases accordingly. The increase in battery consumption is observed worldwide since battery posses the merit of being handy and portable energy sources (Aktas et al., 2004).

Recently, much attention has been focused on the potential environmental and human health risks associated with the heavy metals present in batteries. Such concern has caused many developed countries to consider used household batteries as hazardous wastes. According to US Environmental Protection Agency, all used batteries must be regarded as hazardous wastes. In most of European countries, severe regulations are bringing the production, utilization, collection, recycling and disposal of the used batteries under control (Tchobanoglous and Kreith, 2002; Aktas et al., 2004). In Iran, almost all of the used household batteries are discarded in municipal solid waste (MSW) without any separation or special collection program. In such situation, Iran which has not initiated any program regarding collection, recycling and safe disposal of used batteries would be encountered with serious environmental and human health risks. Battery scrap management as a major environmental issue has not been studied in Iran. Therefore it is necessary to investigate the environmental and human health hazards associated with unsafe and uncontrolled disposal of used household batteries in developing countries like Iran. The main objective of this paper is to present current situation of household battery scrap in Iran and appropriate policies which can be followed to assure their safe disposal.

2. Method

Many articles, reports and related documents were studied to obtain basic information about the household battery characteristics. Since this is for the first time that a survey has been conducted in the field of health and environmental risks associated with discarded household batteries and battery scrap management in Iran, the literature information have been obtained from appropriate foreign documents. The presented data related to battery situation in Iran were obtained from annual statistics of Ministry of Commerce. In addition, some mathematical calculations were conducted on raw data to facilitate interpretation of them.

3. Current situation of household batteries in Iran

As mentioned above, Iran has not planned any program regarding collection, recycling and safe disposal of used household batteries. Unfortunately, majority of people (and also authorities) in Iran are unaware of the importance of safe disposal of used household batteries. Safe disposal of waste batteries in Iran would not be successfully initiated without widespread awareness of its importance. Thus, in the first step we should aware of the risks associated with unsafe disposal of discarded batteries in MSW, which described in former sections in detail. Secondly, the current situation of household batteries in Iran should be investigated to get a proper outlook for future planning and establishment of appropriate collection, recycling and safe disposal programs. Clarification of exist situation of household batteries in Iran as a basic step for future projections carried out in the present research.

In general, clear and exact information about household battery trading and consumption in Iran is not available. However it seems that the majority of batteries used in Iran, are imported from foreign countries. Thus we would focus on imported batteries and their marketing value in current study. The quantities of household battery import into Iran between 1995 and 2004 are presented in Table 1. As it can be seen in Table 1, the household battery import of Iran was about 117 metric tons in 1995. This value was reached up to 3969 metric tons in 2004 (approximately 34 times increase). Household battery importation into Iran was relatively low before 2001. This trend has significantly increased since 2001.

This is indicated that household battery demand has rapidly increased in recent years. The observed trend is in consistent with rapidly spreading use of cell phones, notebooks, digital cameras, and other modern electrical appliances, in recent years (Abduli and Daryabeigi Zand, 2005).

Rapid advances in technology and consumer behavior have an important role in battery consumption (and also battery lifetime). For instance, new cell phones have more capabilities than old generations, like shooting pictures and short filming. This leads to rapid depletion of cell phone battery, thus cell phone battery should be recharged more frequently. As a result, complete discharge of battery occurred more quickly than usual. More rapid generation of battery scrap will be expected in following years, as a consequence of rapid changes in development and performance of modern battery consumer devices and also the manner of their uses.

The import rate of mercuric-oxide batteries was low before 2001, however; mercuric-oxide battery import of Iran has increased in recent years (except for the year of 2004) (Table 1, Fig. 1). In the year of 2001, more than 80 tons of household mercuric-oxide batteries were imported, whereas the use of batteries containing mercury has strictly limited (or banned) in many developed countries. For example in line with the EU Directives, from 1 June 2000 the use of batteries containing more than 25 mg mercury

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Table 1
Iran's annually battery import by weight between 1995 and 2004 (kg)

Year	Battery type								Total costs (Million US$)
	Alkaline	Mercuric-oxide	Silver oxide	Lithium	Zinc–air	Nickel–cadmium	Miscellaneous	Total	
1995	–	–	–	–	–	–	116,855	116,855	3.82
1996	4879	–	–	–	–	10,777	17,671	33,327	0.56
1997	8419	4022	–	–	–	35,819	41,689	89,949	1.83
1998	4021	785	–	–	–	74,344	177,722	256,872	2.85
1999	–	1251	208	6299	–	49,233	58,024	115,015	1.60
2000	15,698	5	620	3205	–	67,460	44,416	131,404	2.58
2001	32,976	80,686	640	7495	6866	337,390	275,345	741,398	6.97
2002	72,165	58,525	8900	1482	17,725	332,432	1,279,235	1,770,464	5.30
2003	411,539	31,192	20	100,372	227,119	170,895	1,709,193	2,650,330	6.92
2004	1,164,766	223	4627	37,604	778,670	265,403	1,717,911	3,969,204	10.13
Total	1,714,463	176,689	15,015	156,457	1,030,380	1,343,753	5,438,061	9,874,818	42.56

Ref.: Iran Ministry of Commerce (1995–2004).

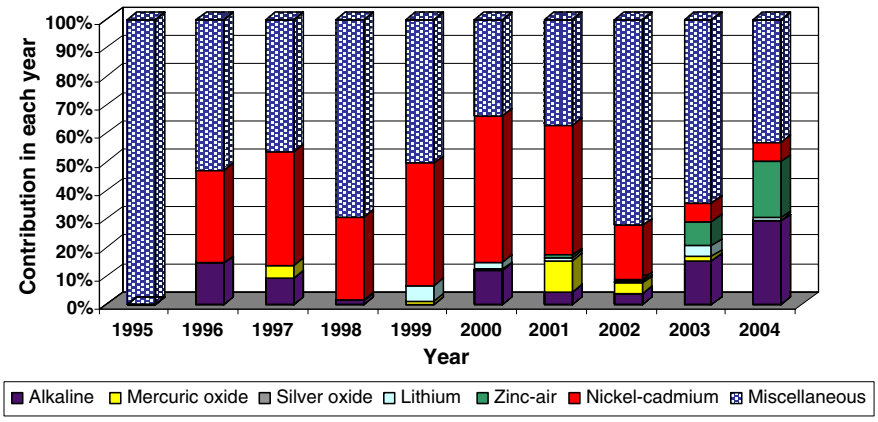

Fig. 1. Contribution of different types of imported household batteries by weight.

per unit has been prohibited throughout EU countries (Aktas et al., 2004). The average price of imported mercuric-oxide batteries was about US$ 10.87 kg^{-1} in 1999 while their price decreased to US$ 1.87 kg^{-1} in 2001. This is originating from the fact that well-informed countries which carefully aware of the risks associated with mercury contained discarded batteries (especially developed countries) have not still interested in consumption of mercuric-oxide batteries. However, other determinant factors such as battery capabilities, lifetime, and changes in world price of batteries based on relevant policies and circumstances may affect the world price of different types of household batteries.

In Iran, demand for alkaline, nickel–cadmium and lithium-ion batteries has increased relatively more than other types of household batteries, in recent years (Table 1, Fig. 1). This trend is consistent with that observed in other world regions. The alkaline battery consumption in Iran has rapidly increased since 2000. The market share of alkaline batteries reached 29.3% in 2004. Demand for alkaline battery consumption is expected to increase in following years due to their high performance, long shelf life and suitable price.

It is also seen from Fig. 1 that miscellaneous, nickel–cadmium and alkaline batteries have had the most shares of imported batteries into Iran, respectively. Unfortunately there are no data available about the types and components of miscellaneous batteries. The significant share of miscellaneous batteries in MSW and lack of information about their composition would complicate finding the exact share of different elements and compounds in waste batteries. However, awareness of available information about share of different types of household batteries in MSW of Iran would be beneficial for establishment of appropriate collection, separation, recycling or disposal programs.

The growth of nickel–cadmium importation into Iran indicates that demand for rechargeable battery consumption is going to increase in Iran. This is in conjunction with increment of rechargeable-battery-consumer-device development in Iran and awareness of their capabilities. However, the consumption of Ni–Cd batteries must be accompanied by safe disposal of them, due to serious environmental and human health risks related to release of toxic components of Ni–Cd batteries. It is noticeable that, Ni–MH batteries are considered environmental friendly and can replace Ni–Cd batteries in many applications. However, the costs of production are higher when compared to Ni–Cd batteries (Putois, 1995). Consumption of Ni–MH batteries is negligible in Iran due to their high prices, specially in recent years.

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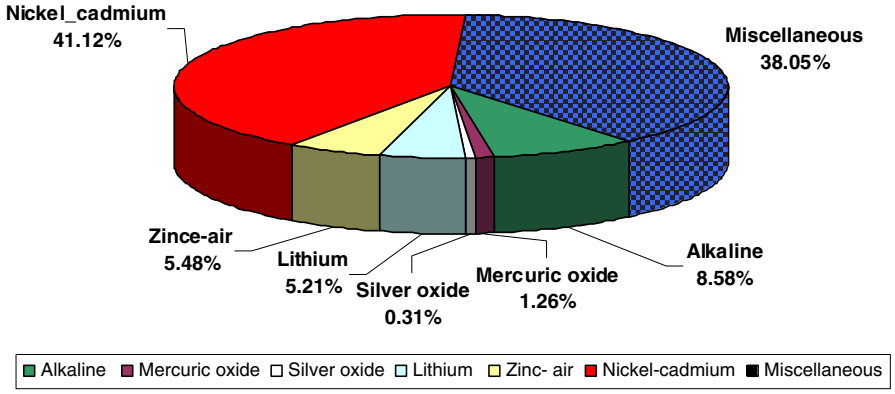

Fig. 2. Share of different types of imported household batteries by price.

Table 2
Weight percentage of potentially toxic and heavy metals in typical household batteries

Battery type	Metal (%)					
	Cadmium	Mercury	Nickel	Silver	Zinc	Lithium
Alkaline	0.01	0.025–0.5	–	–	8–18	–
Zinc–carbon	0.03	0.01	–	–	12–20	–
Mercuric-oxide	–	30–43	–	–	10–15	–
Silver oxide	–	1	–	30–35	30–35	–
Zinc air	–	2	–	–	35–40	–
Nickel–cadmium	11–15	–	15–25	–	–	–
Lithium	–	–	5–10	–	–	5–7

Ref.: Tchobanoglous and Kreith (2002), Bernardes et al. (2004), Nanwen et al. (2003), Shin et al. (2005).

Demand for Li-ion battery consumption has increased in recent years due to their good performance, especially in laptops and cell phones which are being used extensively in Iran. Li-ion battery import began in 1999, almost coincident with introduction of cell phone in Iran market. Since increasing trend in cell phone usage (and also laptop use) is available in Iran, the consumption and importation of Li-ion batteries are expected to increase in next years.

The worth shares of different types of imported household batteries into Iran are shown in Fig. 2. The spent cost for import of household batteries in recent surveyed years (2001–2004) comprises more than 68% of the total spent money for household battery import in recent decade (1995–2004). This is in accordance with significant rise of household battery importation in recent surveyed years (Table 1).

Almost 10,000 metric tons (9,874,818 kg) of household batteries were imported into Iran in recent decade. Most of them have been discarded in MSW without any separation and have been sent to sanitary landfills. Imported household batteries have had the value about US$ 42.6 million. In addition to environmental and human health risks associated with unsafe disposal of household batteries in MSW stream, their landfilling implies the wastage of valuable resources available in used batteries which may be important from both sustainable development and economical viewpoints.

Knowledge of the composition of spent batteries in MSW is an important step for evaluating the environmental impact of the alternatives to deal with this type of waste, usually landfilling or incineration, since those characteristics determine the quality, quantity and timeframe for release of emissions (Almeida et al., 2006). The metallic composition of typical household batteries found in MSW is presented in Table 2.

Iran imports a large number of household batteries from UAE, China, South Korea, Sweden, Germany, Hong Kong, Singapore, Japan, England, Switzerland, Turkey, France, and Austria. The contribution of UAE and China in battery export to Iran is much more than other countries in recent decade, as shown in Fig. 3. As it can be seen in Table 3, UAE, Germany, China, South Korea, and France exported almost all different types of household batteries to Iran.

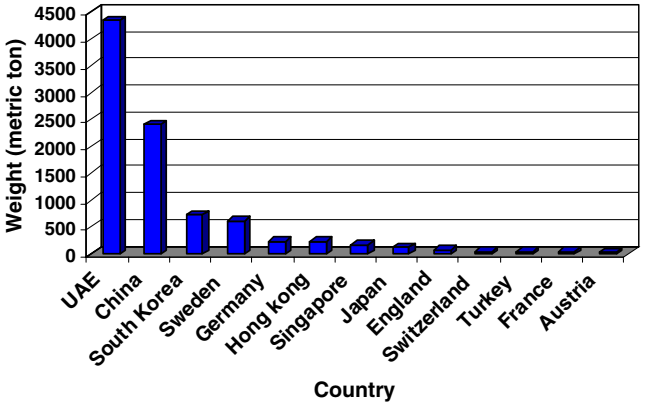

Fig. 3. Main exporters of household batteries to Iran between 1995 and 2004.

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Table 3
Quantity of different types of exported batteries to Iran by different countries (Kg)

Year	Battery type							
	Alkaline	Mercuric-oxide	Silver oxide	Lithium	Zinc–air	Nickel–cadmium	Miscellaneous	Total
UAE	573,313	24,599	9528	66,357	987,049	41,721	2,649,272	4,351,839
China	373,417	40,636	–	58,642	31,775	34,723	1,867,857	2,407,050
South Korea	507,382	1036	–	1353	50	8702	211,064	729,587
Sweden	4193	–	–	1	–	612,963	421	617,578
Germany	24,403	6576	350	1968	1578	141,501	55,581	231,957
Hong kong	168,486	–	797	3063	–	4370	53,094	229,810
Singapore	18,295	–	–	704	1405	4227	139,331	163,962
Japan	460	72,690	–	6342		12,409	28,766	120,667
England	1851	–	–	4982	8487	20,396	37,991	73,707
Switzerland	–	–	–	–	–	4603	41,883	46,486
Turkey	220	–	–	–	–	16,217	29,344	45,781
France	200	2865	640	1686	–	29,437	6659	41,487
Austria	6042	–	–	–	–	6010	21,723	33,775
Total	1,678,262	148,402	11,315	145,098	1,030,344	937,279	5,142,986	9,093,686

Ref.: Iran Ministry of Commerce (1995–2004).

4. Management of spent household batteries in Iran

Almost all of the spent household batteries have been discarded into MSW in Iran. Thus they have been accumulated in municipal landfills in Iran over many years. It is expected that more than 9000 metric tons of spent household batteries have been dumped in municipal landfills of Iran in recent decade. It has represented almost 0.01% of the total landfilled MSW in recent decade. The most concern regarding battery disposal in MSW is directed to the high percentage of mercury, cadmium, lithium, nickel, arsenic and other toxic and heavy metals in MSW that is attributed to used batteries. Adverse effects of heavy metals on surrounding environment and human health have been well documented (Wang et al., 2006; Loredo et al., 2006; Bertin and Averbeck, 2006). Disposal of used household batteries into MSW must be assessed for its potential human and environmental health impacts.

However, the environmental fate of toxic materials of batteries in a landfill is considerably influenced by the conditions of the batteries when landfilled and the conditions of the landfill itself (Bernardes et al., 2004; Shin et al., 2005). Unfortunately, most of the available landfills in Iran have not equipped with engineering liners (Abduli, 2005). Some studies conducted in Iran show that the infiltration of landfill leachate has contaminated the groundwater in vicinity of municipal landfills and has deteriorated its chemical quality (Raghimi et al., 2004).

Recycling of spent household batteries not only prevents risks associated with battery landfilling or incineration, but also assists the environmental preservation and recovery of valuable resources. So far, Iran has not planned any program regarding proper management of used household batteries (specially establishment of separation programs) while household battery discarding is ongoing and progressive. The continuation of current trend in Iran may lead to serious environmental and human health risks. On the other hand establishment of recycling programs in Iran is not feasible in short term due to the lack of recycling infrastructures (Abduli, 2005). This is originating from the fact that, the separation and collection of batteries must be well established before any recycling process is organized. Furthermore, technical and economical aspects of household battery recycling should be considered.

Thus in such a situation and in the first step, appropriate and applicable laws must be legislated regarding proper management of waste household batteries in Iran, following by establishment of household battery collection and separation programs. Safe disposal of spent household batteries in Iran requires widespread awareness of people, since without creating people awareness and a nationwide contribution of them, collection and following programs cannot be put into life. Thus, people's participation is an indispensable element of this process and should be supported by the media and government. In addition, recycling concept should be put into national curriculum as a lesson starting from elementary schools.

Until the establishment of well-organized recycling programs in Iran collected and sorted batteries should be either disposed in approved hazardous waste landfills separated from MSW landfills (some projects regard with site selection and design of hazardous waste landfills have been initiated in some important cities of Iran like Tehran, Shiraz, Hormozgan, etc.) or shipped overseas for reclamation in foreign recycling facilities which need spent household batteries as their input feed.

5. Conclusion

Unsafe disposal of used household batteries may be associated with human health and environmental hazards. From the viewpoints of human health protection, environmental preservation, and sustainable development scopes, uncontrolled disposal of spent household batteries into MSW is not justifiable. Iran has not organized any collec-

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tion and separation program to avoid battery intrusion into MSW stream yet. It is estimated that more than 9000 metric tons of discarded household batteries have been sent to municipal landfills of Iran, which mainly vulnerable to release of leachate into the environment.

The rapid rate of household battery demand in recent years is in consistent with rapidly spreading use of modern electrical appliances like cell phones, notebooks, and digital cameras. In addition, demand for alkaline, nickel–cadmium and lithium-ion batteries is more than other types of household batteries in Iran. Recycling of spent household batteries in Iran is not feasible in short term. Establishment of collection and separation programs is the first step toward safe disposal of these hazardous wastes in Iran. Disposal of collected household batteries in hazardous waste landfills or export them to foreign recycling facilities (if needed as input feed) may assure safe disposal of spent household batteries in Iran in current situation.

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