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Review

Selective Collection of Used Portable Batteries

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Abstract

One of the main sources of pollution with heavy metals in municipal landfills, is the used portable batteries. An analysis of soil pollution with heavy metals from the waste landfills show that the predominantly heavy metals are: lead, zinc, cadmium, manganese and nickel.

The selective collection of portable batteries has been required by EU legislation (2006) transposed in Romanian legislation (2008), and is important because of heavy metals content of portable batteries. Under the law, the minimum collection rate to be achieved by producers is 25% until September 26, 2012 and 45% until September 26, 2016. Currently, the selective collection of portable batteries is practiced by a very small scale, the population like the end user, is not sufficiently informed about the importance of this category of waste, and the facilities themselves are relatively small.

Keywords: collection, portable batteries, hazardous waste, metals

1. Introduction

Generally, waste has become a major problem because it comes to affect human health and the environment. To produce consumer goods, is using increasing amounts of high raw materials and natural resources, energy and water. These consumer goods at some point become waste, the waste diversified, many of which are difficult to assimilate the environment. Selective collection and recycling are solutions with immediate effect. Selective waste collection involves the temporary storage of waste categories in special places, and recycling waste is processing some of its components in order to transform them into useful products.

By selective collection and recycling, nature is protected, reducing consumption of natural resources, and by reuse of metals can reduce the pollution of soil, water and air. A major category of waste is the municipal waste containing hazardous chemicals, which in turn poses a threat to human health. Hazardous waste must be selected and stored in special conditions.A category of the hazardous municipal waste is the used portable batteries and accumulators. In the Government Decision no. 1132/2008 is defined a portable battery and accumulator like a battery type pill, or a battery pack, that can be moved manually, and is not an industrial battery or accumulator, or a car battery. Also under the same ruling, the battery or the accumulator is any source of electricity generated by direct conversion of chemical energy and consists of one or more primary cells (non-rechargeable) or in one or more secondary cells (rechargeable batteries). Portable batteries or accumulators have mass below 1 kg, and are used in small devices [3].

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Table 1. Types of portable batteries [2]

Portable non-rechargeable primary batteries	Portable secondary rechargeable batteries
Zinc-carbon batteries	Gel Batteries
Zinc Chloride Batteries	Lithium-ion batteries
Alkaline batteries - alkaline/manganese	Polymer lithium ion batteries
Silver-oxide batteries	NaS battery
Lithium batteries	Batteries Ni-Fe
Mercury batteries	Nickel metal hydride batteries
Zinc-air batteries	Nickel-cadmium batteries
Thermal Batteries	Na-metal chloride batteries
Batteries activated by water	Nickel-Zinc Batteries

2. Material and method

Portable batteries mainly contain metal, but also electrolytes and non-metals. Their construction requires 50 times more energy than they generate, and raw materials are produced are non-renewable resources, sometimes rare and expensive, like Ag and Pt. The chemical composition of a standard portable battery is represented in table 2.

Table 2. Standard chemical composition (g/kg of 100) of batteries sold in the market [2]

	Metals									Electrolytes					Non-metals
System	Pb	Us	CD	Zn	Mn	Ag	Hg	Them	Fe	HSO	KOH	NHCL ZnCl	Electr. Org	HO	Plastic, paper, coal, black carbon
Pb/PbO_2	65	-	-	-	-	-	-	-	-	8.	-	-	-	17	10
NiCd	-	20	15	-	-	-	-	-	45	-	5.	-	-	10	5.
Zn/MnO_2	-	-	-	20	35	-	-	-	20	-	-	5.	-	10	20
Acid -Basis	-	-	-	20	30	-	-	-	20	-	5.	-	-	10	15
Zn/AgO_2	-	-	-	10	-	30	1	-	40	-	3	-	-	6.	10
Zn/HgO	-	-	-	10	-	-	30	-	40	-	3	-	-	6.	11
Zn/O_2	-	-	-	30	-	-	2	-	45	-	4.	-	-	8.	12
Li/MnO_2	-	-	-	-	30	-	-	2	50	-	-	-	10	-	10

Heavy metals (any item with a high atomic weight, between 21 (scandium) and 92 (uranium), like Cd, Cr, Cu, Pb, Hg, Ni, Se, Zn) is a group of pollutants with global distribution, which substantially affect the ecosystems. As natural elements, metals are characterized by a large dispersion in the environment. Have a high potential toxicity, because they have tended to selectively accumulate in tissue [8]. Because of high toxicity of heavy metals such as Hg and Cd, a particular attention should be paid to the portable battery which operated based on these metals.

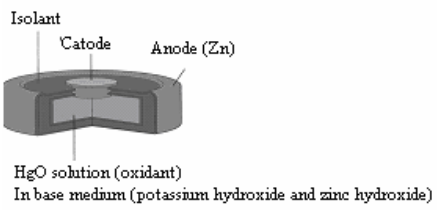

Figure 1. Section by a mercury battery, type pill [9]

Mercury battery (also called battery with mercuric oxide, or mercury cell) is a primary electrochemical battery. Is used as cathode a pure mercuric oxide (HgO) or a mixture of mercuric oxide with manganese dioxide. The anode consists of zinc and is separated by cathode by a layer print paper or other porous material impregnated with electrolyte [2]. During discharge, zinc is oxidized to zinc oxide and mercuric oxide is reduced to elemental mercury. Mercury batteries are very similar to batteries with silver oxide. Batteries with mercuric oxide cathode have a constant voltage of

1.5 V, almost to the end of their life, when the voltage decreases rapidly.

Batteries with mercury cathodes formed from a mixture of mercuric oxide and manganese dioxide have a 1.4 V output voltage.

Because of mercury content, the sale of mercury batteries is banned in many countries [2]. The mercury contained in a watch battery can contaminate 500 gallons of water or a square meter of soil over a period of 50 years [4].

Nickel-cadmium batteries (NiCd) are a popular type of rechargeable batteries used for portable electronics and toys. Because of the relationship between weight and energy supplied, and the long operating life, the high capacity NiCd batteries with wet electrolyte (wet batteries NiCd), are used for electric cars, as well as starting batteries for aircraft.

NiCd batteries contain a positive electrode nickel hydroxide, a negative electrode cadmium dioxide, a separator, and an alkaline electrolyte. It has a metal housing with a locking plate and a safety valve with self-closing. The positive and negative electrode plates, isolated from one another by a eparator, are rolled into a spiral casing.

Chemical reactions occurring in a NiCd battery are:

$$2\ NiO(OH) + Cd + 2\ H_2O \leftrightarrow 2\ Ni(OH)_2 + Cd(OH)_2$$

NiCd secondary batteries have a nominal potential of 1.2 V, less than most primary batteries with 1.5 V, making it unsuitable to many uses, but keeps a constant voltage over their use. Despite their nominal low voltage (1.2 V), NiCd batteries fit applications with a high power consume [2].

In Romania there are legal provisions concerning the importation, sale, storage of portable batteries and the conditions of collection and recycling of waste batteries.

The legislative framework governing the management of portable batteries and accumulators and waste of the portable batteries and accumulators includes the following laws:

1. Directive 2006/66/EC on batteries and accumulators and waste of the batteries and accumulators transposed into Romanian legislation by Government Decision no. 1132/2008 on batteries and accumulators and waste of the batteries and accumulators. [3].
2. Directive no. 2002/96/EC on electrical and electronic waste, transposed into Romanian legislation through Government Decision no. 448/2005 on electrical and electronic equipment waste with subsequent changes [10].
3. Directive no. 2008/98/EC on waste and repealing certain Directives, which will come into force on 12.12 2010 [11] .
4. Regulation (EC). no. 1.013/2006 of the European Parliament and the Council of 14 June 2006 on shipments of waste [12] .

Under law, the minimum collection rate to be achieved by producers is: 25% until September 26, 2012 and 45% until September 26, 2016 [11]. The markets which are selling portable batteries are required by law to accept used batteries, and to provide buyers special containers for selective collection of them.

Figure 2. Container for the selective collection of waste portable batteries, Carrefour Polus Center, Photo: Gabriela Popița

The law also prohibits the marketing of all batteries and accumulators containing mercury at a rate greater than 0.0005% by weight, whether or not incorporated into appliances, and portable batteries and accumulators, including the integrated one in devices, which contain cadmium at a rate greater

than 0.002% by weight [3]. Although legislation provides for the selective collection of portable batteries waste, they are often discarded with household waste. In the municipal solid waste stream, heavy metals from portable batteries waste represent approximately 88% of total mercury and 50% of cadmium in municipal landfills [5]. High concentrations of heavy metals and other toxic or corrosive hazardous components from used batteries are contaminating water, soil and air when they treated at the landfill.

To check the existing concentrations of heavy metals in municipal solid waste landfills were conducted laboratory chemical analysis of the untreated leachates (directly from the landfill body), from the Ecological Landfill for non-hazardous waste Oradea, Bihor County. The results shown a high level of certain metals, compared with normative values admitted on infringement pollutant load limits NTPA 001, Annex 3 of the GD 188/2002, amended and completed by GD 352/2005 [6, 7].

Table 3.Limits Comparison of pollutant metals and values [6] and analysis in July 2009

Sample analysis	-	Collected leachates values mg/l 2008	Collected leachates values mg/l 2009	Discharge accepted values NTPA 001 mg /dm^3
Nickel	Ni	0.10 *	1.65 *	0.5
Lead	Pb	7.6 *	0.46 *	0.2
Copper	Cu + +	0.074	0.14 *	0.1
Zinc	Zn + +	0.339	0.85 *	0.5
Manganese	Mn +	1530 *	-	1.0 (all)
Iron	Fe + +	<0.01	-	5 (all)
Mercury	Hg	<0.2 *	<0.1 *	0.05
Cadmium	Cd	<0.001	0.116	0.2

Values marked with an asterisk are above legal limits

In table 3 it is noted that the values of Ni, Pb, Cu, Zn, Mn, and Hg in untreated leachates, exceed the limit allowed by law.

Concentration of certain metals may be higher or lower depending on the composition of waste entering the warehouse.

If the amount of the used portable batteries and accumulators that reaches the landfill is higher, then metals concentration in untreated leachates will increase.

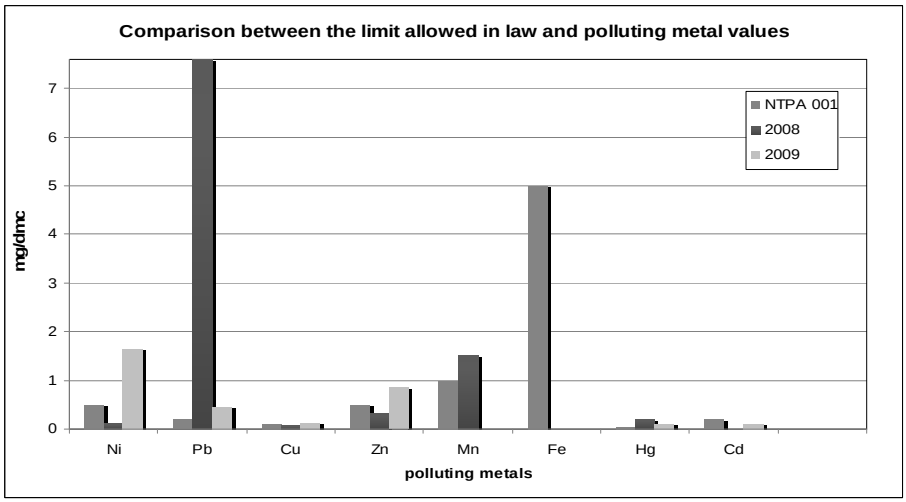

Figure 3. Comparison between the limit values allowed in law and polluting metal values

Recycling of portable batteries and accumulators is necessary to: protect the environment and human health, avoiding the enormous costs involved in water and soil decontamination and supporting industries that can use recycled metals, with lower production costs.

Thus treatment of 100 tones of used batteries allow recovery of 39 tones of ferro-manganese (alloy for foundries), 20 tons of zinc and 150 kg of mercury [4].

In Romania, because of the lack of an effective system of collection, the recovery of mercury, lead and cadmium from spent batteries (operation economically feasible and environmentally) is practically impossible.

In Europe, the infrastructure for recycling of portable batteries waste already exist in some countries, as in 2002, the portable battery collection rate, in the six countries that have already established networks for this purpose, was: 59% in Belgium, 55% in Sweden, 44% in Austria, 39% in Germany, 32% in the Netherlands, and 16% in France [4].

3. Results and discussions

The selective collection of portable batteries is in Romania in the early stages of implementation of legislation. There are specific initiatives of private institutions and public institutions for the environment. An example is a pilot educational project for Cluj-Napoca, "What to do with used batteries?" conducted over three phases, supported by the Lions Club and its partners: Cluj County School Inspectorate, IF Technology Society and Regional Environmental Protection Agency Cluj Napoca. With students help from 15 schools in Cluj-Napoca, were collected a total of 3340 kg portable batteries thus divided into three stages: Stage I from 2006 to 2007 - 1569kg, Stage II 2008-1094 kg, Stage III-2009 - 677 kg [13].

These specific initiatives are a minor importance, given that Romania is sold annually in an amount of 40 million batteries that go to after use to a municipal landfill of solid waste.

For portable batteries waste, to reach places for hazardous waste, or to be recycled, the manufacturers must establish appropriate collection systems which in turn, must be:

a) allowing the end users to discard the portable batteries or accumulators waste to an accessible collection point in their vicinity, taking into account population density;

b) requiring the distributors to receive free back portable batteries or accumulators waste, where they provide new portable batteries or accumulators;

c) involving no cost from the end users who disposes portable batteries or accumulators waste, and no obligation to buy a new battery;

d) using in conjunction with systems for collecting electrical and electronic equipment waste [3].

The content of heavy metals of the used portable batteries can seriously affect health. Thus, the pure elemental mercury is a toxic heavy metal that accumulates and is partially absorbed through the skin and easily through the lungs. Mercury compounds, especially the organic ones, are more toxic than elemental mercury itself. Mercury affects the central nervous system, endocrine system, kidneys and other organs, the secondly affects the mouth, gums and teeth. In children, the exposure to mercury can have serious neurological consequences, preventing formation of neural layers and in particular myelin [4].

On aquatic creatures, both mercury and its compounds have high toxic effects, acute on short term and chronic on long time because persist in the aquatic environment and bioaccumulates in fish tissues. Cadmium and its compounds are highly toxic even in low concentrations and bioaccumulates in organisms and ecosystems. Generally the cadmium effects on organisms include liver damages, decreased and softening bone mass, kidney failure and respiratory problems.

4. Conclusions

Because Romania is an early period of implementation of legislation and a functioning system of the selective collection of portable batteries, the quantities of the used portable batteries collected national inventory is not yet available, it will be validated on the next period.

So, at national level on 01/27/2010, were registered 27 authorized operators for the portable battery collection and were not allowed traders to carry out treatment of portable batteries [14]. Also there are still not operators to carry out recycling and recovery of metals especially existing on the portable batteries: iron, zinc, cadmium, nickel, mercury. The options for the disposal of quantities of portable batteries and accumulators collected by stores and delivered to the authorized collectors could be: the incineration and the treatment and recovery in the European Union.

But the incineration of the portable batteries present a safety concern due to the release of metals in air and because concentration of metals in ash which then reach deposits. Batteries containing mercury, cadmium and lead present by incineration a largest environmental impact. Overall mercury is emitted into the atmosphere as a gas and cadmium and lead concentrations are found in some ash [1].

In this context it is imperative to implement legislation already transposed, with an emphasis on public awareness on the need for selective collection of household hazardous waste and particularly by limiting the use of portable batteries, preferably using the rechargeable batteries and accumulators.

It is important to establish an effective waste portable batteries integrated management system which includes: collection, sorting based on metals

and materials contained, transportation and economically feasible and environmental protection disposal option. Also are badly needed the portable collected and recycled batteries quantities inventory and setting up national companies recycler for the portable batteries waste.

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