

HEAVY METALS QUANTIFICATION ON ALKALINE BATTERIES INCINERATION

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Heavy metals emissions associated with municipal solid waste (MSW) incineration is a point of discussion and care due to the known harmful effects of these metals on humans and environment. Batteries are appointed as one of the main contributors for those emissions, particularly for mercury, cadmium, zinc and lead. In this paper, results for heavy metals emissions from alkaline batteries obtained in a laboratorial incinerator are presented. The incineration process took place in a tubular oven where batteries were heated at 1000°C with a constant airflow. Heavy metals on released gas were collected with concentration by absorption on a set of serial bubblers, and, following, quantified by atomic absorption spectroscopy. The results obtained estimate the potential contribution of alkaline batteries to heavy metals emissions in a municipal solid waste incinerator.

METHODS

❖ Batteries

- AA alkaline batteries (set of 10) opened
- plastic jacket and paper disc under the anodic collector were removed

❖ Incineration process simulation

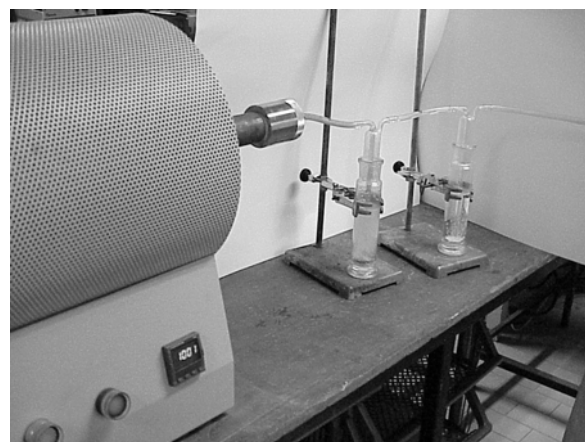
- laboratory tubular oven made with refractory steel
- each battery was loaded and heated at 1000°C for 1 hour under a constant flow of air

❖ Sampling and quantification

- gases produced, after passing through a 0,45µm filter are collected by concentration on a series of 2 bubblers with 100ml of 10% nitric acid solution
- following combustion experiments, fitting tubes, filter support, tubular oven and bubblers, all were washed with fresh acid nitric solution
- using the solutions obtained, heavy metals as zinc, copper, cadmium, manganese and lead were quantified by flame atomic absorption spectroscopy, mercury was determined by cold vapor atomic absorption spectroscopy
- a prior blank experiment was also performed

❖ Leaching test

- to evaluate the relative environmental impact of batteries after combustion when landfilled
- 100 grams of burned batteries for 1liter of distilled water
- flask continuously mixed in a up to bottom rotational movement with a speed of 21rpm for 24 hours
- the resulting solution was filtered and heavy metals determined
- similar tests with non-burned batteries, either entire or transversally opened were also carried out to assess its comparative pollutant potential.



RESULTS

The results obtained for heavy metals quantification on gases from batteries incineration are presented on Table 1, expressed as milligrams per battery (mg/bat.) for all metals except for mercury that is expressed as micrograms per battery (µg/bat.). Filter+tubular oven solution includes all the solution used to wash filter and filter support (50ml) and oven (100 ml) following burning process. Bubblers solutions include solution used in gas collection (100 ml) and washing solution (50 ml). Results from leaching tests are presented in Table 2. In both tables, the results expressed as less than a given amount were obtained using the detection limit of the equipment for each metal.

Table 1. Heavy metal contents on gases resulting from alkaline batteries (AA) incineration in a tubular laboratorial oven at 1000°C.

	Zn (mg/bat.)	Cu (mg/bat.)	Cd (mg/bat.)	Mn (mg/bat.)	Pb (mg/bat.)	Hg (µg/bat.)
Filter + tubular oven	256.8	0.08	0.01	2.8	0.4	0.3
Bubbler 1	4.1	< 0.06	< 0.0005	0.002	0.06	0.4
Bubbler 2	0.01	< 0.06	< 0.0005	0.0008	< 0.001	0.07
Total	260.9	0.08	0.01	2.8	0.46	0.77

Table 2. Heavy metals contents on leachate obtained with burned, entire and transversally opened alkaline batteries (AA) leaching tests.

	Zn (mg/bat.)	Cu (mg/bat.)	Cd (µg/bat.)	Mn (mg/bat.)	Pb (mg/bat.)	Hg (µg/bat.)
Burned	1.3	0.01	< 0.006	2.4	< 0.018	< 0.21
Entire	0.8	< 0.01	< 0.007	0.06	< 0.023	< 0.28
Opened	1.7	< 0.009	< 0.007	0.4	< 0.023	0.8

These experiments shown **zinc** mainly at the filter and tubular oven, despite it was also transported to the first bubbler. These results are meaningful since at preliminary blank experiment, zinc is only detected at the washing solution of stainless refractory tube under an insignificant amount, i.e., as traces.

Copper at the filter and stainless refractory tube solution referred in Table 1 is looked as not significant, since it has the same order of magnitude than with the blank test. As metal and oxide, Copper is not significantly vaporized at the temperature of the tests that explaining to be not found at the bubblers solutions.

In the burning batteries experiments only traces of **cadmium** were found at filter+stainless refractory tube washing solution.

Manganese is only significantly present at filter+stainless refractory tube washing solution.

In consequence of batteries burning, **lead** is found at filter+stainless refractory tube washing solution and at the first bubbler solution. Probably, it results from metal vaporization much more volatile than its oxide form.

These experiments found **mercury** at the filter+stainless refractory tube washing solution in a total amount of about 0,77 µg/bat.

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