Dioxins and incineration in Antioquia-Colombia

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Introduction

In May 2004, 59 countries ratified the Stockholm Convention by which the parties agreed to demonstrate continuous reduction of persistent organic pollutants (POP). Several Latin-American countries, such as Argentina, Cuba[1], Uruguay, and Paraguay, have released estimated POP inventories using the UNEP toolkit[2]. Colombian authorities signed the Stockholm Convention in May 2001 and are making efforts to accomplish the requirements in order to ratify the Treaty. Recently a law was passed (resolution 0886[3], issued in July 2004) establishing emission limits for waste incineration facilities. The law introduced limit values of 70 ng I-TEQ/Nm^3 for PCDDs and PCDFs in stack gas emissions from medical waste incinerators having capacities below 600 Kg/month; however, by august 1st 2005 those emissions should be less than 40 ng I-TEQ/Nm^3, and by august 1st 2012 the limits should be reduced to 2.0 ng I-TEQ/Nm^3.

In compliance with the current regulation, the Environmental Catalysis Research Group at the University of Antioquia (Medellín-Colombia) has started a research project, sponsored by Corantioquia, with the aim of having the first dioxin inventory in the province of Antioquia (Colombia). Corantioquia is an environmental agency having jurisdiction over 80 Antioquia towns. So far, 8 out of 16 medical waste incinerators within said jurisdiction have been sampled, and at the moment this contribution is written we have characterized dioxin and furan emissions from 6 incinerators.

As in other Colombian regions, medical waste in the province of Antioquia is incinerated on site due to the lack of proper storage and transportation facilities. Thus, each hospital incinerates its waste in a furnace directly connected to a stack, without any effluent treatment (other than gas/solid separators, in a few cases). Moreover, incinerators typically operate in a batch mode and were neither designed nor built to facilitate sampling. As a consequence, sampling conditions are difficult, and sometimes precarious.

In this report we summarize the emissions of PCDD/PCDF from six medical waste incinerators located in semi-rural areas of Antioquia. A diagnosis of the operating conditions of the incinerators is also presented. Sampling was conducted isokinetically and dioxin analysis was performed by high resolution gas chromatography coupled to ion-trap low resolution mass spectrometry- (HRGC-QITMS/MS). The effect of incineration conditions is discussed, along with other variables that may affect dioxin emissions in these combustion processes. Assessment of the main aspects to achieve dioxin emissions reduction[4] required by Colombian laws[3], and comparison of actual emissions with emission factors are also presented. Corantioquia's ultimate goal in pursuing this project is reducing dioxin emissions, either by taking corrective measures or by adopting alternative elimination plans for those incinerators that do not meet law requirements (for example, by shutting down such installations).

Materials and methods

Sampling was performed according to the filter/condenser EPA-23 method[5] and the parameters and apparatus described wherein. However, we used the sampling time required by the EN-1948 as well as the standards prescribed in that method (for compatibility reasons with our European collaborators). It is important to note that a control blank was always used. Each sample was isokinetically withdrawn from the gas stream and collected in a train consisting of a sample probe, a fiber filter, and a packed column of adsorbent material (Amberlite XAD-2) previously spiked with the standard sampling solution formed by a mixture of labeled PCDFs (EN-1948-SS from Wellington). The extracted samples were analyzed by HRGC-QITMS/MS according to the isotope-dilution method. The European method for dioxin analysis requires that sampling time be at least 6 h in order to ensure enough sample volume. Therefore, some of the smaller facilities had to store waste to get such sampling time.

Although EPA-1 method suggests the localization of traverse points on two perpendicular diameters, it was only possible to conduct sampling through a single point in view of the small stack diameters and/or access possibilities in almost all incinerators. The number of sampling points was dictated by the EPA-1 method (eight for stack diameters between 0.30 and 0.61 m and twelve for stack diameter greater than 0.61 m). For stack diameter less than 0.30 m, eight sampling points were also used.

Results and discussion

Operating conditions of incinerators monitored in this study are summarized in Table 1. It is important to note that all

incinerators are operated in batch mode and, as a result, waste is first admitted to the combustion chamber before the feed temperatures reported in Table 1 are attained. Therefore, emission values reported here reflect the actual operation of the incineration process. Although most of the incinerators do have two chambers, as required by Colombian regulations, the second chamber is not equipped with an automatic temperature control. Moreover, with the exception of one installation temperatures in the first and second chambers are lower than those required by the current regulation (750^{o}C and 1000^{o}C, respectively), and temperatures as low as 400^{o}C were measured. Additionally, apart from the air provided to the burners, there is no controlled air-supply system for waste incineration and consequently, air deficiency could lead to an increase in unburned waste. Finally, cyclones, where present, were the only gas depuration system encountered (however, just 1 out of the 2 cyclones found was operating correctly). According to the operating conditions reported in Table 1, there is a high probability of dioxin formation especially due to the high oxygen concentration levels, large emission of particulate matter from several incinerators, and the uncontrolled cooling of stack gases. Indeed, such conditions would favor dioxin-formation schemes such as the Novo synthesis.
According to Colombian regulation, bottom ashes should be tested every 15 days in order to check whether unburned materials are present. It was found, however, that ashes are buried in the hospital grounds without any previous analysis/treatment.
On average, each incinerator operates 24 h per month and burns 300 Kg of waste. However, incinerator E023 is a municipal waste incinerator which also incinerates medical waste twice a week (as soon as it is received): the average amount of medical waste is around 55 Kg/week, and the municipal waste treated is around 1000 Kg/week. Due to this fact, emissions from this incinerator might not be directly comparable to the emissions of the other incinerators.

Table 1 Operating conditions of monitored incinerators.

Sample	E005	E009	E011	E015	E017	E019	E021	E023
# of Chambers	2	2	1	1	2	1	2	1
Temp. Cham.1 (ºC)	733	700	ND	ND	ND	400	788	850
Temp. Cham.2 (ºC)	847	1000	NA	NA	ND	NA	ND	NA
Residence time in chambers (sec)	ND	ND	ND	ND	ND	ND	2,1	ND
Temperature control loop in Chamber 1	Yes	Yes	No	Yes	No	No	Yes	Yes
Independent air supply	No	No	No	No	No	No	No	Yes
Gas cleaning system	No	No	No	No	Yes	No	Yes	No
Temperature stack (ºC)	521,4	651	259,7	400	59,5	382,4	176,9	359
Particulate mater emissions mg/Nm^3	162,4	123,2	156,6	1170,6	1084,4	16,6	39,9	1092
Oxygen stack concentration (%)	11,9	10,2	11,7	11,1	19,9	9,2	13,8	14,8
Incinerated waste amount (Kg)	90	125	110	200	57	69	70,3	415
Gas cooling system	No	No	No	No	No	No	No	No

ND: Not determined (for example, no thermocouple and/or port was present to measure temperature)

NA: No apply

Dioxin emissions determined for each source, along with a comparison with the emissions predicted when the emission factor (Toolkit) is applied to each incinerator are summarized in Table 2. Based on our experimental results, projected emissions (g TEQ/year) are included as well. All incinerators tested in this study can be classified, according to the UNEP classification, as solid waste incinerators category 1, and more specifically as medical/hospital waste incinerator within the class “uncontrolled batch combustion no APCS”.

Table 2. Actual emissions (ng I-TEQ / Nm^3 PCDD/Fs) and comparison between projected and Toolkit emissions

Sample	ng I-TEQ / Nm^3	Projected emission g TEQ/year	Toolkit g TEQ/year
E005	17	0,00018	0,216
E009	50,6	0,000997	0,24
E011	16,5	0,000040	0,048
E015	263,8	0,008519	0,4464
E021	27,5	0,000119	0,048
E023	42,9	0,006670	1,92
Total	418,3	0,016525	0,9984

Emission levels of most incinerators are within permissible limits. This cannot be considered positive by any means as emissions are much higher than the values accepted in industrialized nations. Only one incinerator (E015) displays emission levels above the Colombian norm. Although such incinerator was equipped with two burners linked to an automatic temperature control system, one of the burners was broken and there is no indication whether the set point was attained. In addition, feeding rate was almost twice than in other facilities.

Emissions calculated by using the toolkit are almost two orders of magnitude larger than those projected using actual data from medical waste incinerators. This is in qualitative agreement with previous findings of our group regarding other Colombian incinerators[6]. Actions like improving the second chamber in all incinerators in order to keep a high temperature (higher than 1000 ºC) and residence times longer than 2 seconds are urged. Installing gas cleaning an effective gas cooling systems along with activated carbon will be necessary to reduce emissions below 2.0 ng I-TEQ/Nm^3 as required by the year 2012.

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