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Concentrations of trace elements and PCDD/Fs around a municipal solid waste incinerator in Girona (Catalonia, Spain). Human health risks for the population living in the neighborhood

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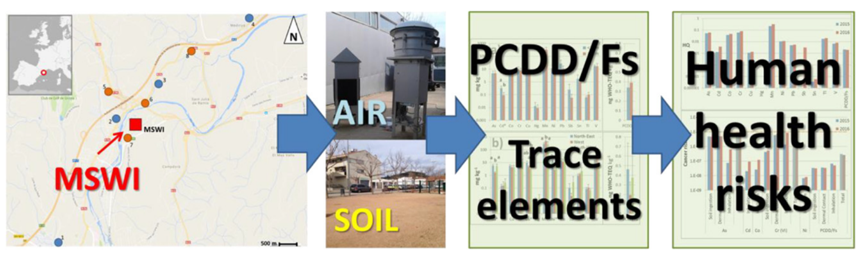
HIGHLIGHTS

- Air and soil levels of elements and PCDD/Fs were analysed around a MSWI in Catalonia.
- No differences were noted respect to distances and directions to the MSWI.
- Some influence of long-range transport pointed (coming from Barcelona area).
- Health risks were below safety limit and in acceptable ranges, according to regulations.

GRAPHICAL ABSTRACT



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ABSTRACT

Previously to the modernization of the municipal solid waste incinerator (MSWI) of Campdorà (Girona, Catalonia, Spain) two sampling campaigns (2015 and 2016) were conducted. In each campaign, 8 soil and 4 air samples (PM_{10} and total particle phase and gas phase) were collected. The levels of As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Sn, Tl and V, and PCDD/Fs were analysed at different distances and wind directions around the MSWI. Environmental levels of trace elements and PCDD/Fs were used to assess exposure and health risks (carcinogenic and non-carcinogenic) for the population living around the facility. In soils, no significant differences were observed for trace elements and PCDD/Fs between both campaigns. In air, significant higher levels of As, Cd, Co, Mn, Ni, Pb, Tl and V were detected in 2016. Regarding soil levels, only Cd (distances) and As, Cu, Mn, and Ni (wind directions) showed significant differences. No differences were noted in the concentrations of trace elements and PCDD/Fs in air levels with respect to distances and directions to the MSWI. No differences were registered in air levels (elements and PCDD/Fs) between points influenced by MSWI emissions and background point. However some differences in congener profile were noted regarding from where back-trajectories come from (HYSPLIT model results), pointing some influence of Barcelona metropolitan area. The concentrations of trace elements and PCDD/Fs were similar -or even lower- than those reported around other MSWIs in Catalonia and various countries. Non-carcinogenic risks were below the safety limit (HQ < 1). In turn, carcinogenic risks due to exposure to trace elements and PCDD/Fs were in acceptable ranges, according to national and international standard regulations.

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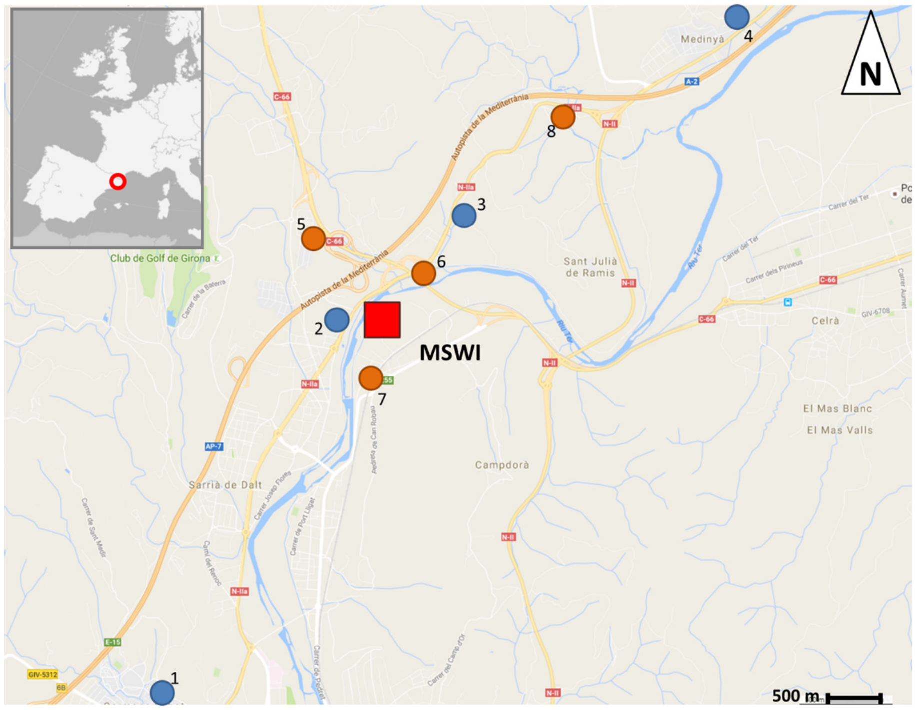

Fig. 1. Sampling points location: soil and air sampling points (form1 to 4) are marked in blue and only soil sampling points (from 5 to 8) are marked in orange. The location of the MSWI is marked in red square. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

1. Introduction

In 2015, each habitant in Catalonia generated a mean of 474 kg of waste, being 301 kg (64%) treated as residual waste fraction (ARC, 2016). Educational and advertising campaigns focused on enhancing the recycle among general public have been conducted. Since 2000, residual waste fraction decreased from 2.99 M tones to 2.26 M tones in 2015 (ARC, 2016). This means a reduction from 86% to 61% regarding total waste generated (ARC, 2016). Despite the increase of reuse and recycle practice, the residual waste fraction should be treated. The Directive 2008/98/EC (European Union Parlament and Council, 2008a) establishes a waste hierarchy with prevention, re-use and recycling being the three top of the rank. The waste hierarchy also indicates that "other recovery", such energy recovery, is a better option than disposal, which is the last option in waste treatment hierarchy.

Modern municipal solid waste incinerators (MSWIs) are adapted to recovery energy (heat or electricity) through the incineration process. In addition to energy recovery, MSWIs minimize the volume of residues. Moreover, modern MSWIs are operating with the best available technologies (BATs), which ensure a high energetic efficiency in the incineration process, as well as a rather low pollutant emission to the environment. However, in spite of this, all combustion processes can generate organic compounds that could be released to the environment with other pollutants such particle matter containing metals and metalloids (Lin et al., 2016; Margallo et al., 2015; Yang et al., 2016). Among other substances, MSWIs release to the environment polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) (Wang et al., 2010a; Wang et al., 2013). In relation to this, a considerable number of studies over the world have been carried out to monitor, control, and assess the impact of MSWI emissions (Caserini et al., 2004; Jin et al., 2012; Liu et al., 2013; Nzihou et al., 2012; Venturini et al., 2013). Our research group has been one of the most active in this topic (Nadal et al., 2002; Schuhmacher et al., 1997a, 1997b, 1998, 1999; Vilavert et al., 2011, 2013, 2015a, 2015b).

Table 1
Levels of trace elements (mg kg^{-1}) and PCDD/Fs (ng kg^{-1}) in soils around the Campdorà's MSWI.

	2015		2016		
	Mean	SD	Mean	SD	*p*
As	4.77	2.44	4.62	2.35	*0.898*
Cd	0.16	0.12	0.20	0.19	*0.665*
Co	4.87	1.28	4.83	1.81	*0.963*
Cr	7.53	3.21	9.31	5.75	*0.455*
Cu	20.6	37.7	25.3	46.3	*0.829*
Hg	0.01	0.01	0.01	0.01	*0.532*
Mn	316	135	344	156	*0.703*
Ni	10.8	6.04	11.4	6.53	*0.857*
Pb	16.1	12.5	18.2	20.5	*0.809*
Sb	<0.05	–	0.24	0.34	*0.104*
Sn	0.98	0.21	1.61	1.47	*0.251*
Tl	0.08	0.05	0.09	0.05	*0.563*
V	15.4	8.66	18.7	9.04	*0.479*
2,3,7,8-TCDD	0.04	0.04	<0.04	–	*0.223*
1,2,3,7,8-PeCDD	0.11	0.07	0.07	0.05	*0.213*
1,2,3,4,7,8-HxCDD	0.15	0.12	0.10	0.07	*0.272*
1,2,3,6,7,8-HxCDD	0.22	0.17	0.63	1.37	*0.416*
1,2,3,7,8,9-HxCDD	0.21	0.16	0.34	0.60	*0.573*
1,2,3,4,6,7,8-HpCDD	2.32	1.81	3.45	4.57	*0.526*
OCDD	13.1	11.8	11.7	8.97	*0.802*
2,3,7,8-TCDF	0.12	0.00	0.15	0.07	*0.297*
1,2,3,7,8-PeCDF	0.19	0.14	0.18	0.20	*0.850*
2,3,4,7,8-PeCDF	0.17	0.09	0.12	0.11	*0.433*
1,2,3,4,7,8-HxCDF	0.21	0.11	0.19	0.17	*0.774*
1,2,3,6,7,8-HxCDF	0.20	0.10	0.15	0.13	*0.395*
1,2,3,7,8,9-HxCDF	0.05	0.02	<0.08	–	*0.441*
2,3,4,6,7,8-HxCDF	0.25	0.16	0.20	0.20	*0.614*
1,2,3,4,6,7,8-HpCDF	1.38	0.75	1.02	0.86	*0.392*
1,2,3,4,7,8,9-HpCDF	0.16	0.10	0.17	0.11	*0.861*
OCDF	5.23	2.40	0.91	0.66	***<0.001***
Total WHO-TEQ	0.39	0.21	0.36	0.30	*0.855*

In bold significant differences at $p < 0.05$.