ASSESSING THE BACKGROUND DIOXIN HEALTH RISK AND THE ADDITIONAL CONTRIBUTION OF MSW INCINERATION PLANT

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Introduction

The assessment of the effects of atmospheric emissions of hazardous air pollutants (HAPs) on human health are a fundamental aspect in the debate on the environmental compatibility of several human activities. In latest years such evaluations are rising an increasing interest when the localization of a new municipal solid waste incineration plant (MSWI) is concerned, which is characterized by the emission of typical HAPs like cadmium, lead, mercury and PCDD/F. Many different approaches have been utilized, even if the most recent tendencies go towards multiple impact pathway risk assessment (MRA) methodologies. MRA applied to stack emissions from MSWI has been extensively described by Zemba[1], while the U.S. Environmental Agency (EPA) has provided since the early 90's with protocols and methodologies for human health risk assessment for hazardous waste combustion facilities[2] and for generic combustion emissions[3].
The incremental risk due to a new MSWI could be evaluated by the comparison with the existing background risk arising from the same pollutants, in order to evaluate the acceptability of the plant from an objective standpoint.
The background health risk typical of an Italian populated urban context has been evaluated based on the results of an experimental campaign on air and soil dioxins contamination, whose results have been previously reported[4]. The campaign was conducted in 1997, before the start-up of a new MSW incineration plant. Another site has been selected for the background risk assessment, where a new plant is supposed to start operating in the following years.
The additional risk related to the dioxin stack emissions from a MSW incineration plant has been evaluated for three different cases: an old plant, not equipped with dedicated dioxin removal units from the flue gas, a new plant whose stack emissions comply with the current European standards and a BAT-equipped plant characterized by very low stack concentrations[5]; all the evaluations are based on the actual emissions data which were measured during the normal activity of the plants.

Methods and Materials

Description of the sites and of the plants

All the selected sites are located in northern Italy. Two sites (# 1 and 3) were selected where MSW incineration plants have never been operating, so that they can be representative of a background situation. Samplings in Site 1 were conducted in 1997, before the start-up of the new plant that is currently operating, while in Site 3 the debate on the future MSWI is still underway. Both sites include a midsize capital town with a population of about 100000 inhabitants; the economic activities are mainly based on small and medium-sized enterprises, while agriculture and cattle-breeding being a significant activity, especially for the first site. At each site, air and soil were collected at three different locations, one rural (potentially not affected by the presence of the city or by major roads), one urban and one where the maximum contribution in terms of ground level concentration from the MSWI emissions is expected.

Three sites were selected where a MSWI was operating from a sufficient amount of time. One of them (# 1) is the same site where the 1997 samplings took place, as the new plant started operating in 1998 and a second campaign was carried out in year 2000, while the others (# 2 and 4) are sites characterized by the stable presence of a fully operating MSWI since many years. In site 2 the plant was not complying with the 0.1 ng I-TEQ m^{-3} EU standard at the time the sampling campaigns took place, while in Site 4 the plant was operating with an average stack emission of 0.01 ngI-TEQ m^{-3} since 1994. The choice of the sites allows to include in the analysis the comparison of the effects of different plants, characterized by a wide range of dioxin emission rates (Tab. 1).

Table 1 – Major characteristics of the MSWI plants located in sites 1, 2 and 4.

	Site 1	Site 2	Site 4
Type	Mass burn	Mass burn	Mass burn
Maximum capacity (t d^{-1})	320	100	250
Year of start-up	1998	1983	1976
Year of revamping	-	2004	1994
Flue gas cleaning technology	Semi-dry (with activated carbon), fabric filter, wet scrubber	Electro-static precipitator, wet scrubber	Fabric filter, wet scrubber, SCR
Average PCDD/F stack concentration (ngI-TEQ m^{-3})	0.1	7.3	0.01
Average PCDD/F emission flow rate (g s^{-1})	1.6E-9	6.7E-8	3.1E-10
Stack height (m)	60	40	50

The risk assessment procedure

Several efforts have been made to standardize the process of exposure assessment, but according to many authors and in an extensive review of the whole process[1], the best approach remains to tailor the assessment to the particular characteristics of the area surrounding the plant and those who inhabit it. The risk assessment has been carried out starting from the distribution of the air and soil concentrations in the area, taking into account the four major impact pathways (air inhalation, dermal contact, soil ingestion, food chain exposure), with equations commonly utilized in the literature and derived mainly from the US-EPA[2,3].

The assessment of the incremental risk

The incremental risk due to the MSWI stack emissions has been assessed starting from the results of atmospheric dispersion modeling, performed with a standard ISC3 model in the short-term version. The depositions have been calculated in the hypothesis that dioxins are completely adsorbed on the surface of the emitted particulates. Starting from the deposition, the concentration of the pollutants in the soil has been calculated with an accumulation model, where the accumulation depth is dependent on the prevalent land use.

The assessment of the background risk

The background risk has been evaluated with the same procedure previously described, but starting from the air and soil concentrations resulting from the monitoring campaigns. In order to allow the data comparison, the same impact pathways, the same exposure parameters and dose-response relationship were considered,.

As a result, two different background risks were obtained for each site, representative of an urban area and a rural one. Actually for Site 2 no rural spots could be individuated, so the calculations

were referred to an urban and an industrial background risk. Due to the characteristics of the highly urbanized Italian territory, no remote risk could be calculated.
The sampling campaigns included air and soil characterization of PCDD/F and heavy metals content; for air concentration, high and medium volume sampler were utilized, with separate collection of the solid phase (dust) on a glass fiber filter and of the gas phase on a polyurethane foam (PUF) plug. In order to obtain significant long-term average values, the air samplings were extended over a period of about 15-20 days, allowing for the sampling of between 8000 to 10000 m^3 of air at ground level. All PCDD/F analyses were conducted with HRGC/HRMS. A more detailed description of the dioxin sampling and analysis methodologies is given in a previous paper[4].

Results and Discussion
The measured dioxin concentrations in air and soil samples are compiled in Table 2. The lowest air concentrations are observed in Site 4 and Site 1 (after the start-up of the MSWI), while Site 2 and Site 1 before the construction of the plant resulted in higher contamination. Similar trends are observed for the soil samples, with Site 4 and Site 3 resulting in lower values. When the differences between urban and rural levels are considered, only Site 4 shows significant variations, the rural concentrations being significantly lower than the urban ones for both air and soil samples; in Site 2 industrial and rural air concentrations result higher than urban ones, and vice-versa for the soil. In the remaining two sites, the differences between the dioxin contaminations are less pronounced and sometimes (as for the soil concentrations in Site 3) opposite to what could be expected. The data confirm the widespread diffusion of PCDD/F in the environment, whose presence is not significantly influenced by the specific land use.

Table 2 – Range of dioxin concentrations in air and soil samples

			Air concentration (fg m^{-3})		Soil concentration (pg g^{-1})	
	Type of MSWI		PCDD/F	I-TEQ	PCDD/F	I-TEQ
Site 1	Absent	Urban	3900-6326	54-124	48-145	0.68-0.95
		Rural	3744-4217	58-73	-	-
	EU compliant	Urban	753-1919	22-39	119-255	0.85-1.5
		Rural	1455	36	-	-
Site 2	Non-EU compliant	Urban	1901-2652	41-60	147-154	1.5-2
		Industrial	1089-6069	47-337	69-110	0.8-1.1
		Rural	1947-6670	68-221	81-152	0.9-1.4
Site 3	Absent	Urban	554-4157	11-110	5.8-51	0.14-0.62
		Rural	941-2569	22-72	12-128	0.09-1.02
Site 4	BAT-equipped	Urban	760-2066	14-67	48-72	0.46-1.2
		Rural	417	9.6	16	0.08

The background individual health risk related to the exposure to the existing environmental levels of PCDD/F and the incremental risk resulting from the PCDD/F stack emissions of the MSW incineration plants are compared in Fig. 1. For all sites the background risk lies between 10^{-5} and 10^{-6}, with lower levels for Site 4 and higher for Site 2, as expected from the measured air and soil concentrations. No relevant differences can be observed between the background risk of sites not affected by the MSWI dioxin emissions (1 and 3) and of sites where the background risk includes the contribution of the existing plant, in operation since several years (2 and 4). On the other side, the incremental risk deriving from the MSWI emissions shows significant variations, included between 10^{-7} for Site 2 and 10^{-10} for Site 4, as a direct consequence of the different dioxin control technologies adopted, leading to different emission rates (Table 1).

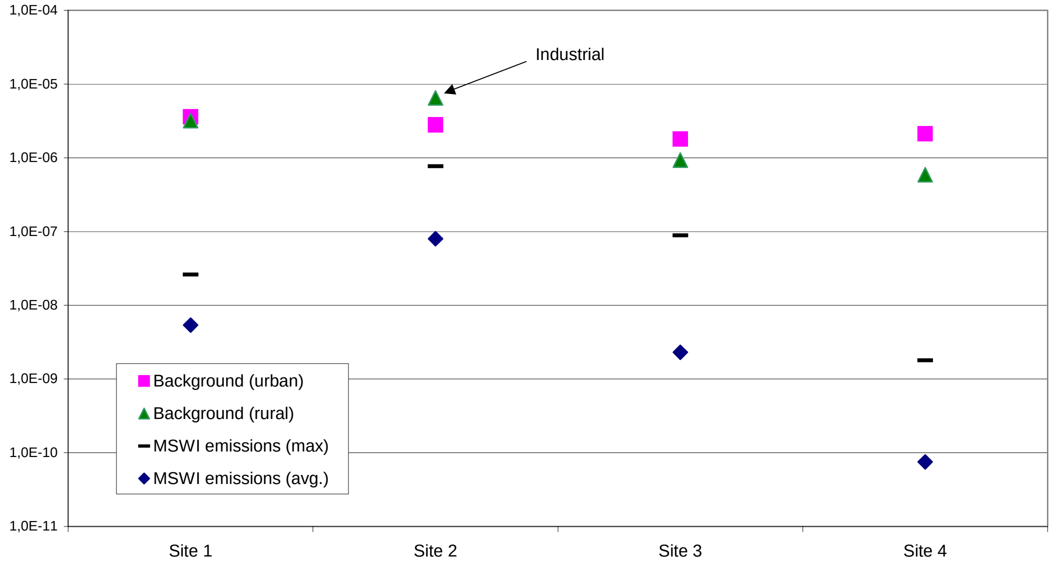

Figure 1 – Individual health risk related to PCDD/F exposure: comparison between the existing (background) risk and the incremental risk due to the emissions of the MSWIs

Notes: for Site 1 the background risk is calculated from the air and soil concentrations measured before the plant construction;
for Site 3 the incremental risk is calculated from the expected emissions of the future new plant

Conclusions

Preliminary results reported in the paper show that the background health risk deriving from the dioxin exposure is included between 10^{-5} and 10^{-6} for four different sites located in Northern Italy. No significant differences in the background risk are observed between sites where MSWI has been and is currently operating and sites where MSWI is absent. The incremental health risk related to the existence of an old incineration plant can be of concern, being only one to two orders of magnitude lower than the background risk. For modern plants equipped with highly effective dioxin control technologies (allowing for the respect of the 0.1 emission standard or lower), the average incremental health risk is three to four orders of magnitude lower than the background. For Sites 1 and 4 the MSWI does not influence significantly the background values, and the same can be expected for the future plant in Site 3. Vice-versa, in Site 2 the long-term operation of the non EU-compliant MSWI might have influenced the existing risk levels.

References

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