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IS ONE VILLAGE ABLE TO PRODUCE AS MANY DIOXINS AS A BIG WASTE INCINERATION PLANT?

MŮŽE JEDNA VESNICE VYPRODUKOVAT STEJNÉ MNOŽSTVÍ DIOXINŮ JAKO SPALOVNA ODPADŮ?

Abstract

Three large waste incineration plants incinerated c. 360 thousand tons of waste in 2009, during which time they emitted c. 40 mg of PCDD/F expressed as TEQ in flue gasses into the air. If heated by solid fuels only (c. 4 thousand tons of fuel), one average (hypothetical) village with two thousand inhabitants would emit c. 2 to 60 mg of PCDD/F expressed as TEQ in flue gasses into the air during the heating season. We can state that in term of PCDD/F emissions into the air, one village being heated with solid fuels has a potential to produce similar (in some cases even higher) amount of dioxins as a large waste incineration plant.

Abstrakt

Tři velké spalovny odpadů spálily v roce 2009 cca 360 tis. tun odpadů. Při tom vyprodukovaly cca 40 mg PCDD/F (vyjádřeno jako TEQ) ve spalinách. Jedna průměrná (hypotetická) vesnice s 2 tis. obyvatel by vyprodukovala během topné sezóny (v případě, že by byla vytápěna jen tuhými palivy – cca 4 tis. tun paliva) cca 2 – 60 mg PCDD/F (vyjádřeno jako TEQ). Lze konstatovat, že jedna vesnice vytápěná tuhými palivy vyprodukuje podobné množství PCDD/F (někdy dokonce i více) do ovzduší jako jedna velká spalovna odpadů.

1 INTRODUCTION

When heating season comes, air quality in many of our villages and towns gets worse dramatically. Solid fuel and waste burning in small-power as well as high-power furnaces is always accompanied by emissions of pollutants. There is a remaining question of their total amount produced per a given time period. This paper is focused on dioxin emissions in flue gasses which are emitted into the air. Balance of amount of pollutants produced by household furnaces represents a specific section and in a sphere of emission factor and fuel consumption it fumbles with a question of credibility and a need of technical discussion. Proportion of household furnaces on the total yearly dioxin emissions (into the air) in the Czech Republic has been determined to c. 10 % [4].

In the testing room of the Energy Research Center, an extensive experimental campaign was performed which was focused on determination of pollutant emissions produced during solid fuel burning in small furnaces for household heating.[5] Five basic design types of combustion devices were used for burning of different sorts of fuels. Five sorts of solid fuels (lignite and hard coal, soft and hard wood and vegetable biomass pellets) were burnt repeatedly. On the basis of the acquired results, new values of emission factors have been proposed which enable to update our national balance, as well as an average (hypothetical) Czech village balance.

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2 YEARLY PCDD/F PRODUCTION FROM LARGE MUNICIPAL WASTE INCINERATION PLANTS RUNNING IN THE CZECH REPUBLIC

The balance of yearly PCDD/F production from waste incineration plants is performed on the basis of regular (twice a year) single-shot measurements which are realized on a given air pollution source. Measurement results render information on PCDD/F specific emission (eg. µg PCDD/F TEQ/t_{waste}) and yearly dioxin emissions are calculated in combination with data on annual incinerated waste amount. PCDD/F emission balance results from three largest municipal waste incineration plants in the Czech Republic are shown in Tab.1. In the year 2009, the three largest Czech waste incineration plants produced c. 40 mg of PCDD/F (as TEQ – toxic equivalent) which is less than half of the amount in comparison with 2007 production. As we can see from the resulting values, the biggest proportion on this reduction is credited to dioxin production decrease in the Malešice incineration plant where De-Diox technology has been installed (4 catalytic reactors). For the need to compare yearly dioxin emissions from incineration plants with yearly dioxin emissions from residential heating, we can then state that this production ranges in orders of several tenths of mg PCDD/F (TEQ) per year. From one ton of waste incinerated in a waste incineration plant (high quality technology), c. 0.12 micrograms of PCDD/F (TEQ) is produced.

Polluters are obliged to report pollutant emissions into the Integrated Pollution Register [7], if their production is higher than the reporting threshold which is for PCDD/F 100 mg PCDD/F (TEQ) per year. It results from the data in the Register, that the reporting threshold is exceeded by polluters within metallurgical industry as well as within power industry [8]. As for data for PCDD/F from waste incineration plants, we cannot find them here as they are below the reporting threshold.

Tab. 1 PCDD/F yearly production from the three largest waste incineration plants in the Czech Republic. [6].

	Incinerated waste amound [t_{waste} / year]		PCDD/F yearly emmisions [mg TEQ / year]		Calculated emmision factor PCDD/F according to balance [µg TEQ /t_{waste}]	
	in 2007	in 2009	in 2007	in 2009	in 2007	in 2009
Pražské služby, a.s., spalovna Malešice	213 387	208 225	70,0	18,0	0,328	0,086
SAKO Brno, a.s.	86 029	54 601	7,7	4,3	0,090	0,079
Termizo, a.s., Liberec	91 165	96 810	15,0	18,1	0,165	0,187
Total (average)	390 581	359 636	92,7	40,4	(0,194)	(0,117)

3 METHODICS OF BALANCE OF POLLUTANT EMISSIONS FROM RESIDENTIAL HEATING

The balance of pollutant emissions produced during solid fuel combustion for household heating needs is performed on the basis of calculations from statistic data, climatologic information and emission factors (EF) [3]. As said in a simplified way, emission amount of a given pollutant for REZZO 3 category can be calculated according to the formula:

$$A = \sum (Bi \cdot EFi), \tag{1}$$

where:

A – yearly emission of the given pollutant $\left[\frac{\text{kg}}{\text{year}}\right]$,

i – fuel sorts (lignite and hard coal, coke, wood),

Bi – yearly consumption of the given fuel $\left[\frac{\text{t}}{\text{year}}\right]$,

EFi – emission factor of the given substance for the given fuel $\left[\frac{\text{kg}}{\text{t}}\right]$

The "B" fuel consumption is also determined i.a. from an average temperature of the heating season which is converted to the numbers of daily degrees and parameters of individual households. Determination of heat energy needs for individual accommodation units is an intermediate stage for fuel consumption determination.

4 USED EMISSION FACTORS

The emission factor is a value indicating a mean amount of a monitored pollutant which has originated from burning the given fuel and this amount is usually related to fuel weight (eg. μg TEQ/t = ng TEQ/kg) or to energy content in fuel (eg. ng TEQ/GJ = μg TEQ/TJ).

It is the very value of the chosen emission factor which, in a substantial way, affects the balance of PCDD/F emissions produced during coal and wood burning in small combustion devices. The emission factor value is essentially influenced by a burnt fuel sort (Cl content in particular), a combustion device type and operation conditions. It is not easy to include these factors into the balance.

For one village PCDD/F emissions calculation, we have used three sets of emission factors, see Tab. 2. The first set, indicated as ČHMÚ, represents emission factors which are used by the Czech Hydrometeorological Institute for calculations of yearly balances of PCDD/F emissions from residential heating in the Czech Republic [2]. The second set of factors, indicated as EEA, represents emission factors which are recommended by the European Environment Agency [1].

The set indicated as VEC represents the results of the extensive experimental campaign which was performed in the Energy Research Center within the scope of the SP/1a2/116/07 project [5]. Experiments were performed on various types of combustion devices representing fundamental design types (over-fire, under-fire, gasification and automatic boiler, fireplace stoves) with various sorts of burnt fuels. In total, 56 experiments were carried out. The values shown in the VEC column represent a weighted average considering combination of the used combustion devices for the given fuel. The results show that hard coal burning is accompanied by markedly higher PCDD/F emissions than lignite and wood burning. One of the main known reasons is that the Silesia Basin hard coal has higher chlorine content than lignite and wood.

The given emission factors (except from VEC factor for lignite and wood) are significantly higher (by one to two orders) in comparison with the emission factor for waste incineration in large incineration plants (see Tab. 1). The VEC values have been acquired when burning high quality solid fuel (sorted hard coal and lignite and dry wood) under conditions near to the nominal heat output. It is obvious that when incinerating waste together and operating combustion devices at lowered output, the emission factor values would be higher.

Tab. 2 PCDD/F emission factors for particular fuels according to various information sources.

	PCDD/F emission factors for particular fuels according to various information sources in μg / t_{fuel}		
	ČHMÚ	EEA	VEC
Lignite	6,0	14,4	0,766
Hard coal	4,0	20,4	10,5
Wood	5,0	10,2	0,368

ČHMÚ - Czech Hydrometeorological Institute
EEA - European Environment Agency
VEC - Energy Research Center, VŠB-TU Ostrava

5 PCDD/F YEARLY EMISSION IN ONE AVERAGE (HYPOTHETICAL) CZECH VILLAGE

Determination of parameters of an average Czech village for needs of the balance encompasses many simplifications and inaccuracies which can be discussed about and optimized. For the basic objective of this paper, which is a comparison of dioxin emissions from households with dioxin emissions from large waste incineration plants, the following assumptions should serve as sufficient:

- 2,000 inhabitants,
- 696 households (from the average number of people living in one household),
- average heat demand (output, not input) for heating of one house has been determined to c. 70 GJ/year (heating season),
- average efficiency of combustion devices used for solid fuel burning has been estimated to c. 65% (this data varies dramatically for various types of combustion devices, as well as in the most cases the boilers are operated at lowered output; the estimation tries to include even these facts),
- lignite calorific power – 18 MJ/kg, wood calorific value – 14.6 MJ/kg, hard coal calorific value – 25.4 MJ/kg.

From the above mentioned assumptions, hypothetic consumption of particular fuel sorts, which would satisfy heat demand for an average hypothetic village heating, has been calculated. In combination with the emission factors shown in Tab. 2, PCDD/F emissions from a hypothetic village have been calculated and their values are shown in Tab. 3. Thus, each line represents PCDD/F amount which would be emitted by the given village, if it was heated by the given fuel. In actual villages, particular sorts of fuel are represented in a different way according to a local situation, as well as a proportion of the rest of heating methods differ according to parameters of the given locality (natural gas, electricity, district heating etc.). The particular columns represent the resulting values when using various sets of emission factors.

Tab. 3 PCDD/F yearly emissions from an average village heating for particular sorts of fuel according to different calculations.

	Dioxin yearly emissions from an average village (2,000 inh.) heating for particular fuels in mg TEQ / year		
	ČHMÚ	EEA	VEC
Lignite (4 165 t/year)	25	60	3
Hard coal (2 951 t/year)	12	60	31
Wood (5 135 t/year)	26	52	2

ČHMÚ - Czech Hydrometeorological Institute
EEA - European Environment Agency
VEC - Energy Research Center, VŠB-TU Ostrava

6 OFFICIAL RESULTS OF THE BALANCE OF PCDD/F EMISSIONS FROM RESIDENTIAL HEATING FOR THE CZECH REPUBLIC

The balance of pollutant emissions produced by small combustion devices is performed by the Czech Hydrometeorological Institute according their own methodics [3]. The results are annually published in the annual bulletin "Air Pollution on the Czech Republic Territory". The results of PCDD/F balance from small pollution sources REZZO 3 (mostly household heating) are shown in Fig.1.

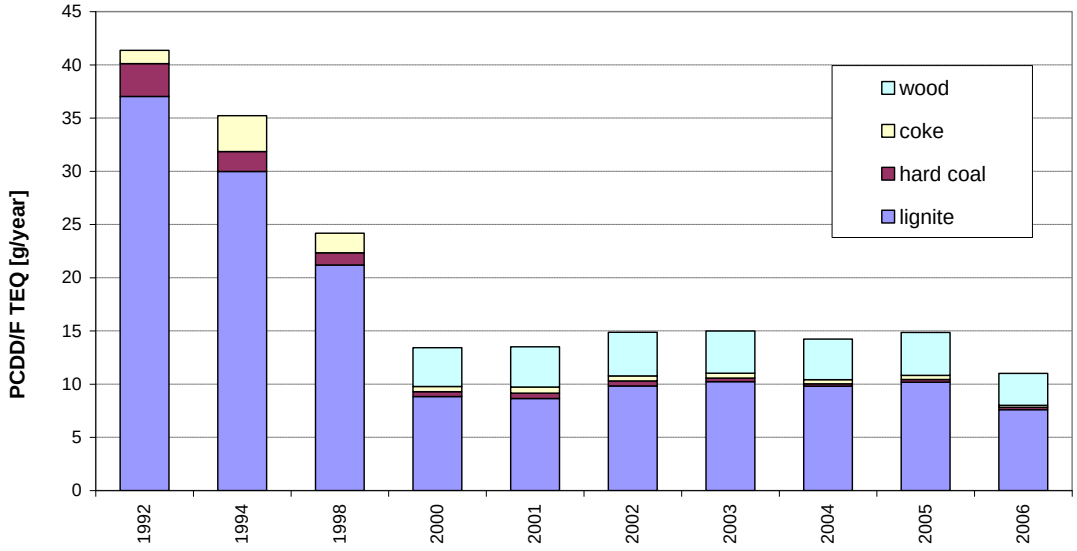

Fig. 1 Yearly dioxin emissions from solid fuel burning in small sources in the whole Czech Republic.

7 CONCLUSIONS

Three large waste incineration plants incinerated c. 360 thousand tons of waste in 2009, during which time they emitted c. 40 mg of PCDD/F (TEQ) in flue gasses into the air. If heated by solid fuels only (c. 4 thousand tons of fuel), one average (hypothetical) village with two thousand inhabitants would emit c. 2 to 60 mg of PCDD/F (TEQ) in flue gasses into the air during the heating season. We can state that in term of PCDD/F emissions into the air, one village being heated with solid fuels has a potential to produce similar (in some cases even higher) amount of dioxins as a large waste incineration plant. Weight of waste incinerated in an incineration plant is quite higher than weight of fuel burnt in an average hypothetical village, so it is evident that the quality of waste incinerating in an incineration plant (0.12 μ_{TEQ}/t_{waste}) is many times higher than the quality of high quality fuel burning within residential heating (0.37 ÷ 20 μ_{TEQ}/t_{fuel}). This fact is caused by high quality technology equipment in incineration plants, a part of which is also multi-level flue gas cleaning. It is estimated that minimally c. 2.3 million tons of solid fuels are burnt each year in residential heating in the Czech Republic [3].

A considerable variance in the estimation of dioxin emissions from residential heating is also caused by the fact that the amount of produced dioxins is influenced by the following factors (in a real life, these factors are very variable according to a locality and such information availability is minimal):

- a combustion device type (over-fire, under-fire, gasification and automatic combustion device),
- a fuel sort (lignite, wood, hard coal, coke; burning household waste together with fuel is a big abuse),
- influence of the service (service can influence the combustion process dramatically – adjustment of combustion air flaps),
- influence of the installation (maintenance of the device and chimney, regulation of minimum temperature of recovery heating water, overdesigned output of the installed device).

Of course, there is still a question on the emitted dioxin absolute amount. When burning lignite and wood, in modern small combustion devices the level of c. 0.77 $\mu_{TEQ}/t_{lignite}$ and 0.37 μ_{TEQ}/t_{wood} has been reached which we could regard as very good values.

Small pollution sources do not produce negligible emission amount, they significantly affect the quality of the air which we breathe. Only a small portion of dioxins gets into a human body

through breathing, but mostly with food; however, when burning solid fuels, many other problematic pollutants are originating, e.g. PM10 and PAH.

Regulatory mechanisms and tools are solved for waste incineration plants but tools regulating or affecting residential heating operators are at minimum and, strictly speaking, inapplicable. What shall we do with a neighbor who burns furniture and brings-in old window frames? A time-proved German way where a chimney-sweep has to check and clean a chimney and to measure a combustion device each year could become an inspiration and when watching dense smoke flowing out from many low chimneys, domestic freedom curb argument might lose its seriousness easily.

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