# DIOXIN AND THE BRUSSELS MUNICIPAL INCINERATOR

A technical note regarding polychlorinated dibenzo-p-dioxins and dibenzofurans in ash residues from Brussels municipal incinerator

Ruth Stringer,
Greenpeace QMW,
School of Biological Sciences,
Queen Mary & Westfield College,
Mile End Road,
London E1 4NS.

April 14, 1991

## Introduction

Fly ash, bottom ash, economiser ash and slag were collected from Brussels municipal incinerator during October 1990. The glass sample bottles were washed with pesticide residue analysis grade (PRAG) hexane and the lids lined with PRAG hexane-washed aluminium foil. The bottles were filled with ash by digging the bottle into an ash pile. This avoided any contamination from spoons or other collecting implements. The sample bottles were tightly sealed for transportation to the analysing laboratory.

## Results

| Polychlorinated dibenzo-dioxins and -furans | Economiser ash (ng/g) | Bottom ash (ng/g) | Slag (ng/g) | Fly ash (ng/g) |
|---|---|---|---|---|
| Total tetraCDD | 0.529 | 2.01 | 0.107 | 19.9 |
| Total pentaCDD | 1.19 | 2.32 | 0.303 | 29.8 |
| Total hexaCDD | 3.09 | 2.22 | 0.529 | 56.3 |
| Total heptaCDD | 7.17 | 1.91 | 0.631 | 82.0 |
| OctaCDD | 36.7 | 3.74 | 1.03 | 138 |
| Total PCDD | 48.68 | 12.20 | 2.60 | 326.00 |
| Total tetraCDF | 1.27 | 3.82 | 0.239 | 106 |
| Total pentaCDF | 3.66 | 4.64 | 0.436 | 103 |
| Total hexaCDF | 7.01 | 3.51 | 0.446 | 55.3 |
| Total heptaCDF | 13.6 | 2.76 | 0.359 | 45.5 |
| OctaCDF | 9.01 | 0.895 | 0.168 | 7.36 |
| Total PCDF | 34.550 | 15.625 | 1.675 | 317.160 |
| Total PCDD and PCDF | 83.229 | 27.825 | 4.275 | 643.160 |
| Tox. equivalents (I-TEQ$^{+}$) | 0.737 | 0.513 | 0.059 | 9.32 |
| Tox. equivalents (BGA$^{\#}$) | 0.745 | 0.503 | 0.062 | 9.66 |
| 2,3,7,8-substituted isomers | | | | |
| 2,3,7,8-TetraCDD | 0.017 | 0.057 | 0.004 | 0.517 |
| 1,2,3,7,8-PentaCDD | 0.076 | 0.172 | 0.013 | 1.63 |
| 1,2,3,4,7,8-HexaCDD | 0.128 | 0.096 | 0.019 | 2.51 |
| 1,2,3,6,7,8-HexaCDD | 0.244 | 0.167 | 0.044 | 4.79 |
| 1,2,3,7,8,9-HexaCDD | 0.191 | 0.161 | 0.032 | 4.49 |
| 1,2,3,4,6,7,8-HeptaCDD | 3.88 | 1.01 | 0.351 | 44.6 |
| 2,3,7,8-TetraCDF | 0.05 | 0.130 | 0.009 | 4.29 |
| 1,2,3,7,8+1,2,3,4,8-PeCDF* | 0.259 | 0.199 | 0.020 | 5.50 |
| 2,3,4,7,8-PentaCDF | 0.270 | 0.282 | 0.025 | 6.32 |
| 1,2,3,4,7,8+1,2,3,4,7,9-HxCDF* | 0.900 | 0.401 | 0.048 | 6.31 |
| 1,2,3,6,7,8-HexaCDF | 0.776 | 0.415 | 0.059 | 6.06 |
| 1,2,3,7,8,9-HexaCDF | 0.109 | 0.041 | 0.007 | 0.81 |
| 2,3,4,6,7,8-HexaCDF | 0.979 | 0.419 | 0.056 | 6.93 |
| 1,2,3,4,6,7,8-HeptaCDF | 10.6 | 2.06 | 0.233 | 29.7 |
| 1,2,3,4,7,8,9-HeptaCDF | 0.655 | 0.124 | 0.030 | 4.28 |

$^{+}$ NATO/CCMS International toxicity equivalents

$^{\#}$ Bundesgesundheitsamt German toxicity equivalents * Not separable

**Discussion**

Dioxins and municipal incinerators

These results show considerable contamination of ashes obtained from all parts of the incinerator. In particular, the levels of PCDD/Fs in the fly ash and economiser ash are cause for concern.

The levels of dioxins in the samples correspond to the following outputs per tonne of ash: economiser ash; 83.2 mg PCDD/F, 0.737 mg TCDD equivalents (I-TEQ); bottom ash, 27.8mg PCDD/F, 0.513 mg TCDD equivalents (I-TEQ); slag, 4.28 mg PCDD/F, 0.059 mg TCDD equivalents (I-TEQ); fly ash, 643.16 mg PCDD/F, 9.32 mg TCDD equivalents (I-TEQ).

Municipal incinerator ash contamination reported by other workers can be compared with the results obtained in this study. The great range of analytical results obtainable are most obvious in the work of Hinton & Lane (1991) who found that the total PCDD/F levels in thirteen municipal fly ash samples ranged between 1 and 1,705 ppb. Others report total PCDD/F levels in fly ash of between 988 and 2960 ppb (van Berkel *et al* 1988, Kuykendal *et al* 1989).

It is not possible to extrapolate quantitatively from concentrations of PCDD/Fs in incinerator ash directly to emissions from the stack, though there is a weak association between flue gas scrubber ash PCDD/F levels and flue gas levels in a variety of combustors (Kuykendal *et al* 1989). Obviously, removal of the PCDD/Fs from flue gases is dependent on the type of scrubbers in use. The Brussels incinerator has only one electrostatic precipitator (ESP) to remove particulates from the gases. A considerable proportion of dioxins and furans, along with other pollutants, will be discharged as gases and so will not be removed by this type of scrubber.

Ahlborg and Victorin (1987) report average flue gas levels of 10-100ng/$Nm^3$ toxic equivalents. It is likely that the Brussels incinerator emissions are in this range. There would therefore need to be an improvement of between 100 and 1000 times if the incinerator were to comply with the German TA-Luft standards of 0.1ng/$Nm^3$. Even among those that do not regard emissions from incineration as a threat to human health these standards are becoming widely accepted as minimum operational requirements. Plans to install further flue gas cleaning equipment at the site are unlikely to decrease the mass of PCDD/Fs produced; merely remove them from the flue gases into scrubber effluents of a liquid or solid nature. These wastes will also require disposal and so, though moves of this sort may slightly decrease exposure of the local population, they will have no overall benefit to the environment.

The unpredictable nature of dioxin and other emissions from municipal incinerators makes it impossible for the local authorities to assure the public that there is no health risk from

the incinerator. Hinton & Lane (1991) attempt to explain the formation of dioxins on fly ash. Their research indicates that the presence of the elements chlorine, copper, sodium, potassium and zinc in fly ash would lead to increased dioxin formation. Since there is no control of the input of these, or any other elements, there can be no control over the concentrations of dioxin formed.

Among the other factors suspected of having influence on the formation of dioxin, temperature in the post-combustion train is the most important. The Brussels incinerator has the capacity to generate steam for the generation of energy. According to the public information on the facility (Siomab, undated) the flue gases, exiting the furnace at 900$^{o}$C gradually cool as they pass through the boilers and economiser of the energy-generating system. By the time they reach the ESP, they have cooled to 250$^{o}$. It is well known that formation of dioxins in the post-combustion zone of an incinerator occurs in the range of 300$^{o}$C (eg Stieglitz *et al* (1989). This steam generation system therefore provides ideal conditions for the formation of dioxins and furans, as indicated by the rising of the levels seen in the ashes as they are taken from sites further and further downstream of the furnace. It has also been shown that dioxins and furans can be formed in electrostatic precipitators (Hiroaka *et al* 1990).

Housekeeping practices regarding contaminated ashes need to be reexamined; under the current regime, piles of ash accumulating at various sites within the plant pose an exposure risk through atmospheric dispersal of fine particles. When laboratory animals were forced to inhale municipal incinerator ash, heavy metals were found in their lung tissue after only 5 days of exposure. Response to $CO_2$ was depressed and changes in the structure of the lung tissue were visible (Alarie *et al* 1989). It is likely that the organic constituents of the ash would be absorbed in the same way as the heavy metals, though because they are present in lower concentrations, this was not observed during this short experiment. Plant workers or members of the public who inhale the dust are therefore subjected to an uncontrolled and unquantified health risk. Contamination of the environment surrounding the site is also increased by poor ash controls.

Amounts of ash generated by municipal waste incineration are given by Reimann (1985). Per tonne, 304-380kg of slag and 27-44kg of scrubber (fly) ash are produced. Thus, with the annual throughput of 450,000 tonnes, the Brussels municipal incinerator could be expected to produce 150,000-190,000 tons of contaminated ash per year. When it is remembered that 25-35% of the original waste was water (Tillman *et al* 1989), it becomes obvious that the mass of waste has not been greatly reduced by the incineration process. The post-incineration waste, however, is a great deal more toxic than the original garbage. This is disposed of in landfills, where heavy metals and organic contaminants can leach out (Francis & White 1987).

Toxicity of dioxin to humans

The toxicity of the dioxins and furans to humans has caused great

controversy over the past decade. The extreme carcinogenic potency of 2,3,7,8-TCDD and related compounds in animals is well established (see, eg Kociba *et al* 1978). However, the majority of human epidemiological work, carried out on workers occupationally exposed to TCDD, did not find TCDD to be carcinogenic although some more recent work contradicts this (eg Eriksson *et al* 1990). Some of the epidemiological studies which found TCDD not to have carcinogenic effects has been called into question as regards statistical validity (eg Rohleder, 1989). Most recently, an extensive reanalysis of epidemiological data collected on US workers has been published by the National Institute for Occupational Safety and Health (NIOSH) in the USA (Fingerhut *et al* 1991). This considers data for over 5000 workers involved in the manufacture of trichlorophenol and its derivatives. The study concluded that workers exposed for more than one year showed a 46% excess of all cancers combined.

Other emissions

Other emissions from the incinerator include acid gases, heavy metals and products of incomplete combustion (PICs). Analyses conducted by the local authorities in November 1990 showed 700 $mg/Nm^3$ of HCl is the exhaust fumes. This compares extremely badly with the 1986 TA-Luft standard of 50 $mg/Nm^3$ and the 1989 limit of $10mg/Nm^3$. The high levels emitted from the Brussels incinerator are due to the absence of any appropriate gas cleaning equipment. This could be installed but would no more solve the problem of acid emissions than it would solve the dioxin problem discussed above. Again the contaminants would merely be transferred from the air in the vicinity of the incinerator to a liquid scrubber effluent that would then need further treatment.

Heavy metals present in the waste will also be emitted in large quantities. Ferrous scrap is recovered after the incineration process, but other metals, often of greater toxicological significance, are not considered. It is worth noting that 3-9% of European municipal waste is metal (Tillman *et al* 1989). Any metal that is not extracted with the ferrous scrap will either have been discharged to the atmosphere or will remain in the ash. This varies from metal to metal; mercury, present in the waste stream in batteries, is mostly discharged directly to the atmosphere (Reimann 1985). Others are found in very high concentrations in ash. As many as 15 different metals can be found in municipal fly ash (Chrostowski & Sager, 1991). Copper can be present at up to 1600 ppm and chromium up to 2,600 ppm (Hinton & Lane, 1991). These metals can leach out of landfilled ash. Over the longer term, 62% of cadmium, 30% of copper, 25% of lead and 32% of the zinc in fly ash can leach out (Denison & Silbergeld 1991). The effects on water supplies cannot be estimated.

The products of incomplete combustion include many polynuclear aromatic hydrocarbons. Some of these are known to be, and others are suspected of being, carcinogenic to humans. One analysis of incinerator fly ash revealed 28 of these PICs as well as PCBs and dioxins (Alarie *et al* 1989).

In the light of this finding, it cannot possibly be considered

that the Brussels incinerator constitutes an environmentally safe way of disposing of municipal waste. Risks both to the local population and the wider environment are increased, rather than decreased by the incineration of municipal waste at this facility.

**Acknowledgements**

Dioxin analyses were carried out by ITU-Forschungsgesellschaft mbH, Berlin.

**References**

Ahlborg & Victorin (1987) Impact on health of chlorinated dioxins and other trace organic emissions. Waste Manag. Res. 5: 203-224 IN: Incineration of Municipal Waste, Dean, R.B., Ed. Academic Press, 631pp

Alarie, Y., Iwasaki, M., Stock, M.F., Pearson, R.C., Shane, B.S. & Lisk, D.J. (1989) Effects of inhaled municipal incinerator ash in the guinea pig. J. Toxicol. Environ. Health 28: 13-25

Chrostowski, P.C. & Sager, S.L. (1991) Management of ash from municipal solid waste combustion. IN: Health Effects of Municipal Waste Incineraton, Hattemer-Frey & Travis, Eds., CRC Press, pp 249-264

Denison, R.A. & Silbergeld, E.K. (1991) Comprehensive management of municipal solid waste incineration: understanding the risks. IN: Health Effects of Municipal Waste Incineraton, Hattemer-Frey & Travis, Eds., CRC Press, pp 275-293

Eriksson, M., Hardell, L & Adami, H.-O. (1990) Exposure to dioxins as a risk factor for soft-tissue sarcoma: a population-based case-control study. J. Nat. Cancer Inst. 82(6): 486-490

Fingerhut, M.A., Halperin, W.E., Marlow, D.A., Piacitelli, L.A., Honchar, P.A., Sweeney, M.H., Greife, A.L., Dill, P.A., Steenland, K. & Suruda, A.J. (1991) Mortality among US workers employed in the production of chemicals contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD): Final report. NIOSH, Cincinnati, OH 45226, 37pp

Francis, C.W. & White, G.H. (1987) Leaching of toxic metals from incinerator ashes. J. WPCF 59(11): 879-986

Hinton, W.S. & Lane, A.M. (1991) Characteristics of municipal solid waste incinerator fly ash promoting the formation of polychlorinated dioxins. Chemosphere 22(5-6): 473-483

Hiroaka, M., Fujii, T., Kashiwabara, H., Ieyama, K. & Kondo, M. (1990) The removal of dioxin in flue gas of MSW incinerator- comparison of a fabric filter with an electrostatic precipitator. IN: Organohalogen compounds, Vol. 3: Dioxin '90- EPRI SEMINAR; Combustion, pulp & paper, chlorine & PVC, soil workshop, general topics, Hutzinger, O. & Fiedler, H., Eds, Ecoinforma Press

Kociba, R.J., Keyes, D.G., Beyer, J.E., Carreon, R.M., Wade, C.E., Dittenber, D., Kalnins, R., Frauson, L., Park, C.N., Barnard, S., Hummel, R. & Humiston, C.G. (1978) Results of a two-year chronic toxicity and oncogenicity study of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in rats. Toxicol. Appl. Pharmacol. 46: 279-303

Kuykendal, W.B., Lamason, W.H.II, Miles, A.J. & Keating, M.H. (1989) Ash data from combustion sources: results of tier 4 of the national dioxin study. Chemosphere 18(1-6): 1227-1234

Reimann, D.O. (1985) Mercury output from garbage incineration. Waste Manag. Res. 4: 45-56 IN: Incineration of Municipal Waste, Dean R.B. Ed, Publ: Associated Press, 1988, pp43-54

Rohleder, F. (1989) Dioxins and cancer mortality- reanalysis of the BASF-cohort. Paper presented at DIOXIN '89; the Ninth International Symposium on Chlorinated Dioxins and Related Compounds, Toronto, September 17-22, 1989

Siomab S.A. (undated) Greater Brussels Refuse Incineration Plant. Publ: Siomab, Brussels 11pp

Stieglitz, L., Zwick, G., Beck, J., Roth, W. & Vogg, H. (1989) On the de-novo synthesis of PCDD/PCDF on fly ash of municipal waste incinerators. Chemosphere 18(1-6): 1219-1226

Tillman, D.A., Rossi, A.J. & Vick, K.M. (1989): Incineration of municipal and hazardous solid wastes. Academic Press, 343pp

Van Berkel, O.M., Olie, K. & van den Berg, M. (1988) Thermal degradation of polychlorinated dibenzofurans on fly ash from a municipal incinerator. Intern. J. Environ. Chem. 34: 51-67

TRANSMISSION VERIFICATION REPORT

TIME: 21/03/1997 15:37
NAME: EARTH-RESOURCES CTR
FAX : +44-1392-253907
TEL :

| | |
|---|---|
| DATE,TIME | 21/03 15:33 |
| FAX NO./NAME | 9004533935399 |
| DURATION | 00:04:14 |
| PAGE(S) | 07 |
| RESULT | ERROR |
| MODE | STANDARD |