Paper No. CB(2)1875/99-00(01)

GREENPEACE

Preliminary Comments on
An Assessment of Dioxin Emissions in Hong Kong: Final Report

By Pat Costner
Greenpeace International
02 May 2000

1. Background

The Government of the Hong Kong Special Administrative Region (HKSAR) of The People's Republic of China has proposed the following thermal waste treatment facilities:

- up to four municipal solid waste (MSW) incinerators;
- co-incineration of clinical waste in the CWTC;
- a sewage sludge incineration facility; and
- an animal cremator.

After advancing this proposal, HKSAR then issued a tender for the provision of *"some positive assurance to the public that the CWTC and any other dioxin sources, including the planned incinerators, will not pose any threat to the public health."* KHSAR commissioned Environmental Resources Management (ERM) to achieve this goal through the preparation of a report, "An Assessment of Dioxin Emissions in Hong Kong," to contain the following advice and information:[1]

i. "Advise on the formation, source and health impacts of dioxins;

ii. Evaluate and assess the health impact of any known dioxin sources in Hong Kong:

iii. Evaluate and assess the potential health impact of the planned incineration facilities resulting from their dioxin emissions; and

iv. Advise on dioxin control measures and their impacts on the adoption of incineration as an integral part of Hong Kong waste management strategy."

The resulting final report prepared by ERM, "An Assessment of Dioxin Emissions in Hong Kong," was released to the public in mid-April, 2000. [a]

[a] Except where otherwise noted, `the report' refers to the study by Environmental Resources Management, "An Assessment of Dioxin Emissions in Hong Kong: Final Report."

Dioxins and their sources in Hong Kong are important not only to the residents of this region but also to the world at large. China and other nations of the world are now engaged in final negotiations for a global treaty on persistent organic pollutants (POPs) under the auspices of the United Nations Environment Programme (UNEP). Dioxins are among the twelve POPs that have been listed as the treaty's first targets for elimination and/or reduction due to the global scope of the threats they pose to public health and the environment.

Heretofore in Hong Kong, *"the historical legacy of PCDD/F emissions due to the operation of thermal waste treatment processes has to a large extent been avoided,"* as noted by ERM. However, with the proposal by HKSAR to increase the number of dioxin sources, such as incinerators for municipal waste, sewage sludge, animal carcasses, etc., the impending global treaty necessarily has important implications for Hong Kong,

With these circumstances in mind, Greenpeace respectfully offers preliminary comments on the report and the underlying issues of the management of Hong Kong's wastes, dioxins[b], their sources and their relevance to public health and the environment in Hong Kong and the world at large.

2. General Scope of the Report

Only dioxin releases to air are addressed in the report by ERM. Dioxin releases to water and land are not included, even though such releases are potentially far greater than those to air. For example, in the U.K., dioxin releases to water and land evidently are as much as 18 times greater than those to air.[2,3]

In the European Dioxin Inventory, the authors noted that dioxin releases to land *"exceed… atmospheric emissions by far."* They also caution that *"even if the transfer rate of dioxins and furans from these reservoirs [so-called secondary sources, for example dioxins disposed of with wastes and sludges] into the food chain might be low this pathway must not be ignored."* [4] Moreover, according to the U.S. Environmental Protection Agency, *"Volatilization and particle resuspension [of PCDD/Fs] from environmental reservoirs are probably important contributors to global distribution."*[5]

3. Dioxin Sources in Hong Kong

ERM identified nine major categories of industrial sources of dioxin releases to air and two major categories of non-industrial sources in Hong Kong. However, the report does not address a number of sources that have been identified in other inventories[6, 7] as well as in UNEP's Standardized Dioxin Release Inventory Toolkit[8]. Some of the excluded dioxin sources that are potentially relevant in Hong Kong are listed in Table 1.

[b] The term `dioxins' as used herein includes both the polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs).

<table>
<tr><td colspan="3">Table 1. Potentially Significant Dioxin Sources Omitted from Hong Kong Dioxin Inventory</td></tr>
<tr><td rowspan="2">Accidental fires
• Landfills
• illegal dumps
• buildings
• vehicles
• warehoused polyvinyl chloride (PVC)
• PCB storage sites, transformers, etc.</td><td rowspan="3">Accidental & deliberate fires involving wood, wood scraps and/or construction debris that contains
• PVC, e.g., PVC cladding, paints containing PVC, etc.
or is treated with
• Pentachlorophenol, e.g., penta-treated wood, wood scraps and construction debris</td><td>Diesel-fired engines
• Marine (ships, tankers, etc.)
• Construction equipment
• Trains</td></tr>
<tr><td>Burning of household waste in domestic stoves, open barrels, etc.</td></tr>
<tr><td>Accidental & deliberate fires involving wood, wood scraps and construction debris</td><td>Waste oil disposal (both combustion and non-combustion)</td></tr>
<tr><td>Leather plants (finishing)</td><td>Textile plants (manufacture and finishing)</td><td>Drying of sewage sludge</td></tr>
</table>

ERM also presented a brief discussion of natural and accidental fires and noted that further work is required to estimate releases from such occurrences in Hong Kong. In addition, the authors of the report discounted gas-fired power plants as dioxin sources, noting that they *"have not identified any data for PCDD/F emissions from gas-fired power station."* However, air emission factors are presented for such facilities in the European Dioxin Inventory.[9] Landfill gas combustion in domestic premises was also discounted on the basis that *"landfill gas will be treated prior to introduction into the Town gas network,"* absent any information on the type or efficacy of the treatment used in 1997 or intended for use in the future.

In summary, a number of dioxin sources require either initial or further consideration to determine their contribution to dioxin releases to air in Hong Kong.

4. Estimated Dioxin Releases to Air

Despite having actual measured values describing dioxin concentrations in gaseous emissions for only one dioxin source, the chemical waste treatment incinerator, ERM estimated a total dioxin release from all identified sources of 23-33 g I-TEQ in 1997. For all other sources, dioxin releases were based on assumptions that air emission factors developed in the U.K. or presented in the scientific literature were applicable or, in some cases, that air emissions would not exceed air emissions standards[c]. The annual dioxin releases to air from the individual source categories, as estimated by ERM, are shown below in Figure 1.

[c] For cement kilns and sewage sludge incinerators, dioxin releases to air were based on the assumption that the average dioxin concentration in stack gases is 0.1 ng I-TEQ/m^3. For crematoria, dioxin releases to air were based on assumptions of an average dioxin concentration in stack gases of 1 ng I-TEQ/m^3 and the release of 1,500 Nm^3 of stack gas per body.

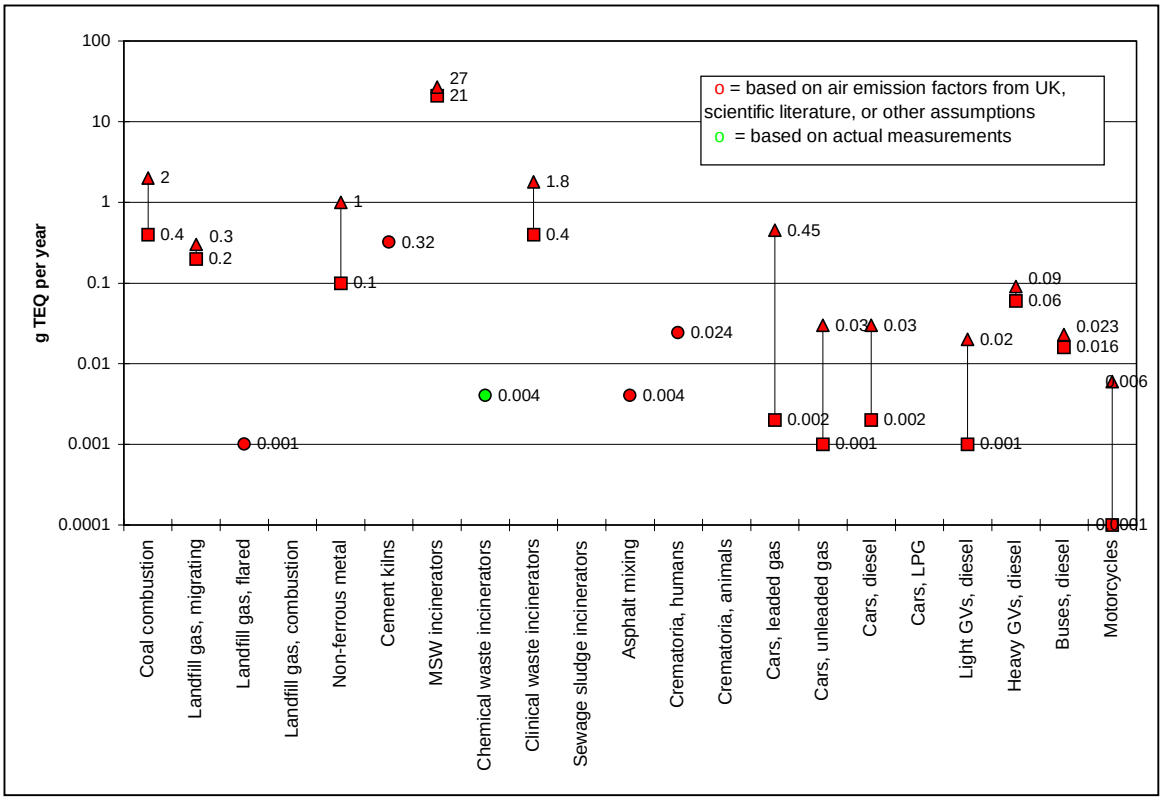

Figure 1. Hong Kong: Contributions of Major Identified Dioxin Sources to Estimated Total Dioxin Release to Air of 23-33 grams I-TEQ in 1997

Such heavy reliance on assumptions rather than actual air emission measurements can result in estimated dioxin releases that have little or no relationship to actual dioxin releases. For example, at one MSW incinerator in the U.S., reliance on air emission factors would have resulted in an estimated annual dioxin release to air that was only a tiny fraction of the 1,000 g I-TEQ per year that was determined from the measured concentration of dioxins in stack gases.[10] In a similar vein, air emission factors for heavy-duty diesel vehicles have been found to differ by a factor of 200.[11]

Based on ERM's high estimate of 33 g I-TEQ total dioxin air emissions in 1997 and a population of 6.8 million people[12], the rate of dioxin release to air was 4,850 ng I-TEQ per person per year in Hong Kong. This per capita release rate is about one-half the per capita rate of dioxin release to air in the U.K., as shown in Figure 2.

Further, ERM reported that in *"April 1997 the MSW incinerator in Hong Kong ceases operation, and in the same year the majority of clinical waste incinerators also ceased operation."* With the shutdown of these facilities, total dioxin releases to air from identified dioxin sources can be estimated as 1.6-4.2 g I-TEQ during 1998, based on ERM's inventory of dioxin sources and their estimated rates of dioxin release in 1997. I.e., during 1998 and 1999, dioxin releases to air in Hong Kong were only 617 ng I-TEQ per capita.

The remarkably low rates of dioxin release to air in Hong Kong are potentially due to a number of factors, including the following:

- Major sources of dioxin releases to air were not included in the assessment;
- Dioxin releases from identified sources were underestimated due to reliance on inappropriate air emission factors or inaccurate activity levels;
- Hong Kong has *"lower levels of industrial activity that have been traditionally associated with historical national inventories (eg. MSW and clinical waste incinerators, and secondary metal refining) and the absence of sources such as sinter plants,"* as noted by ERM.

Another noteworthy aspect of the dioxin assessment is that it shows that the lowest annual dioxin releases to air occurred at the same time that Hong Kong had relatively high dioxin levels in its ambient air, as discussed below.

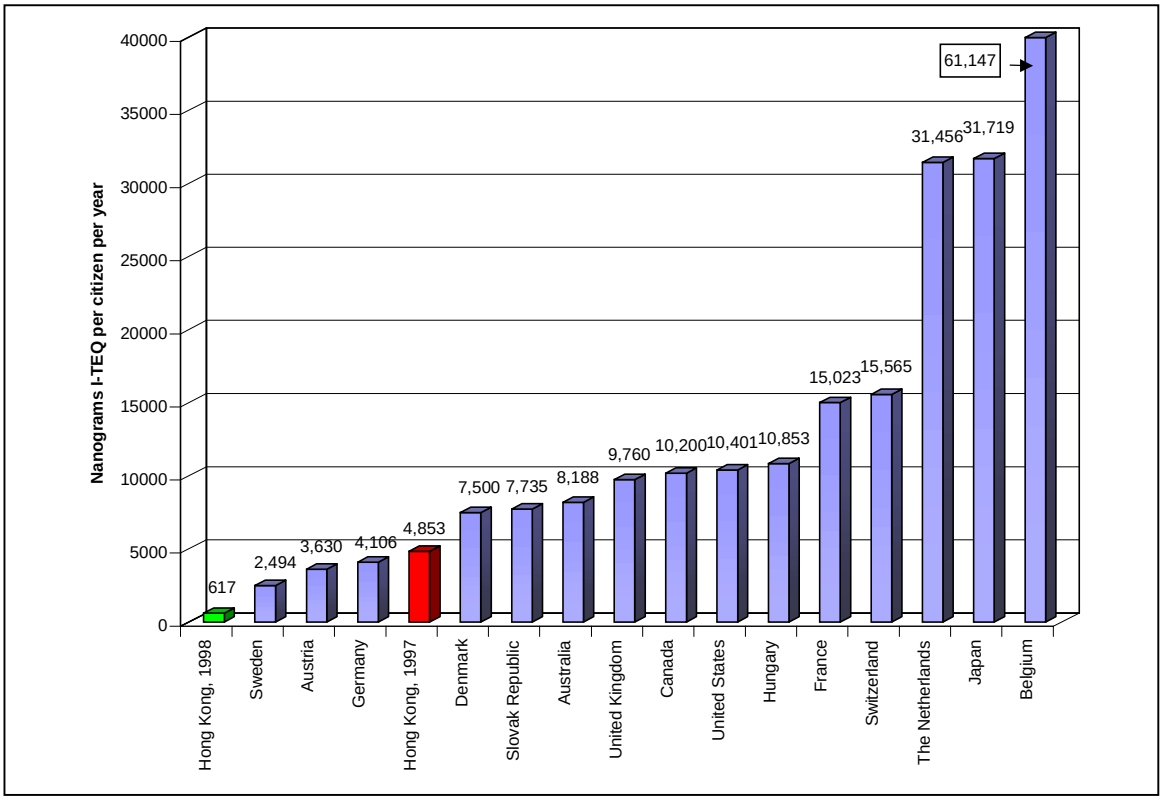

Figure 2. Per Capita Dioxin Emissions to Air from Identified Sources in Hong Kong and Other Selected Countries

5. Dioxins in Ambient Air in Hong Kong

In evaluating the ambient air data, ERM implied that the dioxin concentrations measured in the air of Hong Kong are to be expected with the conclusion that "*urban ambient air PCDD/F data for Hong Kong generally falls within the range of PCDD/F concentrations measured at other locations.*" To the contrary, however, several factors suggest that the dioxin levels in ambient air in Hong Kong are unexpectedly high:

- The per capita dioxin releases to air in Hong Kong were apparently quite low, as discussed earlier; and
- The number of facilities that are commonly recognized as important dioxin sources was very low, as noted by ERM, municipal waste and clinical waste incinerators had been closed and "*the historical legacy of PCDD/F emissions due to the operation of thermal waste treatment processes has to a large extent been avoided.*"

As shown in Figure 3, the dioxin concentrations in ambient air were measured at two stations, Central/Western and Tsuen Wan, during July 1997 through July 1999. Presented in the report by ERM, the summary data show dioxin levels ranging from 0.019 to 1.143 pg I-TEQ/m^3, with an overall average of 0.13 pg I-TEQ/m^3.

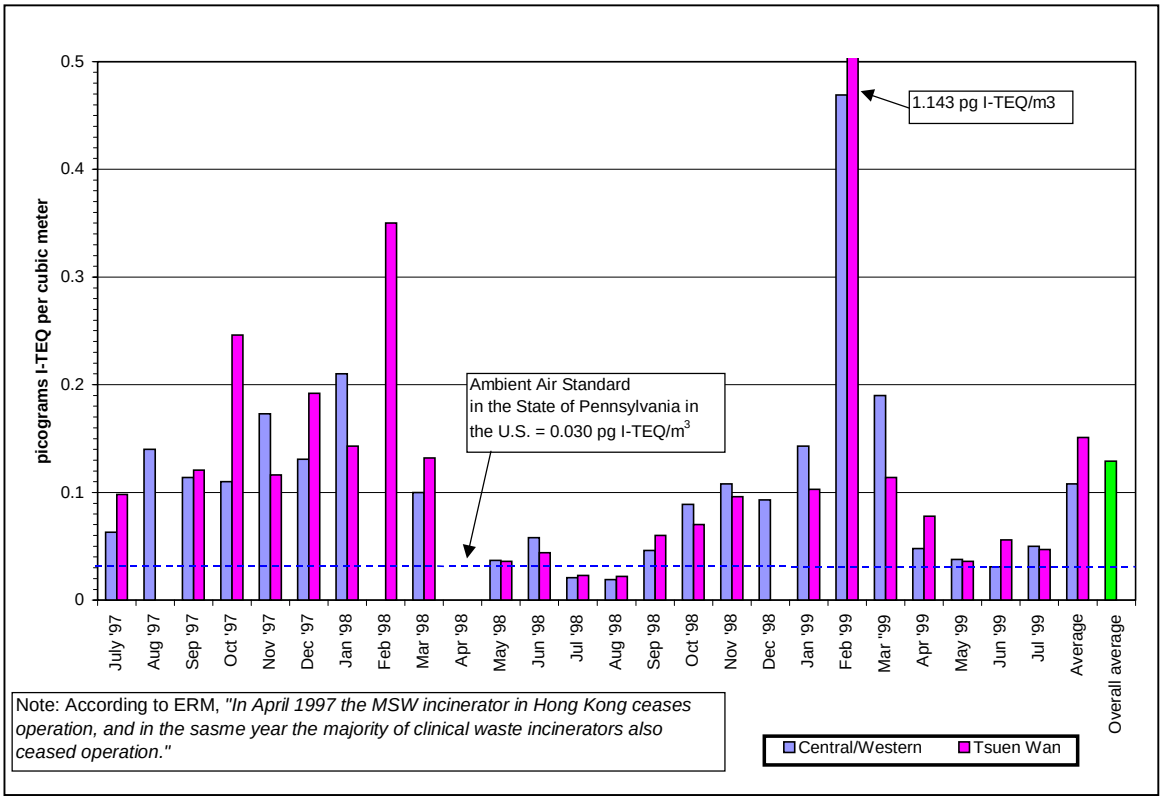

Figure 3. Hong Kong: Dioxin Concentrations in Ambient Air at Two Stations, Central/Western and Tsuen Wan, July 1997-July 1999

Some of the studies ERM relied upon as appropriate for comparing with the ambient air dioxin values reported for Hong Kong are not well suited for that purpose. For example, Hunt et al. (1997), authors of the study cited as showing an average dioxin level in U.S. urban air of 0.25 pg I-TEQ/m^3, were explicit that *"[d]ue to the site-specific bias likely introduced by vehicular traffic … the ambient PCDDs/PCDFs measured should not be construed to be representative of ambient PCDDs/PCDFs burdens in metropolitan Phoenix, as a whole."* These same authors also pointed out that, in the U.S., the states of Pennsylvania and Massachusetts *"have adopted ambient air standards of 0.030 pg I-TEQ/m^3 and 0.045 pg I-TEQ/m^3, respectively."* [13] In addition, another recently published U.S. study by Lorber et al. (1998) presented 0.050 pg I-TEQ/m^3 as an *"urban background level."*[14]

In summary, the dioxin concentrations in ambient air in Hong Kong are, on average, higher than levels in other urban/industrial areas and frequently exceed ambient air standards for other locales. This suggests there is cause for concern with respect to potential impacts on public health and the environment.

6. Dioxin Exposure of the Citizens of Hong Kong

With no data describing the diet and dioxin levels in the diet of an average citizen of Hong Kong -- in fact, with no dioxin data specific to Hong Kong other than dioxin levels in ambient air, ERM estimated a dietary intake of dioxins of 105 pg I-TEQ/day for an average adult living in Hong Kong. ERM noted that this *"conservative estimate of PCDD/F intake for Hong Kong is in line with estimates for dietary intakes in other countries."* The dietary dioxin intake was evidently developed through the following process:

- ERM calculated a daily dioxin intake via inhalation of 2 pg I-TEQ/day for an adult in Hong Kong using the median dioxin concentration in ambient air of 0.1 pg I-TEQ/m^3 and the average rate at which an adult inhales air, 20 m^3 per day.
- Assuming the average adult in Hong Kong has a body weight of 70 kg, ERM then calculated the rate of dioxin intake via inhalation of 0.03 pg I-TEQ/kg bw/day.[d]
- Assuming that *"the inhalation dose represents 2% of the total intake,"* ERM calculated that the a total daily dioxin intake of 1.5 pg I-TEQ/kg bw/day, which is 105 pg I-TEQ/day for a 70 kg adult.

On the other hand, potentially more appropriate assumptions and values can be used to estimate a considerably lower dietary dioxin intake for Hong Kong, as follows

- The kinds of foods generally consumed by residents of Hong Kong and the dioxin content of those foods are undoubtedly different from those of Western Europe and North America. For example, in Germany, about one-third of dioxin intake originates from milk and milk products, one-third from meat, meat products, and eggs, one-quarter from fish and fish products, and the remainder from bread, cereals, vegetables, and ready-to-serve meals.[15]

[d] Pg I-TEQ/kg bw/day = picograms I-TEQ per kilogram of body weight per day.

- Recent studies show that people living in China, a major supplier of food to Hong Kong, have considerably lower dioxin levels in their blood lipids than those of people living in Western European and North American. For example, among people in Jiangxi Province in central China, dioxin levels in blood lipids ranged from 4.8 pg I-TEQ/g for those aged 15 to 19 years and 6.4 pg I-TEQ/g for those of 35 to 70 years.[16]
- Dioxin levels in the blood lipids of the general populations of Germany and the U.S. were reported in 1997 as 19 pg I-TEQ/g and 28 pg I-TEQ/g, respectively.[17] According to a study published in 1999, dioxin levels in the U.S. population have decreased to 17.2 pg I-TEQ/g.[18] In either case, these blood lipid levels are associated with dietary intakes of dioxins of 1-2 pg I-TEQ/kg body weight/day. [19]

Assuming that the relationship of dietary intake of dioxins and dioxin levels in blood lipids is similar for China and the industrialized countries, the average dioxin level in blood lipids of the people in central China, about 5.6 pg I-TEQ/g, is associated with an estimated dietary intake of 0.3-0.6 pg I-TEQ/kg body weight/day, or 18-36 pg I-TEQ/day.

If the dietary intake of dioxins in Hong Kong is similar to that in central China, the contribution to total dioxin intake from air inhalation is significant. The average dioxin concentration in Hong Kong's ambient air is 0.13 pg I-TEQ/m^3, as documented in the report by ERM and shown in Figure 3. For an adult with a normal inhalation rate of 20 m^3/day, the average dioxin intake via inhalation is 2.6 pg I-TEQ/day. I.e., inhalation of airborne dioxins at the concentrations found in Hong Kong would increase the total daily dioxin intake of people in central China by 7-14 percent.

The actual dietary intake of dioxins in Hong Kong may well be intermediate between 105 pg I-TEQ/day, the value predicted by ERM (which is similar to dioxin intakes documented in Western Europe and North America) and 18-36 pg I-TEQ/day, the range estimated for citizens of central China. In this case, the contribution of inhalation to total dioxin intake will still be significant.

References

[1] Environmental Resource Management, Environmental Protection Department, Government of Hong Kong Special Administrative Region (HKSAR) of The People's Republic of China, "Special Conditions of Contract, Tender for the Provision of Services for An Assessment of Dioxin Emissions in Hong Kong.
[2] Dyke P., Foan, C, Wenborn, M, Coleman, P. 1997. A review of dioxin releases to land and water in the UK. Sci Total Environ 207(2-3):119-31.
[3] Alcock, R., Genmill, R., Jones, K. 1998. An updated PCDD/F atmospheric emission inventory based on recent emissions measurement programme. Organohalogen Cpd. 36: 105-108.
[4] Quass, U., and Fermann, M. 1997. Identification of Relevant Industrial Sources of Dioxins and Furans in Europe (The European Dioxin Inventory), Final Report, No. 43. Landesumweltamt Nordrhein-Westfalen: Essen, Germany.
[5] U.S. Environmental Protection Agency, 1999. Polychlorinated Dibenzo-p-dioxins and Related Compounds Update: Impact on Fish Advisories. EPA-823-F-99-015, Washington, D.C., September 1999.
[6] U.S. Environmental Protection Agency, 1998. The Inventory of Sources of Dioxin in the United States. External Review Draft. EPA/600/P-98/002Aa, Washington, D.C., April 1998.
[7] Quass and Fermann (1997)
[8] Fiedler, H., Dyke, P., Hartenstein, H.-U., 1999. "UNEP's Standardized Dioxin Inventory Toolkit: A Tool to Assist Countries in Establishing Standardized National PCDD/PCDF Release Inventories," presented at the Sub-Regional Expert Meeting on the Reduction of Persistent Organic Pollutants (POPs) in Particular Dioxins and Furans, St. Petersburg, Russian Federation, December 1999.
[9] Quass and Fermann (1997)
[10] Lorber, M; Pinsky, P.; Gehring, P.; Braverman, C.; Winters, D.; Sovocool, W. 1998. Relationships between dioxins in soil, air, ash, and emissions from a municipal solid waste incinerator emitting large amounts of dioxins . Chemosphere, Vol 37: 2173-2197.
[11] Gueke, K., Gessner, A., Quass, U., Broker, G., Heister, E., 1999. PCDD/F emissions from heavy duty vehicle diesel engines. Chemosphere 38: 2791-2806.
[12] CIA World Book
[13] Hunt, G., Maisel, B., Zielinska, B. 1997.The origins of PCDDs/PCDFs in the atmosphere of Phoenix, AZ. Organohalogen Cpds. 33: 145-150.
[14] Lorber, M., Pinsky, P., Gehring, P., Braverman, C., Winters, D., Sovocool, W., 1998. Relationships between dioxins in soil, air, ash, and emissions from a municipal solid waste incinerator emitting large amounts of dioxins. Chemosphere 37:2173-97.
[15] Papke, O., 1998. PCDD/PCDF: Human background data for Germany, a 10-year experience. Environ. Health Persp. 106 (Suppl. 2): 723-731
[16] Schecter, A., Li, L., Ke, J., Furst, P., Papke, O., 1996. Pesticide application and increased dioxin body burden in male and female agricultural workers in China. J. Occup. Environ. Med. 38: 906-911.
[17] Schecter, A., Papker, O., Furst, P., Ryan, J., 1997. Temporal changes in dioxin and dibenzofuran levels in general population blood and milk from Germany and the United States, Organohalogen Cpds. 33: 473-478.
[18] U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, 1999. Health Consultation (Exposure Investigation): Calcasieu Estuary (a/k/a Mossville), Lake Charles, Calcasieu Parish, Louisiana, CERCLIS No. LA002368173, November 19, 1999
[19] Papke, O., 1998. PCDD/PCDF: Human background data for Germany, a 10-year experience. Environ. Health Persp. 106 (Suppl. 2): 723-731.