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# Policy Statement on the Incineration of Municipal Waste

International Air Quality Advisory Board

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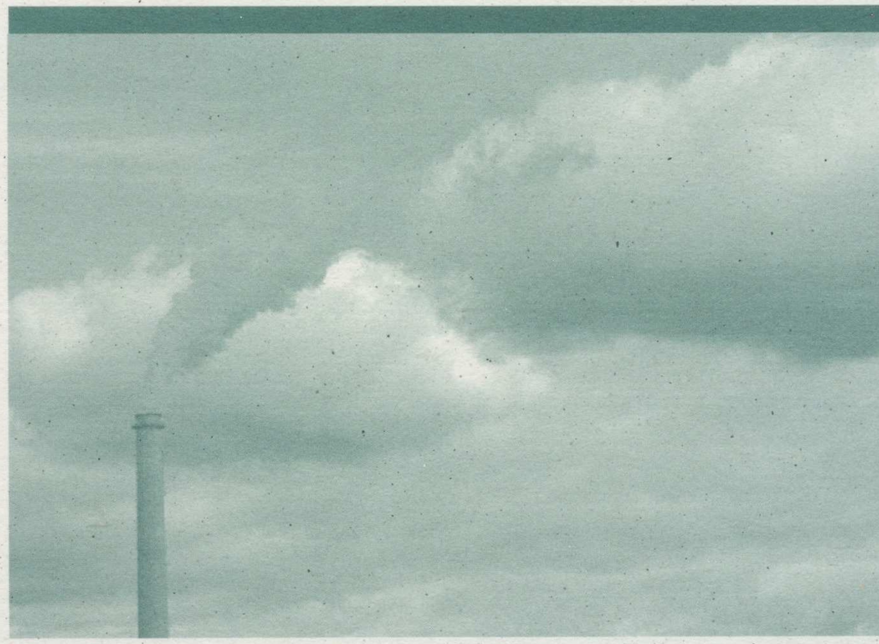

September, 1996

International Joint Commission
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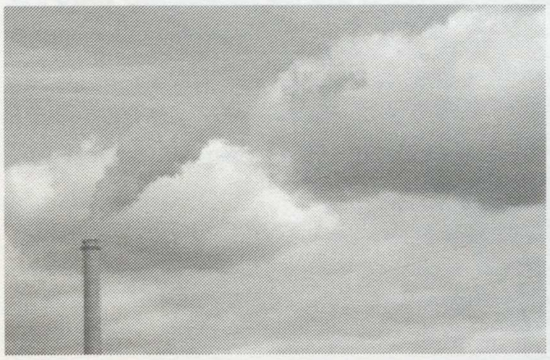

# A Policy Statement on the Incineration of Municipal Waste

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# Foreword

As one aspect of its work under the Great Lakes Water Quality Agreement, the International Joint Commission requested its International Air Quality Advisory Board (IAQAB) to assess available information on emissions from municipal waste incinerators and their contribution to the loadings of persistent toxic substances to the Great Lakes basin. The IAQAB presented the following policy statement and background paper on municipal waste incineration to the Commission in response to this request.

The Commission considered the policy statement in September 1996. In recognition that municipal solid waste incinerators are sources of persistent toxic substances which, when emitted to the air, can have human health implications, can be transported across national boundaries, and can be deposited on land and in waterbodies such as the Great Lakes, the Commission adopted the statement as its position with respect to the incineration of municipal waste. The Commission encourages all jurisdictions and interests engaged in implementing this type of municipal waste treatment to give careful consideration to this statement as the minimum requirements for such facilities to ensure adequate protection of the environment and human health.

# A Policy Statement on Incineration of Municipal Waste*

## Preamble

The International Air Quality Advisory Board (IAQAB) fully endorses the principle of virtual elimination of persistent toxic substances to the Great Lakes and supports the need to manage municipal solid waste facilities toward this end. It further recognizes that municipal solid waste incinerators are sources of persistent toxic substances which can be transported long distances to or from the Basin and across national boundaries.

The IAQAB emphasizes that incineration is only one of a matrix of options and technologies available to currently address management of municipal solid wastes. Any incinerator application should be viewed in the larger context of an integrated solid waste management approach, which includes life-cycle analysis, with a priority on reduction and recycling initiatives. The IAQAB notes that there is an inherent conflict between the maximization of waste recycling, particularly of combustible fibre such as newsprint and cardboard, and sustainable, stable operation of an incinerator, as removal of such materials from the refuse significantly reduces its properties as a fuel.

The IAQAB recognizes that, if the incinerator option is chosen, facilities can be designed and operated to reduce the amount of toxic materials (including pathogens) in the waste, to concentrate the residual toxics in the ash and to minimize releases of same to the atmosphere. The health implications of release of fine (less than 10 microns) particulate matter from such sources must continue to be considered.

## Principles

i) Consideration or deployment of municipal incinerators should not, in any way, compromise programs for waste reduction and recycling, which must remain the cornerstone of waste management.

ii) Should jurisdictions elect to build new incineration facilities, these, at minimum, should be in full compliance with the USEPA and MOEE requirements. Further, jurisdictions and proponents should recognize that emission control technology is constantly improving and should commit to incorporate such improvements at several points in the life span of any given facility.

In keeping with the principle of virtual elimination, the IAQAB wishes to state four additional principles, namely:

iii) Any further deployment of this technology by any jurisdiction should be done on the basis of a net reduction of emissions of persistent toxic substances, jurisdiction wide, from such facilities. Thus, existing units must be further controlled to new source performance standards or decommissioned by the year 2000. The USEPA regulations and those in some European jurisdictions contain this requirement, which should also be embraced by the Province of Ontario.

iv) The total amount of persistent toxic substances released by incineration facilities in a jurisdiction, defined as the sum of those to the atmosphere and in the residuals, must also be decreased whenever a new incineration facility is permitted.

* In September of 1996, the International Joint Commission endorsed this policy statement as its position on municipal waste incineration.

v) Compliance with principle iii) also commits individual jurisdictions to the establishment and ongoing maintenance of publicly accessible emission inventories characterizing all regulated operating parameters, emissions and releases from these units.

vi) The operator and regulatory agencies must make a concerted and ongoing effort toward meaningful public involvement in all aspects of the facility. This includes significant public participation in initial selection of the incineration option, development of a comprehensive justification and related environmental assessment, construction and commissioning of the facility, as well as operation and final decommissioning. These considerations must extend beyond the facility to encompass measurement and publication of assessments of environmental quality including extensive ambient air quality monitoring for persistent toxic substances and other pollutants in the adjacent locale.

**Technical Requirements**

i) Operating facilities should be required to perform regular comprehensive ambient air and deposition monitoring in the vicinity of the plant and associated ash-disposal location.

ii) Emissions from the facility must be subject to continuous monitoring and manual sampling as provided for in the USEPA regulations. If necessary, further sampling to confirm the size distribution of particulate matter in the emission stream should be conducted.

iii) To the extent practicable for specific sites or waste flows, these units should be designed for extended stable operation, which could be realized, in part, by requiring the incorporation of electrical or other energy generation.

iv) The toxic content of residual ash and particulate should be determined at regular intervals to ensure associated disposal strategies are appropriate for the nature of the waste.

v) Source, ash residual and localized ambient air quality data should be collected and incorporated into an ongoing performance review program, with provision for effective public oversight.

vi) As an operational principle, Good Management Practice, including rigorous and certified operator training, is a must.

**Financial Considerations**

While finance is not an area of IAQAB expertise, there is a need to ensure that adequate funds are available for:

i) continuous monitoring, appropriate maintenance activities and updating of process and control equipment throughout the lifespan of the facility;

ii) support for ongoing independent auditing of operations as part of a public review;

iii) sound decommissioning of both the unit and any associated residual disposal site, including long term monitoring of the integrity of any such site.

DISCLAIMER

The following Background Paper to the International Joint Commission by its International Air Quality Advisory Board was prepared with the support of the Commission; however, the specific conclusions and recommendations in this background paper do not necessarily represent the views of the International Joint Commission.

# BACKGROUND PAPER TO THE POLICY STATEMENT ON THE INCINERATION OF MUNICIPAL WASTE

## 1.0 INCINERATION: AN OPTION IN MUNICIPAL SOLID WASTE MANAGEMENT

### Introduction

The intent of this background paper is to provide an overview of the information considered by the International Air Quality Advisory Board (IAQAB) in developing their Policy Statement on the Incineration of Municipal Waste. To provide explicit linkage between this document and the Policy Statement, elements of the Policy Statement will be highlighted in a comment box at appropriate locations of this report.

**Excerpts from the Policy statement of the IAQAB of the IJC, on the Incineration of Municipal Waste appear in comment boxes such as this one throughout this report.**

A scientific study (Commoner/Cohen), discussed with the International Joint Commission in March 1995, indicated the substantial role of municipal waste incineration in the deposition of dioxins and furans in the Great Lakes basin. The subsequent rescinding of a ban on construction of new municipal waste incineration facilities in the Province of Ontario in mid-1995 led the Commission to ask the International Air Quality Advisory Board to assess the role of such sources in the generation of persistent toxic and acidifying substances. In responding to the Commission, the IAQAB has sought information on the management of household waste, including the application of incineration as one of several tools or options, from most parts of the developed world.

### Countries and Options

A summary of the comparative extent to which the three major options are used in the management of household waste (landfill, incineration and recycling) is presented in Table 1 for Canada, the United States, Japan and several countries in Europe.

The table suggests that Canada, the United States and the United Kingdom largely prefer the landfill option, with relatively low levels of incineration and recycling. A more recent study indicated that Ontario incinerates 4% of its MSW (municipal solid waste) compared to 16% in the US and 70% in Sweden. (Globe & Mail, 1996).

Within the European community, Sweden and Denmark are among the highest users of incineration technology for municipal waste management. In Denmark, incineration of such waste for energy recovery is well established, and approximately 25% of the 2.3 Mt annual collection of household waste (13% of the total waste generated, not including garden waste) is consumed in 32 incineration plants. Approximately 30 to 40 percent of household waste is composted.

As the table suggests, incineration is also the preferred option in Japan. In 1992, Japan operated 1892 facilities to incinerate 75% of the 50.2 Mt of municipal solid waste collected annually (Waste Management in Japan, 1995).

TABLE 1 Summary of Municipal Waste Management Strategies in Selected Countries

| Country | Generation kg/person/day | Landfill % | Incineration % | Recycling % |
|---|---|---|---|---|
| Canada (1988) | 1.7 | 82 | 8 | 10 |
| Denmark (1990) | 1.3 | 25 | 25 | 50 |
| France (1990) | 0.95 | 21 | 21 | 58 |
| Germany (1992) | 1.4 | 46 | 36 | 18 |
| Japan (1991) | 0.8 | 10 | 77 | 13 |
| Netherlands (1992) | 1.0 | 42 | 31 | 27 |
| Sweden (1991) | 1.2 | 40 | 55 | 5 |
| Switzerland (1992) | 1.2 | - | 80 | 20 |
| United Kingdom (1988) | 0.8 | 86 | 7 | 7 |
| USA (1991) | 1.6 | 67 | 16 | 17 |

Reference: "An International Perspective on Characterization...," 1994

To place incineration in context, a brief overview of some of the alternative waste handling operations follows.

## Recycling

Recycling allows reuse of parts of the waste stream while realizing savings in energy that would otherwise be required to manufacture them. Recycling is accepted in the developed world as an integral part of any household waste management program. For example, in Canada, the Royal Society for National Conservation report "The Wildlife Trusts Partnership, 1993 Stepping Stones," noted that participation rates in curbside recycling were very high in parts of the country, exceeding 80% in Toronto, 85% in Vancouver and 92% in Edmonton.

The IAQAB noted that an aggressive recycling of fibrous materials, such as newsprint and other paper products, reduces the thermal energy content of the waste stream and, thus, its potential use as an energy source through incineration. In this instance, the IAQAB would support use of the recycling option.

## Landfilling

In Sweden, as well as in many other countries, the use of landfills is currently the principal alternative to waste incineration. However, there are concerns about the impact of this practice within the European community. "Relatively little is known about the effects of waste disposal sites on health and the environment, and this is notably true with respect to long-term effects...There is always risk that stable, toxic substances can leach out into the surrounding area for several decades if adequate safety barriers are not constructed. Conflicts involving other uses of the land also arise." (Energy From Waste, 1986) An evaluation of the magnitude of the relative risks with respect to other options is only now beginning.

Waste gases emitted from landfills are also a significant concern. Some studies in the United States have shown relatively significant mercury content in such gases. Landfills are also sources of organic compounds, such as vinyl chloride, which pose hazards in their own right while adding to the available quantities of an ozone precursor (VOCs - volatile organic compounds), and greenhouse gases. Along with odour, there are potential fire and explosion hazards. In recognition of this, the US EPA has promulgated new requirements for large landfills requiring an estimation of the volume of gaseous releases and, where appropriate, capture and combustion of such gases.

It is also becoming increasingly more difficult to develop MSW landfill sites which are a reasonable distance from urban centres and acceptable to the local populace. These constraints are most keenly felt in countries with a relatively small land mass such as Denmark and Japan. For example, over 2300 landfills are currently operating in Japan; their remaining capacity of 154 million cubic metres is projected to be consumed by the year 2000 (Waste Management in Japan, 1995). Thus, incineration is a very significant element of waste management in such countries.

## Incineration

Incineration is one of several options available in the formulation of a waste management strategy. All strategies for waste management, with the possible exception of prevention, have potential environmental concerns. While prevention may be the most 'environmentally friendly' strategy, as practised today it is not a complete solution. Nor is incineration. With incineration, the need for land disposal of the: 1) ash and residuals, 2) non-combustibles and other elements of the waste stream, remains.

## Management of the Waste Stream

> **"Principles"**
>
> ***i) Consideration or deployment of municipal incinerators should not, in any way, compromise programs for waste reduction and recycling, which must remain the cornerstone of waste management."***

One of the initiatives implied through inclusion of a 'generation' entry in Table 1 is government efforts to reduce the creation of waste and better manage the characteristics of the generated waste. Several jurisdictions, including the United States and Canada, have attempted to lower the volume of waste generated through product packaging guidelines, product stewardship efforts, and restrictions or incentives to constrain disposable products. In addition, household hazardous collection efforts seek to reduce the hazardous content of the municipal refuse stream, benefiting all options exercised thereafter.

## Life-Cycle Analysis

> **"Preamble. . .**
>
> ***"Any incinerator application should be viewed in the larger context of an integrated solid waste management approach, which includes life-cycle analysis, with a priority on reduction and recycling initiatives."***

Today's waste management systems are complex, interrelated webs that can include source-separated materials collection, materials recovery, composting, combustion, and other processing steps. Any full evaluation of waste management systems must incorporate all aspects of the system as well as externalities that affect and are affected by the system and alternatives to the current system.

In the last two decades, major waste management facility projects using accepted technology have often been delayed for years, in part because relevant and credible environmental information was not readily available. Currently, conflicting or incomplete information exists regarding the benefits and effects of source reduction, recycling, composting, landfilling, and combustion of municipal solid waste (MSW).

It is now recognized that the complexities of managing municipal refuse might best be viewed through the application of Life Cycle Analysis (LCA). The Society of Environmental Toxicology and Chemistry defines life-cycle analysis as,

> "...an objective process to evaluate the environmental burden associated with a product, process, or activity by identifying and quantifying energy and material usage and environmental releases, to assess the impact of those energy and material uses and releases on the environment, and to evaluate and implement opportunities to effect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation, and distribution; use/re-use/maintenance; recycling; and final disposal."

This 'quantifying measure' allows particular areas of energy imbalance to be identified and dealt with, thereby increasing the effectiveness of the entire process. Surprisingly, in many cases, the alternative which appears most environmentally sound frequently requires a significant energy expenditure for the extraction of materials or transportation of goods, costs which are reflected in the final price of the goods and the total use of resources. It is crucial that such energy expenditures be included in any quantification of the impact of any process on the larger ecosystem (1993-95 Priorities..., International Joint Commission 1995).

Techniques for analyzing the environmental and economic performance of MSW management operations traditionally have focused on individual processes rather than the entire system. In recent years, in an attempt to consider the entire life cycle of waste, the focus has been on source reduction and recycling options as well as on pollutant generation and energy use some distance *upstream* of the waste disposal system at the point of product manufacture or remanufacture.

Life-cycle analysis studies and workshops centred on waste management strategies are being conducted in all areas of the world. An international workshop entitled, "Life Cycle Assessment and Treatment of Solid Waste," was held in September 1995 in Stockholm, Sweden. This seminar included representatives from Canada, Sweden, The Netherlands and the United States among others.

## Extension of LCA to Municipal Waste

Among other efforts, Life Cycle Analysis (LCA) research to evaluate MSW management options is currently being conducted by the United States Environmental Protection Agency's (USEPA) Air Pollution Prevention and Control Division. Stakeholders for this four year ongoing study include industry (Browning-Ferris Industries, WMX Technology, Inc.), local, state and federal government agencies and other interested parties such as the Environmental Defense Fund and the National Solid Waste Management Association. Also, data from the private sector, such as a life-cycle study currently undertaken by the American Plastics Council, is to be considered and comparisons to data provided by other countries, including Canada, are to be made. Presently, the project is in its second year and is to be completed by August 1998.

An LCA to evaluate MSW management strategies focuses on improving the environmental performance of the management system for a given quantity and composition of MSW. An LCA approach:

- provides a 'systems' view to capture tradeoffs and transfers of environmental impact from one waste management operation to another, or from one life-cycle stage to another;

- provides a framework for analyzing the environmental and economic performance of individual MSW management unit operations and for the MSW management system as a whole;

- allows for the analysis of multiple environmental issues, addressing overall energy consumption and environmental releases rather than analyzing single energy and environmental issues individually; and

- allows for a quantitative and objective analysis of environmental releases.

As shown in Figure 1, in a major unit operation, a life-cycle approach can account for materials and energy tradeoffs from waste management activities related to upstream activities, including the manufacture of materials and products from virgin and/or recovered materials. An LCA can also delineate differences in waste management practices including distinctions between urban and rural locales.

The major unit operations to be included in any MSW management system are:

- collection and transfer
- separation
- treatment
- burial or land disposal
- remanufacturing
- cost, energy and resource consumption

Refuse collection options are divided into:

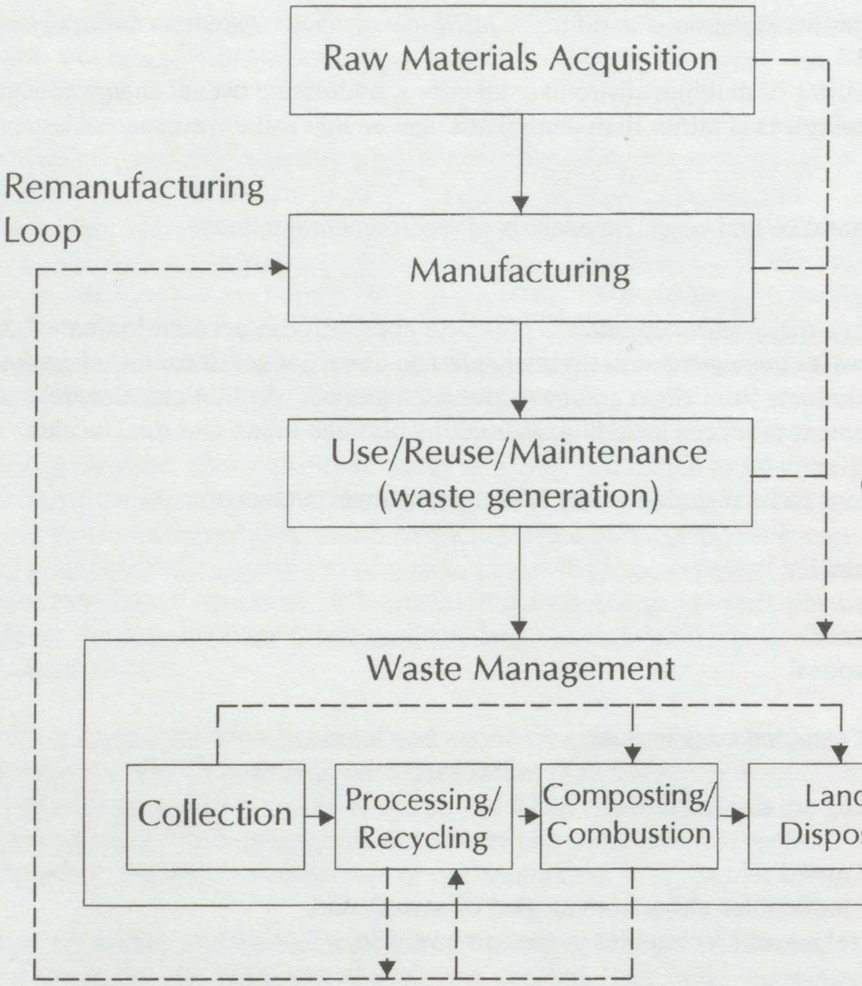
i) the collection of mixed refuse;
ii) the collection of recyclables either commingled or sorted; and,
iii) co-collection of refuse and recyclables in the same vehicle.

The design of a materials recovery facility (MRF) is also considered. Energy and resource consumption, and environmental releases corresponding to manufacturing of a product from recyclable material (remanufacturing) are other segments of the study. Combustion (with or without energy recovery), composting and anaerobic digestion are other possible considerations. Landfill disposal of mixed refuse and combustion ash is also reviewed. Source reduction is to be considered both within the bounds of the system and in a larger more qualitative context.

The information garnered from a life-cycle analysis will provide communities with comprehensive, verified information on accepted municipal solid waste options including combustion, composting, landfilling and recycling.

## Life Cycle Inventory

The Life Cycle Inventory (LCI) of municipal waste management will include topics relating to waste generated in the residential, commercial, institutional, and industrial sectors. The LCI includes material and energy balance calculations for multi-pollutants and media for the evaluation of different MSW management options. Ash that is created from the combustion of MSW is also incorporated in the inventory research.




**Notes:**

- Transportation is embedded within each of the life-cycle stages.
- Source reduction is embedded within each of the life-cycle stages and affects the flow of materials within and between stages.
- Combustion includes incineration with or without energy generation.

FIGURE 1 Life Cycle for Integrated Waste Management

Reference: U.S. EPA "Life Cycle Study of Integrated Waste Management Studies..."

A major component in developing a Life Cycle Inventory and testing an LCI framework is collecting data on material and energy balance calculations. Data in the LCI would be used in material and energy balance calculations to develop emission factors for each unit operation involved in solid waste management.

The LCI data development procedures include three main steps:

1) Defining facility design specifications for each waste management operation.
2) Developing LCI data for each waste management operation.
3) Allocating LCI data for each operation to individual MSW components.

(Status Report of U.S. Life-Cycle Study to Evaluate Integrated Waste Management Strategies, USEPA, 1995)

# Findings

**"Principles**

***"i) Consideration or deployment of municipal incinerators should not, in any way, compromise programs for waste reduction and recycling, which must remain the cornerstone of waste management."***

**In developing a solid waste management plan, strategies for waste minimalization and recycling are key elements; once these elements are in place, other options such as incineration, when technically justified through application of techniques such as life-cycle analyses as the lowest risk and least costly means of managing the waste stream, can be considered.**

**If the use of incineration can be justified as a component of an overall waste management plan, there are certain minimum criteria that should be incorporated into the overall design and operation of the facility. The Policy on Incineration of Municipal Waste outlines those criteria.**

## 2.0 INCINERATION AND PERSISTENT TOXIC SUBSTANCES: THE COMMONER/COHEN REPORT

**"Preamble. . .**

***"It further recognizes that municipal solid waste incinerators are sources of persistent toxic substances which can be transported long distances to or from the Basin and across national boundaries."***

In March of 1995, a workshop on 'Transition to Virtual Elimination' sponsored by the Parties Implementation Workgroup of the Science Advisory Board, IJC, considered a draft report "Quantitative Estimation of the Entry of Dioxins, Furans and Hexachlorobenzene into the Great Lakes from Airborne and Waterborne Sources" authored by Dr. Mark Cohen and Dr. Barry Commoner of the Center for the Biology of Natural Systems, Queens College, CUNY, Flushing N.Y.

The subject of the paper was sources, transport and deposition to the Great Lakes basin of two persistent toxic substances, poly-chlorinated dibenzo-dioxins/furans (PCDD/DF) and hexachlorobenzene (HCB). This paper was the first of a two phase study to develop economically constructive ways of virtually eliminating the entry of several major persistent toxic substances into the Great Lakes. The second phase, examining economic issues related to the further control of these pollutants from sources, including municipal incineration, was made available in June 1996.

In considering emissions to the atmosphere, the Commoner/Cohen paper identified 1661 dioxin/furan and HCB individual emission sources, including 179 US and 17 Canadian municipal incinerators, 124 US and 20 Canadian medical waste incinerators, 263 US and 7 Canadian hazardous waste incinerators and 28 US and 2 Canadian cement and aggregate kilns burning hazardous waste. The ranking of sources is also roughly consistent with those developed on a national basis, as well as some European estimates, discussed in a subsequent section. The source categories considered, and the associated dioxin/dibenzo furan emissions are given in Table 2.

Generally, emissions from individual facilities were estimated by determining feed rates and applying an emission factor. In some cases, the emission factors were developed from a very limited data base and several reviewers have suggested that the resulting estimates, particularly those associated with medical waste, are too high; however, better estimates have yet to be tabulated. The relative paucity of good source data reinforces the Board's ongoing concern regarding the quality of the emission inventories maintained in both countries for sources such as these.

In determining the relative contribution of dioxins/furans to the Basin from various sources, Commoner/Cohen found that municipal waste incinerators were the second largest contributors, at an estimated 24% of the approximate total deposition.

The largest source category identified in the report was medical waste incineration. Following release of the report, the estimate for medical waste incinerators was found to be significantly overvalued due to a gross overestimation of emissions. Thus, municipal waste incinerators assume more prominence as a source.

Only 106 sources account for 85% of the total PCDD/DF deposition. This is a more manageable number than might have been supposed should a policy of virtual elimination of releases of persistent toxic substances, advocated in the Great Lakes Water Quality Agreement, and by the Commission, be adopted for such sources. The authors also note that it is now apparent that the major route of human exposure to PCDD/DF is food - beef and dairy products in particular. This finding is again matched by European studies, all of which suggest that atmospheric transport and deposition is a major pathway for dioxins entering the human food chain.

TABLE 2 Estimated Annual Atmospheric Emissions of PCDD/PCDF (TEQ)* from Sources in the United States and Canada (1993)

| Source Class | Midpoint Value of Emissions (g TEQ/yr) | Range of Emissions (low - high) (g TEQ/yr) | Percent of Total Midpoint Emissions |
|---|---|---|---|
| Medical Waste Incinerators ** | 4,300 | 1,700 - 14,000 | 53% |
| Municipal Waste Incinerators | 1,900 | 350 - 4,200 | 24% |
| Cement and Aggregate Kilns Burning Hazardous Waste | 400 | 130 - 1,300 | 4.9% |
| Secondary Copper Smelters | 360 | 110 - 1,100 | 4.5% |
| Wood Combustion | 260 | 80 - 820 | 3.2% |
| Iron Sintering Plants | 230 | 70 - 710 | 2.8% |
| Coal Combustion | 210 | 40 - 430 | 2.6% |
| Cement and Aggregate Kilns Not Burning Hazardous Waste | 170 | 50 - 530 | 2.1% |
| Heavy Duty Diesel Vehicles | 120 | 40 - 390 | 1.5% |
| Hazardous Waste Incinerators, (not including hazardous waste burned in cement/aggregate kilns or HCB waste incineration) | 80 | 20 - 250 | 1.0% |
| Sewage Sludge Incinerators | 30 | 2 - 70 | 0.3% |
| Secondary Copper Refiners | 6 | 2 - 20 | 0.08% |
| Incineration of Waste from Chemical Manufacturing Contaminated with HCB | 3 | 1 - 10 | 0.04% |
| Vehicles Using Leaded Gasoline | 2 | 0.2 - 20 | 0.03% |
| Vehicles Using Unleaded Gasoline | 1 | 0.4 - 4 | 0.02% |
| Total | 8,100 | 2,600 - 24,000 | 100% |

* The toxic potency of the PCDD/PCDF congeners is commonly expressed in terms of Toxicity Equivalency Factors (TEF), i.e. the toxic potency of a given congener relative to that of 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD). The overall toxicity of a mixture of PCDD and PCDF congeners can be expressed quantitatively by using their respective TEFs to compute the amount of 2,3,7,8-TCDD that is equivalent in its toxicity to that of the mixture. This quantity is expressed as amount of toxic equivalents (TEQ).

** The emissions estimates for medical waste incineration have been based, essentially, on the U.S. EPA's estimate of the amount of medical waste burned in the U.S. and their recommended emissions factors, which were based on their evaluation of emissions data (U.S. EPA 1994A). A slightly different emissions factor, representing a different emitted congener profile, which reduced emissions estimates by 17.6% relative to the U.S. EPA estimate was used. The American Hospital Association (AHA) has submitted comments to the U.S. EPA in response to the Draft Dioxin Exposure Assessment claiming that the emissions from medical waste incinerators are substantially less than these estimates for two main reasons: (a) they claim that less medical waste is being burned than estimated by the U.S. EPA; and (b) that the average emissions factor used by the U.S. EPA (which was based on the assumption of no pollution control) is too high as a significant portion of the waste incinerators now have pollution control equipment. Evaluation of the validity of the AHA's new estimates was not possible, since the primary data on which they are based were unavailable.

Reference: "Quantitative Estimation of the Entry...," 1995 (Commoner/Cohen)

## *Finding*

**While the precision and accuracy of the estimates of emission and deposition of dioxins and dibenzofurans is open to some question, the IAQAB finds that the Commoner/Cohen report is a valuable contribution to targeting significant sources of these contaminants to the Great Lakes basin, particularly large incinerators of municipal solid waste, and suggesting a pathway for this contaminant into the human food chain. However, further research is necessary including the collection of further data to reduce uncertainties in emission estimates and in the significance of potential impacts.**

# 3.0 OVERVIEW OF INCINERATION PRACTICES AND ASSOCIATED POLICIES

**"Principles. . .**

***"ii) Should jurisdictions elect to build new incineration facilities, these, at minimum, should be in full compliance with the USEPA and MOEE requirements. Further, jurisdictions and proponents should recognize that emission control technology is constantly improving and should commit to incorporate such improvements at several points in the life span of any given facility."***

## i ) Review of Current Practices in Municipal Waste Incineration

One of the IAQAB's first actions in responding to the Commission request for an overview on incineration of municipal waste was to engage the services of Mr. A. J. Chandler, an expert in the application of incineration technology to municipal solid waste management both in Europe and North America.

He reviewed the sources of persistent toxics in the feed to municipal incineration units, the nature and characteristics of individual combustion processes, and the various individual processes that collectively can form a pollution control system. This latter section dealt specifically with the treatment and removal of acid gases (HCl, $NO_x$), heavy metals (mercury, cadmium, lead) as well as the capture of dibenzo-dioxin/furan formed in the combustion process. The performance of specific Ontario incinerators was considered, as was the average performance of US facilities.

His report emphasised the following points.

- The modern municipal waste incinerator is significantly more efficient in controlling emissions than units operated ten to fifteen years ago. In the US, with increasing combusted volumes since the early 1980s, specific contaminant emissions were either stable or reduced by 20% to 50%. The new US standards should lower cumulative annual emissions by two thirds or more, with reductions in dioxins and dibenzo furans in the vicinity of 98%.
- The new Ontario guideline will apply to all new facilities, regardless of size; the US regulation excludes smaller units, as this population represents only 1% of the total municipal solid waste incinerated nationwide.

**"Principles. . .**

***"iii) Any further deployment of this technology by any jurisdiction should be done on the basis of a net reduction of emissions of persistent toxic substances, jurisdiction wide, from such facilities. Thus, existing units must be further controlled to new source performance standards or decommissioned by the year 2000. The USEPA regulations and those in some European jurisdictions contain this requirement, which should also be embraced by the Province of Ontario."***

- Ontario specifically excludes existing facilities, whereas the US EPA introduced new, albeit not as stringent, regulations for existing units for compliance by the year 2000.
- Existing units in Ontario will not meet the guideline values applicable for new sources for nitrogen oxides ($NO_x$) and mercury emissions.

"Technical Requirements. . .

*"ii) Emissions from the facility must be subject to continuous monitoring and manual sampling as provided for in the USEPA regulations. If necessary, further sampling to confirm the size distribution of particulate matter in the emission stream should be conducted."*

New regulations require extensive continuous monitoring of operations and testing of emissions.

A higher level of emission control in Ontario, beyond that in the current guideline, would result in tipping fees in the order of $100/Mg; other waste disposal alternatives are available at lower prices; only the largest facilities, with energy recovery, may be economically viable.

With the assistance of Commission staff, Mr. Chandler developed the following tables (Table 3 and Table 4), comparing European and North American jurisdictional standards for emissions of particulate, acid and other gases, as well as specific toxic substances.

## ii ) Status of Incineration in Europe

"Principles. . .

*"iii) Any further deployment of this technology by any jurisdiction should be done on the basis of a net reduction of emissions of persistent toxic substances, jurisdiction wide, from such facilities. Thus, existing units must be further controlled to new source performance standards or decommissioned by the year 2000. The USEPA regulations and those in some European jurisdictions contain this requirement, which should also be embraced by the Province of Ontario."*

Many industrialized countries, including several in Europe, have moved to reduce incinerator emissions. In 1994, the Dutch government, in response to a determination of high dioxin concentrations in milk originating from cows grazing near municipal solid waste incinerators, commissioned a study of significant sources of dioxin within their country. Emissions from each of the major source categories were determined; municipal solid waste, hazardous waste and hospital waste incinerators were among the sectors considered. Their findings roughly parallel those of Drs. Commoner and Cohen, regarding the relative significance of municipal waste incinerators as a source of dioxin emissions. The Dutch program was comparably more rigorous, in that emissions from all municipal solid waste incinerators (9 in total) in the Netherlands were determined by source testing in 1991 and 1992; these data were supplemented with additional measurements from other types of incinerators and, in some cases, by literature values.

The Netherlands total dioxin emissions to air from all sources was reported to be 484 g I-TEQ in 1991, down from an estimated 960 g I-TEQ emitted in 1989. (See Table 5) Approximately 80% of total air emissions were linked to municipal solid waste incineration and it was estimated that three times as many dioxins are removed via the residues (primarily ash) from these operations as via emission into the air. Hazardous waste incineration accounted for only 3.3% and hospital incineration emissions were found to be less than 1% of the total air emission.

While recognizing that levels from municipal incinerators were unacceptable, the Dutch government reaffirmed its commitment to municipal waste incineration with energy recovery and established a nationwide target for total PCDD/DF emissions from this sector of 3-4 grams I-TEQ/year by the year 2000. Major reductions through plant closures, further emission controls on existing plants and the commissioning of several new plants are planned.

TABLE 3 Municipal Solid Waste Incinerator Emissions Limits for Combustion Products and Acid Gases (Values Expressed as mg/Rm³ @ 11% $O_2$)[1.]

| Jurisdiction (Country/State/Province) | Hydrogen Chloride | Hydrogen Fluoride | Sulphur Dioxide | Oxides of Nitrogen | Particulate Matter | Carbon Monoxide | Hydrocarbons (as $CH_4$) |
|---|---|---|---|---|---|---|---|
| European Economic Community 1991 | 46 | 2 | 276 | | 28 | 92 | 18 |
| United Kingdom 1992 (new plants) | 46 | 2 | 276 | | 46 | 92 | 18 |
| Belgium 1991 | 46 | 2 | | 92 | 28 | 92 | 18 |
| Netherlands 1989 | 9 | 1 | 37 | 65 | 5 | 46 | 9 |
| Sweden 1986 | 80 | 1 | 190 | 320 | 17 | 80 | |
| Switzerland 1991 | 18 | 2 | 46 | 74 | 9 | 46 | 18 |
| Germany 1990 (mean 24 hour) | 9 | 1 | 46 | 184 | 9 | 46 | 9 |
| Germany 1990 (1/2 hour max.) | 55 | 4 | 183 | 366 | 55 | 92 | 36 |
| Denmark 1991 (mean 24 hour) | 60 | 2 | 276 | | 37 | 92 | 18 |
| U.S.A. NSPS 1995 New Facilities | 27 (95%)[2.] | | 55 (80%) | 197 (daily) | 17 | various [3.] | |
| Existing >35 tpd & <225 tpd | 261 (50%) | | 147 (50%) | exempt | 49 | | |
| >225 tpd | 33 (95%) | | 58 (75%) | 263-329 | 19 | | |
| Canada CCREM Guidelines 1988 | 75 (90%) | | | | 20 | 57/114 | |
| British Columbia 1991 | 70 | 3 | 250 | 350 | 20 | 55 | 40 |
| Burnaby British Columbia permit[4.] | 55 | | 200 | | 40 | | |
| Ontario Peel Permit 1991 | 50 (90%) | | | | 20 | 57 | 33 |
| Ontario Guideline A-7 1991 | 27 | | 55 | 207 | 17 | | |

1. Reference cubic metre of dry gas at 25°C and 101.3 kPa pressure. Wet standard levels are converted to dry assuming an average moisture level of 20%.
2. where percentage values are provided in brackets following the emission level, they refer to a minimum removal efficiency required by the jurisdiction. In most cases these conditions are enforced as the lesser of the two conditions, either 27 mg/m³ or 95% removal.
3. 'Various' refers to levels for different types of incineration facilities
4. Burnaby permit data taken from "Rationale for the Development of Guideline A-7"

Reference: "State-of-the-Art Assessment of Municipal Waste Incineration," 1996

As reported in Table 5, hazardous waste and hospital incinerators contribute only a small fraction of the total atmospheric dioxin burden. However, the Dutch use several different types of furnaces to incinerate industrial wastes, and hospital wastes are treated differently depending on whether they are classified as specific hospital waste (e.g. human remains) or as other hospital waste (e.g. non-contaminated waste). Specific hospital waste is treated as a special form of hazardous waste, while other hospital waste is frequently incinerated on-site as a batch operation with no additional flue gas cleaning; energy recovery is usually not done. Data on the occurrence of dioxins in bottom ash are not available, but amounts are thought to be small. It is assumed that all on-site hospital installations that are operating now will be closed by the year 2000.

Table 6 outlines the spectrum of dioxin emissions from individual incinerators in the Netherlands. Information was excerpted from a report by H.J. Bremmer, L.M. Troost, G. Kuipers, J. De Koning, and A.A. Sein entitled "Emissions of Dioxins in the Netherlands" published by the National Institute of Public Health and Environmental Protection and the Netherlands Organization for Applied Scientific Research in 1994.

TABLE 4 Municipal Solid Waste Incinerator Emissions Limits Trace Metals and Organics (Values Expressed as mg/Rm³ @ 11% $O_2$)

| Jurisdiction (Country/State/Province) | Trace Metals By Category | | | PCDD/PCDF ng I-TEQ/Rm³ ^ unless noted |
|---|---|---|---|---|
| | I | II | III | |
| European Economic Community 1991 | 0.20 | 1.0 | 5.0 | |
| France 1991 | 0.05* | 0.05* | 5.0 | |
| Netherlands 1989 | 0.10 | | 5.0 | 1.0 |
| Sweden 1986 | 0.08 | | | 0.1 Eadon** |
| Switzerland 1986 | 0.22 | 1.0 | 5.4 | |
| Germany 1990 | 0.05 Cd & Tl | 0.05 | 0.5 | 0.1** |
| Denmark 1991 | 0.20 | 1.0 | 5.0 | 0.82 Eadon** |
| U.S.A. 1995 Regulations | | | | |
| Existing Facilities: >35 and <225 tpd | 0.07 (Cd) | 1.12 (Pb) | 0.056 (Hg) | 88 (total) |
| Existing Facilities >225 tpd | 0.028 (Cd) | 0.34 (Pb) | 0.056 (Hg) | 21 total except ESP equipped 42 |
| New Facilities | 0.014 (Cd) | 0.14 (Pb) | 0.056 (Hg) | 9 (total) |
| Canada CCREM Guidelines 1988 | none | none | none | 0.5 |
| British Columbia 1991 | 0.2 Hg/ 0.1 Cd | 0.004 As/ 0.01 Cr | 0.05 Pb | 0.5 |
| Burnaby permit 1983 | 0.2 | 1.0 | 5.0 | |
| Ontario Peel Permit 1991 | point of° impingement | point of° impingement | point of° impingement | 0.5 |
| Ontario Guideline 1995 | 0.014 (Cd) | 0.14 (Pb) | 0.057 (Hg) | 0.14 |

NOTE:

Unless specifically noted the metals contained in the various classes are as outlined below:

Generally, Hg and Cd are in Class I. Sweden has Hg only and the old German and British Columbia standards include Tl in Class I.

Class II has As and Ni in the EC; the old German standard included Co, Cr, Ni, Se and Te with these elements whereas the new German standard combined Co, Cr, Ni, with V, Sn, Sb, Pb, Cu, and Mn that were in Class III to create a new combined Class III. The new German Class II contains only Hg.

Class III for the EC is Pb, Cr, Mn and Cu; in the Netherlands, Pb and Zn is as it is in Switzerland; Germany's list is included above; elsewhere the class contains Pb and Cr.

^ I-TEQ: The TEQ determined using the single International Scheme (Table 3.2) adopted at the 7th International Dioxin Symposium in Las Vegas (CCME, 1989).

* the French regulations adopted the EC Directive but tightened the cadmium and mercury emissions levels.

** these two PCDD/F standards are measured by different methods than used in North America. Some differences in the method make direct comparisons of emission values difficult. The German emission value is also reported on a wet basis with a much longer averaging time than used in North America and could actually be similar to a value on the order of 0.3 ng I-TEQ/Rm³ @ 11% oxygen.

° requirement based on concentration at point at which emitted gases 'impinge' on adjacent lands or structures (not direct source measurement)

Reference: "State-of-the-Art Assessment of Municipal Waste Incineration," 1996

TABLE 5 Estimated Dioxin Emissions Into the Air in 1992 and Expected Emissions in the Year 2000: The Netherlands

| Process category | Emission 1991[2.] [g I-TEQ $yr^{-1}$] | Emission 2000[1.,2.] [g I-TEQ $yr^{-1}$] |
|---|---|---|
| Municipal solid waste incineration | 382 | 2 - 4 |
| Incineration of hazardous wastes | 16 | 1.7 |
| Incineration of landfill, biogas and sludge | 0.3 | 1.5 |
| Cable and electromotor burning | 1.5 | 1.5 |
| Waste incineration at hospitals | 2.1 | 0 |
| Asphalt-mixing installations [3.] | 0.3 | 0.3 |
| Oil combustion | 1.0 | 1.0 |
| Coal combustion | 3.7 | 3.7 |
| Wood combustion [4.] | 12 | 9 |
| Crematoria | 0.2 | 0.2 |
| Fires | ? | ? |
| Various high-temperature processes | 2.7 | 2.7 |
| Traffic | 7.0 | 0.2 - 5 |
| Sintering processes | 26 | 3 |
| Metal industry | 4.0 | 4.0 |
| Chemical production processes [3.] | 0.5 | 0.5 |
| Use of wood preservatives | 25 | 20 |
| Total (fires excluded) | 484 | 58 (maximum) |

1. The emission estimate in the year 2000 (with the exception of MSW incinerators) does not account for the growth or a shift in certain categories.
2. Values lower than 10 are rounded off to first decimal place.
3. Emission as a result of heat generation is included in the energy generators concerned.
4. Much uncertainty as to the emission factors; additional research is recommended.

Reference: "Emissions of Dioxins in The Netherlands," 1994

TABLE 6 Estimated Dioxin Emission per Municipal Solid Waste Incinerator in 1991: The Netherlands

| Installation | Waste throughput [2] [k tonne yr$^{-1}$] | Dioxin emission (I-TEQ) | |
|---|---|---|---|
| | | [$\mu$g tonne$^{-1}$] [5] | [g yr$^{-1}$] |
| Alkmaar | 112 [6] | 7 [4] | 0.8 |
| Amsterdam-North | 521 [3] | 28 | 15 |
| The Hague | | 45 | 15 |
| AVR | 331 | 262 | 234 |
| ROTEB | 895 | 277 | 92 |
| Philips [1] | 331 | 43 | 1.2 |
| Roosendaal | 27 | 42 | 0.8 |
| GEVUDO | 19 | 81 | 12 [7] |
| AVIRA | 148 | 27 | 8.0 |
| ARN [1] | 296<br>75 | 40 | 3.0 |
| Total | 2760 | | 382 |

1. Incineration of RDF (Refuse Derived Fuel).
2. VVAV, 1992.
3. Information given by Amsterdam-North.
4. Kuipers, 1991.
5. 1990 Emission factors (Slob et al., 1992).
6. Incineration re-started in the course of 1991; waste throughput over 1990 is 112 ktonnes.
7. Including the dioxin emission from the sludge incineration furnace.

Reference: "Emissions of Dioxins in The Netherlands," 1994

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The German literature reviewed treated incineration as one of the continuing and viable options in the disposal of municipal refuse. Progress in technology available since 1970 to reduce emissions of seven contaminants of concern at waste incineration facilities, as listed in Table 7, is reviewed. The specific treatment and handling of distinct waste streams increasingly allows such materials to be recycled or made highly inert, resulting in additional environmental impacts of less than 1% of the existing background levels. A number of the most toxic materials can be reduced to 'negligible' levels. From the perspective of the authors, the real problem is no longer the lack of appropriate available technology, but rather "the courage to implement the right strategies of modern residue management in the light of honest and complete ecological balances." Immediate adoption of state-of-the-art control technology and procedures at incineration sites is strongly encouraged.

TABLE 7 Development of Emissions From Solid Municipal Waste Incineration Plants as a Function of Time: Germany

| | Dust mg m$^{-3}$ | Cadmium mg m$^{-3}$ | HCl mg m$^{-3}$ | $SO_2$ mg m$^{-3}$ | $NO_x$ mg m$^{-3}$ | Mercury mg m$^{-3}$ | Dioxins (TEQ) mg m$^{-3}$ |
|---|---|---|---|---|---|---|---|
| **1970** | 100 | 0.2 | 1000 | 500 | 300 | 0.5 | 40 |
| **1980** | 50 | 0.1 | 100 | 100 | 300 | 0.2 | 40 |
| **1990-95** | 1 | 0.005 | 5 | 20 | 100 | 0.01 | 0.1 |

Reference: "Low Pollutant Waste Incineration...," 1993

For Germany, information was excerpted from a paper by Professor H. Vogg and Dr. J. Vehlow entitled "Low Pollutant Waste Incineration: A Systems Approach to Emissions and Residues" published in Interdisciplinary Science Reviews in 1993.

An overview of the Swedish situation was provided by Dr. Maria Åhlander of the Department of Water and Environmental Studies at Linköping University. It appears that a number of taxes have been levied to control emissions of sulfur and carbon dioxide from coal, oil, and peat, but not for "biofuels." Refuse is considered to be a biofuel and is thus exempt from such taxes, although it may be subject to an oxides of nitrogen tax, depending on the quantity of $NO_x$ emitted from a given plant.

Responsibility for household and industrial waste disposal lies with each community. In order to be profitable, communities that rely on incineration typically purchase waste from nearby areas to provide an adequate waste fuel stream. Currently some waste is even imported from Germany which has more restrictive incinerator emission standards. Efforts to further recycle or to otherwise restrict the quantity of wastes available will likely force some incinerators to close. About 10% of Swedish hazardous wastes and approximately 40% of household wastes are incinerated in Sweden.

In 1985, in response to data on releases of significant quantities of dioxins and other persistent toxic substances from household waste incinerators, the Swedish government declared a moratorium on the construction of such facilities. Following extensive review and a commitment to a plan for a substantial reduction in such releases from existing units, the moratorium was lifted.

**"Principles**

***"i) Consideration or deployment of municipal incinerators should not, in any way, compromise programs for waste reduction and recycling, which must remain the cornerstone of waste management."***

The following are requirements set forth by the National Energy Administration and the National Swedish Environment Protection Board:

- The use of waste to produce energy should not conflict with other uses that are more important to society, for example the recycling of paper as a fibre raw material.
- It should be possible to use the energy efficiently in existing energy systems, and on a viable financial basis.
- The production/recovery of energy from waste must occur in such a way that society's goals in terms of limiting emissions can be achieved.

(Energy From Waste, 1986)

"Principles. . .

*"iii) Any further deployment of this technology by any jurisdiction should be done on the basis of a net reduction of emissions of persistent toxic substances, jurisdiction wide, from such facilities. Thus, existing units must be further controlled to new source performance standards or decommissioned by the year 2000. The USEPA regulations and those in some European jurisdictions contain this requirement, which should also be embraced by the Province of Ontario."*

All three of the jurisdictions surveyed in some detail (Holland, Germany and Sweden), notwithstanding the determination that existing municipal refuse incineration facilities have been sources of significant quantities of persistent toxic substances, particularly dioxin, have committed to continued use of this technology. All are planning improvements in control and operation of existing units and the construction of new, state-of-the-art facilities to substantially reduce total emissions throughout their jurisdictions. Energy recovery and the minimalization of land dedicated to waste disposal are cornerstones of their strategy. Technical experts remain confident that emissions of persistent toxic substances from these units can be reduced to background levels, while recognizing that elevated concentrations in associated residuals will then pose a significant concern. (Personal Communication - Erhardt Mogensen, Vølund Ecology Systems A|S; February 12, 1996)

## Findings

**The IAQAB notes that the United States and several European countries have focused on improving pollution control performance or discontinuing use of existing incineration units by the year 2000. Similarly, several domains have a jurisdiction-wide plan in place for this source category, with numerical goals for the reduction of the release of specific pollutants from this source sector within a specific time frame. Maintenance of an emission inventory of reasonable quality is inferred or stated in these plans.**

**To date, Ontario has not forwarded any strategy to reduce emissions from their existing municipal incineration facilities through application of newer technology.**

"Technical Requirements. . .

*"iv) The toxic content of residual ash and particulate should be determined at regular intervals to ensure associated disposal strategies are appropriate for the conditions encountered."*

*"v) Source, ash residual and localized ambient air quality data should be collected and incorporated into an ongoing performance review program, with provision for effective public oversight."*

**Management of residuals from incineration units with stringent emission controls is or will be the focus of enhanced attention, as the amount of persistent toxic substances increases in these residuals.**

"Preamble. . .

The IAQAB notes that there is an inherent conflict between the maximization of waste recycling, particularly of combustible fibre such as newsprint and cardboard, and sustainable, stable operation of an incinerator, as removal of such materials from the refuse significantly reduces its properties as a fuel."

"Principles

*"i) Consideration or deployment of municipal incinerators should not, in any way, compromise programs for waste reduction and recycling, which must remain the cornerstone of waste management."*

**Jurisdictions, particularly Sweden, have recognized the complexity introduced by a municipal waste management strategy that includes both recycling and incineration. The impact of removal of paper fibre from the waste streams, with subsequent reduction in fuel value and associated energy from waste opportunities, was noted. In the case of Sweden, a preference for recycling activities in such situations is clearly stated.**

## 4.0 IAQAB INTERPRETATION OF VIRTUAL ELIMINATION IN THE CONTEXT OF INCINERATION

"Principles. . .

"iii) ***Any further deployment of this technology by any jurisdiction should be done on the basis of a net reduction of emissions of persistent toxic substances, jurisdiction wide, from such facilities. Thus, existing units must be further controlled to new source performance standards or decommissioned by the year 2000. The USEPA regulations and those in some European jurisdictions contain this requirement, which should also be embraced by the Province of Ontario.***

"iv) ***The total amount of persistent toxic substances released by incineration facilities in a jurisdiction, defined as the sum of those to the atmosphere and in the residuals, must also be decreased whenever a new incineration facility is permitted."***

### i) Previous Commission Comments on Incineration

The Commission has noted over the last several years that further reduction in the amount of persistent toxic substances produced or transported and deposited in the Basin via the air pathway is crucial to the safeguarding and remediation of the Great Lakes. Additional quantities of dioxin and other compounds from sources such as municipal incinerators could be viewed as representing an excessive burden to the Basin. Any consideration of additional such facilities should be rooted in the Great Lakes Water Quality Agreement and acknowledge its commitment to the virtual elimination of persistent toxic substances, as well as being mindful of the Commission's recommendations on the subject of incineration.

In its "Seventh Biennial Report on Great Lakes Water Quality," the Commission, in a section entitled 'Burning the Evidence' stated:

> "The Commission has increasingly received expressions of public concern about the number of large incinerators and their impacts on public and environmental health. While many specific sources lie outside the basin, they are in a real sense within the Great Lakes ecosystem. . .contributing significantly to the load of contaminants, especially from the low-temperature incineration of industrial, commercial and household refuse containing plastics and solvents, coated papers and many other products."

The Commission expressed strong concern about this issue in its 1993 Report on Air Quality in the Detroit-Windsor/Port Huron-Sarnia Region. The Commission's recommendations in that report included the phase-out of incineration facilities, or a requirement to eliminate the production and emission of a variety of persistent toxic and other substances, and establishment of uniform requirements for incinerators in the Great Lakes region based on the principle of zero discharge. They noted that "any strategy towards virtual elimination and zero discharge of persistent toxic substances must address the significant inputs from incineration... The Commission urges the stringent regulation of existing facilities throughout North America, taking into account the need to ensure the zero discharge of persistent toxic substances from those stacks to the Great Lakes."

## ii) The Commission's Consideration of a Virtual Elimination Approach

In defining a path to the virtual elimination goal, the Commission's Virtual Elimination Task Force report "Strategy for Virtual Elimination of Persistent Toxic Substances" (1993) makes the following comments about the concept [emphasis as in original text]:

- virtual elimination is an overall **strategy** that requires preventative and remedial approaches to control or eliminate different inputs
- the virtual elimination strategy must **apply to all point and non-point sources** in all media
- the virtual elimination strategy must apply to **new** potentially persistent toxic substances (PTS) that may be created, as well as **existing** such substances
- virtual elimination must apply to persistent toxic substances already present in the Great Lakes Basin Ecosystem...the qualifier "virtual" is appropriate as applied to **eliminating the presence** of persistent toxic substances from the ecosystem

As a fundamental principle, any strategy must **anticipate and prevent** the deliberate input of any additional quantities of persistent toxic substances to the ecosystem. Given the technological capability to measure lower and lower concentrations of contaminants in the ecosystem, virtual elimination programs may never reach absolute zero. Rather the strategy is a challenge to **continuously strive to reduce the amount entering the environment, through, if necessary, remediation, treatment and control** en route to fulfilling the Agreement's virtual elimination obligation.

Because some of these substances already are present in the ecosystem, and because life in the Great Lakes Basin Ecosystem is vulnerable to contamination from those imported into the region, implementation of the virtual elimination strategy requires application of a policy of zero discharge to prevent further releases from all sources of persistent toxic substances. For new substances that meet the definition of a persistent toxic substance, the application of the zero discharge concept is straightforward: no synthesis or production and no release. The IJC recognized that **minuscule quantities** of persistent toxic substances already in the environment **may escape** capture or interception before entering the Great Lakes, **even with the application of prevention, treatment or control measures**.

The virtual elimination strategy adopts eight additional principles, as follows:

- the **precautionary principle** - where information is incomplete but there is a threat of serious, cumulative and/or irreversible damage, measures to prevent degradation to the environment should not be postponed
- consideration of the **complete life cycle** of the persistent toxic substances
- **all sources and pathways** are to be considered
- application to releases to **all media** (air, water, land)
- applies **globally**
- apply an approach based on the **reverse onus principle;** the discharger of the persistent toxic substances bears an active responsibility to protect the ecosystem
- involve **all stakeholders,** including business, industry, people and wildlife that co-habit the region, while assuming the maintenance of a robust economy
- apply the **principle of risk management** to evaluate proposed options

## iii) The IAQAB Application of the Virtual Elimination Strategy

In considering the Commission's deliberation on this goal, the IAQAB recognizes that the strategy of virtual elimination:

- must be applied to the management of municipal solid waste
- must be applied to incinerators
- must recognize that persistent toxic substances can be both created in an incinerator as well as destroyed or captured by an incinerator
- must present practical approaches for moving toward the goal of virtual elimination through an ongoing reduction in the amount entering the environment
- must demand the continual adaption of the best prevention, treatment or control measures available at any point in time

In developing a policy statement on incineration of municipal waste, the IAQAB adopted and applied these virtual elimination principles and associated components throughout their policy statement. What follows is a brief outline of specific instances of application of the virtual elimination principles, with reference to specific subsections of the Policy Statement, which are referred to in parentheses. The Policy Statement itself should be consulted for specific language and detail.

- **endorsement of the Principle of Virtual Elimination** of persistent toxic substances to the Great Lakes (preamble)
- recognition of the need to manage municipal solid waste towards this end (preamble)
- as incineration is one of several technologies available to manage municipal solid waste, in the selection of any option a **complete life-cycle analyses** should be performed to ensure that the total impact on the ecosystem is considered (preamble)
- in viewing this technology in a **global** context, new incineration facilities must, at a minimum, be in full compliance with the USEPA, Environment Canada and state/provincial requirements. Also, as incineration process and control technology improve on a global basis, identified enhancements to further reduce the release of persistent toxic substances should be continually incorporated during the life of all incineration facilities, new and existing. Such incorporation should be done on a '**reverse onus**' basis, that is, on the operator's initiative. (Principle ii)
- any application of incineration technology must result in a demonstrated net reduction of the release to all pathways of persistent toxic substances on a jurisdictional basis (Principle iii and Principle iv)
- within the incineration process, application of the principle of **'all sources and pathways'** including consideration of all releases from the process via emissions, effluent and solid residual material. Extensive ambient air and deposition monitoring in the vicinity of the plant and at the ash disposal location and continuous monitoring of the emissions and analysis of the residual ash further support the principle of '**all sources and pathways.**(Principle v and Technical Requirement i)
- The participation of the public in all aspects of the facility, including the review of data on the release of persistent toxic substances via whatever pathway, supports the virtual elimination principle of involvement of '**all stakeholders**' (Principle vi)
- As a further application of the principles of '**reverse onus**' and '**complete life cycle,**' the IAQAB added an operational principle regarding '**good management practice**' (Technical Requirement vi). The principle of '**complete life cycle**,' as applied to the facility, also led the IAQAB to identify a need for adequate funds to support monitoring, maintenance, updating process and control equipment, independent auditing, and sound decommissioning of both the site and the ash disposal facility.

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