

Interim Evaluation of Health Risks Associated with  
Emissions of Tetrachlorinated Dioxins  
From Municipal Waste Resource Recovery Facilities

November 1981

Background

Concern has been raised within the United States regarding the possible emission of trace amounts of highly toxic organic pollutants as a consequence of the large scale combustion of municipal wastes for recovery of energy. Such resource recovery facilities are also referred to as municipal waste combustors. The concern first came to a focus at the Hempstead Resource Recovery Corporation (HRRC) facility in Hempstead, Long Island, where in 1979 the owners and operators of the plant permitted EPA to sample its emissions. Subsequent analyses indicated that tetrachlorodibenzo-p-dioxins (TCDDs), including 2,3,7,8-TCDD, were present. However, due to the nature of the sampling method and the operating conditions of the plant at the time, only a qualitative statement could be made on the presence of these materials. Based on these findings the Agency concluded that more rigorous testing would be required in order to quantitate the results.

By the time this qualitative information was becoming available, the Exposure Evaluation Division (EED) of the Office of Pesticides and Toxic Substances (OPTS) had already initiated

a pilot study of emissions from two other municipal waste combustors in the United States. In addition, the Office of Solid Waste (OSW) had begun a series of similar studies to determine whether or not potential problems existed at other municipal waste combustors. The analytical results from five plants are now available.

Even before the above data became available to the Agency, a considerable amount of information had been accumulated by scientists working on similar and related facilities outside the United States. In 1979 a report appeared on the analysis of a number of micro-pollutants, including TCDDs, in fly ash from five municipal incinerators in The Netherlands, Canada, and Japan (Eiceman, et al, 1979). This was followed in the next year by an investigation of fly ash and stack emissions from four municipal incinerators in Italy (Cavallaro, et al, 1980) and by an extensive review (Lustenhower, et al, 1980) on the amounts of micro-pollutants found in the fly ash of various municipal incinerators in Europe. Amplification of this information was provided in testimony presented during EPA's cancellation hearings on the herbicide 2,4,5-T (Hutzinger, 1980). Each of these investigators reported TCDDs in the emissions and fly ash of municipal incinerators.

The Agency's review of the foreign data did not suggest the existence of any problem that called for precipitous action due to the emission of TCDDs associated with the combustion of municipal

wastes. The Agency continued its program of systematic testing at municipal waste combustors in order to assess the domestic situation more completely.

Now that the EPA-generated emissions data from American municipal waste combustors are available, it is appropriate to publish an interim assessment of the toxic effects which could conceivably be associated with TCDDs emissions from municipal waste combustors in this country.

### Overview

The human health implications associated with the emission of TCDDs from five municipal waste combustors have been assessed. The evaluation was based on the information available on the estimated levels of the exposure that people living near municipal waste combustors are likely to experience, and on estimates of health hazards associated with TCDDs. The Hempstead, Long Island plant is not one of the five analyzed as the EPA data for this plant are not sufficient to support a quantitative evaluation.

Exposure information on TCDDs was obtained by field sampling of stack emissions from the five municipal waste combustors, followed by complex chemical analyses for TCDDs. To obtain an estimate of the amount of TCDDs that were emitted into the atmosphere, it was necessary to collect and analyze both the flue-gas and the particulate materials as TCDDs have a tendency to firmly adhere to small particles (Lustenhouwer, et al, 1980).

Computer modeling was used to derive approximate exposure levels experienced by the population as a result of the dilution and dispersion that takes place as the flue-gas and particulate material make their way to ground-level after stack emission.

Estimates of the risk to human health from these TCDDs emissions were obtained by extrapolating from animal data on the basis of an important assumption. The levels of exposure are far below those causing acute (short term, high dose) effects in animals. Therefore, this assessment focuses on chronic (long term, low dose) effects with an emphasis on the two most sensitive toxic effects seen in animals: reproduction and carcinogenicity.

The fundamental assumption that was made was that if TCDDs are a human carcinogen, or if they pose a health hazard due to adverse reproductive effects in humans, then these effects will be manifested at the same relative dose levels as observed in the reported animal studies, taking the relative body surface of animals and humans into account. The inclusion of this assumption is essential in the interpretation of the significance that animal data may have with regard to any human experience. The exposure data and the health hazard information on TCDDs were then combined in a number of mathematical models to estimate the risk associated with human exposure to TCDDs emitted from municipal waste combustors.

Toxicity Data.

Although there are a total of 22 tetrachlorodibenzo-p-dioxin (TCDD) isomers, the 2,3,7,8-TCDD isomer has been subjected to the most extensive testing. While a variety of studies point to a range of effects produced by this material, the appearance of adverse reproductive and carcinogenic effects at very low doses in chronic feeding studies in animals has generated special interest and concern.

The effects of a combination of isomers is difficult to assess, but a conservative assumption is that all of the isomers are as toxic as 2,3,7,8-TCDD. There are biochemical reasons, supported by some experimental data (Poland, et al, 1979), to suggest that the mechanism of toxic action of 2,3,7,8-TCDD is associated with the chlorine atoms on the lateral ring positions (positions 2, 3, 7, and 8). In fact, there is no evidence to indicate that any of the isomers are more toxic than 2,3,7,8-TCDD.

Data on the other chlorinated dioxins were insufficient to be included in this interim assessment.

A. Reproductive effects of 2,3,7,8-TCDD

2,3,7,8-TCDD has been investigated and shown to have reproductive effects in numerous animal studies. In one of the most recent studies, a three-generation study in rats (Murray, et al, 1979), adverse reproductive effects appeared inconsistently in the different generations at the lowest dose tested (0.001 ug TCDD /kg /day),

although this may be at or very close to the "no-observed-effect level" (NOEL). Human epidemiological studies in this area are limited in number and statistical power; those that have been conducted do not demonstrate clear exposure-related effects.

B. Carcinogenicity of 2,3,7,8-TCDD

Bioassays have demonstrated that 2,3,7,8-TCDD is an animal carcinogen in rats and mice (Kociba, et al, 1978; National Cancer Institute, 1980), under the test conditions imposed. The information with respect to human exposure is less conclusive. Epidemiological studies of cohorts of workers engaged in chlorophenol production and use, and their exposure to TCDDs in this country (Zack and Suskind, 1980; Cook, et al, 1980), suggest that any overall carcinogenic effect on humans is small. A significant excess of stomach cancer, however, has been reported in a similar cohort of German workers (Theiss, et al, 1981). In addition, a recent series of reports (Hardell and Sandstrom, 1979; Eriksson, et al, 1981; Honchar and Halperin, 1981; Cook, 1981) indicate that soft tissue sarcomas (a form of cancer) may be associated with long term exposure to phenoxy herbicides which contain 2,3,7,8-TCDD. The human information available from the Seveso, Italy explosion in 1976 has not indicated that the local populations have developed any excess of cancer. However,

it may be too early to evaluate the long term effects from this exposure (Reggiani, 1980) in view of the short period of time that has elapsed since the Seveso incident and the generally longer latency period for cancer development. More definitive work to address this question has been initiated by the National Institute of Occupational Safety and Health (NIOSH) and the National Cancer Institute (NCI).

#### Exposure Data

There are<sup>a</sup> about 40 municipal waste combustors in the country. A large number of additional units are under consideration for construction, some of them involving very different technologies. Consequently, the recently obtained emission data from the stacks of five municipal waste combustors cannot be said to characterize totally the industry today nor what the industry is likely to become (see Tables 1 and 2). However, the data can give some indication of current conditions and what might be expected in the future as data collection proceeds. In order to analyze these data more completely, information is needed on the interaction between the various factors that may affect the output of dioxins from municipal waste combustors. Included among these are the nature of the combustible materials, temperature, flow rate, process, stack heights, local topography, and/or combustion chamber design.

In the present estimates, the relation between the emission data and the maximum concentration to which people in the surrounding area are likely to be exposed has been obtained through a theoretical air dispersion model, PTMAX (EPA, 1977). This computer program calculates the location and magnitude of the maximum short term (1 hour) concentration in the area around the stack. Data from the five sampled sites provided the input. Basically, the results show the ground concentration to be a slowly varying function of stack height, temperature, diameter, and exit velocity. To obtain annual maximum average ground level concentrations, reasonable, if rough, estimates were made on the assumption that the maximum annual average concentration is 1/40 of the maximum hourly concentration (see Table 3) (Tikvart, 1981). While there is no guarantee that the results of future studies (some are already in progress and will continue through FY 82) will fall within these ranges, the current data can be used to suggest the range of variations that is expected to be encountered.

#### Toxicity and Exposure Assumptions

Emission data can be used with other data to estimate potential human exposure to TCDDs from municipal waste combustion sources. However, many unanswered questions relating to TCDDs' toxicity and exposure remain. Since there are insufficient data to answer these important questions and because this information is needed to assess the risk to people breathing emissions from



the stack, the Agency has adopted a series of assumptions which are designed to represent the "worst case" possible. Some of these questions and related assumptions are presented below:

1. What are the toxicological properties of the different TCDD isomers? (There are considerable experimental data on the properties of 2,3,7,8-TCDD, but relatively little on the other 21 isomers. The evidence that does exist, however, suggests that they may be less toxic than 2,3,7,8-TCDD.)

In the absence of data the assumption is:

The carcinogenic properties and reproductive effects of all TCDDs are the same as that of 2,3,7,8-TCDD.

2. Given the concentration and composition of TCDDs measured in emissions from a stack, what are the resulting air concentrations and compositions at ground level to which people would be exposed? In the absence of data the assumption is:

The PTMAX air dispersion model (EPA 1977) and the factor used to convert to the annual concentration, adequately represent the transport of the emissions to ground level. The composition of emission products found at ground level is identical to the composition (but not the concentration) in the stack.

3. How does the ground level concentration vary relative to the position from the stack? In the absence of data the assumption is:

All of the exposed population is subjected to the maximum average annual concentration found at the point of concentration.

4. How do the TCDD concentrations in the air behave when they are breathed by humans? (The TCDDs in the stack gases are generally associated with particulate matter from which they are difficult to remove in the laboratory). In accord with available data (ICRP, 1968) the assumption is:

Seventy-five percent of the inhaled particles are retained in the body.

In the absence of data the assumption is:

All the TCDDs that are retained in the respiratory tract are biologically available to the organism.

5. How often and for how long will people be subject to a given level of exposure? (The lifetime of municipal waste combustors is approximately 30 to 40 years.)

Even given this approximation, the following is assumed:

The population is exposed to this maximum average annual concentration from the source for 24 hours a day throughout a 70 year lifetime.

6. What is the relative sensitivity of man versus the animals used in these studies?

In the absence of data the assumption is:

Man is of comparable sensitivity to animals for reproductive and carcinogenic effects, taking body surface areas into account.

#### Health Risk Estimates

The health risk estimates were calculated using a variety of mathematical models - linearized multi-stage (Crump, 1981); probit, logit, Weibull and gamma multi-hit (Food Safety Council, 1980) - which were applied to the rat carcinogenicity data (Kociba, 1978) and the TCDDs exposure data associated with the emissions from municipal waste combustors. The results from the models were consistent in estimating low risks.

Potential reproductive effects were assessed by comparing the calculated levels of exposure from TCDDs to the lowest level tested in animals (Murray, et al, 1979). The anticipated levels of TCDDs to which humans may be exposed are far below the level used in the animal study.

#### Summary

An evaluation of the public health considerations related to TCDDs emissions has been made by applying the various mathematical models to the data from the five US sites under the many combinations of assumptions that must be made in analyzing

the data. These estimates suggest that the present emissions levels of TCDDs from the five municipal waste combustors described in this report do not present a public health hazard for residents living in the immediate vicinity. In addition, the health risk estimates presented in the assessment indicate that as long as emission levels of TCDDs do not greatly exceed the emissions measured at the five US sites evaluated in this interim assessment, there should be no reason for concern. This conclusion is valid for all toxicological effects (including reproductive and cancer) for which the available animal and human data have been analyzed.

This is an interim report and EPA intends to periodically monitor representative resource recovery facilities such as these for emissions of TCDDs. EPA will take steps to regulate TCDDs emissions if it appears necessary. However, at the present time, this need has not been demonstrated.

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TABLE 1

RANGE OF STACK CONCENTRATIONS

<u>Pollutant(s)</u>	Range (ng/dscm <sup>a</sup> )
2,3,7,8-TCDD	ND <sup>b</sup> - 3.5 <sup>c</sup>
TCDDs <sup>d</sup>	ND - 3.5

a - ng = 10<sup>-9</sup> grams; dscm = dry standard cubic meter

b - "ND" not detected at a detection limit of 0.25 ng/dscm.

c - The analytical method used could not distinguish 2,3,7,8-TCDD from several of the other TCDD isomers. It is recognized that some molecular forms may be co-eluting with the 2,3,7,8 isomer; therefore this value could be an overestimate of the amount of 2,3,7,8-TCDD actually present.

d - "TCDDs" includes any and all of the tetrachlorodibenzo-p-dioxin isomers present.

TABLE 2

RANGE OF STACK PARAMETERS  
REPRESENTED BY THE FIVE COMBUSTORS TESTED

<u>Parameter</u>	<u>Range</u>
Stack Height (meters)	10 - 76
Stack Temperature (Centigrade)	139 - 232
Flue gas flow-rate (dscm/sec <sup>a</sup> )	3.7 - 83.3

a - dscm = dry standard cubic meter; sec = second.

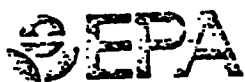


TABLE 3

RANGE OF ANNUAL MAXIMUM AVERAGE GROUND LEVEL CONCENTRATIONS  
OF DIOXIN ISOMERS  
ESTIMATED FOR FIVE US SOURCES SAMPLED TO DATE  
USING PTMAX COMPUTER AIR DISPERSION MODEL<sup>a</sup>

<u>Pollutant (s)</u>	<u>Range (ng/m<sup>3</sup>)<sup>b</sup></u>
2,3,7,8-TCDD <sup>c</sup>	up to $3.8 \times 10^{-5}$
TCDDs	up to $9.2 \times 10^{-5}$

- a - Although sampling was conducted at only one stack at each site, the results have been adjusted to reflect the estimated contributions from all boilers present at each site.
- b - The lower level of estimated concentration is an indeterminate small number based on the non-detectable amounts of the pollutant found in the stack emissions.
- c - The analytical method could not distinguish 2,3,7,8-TCDD from a number of co-eluting isomers. Therefore, this could be an overestimate of the 2,3,7,8-TCDD actually present.



# Environmental News

FOR RELEASE: THURSDAY, NOVEMBER 19, 1981

INTERIM EPA EVALUATION FINDS NO  
DIOXIN HAZARD AT RESOURCE  
RECOVERY FACILITIES

Handy (202) 755-0344

U.S. Environmental Protection Agency Deputy Administrator John W. Hernandez, Jr. today said that an interim evaluation of resource recovery facilities at five locations indicates that tetrachlorinated dioxin emissions from the combustion of municipal wastes are "far below the level of a credible health risk."

The interim evaluation was made from data collected on municipal resource recovery facilities in Arkansas, Illinois, Iowa, Florida, and Ohio. EPA said there are about 40 resource recovery combustors in the United States and that a number of additional units are being planned, some of them involving very different technologies. The interim data do not totally represent the industry, although the data do give some indication of current conditions, and what might be expected in the future.

"The approach used in EPA's analysis," Dr. Hernandez said, "is extremely conservative, in that the assumptions err on the side of public health protection. The conclusions reached concerning public health risks are

(more)

likely to be applicable to similar facilities when those facilities are properly designed, constructed and operated."

Hernandez cautioned that EPA has not developed anything that should be interpreted as an emissions standard for tetrachlorinated dioxins, nor should the levels measured at the five facilities be interpreted as an upper boundary in terms of setting emissions limitations.

"Setting such a standard would involve a long and complex rulemaking process which, given the results of our interim analysis, is not deemed to be necessary," Hernandez said. "The agency intends to periodically monitor representative resource recovery facilities," he added, "and if we find that the emissions are significantly greater than those evaluated in this assessment, we will consider the need for regulatory action."

Concern first arose at the Hempstead Resource Recovery Corporation facility in Hempstead, N.Y. In 1979 the operators of the plant permitted EPA to begin sampling emissions. However, in an unrelated action, the village of Hempstead, late in 1979, ordered the facility closed because of odor problems. It has not been reopened. The Hempstead facility is not included in the interim evaluation because EPA had not collected sufficient data before the facility was closed.

(more)

There are a total of 22 different forms (isomers) of tetrachlorinated dioxins; only the tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) isomer has been subjected to extensive testing. EPA said there is no scientific evidence that any of the isomers are more toxic than 2,3,7,8-TCDD. Therefore, for the purposes of the interim evaluation, EPA said it made the conservative assumption that all the isomers are as toxic as 2,3,7,8-TCDD.

Since there are insufficient data to completely answer questions relating to TCDD's toxicity and exposure, and because this information is needed to assess the risk to people breathing emissions from the stack, EPA said it conducted its analysis by adopting a series of assumptions designed to represent the "worst case" possible.

The specific isomer, 2,3,7,8-TCDD has been shown to have effects on the reproductive systems of various animal species. Bioassays have demonstrated that 2,3,7,8-TCDD is an animal carcinogen in rats and mice. Existing epidemiological studies do not demonstrate clear exposure-related reproductive effects in humans. Other epidemiological studies suggest an association between exposure to 2,3,7,8-TCDD and certain types of human cancer. Further studies are underway to address this question. In its assessment EPA assumes that all of the tetrachlorinated dioxins found in the emissions were carcinogenic.

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(For further information on technical aspects of the evaluation, contact Dr. Don Barnes, senior science advisor, Office of Pesticides and Toxic Substances, tel. (202)382-2897.)