UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30365

JAN 13 1984

4AW-RM

Mr. Robert W. McVety
Administrator
Solid and Hazardous Waste Section
Florida Department of Environmental
Regulation
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32301 - 8241

Dear Mr. McVety:

Enclosed is a copy of a memo and attachments from Michael Cook, the Agency's Dioxin Management Coordinator, on emission evaluations from a municipal waste combustion facility. Potential exposure levels of 2, 3, 7, 8 TCDD from this incinerator were approximately six times greater than any previously reported. However, the Agency has tentatively concluded that even these levels do not represent a significant health concern. A copy of the 1981 interim evaluation on five other incinerators is also enclosed. Both of these documents are in the draft stage, but may be shared with the public.

Sincerely,

James H. Scarbrough
Chief
Residuals Management Branch

Enclosures

16 DEC 1983

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: TCDD Emissions for Municipal Waste Combustors

FROM: Michael B. Cook
Dioxin Management Coordinator

TO: Addressees

We have recently completed an assessment of tetrachlorodibenzo-p-dioxin (TCDD) emissions from another municipal waste combustion (MWC) facility sampled early this year. This is the sixth MWC plant sampled by the Agency in its continuing program to evaluate the health risks associated with emissions of TCDD from combustion facilities.

EPA assessed TCDD emissions from the first five MWC facilities sampled in a report dated November, 1981, entitled "Interim Evaluation of Health Risks Associated with Emissions of Tetrachlorinated Dioxins from Municipal Waste Resource Recovery Facilities". The report concluded that ". . . the levels of TCDD's from the five municipal waste combustors . . . do not present a public health hazard for residents living in the immediate vicinity."

The emissions of TCDD from the sixth plant were higher than had previously been found. We have nonetheless concluded (p. 11) that ". . . in light of: . . . conservative assumptions . . . steps being taken . . ., the Agency does not believe that this most recently sampled MWC represents a significant health concern . . ."

I have attached a copy of the November 1981 interim evaluation and the recent assessment for your use. These assessments may be shared with interested members of the public.

Attachments

Addressees:

Regional Dioxin Coordinators
Regional Solid Waste Branch Chiefs
Regional Division Directors
Office of Pesticides and Toxic Substances
State of Virginia

ASSESSMENT OF EMISSIONS FROM A RECENT MUNICIPAL WASTE COMBUSTOR

Background

In the late 1970's concern was raised in the United States regarding the possible emission of trace amounts of highly toxic organic pollutants as a consequence of large scale combustion. Following suggestive findings in this country, which essentially confirmed reports from overseas where emissions testing had first identified the presence of chlorinated dibenzo-p-dioxins (CDDs), particular attention was directed to municipal waste combustors (MWCs).

In response, the Environmental Protection Agency (EPA) conducted a program which performed sampling and analysis at five separate MWCs. The focus of these studies was the emission of tetrachlorodibenzo-p-dioxins (TCDDs), with an emphasis on the specific isomer, 2,3,7,8tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). This latter compound is known to be quite toxic, even at very low doses, as demonstrated in animal studies. Documented evidence of its presence in emissions evoked special concerns.

In November, 1981, the Agency published a report entitled "Interim Evaluation of Health Risks Associated with Emissions of Tetrachlorinated Dioxins From Municipal Waste Resource Recovery Facilities". (EPA, 1981). The report presented upper limit estimates of what the health risks might be to

people living in the vicinity of the MWCs and concluded:

> "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."

In the past few months, data have been generated by the Agency on the emission of TCDDs (and other pollutants) from a sixth MWC. These data and the supporting contractor report on the sampling and analysis are currently undergoing the normal review procedure within the Agency.

The existence of these data and their qualitative indication of the presence of TCDDs in the emissions from this MWC, however, have raised public concerns. Therefore, in order to give some perspective to these findings, the Agency is issuing this assessment employing the same procedures used

in the November, 1981 document. These procedures incorporate a series of conservative assumptions which the Agency believes tend to overestimate the risks due to TCDD emissions. If this "worst case" assessment projects risks which are so low as to not present a health concern to people living in the vicinity, then there is additional assurance that the actual risk from the TCDD emissions should not form a health concern to nearby residents.

In sum, the purpose of this document is to project the results from a sixth MWC on the scale generated by the results from the five MWCs which were assessed in 1981, thereby providing a basis for interpreting the significance of the new data and the efforts already underway to modify conditions at the plant.

Note that the present document is being issued before the final report on the sampling and analysis that underlie this effort have been thoroughly reviewed. Consequently, the conclusions of this assessment are subject to changes that might be necessitated by changes in the final report.

Overview

This document presents an assessment of the health implications associated with the emission of TCDDs from a recently sampled MWC. The assessment is based on stack emission data which were used to estimate the level of exposure that people living near this facility might encounter, and

on estimates of the health hazards that might be associated with these emissions.

Exposure information on the TCDDs was obtained by field sampling of stack emissions, followed by chemical analysis using gas chromatography and mass spectrometry (GC/MS). The actual amount of TCDDs from the stacks that would reach people living in the areas surrounding the plant was expected to be so small that it would not be detectable by available analytical techniques. Therefore, the Agency used a mathematical air dispersion model to estimate the ground level concentration levels of TCDDs to which people were likely to be exposed.

Estimates of the risk to human health from these TCDDs emission were obtained by extrapolating from animal data on the carcinogenic and reproductive effects of 2,3,7,8-TCDD. While the toxicity information on the other isomers of TCDD is limited, there is reason to believe that none of the other isomers are as toxic as 2,3,7,8-TCDD.

Hazard Assessment

The reader is referred to other sources which discuss the toxic properties of TCDDs in detail (Huff, 1980). The present document makes use of the same hazard assessment as was used in the November, 1981 document.

Dose-Response Assessment

The reader is referred to other sources for a discussion

of the dose-response assessment that the Agency associates with 2,3,7,8-TCDD (EPA, 1980), based on a lifetime feeding study in rats (Kociba, et al, 1978). The present document makes use of the same dose-response assessment as was used in the November, 1981 document.

Exposure Assessment

Table I contains information on the MWC facility and the TCDD emissions detected there.

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. The necessary input data are contained in Table I. In order to obtain a maximum annual average ground level concentration, a reasonable assumption was made that the maximum annual average concentration is 1/40 of the maximum hourly concentration (Tikvart, 1981). These results are found in Table II.

Toxicity and Exposure Assumptions

Ideally, there would be sufficient information compiled during the Hazard, Dose-Response, and Exposure Assessments to directly combine the data in a Risk Characterization step

(National Research Council, 1983). However, many unanswered questions relating to the toxicity of and exposure to these TCDD emissions remain. Since there are insufficient data to answer these questions definitively, and because some type of answers is needed in order to characterize the risk to people breathing the emissions, the Agency has adopted a series of assumptions which are designed to represent "reasonable worst cases". These are the same assumptions used in the November, 1981 document. Some of these unanswered questions and related assumptions are presented below:

Question 1

What are the toxicological properties of the 21 TCDD isomers, other than 2,3,7,8-TCDD?

Assumption 1

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

Question 2

How can the toxicological effects in humans be assessed in the absence of data in humans?

Assumption 2

The Agency has established methods (EPA, 1978) to address this question which include the following:

a. Use of the no-threshold assumption for carcinogenicity.

b. Use of the most sensitive, valid animal study.

c. Use of the linearized multi-stage model to generate an estimate of the upper limit of the excess cancer risk at low doses. The actual risk could be nearly any number between this upper limit and some lower number (possibly zero).

d. Conversion of animal dose to human equivalent dose by use of relative body surface area.

Question 3

Given the concentration and composition of TCDDs measured in emissions from the stack, what are the resulting air concentrations and compositions at ground level to which people would be exposed?

Assumption 3

The computerized PTMAX air dispersion model and the factor used to convert to the annual concentration is assumed to adequately represent the transport of the emissions to ground level. In lieu of a definitive analysis of atmospheric conditions, the result from the worst of six atmospheric classes modeled by the computer is

assumed to be applicable. The composition of emission products found at ground level is taken to be identical to the composition (but not the concentration) in the stack.

Question 4

How do the TCDD contaminants 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).

Assumption 4

Seventy-five percent of the inhaled particulates are assumed to be retained in the body (ICRP, 1968). Further, 100% of the TCDDs (gaseous or particulate-bound) are treated as being biologically available to exhibit a toxic response.

Question 5

How often, for how long, and at what level will people be exposed?

Assumption 5

People are assumed to be exposed continuously to the maximum annual average ground level concentration 24 hours/day, under the worst atmospheric conditions, for a 70 year lifetime.

Health Risk Characteration

Within the limitations of the assumptions discussed in the previous section, Table III contains the results of the health risk characterizations for the upper limit of excess cancer and for reproductive effects resulting from lifetime exposure to the maximum annual average concentration of TCDDs which are likely to be generated at the MWC. The details of these calculations are contained in the Appendix.

The cancer risk is characterized by an "estimated upper limit of excess cancer risk", which is expressed as a probability. For example, the upper limit of excess cancer risk for the MWC, based on maximum total TCDDs, is 4.6×10^{-6}. This figure can be interpreted as the upper limit of the excess cancer risk (probability) for an individual living at the point of maximum annual average concentration of TCDDs (resulting from emissions from the MWC) for 24 hrs/day, under the worst atmospheric conditions, for a 70 year lifetime. Alternatively expressed, this is a upper limit of risk of 46 in a 1,000,000 or 1 in 22,000. That is, based upon the assumptions above, the excess risk of contracting cancer is likely to be something less than 1 in 20,000. Again, this is not a prediction of the risk but simply a statement that the risk is not likely to exceed this level.

For comparison, the highest upper limit of excess cancer risk reported in the November, 1981 document for total TCDDs was 8×10^{-6}.

The reproductive effects risk is characterized in this assessment by a "confidence ratio", which is the ratio of the lowest level tested in animals divided by the anticipated exposure level in humans. Note that if this lowest dose tested is seen as a "no effect level" (this point is currently the subject of some scientific dispute), then the confidence ratio would become the more familiar "margin of safety".

For comparison, the lowest confidence ratio reported in the November, 1981 document was total TCDDs was 30,000.

Conclusion

The information in Tables I and II indicates that compared to the situations at the five MWCs evaluated in 1981, the most recently sampled MWC, when sampled, was emitting greater amounts of TCDDs, resulting in higher ground level exposures at the point of maximum impact (approximately .6 km from the stack under the worst atmospheric conditions). Table III shows that, under the conditions prevailing at the time of the test, the emissions represented a risk approximately 6-fold greater than that seen at any of the MWCs included in the 1981 survey.

A preliminary inquiry into the design and operation of this MWC has revealed a number of conditions that could be contributing to the increased level of emissions. Discussions are already underway with responsible parties in the public and private sectors to determine appropriate corrective measure that will likely lead to reduction into the emissions of TCDDs. In light of:

a. the conservative assumptions made in this current assessment,

b. the steps being taken to ameliorate the situation, and

c. the relatively short time span anticipated before these corrective measures are in place, the Agency does not believe that this most recently sampled MWC represents a significant health concern to people living in its vicinity.

The Agency will continue to work with all parties concerned to see to it that the planned changes in the facility and its operations are carried out expeditiously and that a subsequent re-sampling and analysis of the emissions is conducted effectively and efficiently.

TABLE I

PLANT PARAMETERS AND EMISSION RATES FOUND AT
A MUNICIPAL WASTE COMBUSTOR IN 1983

Parameters	
Stack height	27.4 meters
Stack diameter	1.22 meters
Stack temperature	271 ^{o}C
Flue gas flow rate(a)	12 m^3/sec
Flue gas velocity	11.4 m/sec
Ambient temperature	4 ^{o}C
Average Emission Rate	
Total TCDDs	2.9×10^{-6} gram/sec

(2,3,7,8-TCDD constitutes 21% of the total)

(a) --- total from both stacks averaged over four tests

TABLE II

MAXIMUM ANNUAL AVERAGE GROUND LEVEL CONCENTRATION OF TCDDs CALCULATED[1] AT A MUNICIPAL WASTE COMBUSTOR (MWC) IN 1983.

Facility	Pollutant	Concentration
MWC	Total TCDDs	5.1×10^{-4} nanograms/m^3

1 --- These values were generated through the air dispersion model PTMAX (EPA, 1977) with a correction factor of 1/40 to convert to maximum annual average. [Acknowledgement of the assistance by OPTS (Kinerson) and OANR (McGinnity)].

HEALTH RISK CHARACTERIZATION[1] AT A MUNICIPAL WASTE COMBUSTOR IN 1983, BASED ON TOTAL TCDDs IN STACK EMISSIONS.

FACILITY	UPPER LIMIT OF EXCESS CANCER RISK[2]	CONFIDENCE RATIO FOR REPRODUCTIVE EFFECTS[3],
Municipal Waste Combustor	4.6×10^{-5}(a)	9,100(b)

1 --- These results cannot be effectively interpreted independent of the underlying conservative assumption upon which they are based. (See text for further details)

a. All of the 22 possible TCDD isomers are assumed to have carcinogenic and reproductive effects properties equal to those of 2,3,7,8-TCDD.

b. The established procedures for extrapolating from high dose to low dose and from animals to man are assumed to be appropriate.

c. The air dispersion model (with worst atmospheric assumptions) is assumed to be an effective method for extrapolating from concentrations in the stack emissions to concentrations to which people will be exposed.

d. The majority of inhaled particulate matter is assumed to be retained in the body and all of the particulate bound TCDD is assumed to be bioavailable.

e. Exposure to the annual maximum average ground level concentration is assumed to occur continously for 70 years.

2 --- Using linearized multi-stage extrapolation model (EPA, 1978).

3 --- Confidence Ratio = $\frac{\text{Lowest dose tested}}{\text{Estimated human dose}} = \frac{1 \text{ ng/kg-d}}{\text{Estimated human dose}}$

a --- For comparison, the highest value from the five previously tested MWCs was 8×10^{-6}.

b --- For comparison, the lowest value from the five previously tested MWCs was 30,000.

APPENDIX

DETAILS OF CALCULATIONS
(using MWC maximum data as an example)

The PTMAX model was run using the input parameters in Table I. For general purposes, however, the emission rate entered into the model was 1 g/s. This permitted easy scaling to whatever specific emission rate might be of interest, since the model is linear in mass emission rate.

Specifically, for the MWC:

a. PTMAX showed that with 1 g/s the maximum hourly concentration of 7×10^{-6} g/m^3 was obtained for atmospheric stability class I (or A); that is, "unstable".

b. Applying the correction factor to estimate the annual maximum average concentration, we obtain

$$7 \times 10^{-6} \text{ g/m}^3 \; / \; 40 = 1.75 \times 10^{-7} \text{ g/m}^3$$

c. Table I indicates that a total of 2.9×10^{-6} g/s was the observed emission rate at the MWC. Applying the factor from b, we obtain as annual maximum average concentration:

$$(2.9 \times 10^{-6} \text{ g/s}) \left(1.75 \times 10^{-7} \frac{\text{g/m}^3}{\text{g/s}}\right) = 5.1 \times 10^{-13} \text{ g/m}^3 = 5.1 \times 10^{-4} \text{ ng/m}^3$$

(See Table II)

The estimated upper limit of excess risk of cancer was obtained using the unit risk factor developed by the Agency's Cancer Assessment Group (CAG) for 2,3,7,8-TCDD (EPA, 1981).

d. Upper limit of excess cancer risk = (unit risk factor) (conc.)

$= [.091\ (ng/m^3)^{-1}]\ [5.1 \times 10^{-4}\ ng/m^3]$

$= 4.6 \times 10^{-5}$ (See Table III)

The confidence ratio makes use of the data from the three-generation reproduction study in the rat conducted by Murray (Murray, 1979) and compares the lowest dose in that study (1 ng/kg-d) to the estimated human dose derived from breathing the dispersed emissions.

f. Estimated human dose =

(Conc) x (Breathing rate) x (75% retention) / (Body mass)

$= (5.1 \times 10^{-4}\ ng/m^3)\ (20\ m^3/d)\ (.75) / (70\ kg)$

$= 1.1 \times 10^{-4}$ ng/kg-d

g. Therefore, using results from f,

Confidence Ratio =

(Lowest dose in animals) / (Estimate human dose)

$= (1\ ng/kg-d) / (1.1 \times 10^{-4}\ ng/kg-d)$

= 9,100 (See Table III)

References

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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 (Lustenhouwer, 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 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.

TABLE 1

RANGE OF STACK CONCENTRATIONS

Pollutant(s)	Range (ng/dscm[a])
2,3,7,8-TCDD	ND[b] - 3.5[c]
TCDDs[d]	ND - 8.5

a - ng = 10^{-9} 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

Parameter	Range
Stack Height (meters)	10 - 76
Stack Temperature (Centigrade)	139 - 232
Flue gas flow-rate (dscm/sec[a])	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[a]

Pollutant (s)	Range (ng/m^3)[b]
2,3,7,8-TCDD[c]	up to 3.8×10^{-5}
TCDDs	up to 9.2×10^{-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 indeterminately 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.

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