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Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Carbon Tetrachloride

PREFACE

This document is one of a series of preliminary assessments dealing with chemicals of potential concern in municipal sewage sludge. The purpose of these documents is to: (a) summarize the available data for the constituents of potential concern, (b) identify the key environmental pathways for each constituent related to a reuse and disposal option (based on hazard indices), and (c) evaluate the conditions under which such a pollutant may pose a hazard. Each document provides a scientific basis for making an initial determination of whether a pollutant, at levels currently observed in sludges, poses a likely hazard to human health or the environment when sludge is disposed of by any of several methods. These methods include landspreading on food chain or nonfood chain crops, distribution and marketing programs, landfilling, incineration and ocean disposal.

These documents are intended to serve as a rapid screening tool to narrow an initial list of pollutants to those of concern. If a significant hazard is indicated by this preliminary analysis, a more detailed assessment will be undertaken to better quantify the risk from this chemical and to derive criteria if warranted. If a hazard is shown to be unlikely, no further assessment will be conducted at this time; however, a reassessment will be conducted after initial regulations are finalized. In no case, however, will criteria be derived solely on the basis of information presented in this document.

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SECTION 1

INTRODUCTION

This preliminary data profile is one of a series of profiles dealing with chemical pollutants potentially of concern in municipal sewage sludges. Carbon tetrachloride (CCl_4) was initially identified as being of potential concern when sludge is incinerated.* This profile is a compilation of information that may be useful in determining whether CCl_4 poses an actual hazard to human health or the environment when sludge is disposed of by this method.

The focus of this document is the calculation of "preliminary hazard indices" for selected potential exposure pathways, as shown in Section 3. Each index illustrates the hazard that could result from movement of a pollutant by a given pathway to cause a given effect (e.g., sludge → air → human toxicity). The values and assumptions employed in these calculations tend to represent a reasonable "worst case"; analysis of error or uncertainty has been conducted to a limited degree. The resulting value in most cases is indexed to unity; i.e., values >1 may indicate a potential hazard, depending upon the assumptions of the calculation.

The data used for index calculation have been selected or estimated based on information presented in the "preliminary data profile", Section 4. Information in the profile is based on a compilation of the recent literature. An attempt has been made to fill out the profile outline to the greatest extent possible. However, since this is a preliminary analysis, the literature has not been exhaustively perused.

The "preliminary conclusions" drawn from each index in Section 3 are summarized in Section 2. The preliminary hazard indices will be used as a screening tool to determine which pollutants and pathways may pose a hazard. Where a potential hazard is indicated by interpretation of these indices, further analysis will include a more detailed examination of potential risks as well as an examination of site-specific factors. These more rigorous evaluations may change the preliminary conclusions presented in Section 2, which are based on a reasonable "worst case" analysis.

The preliminary hazard indices for selected exposure routes pertinent to incineration are included in this profile. The calculation formulae for these indices are shown in the Appendix. The indices are rounded to two significant figures.

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* Listings were determined by a series of expert workshops convened during March-May, 1984 by the Office of Water Regulations and Standards (OWRS) to discuss landspreading, landfilling, incineration, and ocean disposal, respectively, of municipal sewage sludge.

SECTION 2

PRELIMINARY CONCLUSIONS FOR CARBON TETRACHLORIDE IN MUNICIPAL SEWAGE SLUDGE

The following preliminary conclusions have been derived from the calculation of "preliminary hazard indices", which represent conservative or "worst case" analyses of hazard. The indices and their basis and interpretation are explained in Section 3. Their calculation formulae are shown in the Appendix.

I. LANDSPREADING AND DISTRIBUTION-AND-MARKETING

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.

II. LANDFILLING

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.

III. INCINERATION

The incineration of municipal sewage sludge is not expected to increase the concentration of CCl_4 in air to any appreciable degree above background urban levels (see Index 1). Also, sludge incineration is generally not expected to pose an increased cancer risk due to the inhalation of CCl_4. There may be a slight increase when sludge containing high concentrations of CCl_4 is incinerated at high rates with worst-case levels of stack emissions (see Index 2).

IV. OCEAN DISPOSAL

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.

SECTION 3

PRELIMINARY HAZARD INDICES FOR CARBON TETRACHLORIDE IN MUNICIPAL SEWAGE SLUDGE

I. LANDSPREADING AND DISTRIBUTION-AND-MARKETING

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.

II. LANDFILLING

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.

III. INCINERATION

A. Index of Air Concentration Increment Resulting from Incinerator Emissions (Index 1)

1. **Explanation** - Shows the degree of elevation of the pollutant concentration in the air due to the incineration of sludge. An input sludge with thermal properties defined by the energy parameter (EP) was analyzed using the BURN model (Camp Dresser and McKee, Inc. (CDM), 1984). This model uses the thermodynamic and mass balance relationships appropriate for multiple hearth incinerators to relate the input sludge characteristics to the stack gas parameters. Dilution and dispersion of these stack gas releases were described by the U.S. EPA's Industrial Source Complex Long-Term (ISCLT) dispersion model from which normalized annual ground level concentrations were predicted (U.S. EPA, 1979). The predicted pollutant concentration can then be compared to a ground level concentration used to assess risk.

2. **Assumptions/Limitations** - The fluidized bed incinerator was not chosen due to a paucity of available data. Gradual plume rise, stack tip downwash, and building wake effects are appropriate for describing plume behavior. Maximum hourly impact values can be translated into annual average values.

3. **Data Used and Rationale**

   a. **Coefficient to correct for mass and time units (C) =** 2.78×10^{-7} hr/sec x g/mg

b. **Sludge feed rate (DS)**

i. **Typical** = 2660 kg/hr (dry solids input)

A feed rate of 2660 kg/hr DW represents an average dewatered sludge feed rate into the furnace. This feed rate would serve a community of approximately 400,000 people. This rate was incorporated into the U.S. EPA-ISCLT model based on the following input data:

EP = 360 lb H_2O/mm BTU
Combustion zone temperature - 1400°F
Solids content - 28%
Stack height - 20 m
Exit gas velocity - 20 m/s
Exit gas temperature - 356.9°K (183°F)
Stack diameter - 0.60 m

ii. **Worst** = 10,000 kg/hr (dry solids input)

A feed rate of 10,000 kg/hr DW represents a higher feed rate and would serve a major U.S. city. This rate was incorporated into the U.S. EPA-ISCLT model based on the following input data:

EP = 392 lb H_2O/mm BTU
Combustion zone temperature - 1400°F
Solids content - 26.6%
Stack height - 10 m
Exit gas velocity - 10 m/s
Exit gas temperature - 313.8°K (105°F)
Stack diameter - 0.80 m

c. **Sludge concentration of pollutant (SC)**

Typical	0.048 mg/kg DW
Worst	8.006 mg/kg DW

The typical and worst sludge concentrations are the geometric mean and 95th percentile values derived from sludge concentration data from a survey of 40 publicly-owned treatment works (POTWs) (U.S. EPA, 1982). (See Section 4, p. 4-1.)

d. **Fraction of pollutant emitted through stack (FM)**

Typical	0.05 (unitless)
Worst	0.20 (unitless)

These values were chosen as best approximations of the fraction of pollutant emitted through stacks (Farrell, 1984). No data was available to validate these values; however, U.S. EPA is currently testing incinerators for organic emissions.

e. **Dispersion parameter for estimating maximum annual ground level concentration (DP)**

Typical 3.4 μg/m^3
Worst 16.0 μg/m^3

The dispersion parameter is derived from the U.S. EPA-ISCLT short-stack model.

f. **Background concentration of pollutant in urban air (BA) = 1.4 μg/m^3**

The urban background concentration value was derived by averaging the mean urban concentrations over seven U.S. cities (U.S. EPA, 1984). These values were used because they represent a variety of locations across the continental United States.

The urban concentration range stated by the U.S. EPA (1984) is 0.75 to 8.8 μg/m^3. The high value of 8.8 μg/m^3 was reported for Tokyo, Japan in 1974 to 1975. Since this value is not for a U.S. city and appears to be an isolated elevated case, it was not considered when selecting the BA. The BA value of 1.4 μg/m^3 is therefore considered a conservative best estimate.

Values stated in Section 4, p. 4-3 are in mg/m^3 and were converted to μg/m^3 for this index.

4. **Index 1 Values**

Fraction of Pollutant Emitted Through Stack	Sludge Concentration	Sludge Feed Rate (kg/hr DW)[a]		
		0	2660	10,000
Typical	Typical	1.0	1.0	1.0
	Worst	1.0	1.0	1.0
Worst	Typical	1.0	1.0	1.0
	Worst	1.0	1.0	1.0

[a] The typical (3.4 μg/m^3) and worst (16.0 μg/m^3) dispersion parameters will always correspond, respectively, to the typical (2660 kg/hr DW) and worst (10,000 kg/hr DW) sludge feed rates.

5. **Value Interpretation** - Value equals factor by which expected air concentration exceeds background levels due to incinerator emissions.

6. **Preliminary Conclusion** - The incineration of municipal sewage sludge is not expected to increase the concentration of CCl_4 in air to any appreciable degree above background urban levels.

B. Index of Human Cancer Risk Resulting from Inhalation of Incinerator Emissions (Index 2)

1. **Explanation** - Shows the increase in human intake expected to result from the incineration of sludge. Ground level concentrations for carcinogens typically were developed based upon assessments published by the U.S. EPA Carcinogen Assessment Group (CAG). These ambient concentrations reflect a dose level which, for a lifetime exposure, increases the risk of cancer by 10^{-6}.

2. **Assumptions/Limitations** - The exposed population is assumed to reside within the impacted area for 24 hours/day. A respiratory volume of 20 m^3/day is assumed over a 70-year lifetime.

3. **Data Used and Rationale**

   a. **Index of air concentration increment resulting from incinerator emissions (Index 1)**

   See Section 3, p. 3-3.

   b. **Background concentration of pollutant in urban air (BA) = 1.4 $\mu g/m^3$**

   See Section 3, p. 3-3.

   c. **Cancer potency = 5.2×10^{-2} $(mg/kg/day)^{-1}$**

   This value was calculated from the oral cancer potency of 1.3×10^{-1} $(\mu g/kg/day)^{-1}$ times the assumed inhalation absorption efficiency of 40 percent (U.S. EPA, 1984). (See Section 4, pp. 4-4 to 4-6.)

   d. **Exposure criterion (EC) = 6.7307×10^{-2} $\mu g/m^3$**

   A lifetime exposure level which would result in a 10^{-6} cancer risk was selected as ground level concentration against which incinerator emissions are compared. The risk estimates developed by CAG are defined as the lifetime incremental cancer risk in a hypothetical population exposed continuously throughout their lifetime to the stated concentration of the carcinogenic agent. The exposure criterion is calculated using the following formula:

$$EC = \frac{10^{-6} \times 10^{3}\ \mu g/mg \times 70\ kg}{\text{Cancer potency} \times 20\ m^3/day}$$

4. **Index 2 Values**

Fraction of Pollutant Emitted Through Stack	Sludge Concentration	Sludge Feed Rate (kg/hr DW)[a] 0	2660	10,000
Typical	Typical	21	21	21
	Worst	21	21	21
Worst	Typical	21	21	21
	Worst	21	21	22

[a] The typical (3.4 $\mu g/m^3$) and worst (16.0 $\mu g/m^3$) dispersion parameters will always correspond, respectively, to the typical (2660 kg/hr DW) and worst (10,000 kg/hr DW) sludge feed rates.

5. **Value Interpretation** - Value > 1 indicates a potential increase in cancer risk of > 10^{-6} (1 per 1,000,000). Comparison with the null index value at 0 kg/hr DW indicates the degree to which any hazard is due to sludge incineration, as opposed to background urban air concentration.

6. **Preliminary Conclusion** - Municipal sewage sludge incineration is generally not expected to pose an increased cancer risk due to the inhalation of CCl_4. There may be a slight increase when sludge containing high concentrations of CCl_4 is incinerated at high rates with worst-case levels of stack emissions.

IV. OCEAN DISPOSAL

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.

SECTION 4

PRELIMINARY DATA PROFILE FOR CARBON TETRACHLORIDE IN MUNICIPAL SEWAGE SLUDGE

I. Occurrence

CCl_4 is a haloalkane with a wide range of industrial applications. In 1980, 3.22 x 10^8 kg of CCl_4 were synthesized in the United States. Production and use of CCl_4 has been declining and is expected to continue to decline. CCl_4 is also used as a pesticide, primarily as a grain and soil fumigant.

A. Sludge

1. Frequency of Detection

Detected in 16 of 436 samples (4%) from 40 POTWs studied	U.S. EPA, 1982 (p. 42)
Detected in 1 of 41 samples (2%) from 10 POTWs studied	U.S. EPA, 1982 (p. 50)
Detected in 1 of 13 (8%) combined undigested sewage sludges	Naylor and Loehr, 1982 (p. 19)

2. Concentration

Data from 40 POTWs: — Statistically derived from U.S. EPA, 1982

Median	Not detected
Geom. Mean	0.048 μg/g DW
95th percentile	8.006 μg/g DW
Range (DW)	Not detected to 9.698 μg/g DW
Range (WW)	Not detected to 3030 μg/L WW

33 μg/L for 1 sample from 10 POTWs studied	U.S. EPA, 1982 (p. 50)
270 μg/L (WW), 4.2 μg/g (DW) from 1 sample	Naylor and Loehr, 1982 (p. 19)

B. Soil - Unpolluted

1. Frequency of Detection

Little research has been done to detect CCl_4 in soil	U.S. EPA, 1984 (p. 3-7)

2. Concentration

Data not immediately available.

C. Water - Unpolluted

1. Frequency of Detection

10% of samples from 113 drinking water systems had CCl_4 in range of 0.0024 to 0.0064 mg/L	U.S. EPA, 1984 (p. 4-3)

2. Concentration

a. Freshwater

µg/L (ppb) or lower range for rain and surface water	U.S. EPA, 1984 (p. 4-4)

b. Seawater

60 $\pm$ 17 ng/L (ppt) detected in Atlantic Ocean	U.S. EPA, 1984 (p. 4-4)

c. Drinking water

<0.003 mg/L in drinking water from 80 cities 0.0024 to 0.0064 mg/L range in 10% of samples from 113 public drinking water systems 0.005 mg/L in Washington, D.C. drinking water	U.S. EPA, 1984 (pp. 4-3 and 4-4)

D. Air

1. Frequency of Detection

CCl_4 has been measured extensively in the atmosphere	U.S. EPA, 1980 (p. 9)

2. Concentration

a. Urban

0.00075 to 0.0088 mg/m^3 urban range	U.S. EPA, 1984 (p. 4-7)

CCl_4 over 7 U.S. Cities (1979-80 data) U.S. EPA, 1984 (p. 4-8)

City	CCL_4 (mg/m^3) Mean	Maximum	Minimum
Los Angeles	0.0014	0.0064	0.0006
Phoenix	0.0018	0.0055	0.0008
Oakland	0.0011	0.0063	0.0006
Houston	0.0026	0.0188	0.0008
St. Louis	0.0008	0.0009	0.0007
Denver	0.0011	0.0018	0.0007
Riverside	0.0011	0.0017	0.0010

b. **Rural**

0.00070 to 0.00084 mg/m^3 in continental and marine air masses — U.S. EPA, 1984 (p. 4-7)

E. Food

1. **Total Average Intake (market basket technique)**

0.21 to 7.33 mg/yr range, 1.12 mg/yr mean uptake of CCL_4 from food — U.S. EPA, 1984 (p. 4-22)

Relative Uptake of CCl_4 by Adult Male — U.S. EPA, 1984 (p. 4-24)

Source	Typical (mg/yr)	(%)	Minimum (mg/yr)	(%)	Maximum (mg/yr)	(%)
Fluids	3.13	34	0.73	16	8.65	1
Atmosphere	4.75	51	3.60	79	618	98
Food Supply	1.42	15	0.21	5	7.63	1
Total	9.30		4.54		634.28	

2. **Concentration**

Up to 115 μg/g and 21 μg/g CCl_4 in wheat and flour from CCl_4 fumigated grain. 0.005 to 2.61 μg/g range, 0.051 μg/g mean, CCl_4 in flour from 11 U.S. cities. — U.S. EPA, 1984 (p. 4-10, 4-11)

Summary of CCl_4 in British Food Supplies — U.S. EPA, 1984 (p. 4-9)

Food Group	CCl_4 (ng/g) Minimum	Maximum
Milk Products	0.2	14.0
Meats	7.0	9.0
Fats & Oils	0.7	18.0
Vegetables & Fruits	3.0	8.0
Fish & Seafood	0.1	6.0

50 ng/g (NAS) maximum concentration permitted in cooked cereals — U.S. EPA, 1984 (p. 13-3)

The ubiquitous occurrence of CCl_4 in air could result in contamination of food items and thus be the actual source of observed CCl_4 residues in food. — U.S. EPA, 1980 (p. 10)

II. HUMAN EFFECTS

A. Ingestion

1. Carcinogenicity

a. Qualitative Assessment

Numerous animal experiments show a carcinogenic response although there is no firm epidemiological data showing carcinogenic effects in humans due to oral ingestion. CAG classifies weight of evidence as 2B using IARC system, or "probably carcinogenic in humans." — U.S. EPA, 1984 (p. 2-8)

b. Potency

Hamsters, mice, and rats given CCl_4 orally in doses ranging from 9 to 1500 mg/kg/day displayed carcinogenic effects. Cancer potency for oral application in above animals = 1.3×10^{-1} $(mg/kg/day)^{-1}$ — U.S. EPA, 1984 (p. A-4 and A-11)

c. **Effects**

Liver tumors	U.S. EPA, 1984 (p. 11-37)

2. **Chronic Toxicity**

Data not presented because cancer potency will be used to assess hazard.

3. **Absorption Factor**

At least 80% in rats	U.S. EPA, 1984 (p. 7-3)

4. **Existing Regulations**

No data exist on formal regulations, but the following recommendations are given:

a. **Drinking water limit**

Suggested no-adverse-response level (SNARL):	U.S. EPA, 1984 (p. 13-1)

1-day SNARL	0.2 mg/L
10-day SNARL	0.02 mg/L/day

b. **Food**

50 ng/g maximum concentration in cooked cereals	U.S. EPA, 1984 (p. 13-3)

B. **Inhalation**

1. **Carcinogenicity**

a. **Qualitative Assessment**

International Agency for Research on Cancer (IARC) rating: Group 2B--there is "sufficient" evidence for carcinogenicity in animals, "inadequate" evidence for carcinogenicity in humans, an overall evaluation that CCl_4 is "probably carcinogenic to humans"	U.S. EPA, 1984 (p. 11-37)

b. **Potency**

The cancer potency for inhalation of CCl_4 in humans is 5.2×10^{-2} $(mg/kg/day)^{-1}$, which was calculated from the oral cancer potency	Derived from U.S. EPA, 1984 (p. A-24)

of 1.3 x 10^{-1} (μg/kg/day)$^{-1}$ times the assumed inhalation absorption efficiency of 40%.

c. **Effects**

There are no definitive studies documenting the carcinogenic effects of CCl_4 inhalation by humans. However there are reports of cases of liver tumors appearing following exposure to CCl_4	U.S. EPA, 1984 (p. 11-37)

2. **Chronic Toxicity**

Data not presented because cancer potency will be used to assess hazard.

3. **Absorption factor**

40%	U.S. EPA, 1984 (p. A-24)

4. **Existing Regulations**

American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values: Time weighted average (TWA) 30 mg/m^3 Short-term exposure limit 125 mg/m^3	U.S. EPA, 1984 (p. 13-2)
Occupational Safety and Health Administration (OSHA) standard 65 mg/m^3 (8-hour TWA) Acceptable ceiling exposure concentration, 162.5 mg/m^3	U.S. EPA, 1984 (p. 13-2)
National Institute of Occupational Safety and Health (NIOSH, 1975) recommended exposure limit 12.6 mg/m^3 (10-hour TWA)	U.S. EPA, 1984 (p. 13-2)
Recommended concentration not be >12.6 mg/m^3 of breathing zone air in a 45 L air sample taken over $\leq$1 hour period	U.S. EPA, 1984 (p. 13-3)

III. **PLANT EFFECTS**

A. **Phytotoxicity**

Data not immediately available.

B. Uptake

The potential uptake of CCl_4 from soil is unknown. This includes agricultural runoff as well as uptake from plants. — U.S. EPA, 1984 (p. 4-21)

IV. DOMESTIC ANIMAL AND WILDLIFE EFFECTS

A. Toxicity

See Table 4-1.

Hepatotoxicity is the major effect reported to be produced by acute exposure to CCl_4 — U.S. EPA, 1984 (p. 8-1)

B. Uptake

CCl_4 metabolites in tissues of rabbits after single oral administration of 1 mL/kg of body weight (5 rabbits/group) — U.S. EPA, 1984 (p. 7-15)

Sample Time	Tissue	$CHCl_3$ (μg/g tissue)	Cl_3CCCl_3 (μg/g tissue)
6 hr	Fat	4.7±0.5	4.1±1.2
	Liver	4.9±1.5	1.6±0.5
	Kidney	1.4±0.6	0.7±0.2
	Muscle	0.1±0.1	0.3±0.2
24 hr	Fat	1.0±0.2	16.5±1.6
	Liver	1.0±0.4	4.2±1.8
	Kidney	0.4±0.2	2.2±1.1
	Muscle	0.1±0.1	0.5±0.2
48 hr	Fat	0.4±0.1	6.8±2.4
	Liver	0.8±0.2	1.0±0.3
	Kidney	0.2±0	trace
	Muscle	0.1±0.1	trace

V. AQUATIC LIFE EFFECTS

Data not immediately available.

VI. SOIL BIOTA EFFECTS

Data not immediately available.

VII. PHYSICOCHEMICAL DATA FOR ESTIMATING FATE AND TRANSPORT

Chemical formula: CCl_4 Molecular weight: 153.82 Water solubility: 0.785 g/L at 20°C Vapor pressure: 115.2 mm Hg at 25°C Air/water partition coefficient: 1.1 by volume, 1,000 by weight at 20°C Density: 1.94 g/mL at 4°C Melting point: -22.9°C Boiling point: 76.54°C Log octanol/water partition coefficient: 2.64	U.S. EPA, 1984 (p. 3-2)
70,000 year half-life in water Decomposition rate accelerated in presence of iron and zinc	U.S. EPA, 1984 (p. 3-1)
CCl_4 is extremely stable in water with losses due to factors such as evaporation, sediment adsorption, and organism uptake	U.S. EPA, 1984 (p. 5-1)
Although CCl_4 is not easily transported to groundwater due to its high volatility, low solubility and low mobility in soil, any contamination is likely to persist for several years and accumulate	U.S. EPA, 1984 (p. 5-1)
CCl_4 is quite volatile, and does not readily accumulate in either terrestrial or aquatic environments and is rapidly diluted to low concentrations in the troposphere	U.S. EPA, 1984 (p. 5-1)
Information concerning the degradation of CCl_4 in soil could not be located in available literature	U.S. EPA, 1984 (p. 5-6)

TABLE 4-1. TOXICITY OF CARBON TETRACHLORIDE TO DOMESTIC ANIMALS AND WILDLIFE

Species (N)[a]	Chemical Form Fed	Feed Concentration (µg/g)	Water Concentration (mg/L)	Daily Intake (mg/kg)	Duration of Study	Effects	References
Rat	CCl_4	NR	NR	2,800	NR	LD_{50}	U.S. EPA, 1984 (p. 8-2)
Mouse	CCl_4	NR	NR	12,800	NR	LD_{50}	
Dog	CCl_4	NR	NR	1,000	NR	LD_{10}	
Rabbit	CCl_4	NR	NR	6,380	NR	LD_{50}	
Rat	CCl_4 in gavage			800	1 dose	Increase liver and plasma enzyme activity, increased liver weight	U.S. EPA, 1984 (p. 8-6)
Rat	CCl_4 in feed	200	NR	10-18	2 years	Author reported 200 µg/g as NOAEL; disputed by EPA due to high death rate due to respiratory infection	U.S. EPA, 1984 (p. 8-23)
Rat (50 male)	CCl_4 in gavage	NR	NR	47	5 times weekly for 78 weeks	No effect on survival rate; no effect on cancer rate	U.S. EPA, 1984 (p. 11-7)
Rat (50 female)	CCl_4 in gavage	NR	NR	80	5 times weekly for 78 weeks	No effect on survival rate; significant increase in heptacel-lular carcinomas	U.S. EPA, 1984 (p. 11-7)
Rat (50 male)	CCl_4 in gavage	NR	NR	94	5 times weekly for 78 weeks	Increased mortality rate	U.S. EPA, 1984 (p. 11-7)
Rat (50 female)	CCl_4 in gavage	NR	NR	159	5 times weekly for 78 weeks	Increased mortality rate	U.S. EPA, 1984 (p. 11-7)
Rat (143)	CCl_4 in gavage	NR	0.04	NR	4 months	88.1% incidence of hepatomas vs. 4.3% for olive oil control	U.S. EPA, 1984 (p. 11-11)
Rat	CCl_4	NR	NR	22	6 weeks	No observed effect level	U.S. EPA, 1984 (p. 14-18)

[a] N = Number of experimental animals when reported.
[b] NR = Not reported.

SECTION 5

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APPENDIX

PRELIMINARY HAZARD INDEX CALCULATIONS FOR CARBON TETRACHLORIDE IN MUNICIPAL SEWAGE SLUDGE

I. LANDSPREADING AND DISTRIBUTION-AND-MARKETING

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.

II. LANDFILLING

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.

III. INCINERATION

A. Index of Air Concentration Increment Resulting from Incinerator Emissions (Index 1)

1. Formula

$$\text{Index 1} = \frac{(C \times DS \times SC \times FM \times DP) + BA}{BA}$$

where:

C = Coefficient to correct for mass and time units (hr/sec x g/mg)
DS = Sludge feed rate (kg/hr DW)
SC = Sludge concentration of pollutant (mg/kg DW)
FM = Fraction of pollutant emitted through stack (unitless)
DP = Dispersion parameter for estimating maximum annual ground level concentration ($\mu g/m^3$)
BA = Background concentration of pollutant in urban air ($\mu g/m^3$)

2. Sample Calculation

$$1.000004 = [(2.78 \times 10^{-7} \text{ hr/sec} \times \text{g/mg} \times 2660 \text{ kg/hr DW} \times 0.048 \text{ mg/kg DW} \times 0.05 \times 3.4\ \mu g/m^3) + 1.4\ \mu g/m^3] \div 1.4\ \mu g/m^3$$

B. Index of Human Cancer Risk Resulting from Inhalation of Incinerator Emissions (Index 2)

1. Formula

$$\text{Index 2} = \frac{[(I_1 - 1) \times BA] + BA}{EC}$$

where:

I_1 = Index 1 = Index of air concentration increment resulting from incinerator emissions (unitless)

BA = Background concentration of pollutant in urban air (μg/m^3)

EC = Exposure criterion (μg/m^3)

2. Sample Calculation

$$20.8003035 = \frac{[(1.000004 - 1) \times 1.4\ \mu g/m^3] + 1.4\ \mu g/m^3}{0.067307\ \mu g/m^3}$$

IV. OCEAN DISPOSAL

Based on the recommendations of the experts at the OWRS meetings (April-May, 1984), an assessment of this reuse/disposal option is not being conducted at this time. The U.S. EPA reserves the right to conduct such an assessment for this option in the future.