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Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: 2,4,6-Trichlorophenol

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. 2,4,6-Trichlorophenol was initially identified as being of potential concern when sludge is ocean disposed.* This profile is a compilation of information that may be useful in determining whether 2,4,6-trichlorophenol 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 → seawater → marine organisms → 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 ocean disposal practices 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 2,4,6-TRICHLOROPHENOL 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. 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. EPA reserves the right to conduct such an assessment for this option in the future.

III. INCINERATION

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. EPA reserves the right to conduct such an assessment for this option in the future.

IV. OCEAN DISPOSAL

Slight increases in seawater concentration of 2,4,6-trichlorophenol is evident in all the scenarios evaluated for initial mixing of disposed sludge (see Index 1).

Slight concentration increases were apparent in all the scenarios evaluated for a 24-hour dumping cycle (see Index 2).

The index of toxicity to aquatic life could not be calculated due to lack of data (see Index 3).

Slight incremental increases related to human health were assessed for all the scenarios evaluated (see Index 4).

SECTION 3

PRELIMINARY HAZARD INDICES FOR 2,4,6-TRICHLOROPHENOL 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. EPA reserves the right to conduct such an assessment for this option in the future.

II. LANDFILLING

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III. INCINERATION

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. EPA reserves the right to conduct such an assessment for this option in the future.

IV. OCEAN DISPOSAL

For the purpose of evaluating pollutant effects upon and/or subsequent uptake by marine life as a result of sludge disposal, two types of mixing were modeled. The initial mixing or dilution shortly after dumping of a single load of sludge represents a high, pulse concentration to which organisms may be exposed for short time periods but which could be repeated frequently; i.e., every time a recently dumped plume is encountered. A subsequent additional degree of mixing can be expressed by a further dilution. This is defined as the average dilution occurring when a day's worth of sludge is dispersed by 24 hours of current movement and represents the time-weighted average exposure concentration for organisms in the disposal area. This dilution accounts for 8 to 12 hours of the high pulse concentration encountered by the organisms during daylight disposal operations and 12 to 16 hours of recovery (ambient water concentration) during the night when disposal operations are suspended.

A. Index of Seawater Concentration Resulting from Initial Mixing of Sludge (Index 1)

1. **Explanation** - Calculates increased concentrations in µg/L of pollutant in seawater around an ocean disposal site assuming initial mixing.

2. **Assumptions/Limitations** - Assumes that the background seawater concentration of pollutant is unknown or zero. The index also assumes that disposal is by tanker and that the daily amount of sludge disposed is uniformly distributed along a path transversing the site and perpendicular to the current vector. The initial dilution volume is assumed to be determined by path length, depth to the pycnocline (a layer separating surface and deeper water masses), and an initial plume width defined as the width of the plume 4 hours after dumping. The seasonal disappearance of the pycnocline is not considered.

3. **Data Used and Rationale**

a. **Disposal conditions**

	Sludge Disposal Rate (SS)	Sludge Mass Dumped by a Single Tanker (ST)	Length of Tanker Path (L)
Typical	825 mt DW/day	1600 mt WW	8000 m
Worst	1650 mt DW/day	3400 mt WW	4000 m

The typical value for the sludge disposal rate assumes that 7.5×10^6 mt WW/year are available for dumping from a metropolitan coastal area. The conversion to dry weight assumes 4 percent solids by weight. The worst-case value is an arbitrary doubling of the typical value to allow for potential future increase.

The assumed disposal practice to be followed at the model site representative of the typical case is a modification of that proposed for sludge disposal at the formally designated 12-mile site in the New York Bight Apex (City of New York, 1983). Sludge barges with capacities of 3400 mt WW would be required to discharge a load in no less than 53 minutes traveling at a minimum speed of 5 nautical miles (9260 m) per hour. Under these conditions, the barge would enter the site, discharge the sludge over 8180 m and exit the site. Sludge barges with capacities of 1600 mt WW would be required to discharge a load in no less than 32 minutes traveling at a minimum speed of 8 nautical miles (14,816 m) per hour. Under these conditions, the barge would enter the site, discharge the sludge over 7902 m and exit the site. The mean path length for the large and small tankers is 8041 m or approximately 8000 m. Path length is assumed to lie perpendicular to the direction of prevailing current flow. For the typical disposal rate (SS) of 825 mt DW/day, it is assumed that this would be accomplished by a mixture of four 3400 mt

WW and four 1600 mt WW capacity barges. The overall daily disposal operation would last from 8 to 12 hours. For the worst-case disposal rate (SS) of 1650 mt DW/day, eight 3400 mt WW and eight 1600 mt WW capacity barges would be utilized. The overall daily disposal operation would last from 8 to 12 hours. For both disposal rate scenarios, there would be a 12 to 16 hour period at night in which no sludge would be dumped. It is assumed that under the above described disposal operation, sludge dumping would occur every day of the year.

The assumed disposal practice at the model site representative of the worst case is as stated for the typical site, except that barges would dump half their load along a track, then turn around and dispose of the balance along the same track in order to prevent a barge from dumping outside of the site. This practice would effectively halve the path length compared to the typical site.

b. Sludge concentration of pollutant (SC)

Typical	2.3 mg/kg DW
Worst	4.6 mg/kg DW

The typical and worst sludge concentrations are the mean and maximum values, respectively, from a summary of sludge data from a U.S. EPA study of 50 publicly-owned treatment works (POTWs) (Camp Dresser and McKee, Inc. (CDM), 1984a). Concentrations of 2,4,6-trichlorophenol were detected in only 2 of 438 samples (0.46 percent) from 40 POTWs and in none of the samples from an additional 10 POTWs (U.S. EPA, 1982a). It has been reported that trichlorophenols disappear within a few days from activated sludge systems and aerated lagoons, possibly as a result of microbiological degradation mechanisms (U.S. EPA, 1979a).

c. Disposal site characteristics

	Depth to pycnocline (D)	Average current velocity at site (V)
Typical	20 m	9500 m/day
Worst	5 m	4320 m/day

Typical site values are representative of a large, deep-water site with an area of about 1500 km^2 located beyond the continental shelf in the New York Bight. The pycnocline value of 20 m chosen is the average of the 10 to 30 m pycnocline depth range occurring in the summer and fall; the winter and spring disappearance of the pycnocline is not considered and so represents a conservative approach in evaluating annual or long-term impact. The current velocity of 11 cm/sec (9500 m/day) chosen is based on the average current velocity in this area (CDM, 1984b).

Worst-case values are representative of a near-shore New York Bight site with an area of about 20 km^2. The pycnocline value of 5 m chosen is the minimum value of the 5 to 23 m depth range of the surface mixed layer and is therefore a worst-case value. Current velocities in this area vary from 0 to 30 cm/sec. A value of 5 cm/sec (4320 m/day) is arbitrarily chosen to represent a worst-case value (CDM, 1984c).

4. Factors Considered in Initial Mixing

When a load of sludge is dumped from a moving tanker, an immediate mixing occurs in the turbulent wake of the vessel, followed by more gradual spreading of the plume. The entire plume, which initially constitutes a narrow band the length of the tanker path, moves more-or-less as a unit with the prevailing surface current and, under calm conditions, is not further dispersed by the current itself. However, the current acts to separate successive tanker loads, moving each out of the immediate disposal path before the next load is dumped.

Immediate mixing volume after barge disposal is approximately equal to the length of the dumping track with a cross-sectional area about four times that defined by the draft and width of the discharging vessel (Csanady, 1981, as cited in National Oceanic and Atmospheric Administration (NOAA), 1983). The resulting plume is initially 10 m deep by 40 m wide (O'Connor and Park, 1982, as cited in NOAA, 1983). Subsequent spreading of plume band width occurs at an average rate of approximately 1 cm/sec (Csanady et al., 1979, as cited in NOAA, 1983). Vertical mixing is limited by the depth of the pycnocline or ocean floor, whichever is shallower. Four hours after disposal, therefore, average plume width (W) may be computed as follows:

W = 40 m + 1 cm/sec x 4 hours x 3600 sec/hour x 0.01 m/cm
= 184 m = approximately 200 m

Thus the volume of initial mixing is defined by the tanker path, a 200 m width, and a depth appropriate to the site. For the typical (deep water) site, this depth is chosen as the pycnocline value of 20 m. For the worst (shallow water) site, a value of 10 m was chosen. At times the pycnocline may be as shallow as 5 m, but since the barge wake causes initial mixing to at least 10 m, the greater value was used.

5. **Index 1 Values (µg/L)**

Disposal Conditions and Site Characteristics	Sludge Concentration	Sludge Disposal Rate (mt DW/day) 0	825	1650
Typical	Typical	0.0	0.0046	0.0046
	Worst	0.0	0.0092	0.0092
Worst	Typical	0.0	0.039	0.039
	Worst	0.0	0.078	0.078

6. **Value Interpretation** - Value equals the expected increase in 2,4,6-trichlorophenol concentration in seawater around a disposal site as a result of sludge disposal after initial mixing.

7. **Preliminary Conclusion** - Slight increases in seawater concentration of 2,4,6-trichlorophenol is evident in all the scenarios evaluated for initial mixing of disposed sludge.

B. **Index of Seawater Concentration Representing a 24-hour Dumping Cycle (Index 2)**

1. **Explanation** - Calculates increased effective concentrations in µg/L of pollutant in seawater around an ocean disposal site utilizing a time weighted average (TWA) concentration. The TWA concentration is that which would be experienced by an organism remaining stationary (with respect to the ocean floor) or moving randomly within the disposal vicinity. The dilution volume is determined by the tanker path length and depth to pycnocline or, for the shallow water site, the 10 m effective mixing depth, as before, but the effective width is now determined by current movement perpendicular to the tanker path over 24 hours.

2. **Assumptions/Limitations** - Incorporates all of the assumptions used to calculate Index 1. In addition, it is

assumed that organisms would experience high-pulsed sludge concentrations for 8 to 12 hours per day and then experience recovery (no exposure to sludge) for 12 to 16 hours per day. This situation can be expressed by the use of a TWA concentration of sludge constituent.

3. **Data Used and Rationale**

See Section 3, pp. 3-2 to 3-4.

4. **Factors Considered in Determining Subsequent Additional Degree of Mixing (Determination of TWA Concentrations)**

See Section 3, pp. 3-5 to 3-6.

5. **Index 2 Values (µg/L)**

Disposal Conditions and Site Characteristics	Sludge Concentration	Sludge Disposal Rate (mt DW/day) 0	825	1650
Typical	Typical	0.0	0.0012	0.0025
	Worst	0.0	0.0025	0.0050
Worst	Typical	0.0	0.011	0.022
	Worst	0.0	0.022	0.044

6. **Value Interpretation** - Value equals the effective increase in 2,4,6-trichlorophenol concentration expressed as a TWA concentration in seawater around a disposal site experienced by an organism over a 24-hour period.

7. **Preliminary Conclusion** - Slight concentration increases were apparent in all the scenarios evaluated for a 24-hour dumping cycle.

C. **Index of Toxicity to Aquatic Life (Index 3)**

1. **Explanation** - Compares the effective increased concentration of pollutant in seawater around the disposal site resulting from the initial mixing of sludge (Index 1) with the marine ambient water quality criterion of the pollutant, or with another value judged protective of marine aquatic life. For 2,4,6-trichlorophenol, this value is the criterion that will protect marine aquatic organisms from both acute and chronic toxic effects.

Wherever a short-term, "pulse" exposure may occur as it would from initial mixing, it is usually evaluated using the "maximum" criteria values of EPA's ambient water

quality criteria methodology. However, under this scenario, because the pulse is repeated several times daily on a long-term basis, potentially resulting in an accumulation of injury, it seems more appropriate to use values designed to be protective against chronic toxicity. Therefore, to evaluate the potential for adverse effects on marine life resulting from initial mixing concentrations, as quantified by Index 1, the chronically derived criteria values are used.

2. **Assumptions/Limitations** - In addition to the assumptions stated for Indices 1 and 2, assumes that all of the released pollutant is available in the water column to move through predicted pathways (i.e., sludge to seawater to aquatic organism to man). The possibility of effects arising from accumulation in the sediments is neglected since the U.S. EPA presently lacks a satisfactory method for deriving sediment criteria.

3. **Data Used and Rationale**

   a. **Concentration of pollutant in seawater around a disposal site (Index 1)**

      See Section 3, p. 3-5.

   b. **Ambient water quality criterion (AWQC)** - Data not immediately available

      Water quality criteria for the toxic pollutants listed under Section 307(a)(1) of the Clean Water Act of 1977 were developed by the U.S. EPA under Section 304(a)(1) of the Act. These criteria were derived by utilization of data reflecting the resultant environmental impacts and human health effects of these pollutants if present in any body of water. No criteria were available for this compound; thus Index 3 values could not be calculated.

4. **Index 3 Values** - Values were not calculated due to lack of data.

5. **Value Interpretation** - Value equals the factor by which the expected seawater concentration increase in 2,4,6-trichlorophenol exceeds the protective value. A value > 1 indicates that acute or chronic toxic conditions may exist for organisms at the site.

6. **Preliminary Conclusion** - Conclusion was not drawn because index values could not be calculated.

D. Index of Human Cancer Risk Resulting from Seafood Consumption (Index 4)

1. **Explanation** - Estimates the expected increase in human pollutant intake associated with the consumption of seafood, a fraction of which originates from the disposal site vicinity, and compares the total expected pollutant intake with the cancer risk-specific intake (RSI) of the pollutant.

2. **Assumptions/Limitations** - In addition to the assumptions listed for Indices 1 and 2, assumes that the seafood tissue concentration increase can be estimated from the increased water concentration (Index 2) by a bioconcentration factor. It also assumes that, over the long term, the seafood catch from the disposal site vicinity will be diluted to some extent by the catch from uncontaminated areas.

3. **Data Used and Rationale**

   a. **Concentration of pollutant in seawater around a disposal site (Index 2)**

      See Section 3, p. 3-6.

      Since biconcentration is a dynamic and reversible process, it is expected that uptake of sludge pollutants by marine organisms at the disposal site will reflect TWA concentrations, as quantified by Index 2, rather than pulse concentrations.

   b. **Dietary consumption of seafood (QF)**

Typical	14.3 g WW/day
Worst	41.7 g WW/day

      Typical and worst-case values are the mean and the 95th percentile, respectively, for all seafood consumption in the United States (Stanford Research Institute (SRI) International, 1980).

   c. **Fraction of consumed seafood originating from the disposal site (FS)**

      For a typical harvesting scenario, it was assumed that the total catch over a wide region is mixed by harvesting, marketing and consumption practices, and that exposure is thereby diluted. Coastal areas have been divided by the National Marine Fishery Service (NMFS) into reporting areas for reporting on data on seafood landings. Therefore it was convenient to express the total area affected by sludge disposal as a fraction of an NMFS reporting area.

The area used to represent the disposal impact area should be an approximation of the total ocean area over which the average concentration defined by Index 2 is roughly applicable. The average rate of plume spreading of 1 cm/sec referred to earlier amounts to approximately 0.9 km/day. Therefore, the combined plume of all sludge dumped during one working day will gradually spread, both parallel to and perpendicular to current direction, as it proceeds down-current. Since the concentration has been averaged over the direction of current flow, spreading in this dimension will not further reduce average concentration; only spreading in the perpendicular dimension will reduce the average. If stable conditions are assumed over a period of days, at least 9 days would be required to reduce the average concentration by one-half. At that time, the original plume length of approximately 8 km (8000 m) will have doubled to approximately 16 km due to spreading.

It is probably unnecessary to follow the plume further since storms, which would result in much more rapid dispersion of pollutants to background concentrations are expected on at least a 10-day frequency (NOAA, 1983). Therefore, the area impacted by sludge disposal (AI, in km^2) at each disposal site will be considered to be defined by the tanker path length (L) times the distance of current movement (V) during 10 days, and is computed as follows:

$$AI = 10 \times L \times V \times 10^{-6} \ km^2/m^2 \qquad (1)$$

To be consistent with a conservative approach, plume dilution due to spreading in the perpendicular direction to current flow is disregarded. More likely, organisms exposed to the plume in the area defined by equation 1 would experience a TWA concentration lower than the concentration expressed by Index 2.

Next, the value of AI must be expressed as a fraction of an NMFS reporting area. In the New York Bight, which includes NMFS areas 612-616 and 621-623, deep-water area 623 has an area of approximately 7200 km^2 and constitutes approximately 0.02 percent of the total seafood landings for the Bight (CDM, 1984b). Near-shore area 612 has an area of approximately 4300 km^2 and constitutes approximately 24 percent of the total seafood landings (CDM, 1984c). Therefore the fraction of all seafood landings (FS_t) from the Bight which could originate from the area of impact of either the

typical (deep-water) or worst (near-shore) site can be calculated for this typical harvesting scenario as follows:

For the typical (deep water) site:

$$FS_t = \frac{AI \times 0.02\%}{7200\ km^2} = \qquad (2)$$

$$\frac{[10 \times 8000\ m \times 9500\ m \times 10^{-6}\ km^2/m^2] \times 0.0002}{7200\ km^2} = 2.1 \times 10^{-5}$$

For the worst (near shore) site:

$$FS_t = \frac{AI \times 24\%}{4300\ km^2} = \qquad (3)$$

$$\frac{[10 \times 4000\ m \times 4320\ m \times 10^{-6}\ km^2/m^2] \times 0.24}{4300\ km^2} = 9.6 \times 10^{-3}$$

To construct a worst-case harvesting scenario, it was assumed that the total seafood consumption for an individual could originate from an area more limited than the entire New York Bight. For example, a particular fisherman providing the entire seafood diet for himself or others could fish habitually within a single NMFS reporting area. Or, an individual could have a preference for a particular species which is taken only over a more limited area, here assumed arbitrarily to equal an NMFS reporting area. The fraction of consumed seafood (FS_w) that could originate from the area of impact under this worst-case scenario is calculated as follows:

For the typical (deep water) site:

$$FS_w = \frac{AI}{7200\ km^2} = 0.11 \qquad (4)$$

For the worst (near shore) site:

$$FS_w = \frac{AI}{4300\ km^2} = 0.040 \qquad (5)$$

d. Bioconcentration factor of pollutant (BCF) = 150 L/kg

The value chosen is the weighted average BCF of 2,4,6-trichlorophenol for the edible portion of all freshwater and estuarine aquatic organisms consumed by U.S. citizens (U.S. EPA, 1980). The weighted average BCF is derived as part of the water quality criteria developed by the U.S. EPA to protect human

health from the potential carcinogenic effects of 2,4,6-trichlorophenol induced by ingestion of contaminated water and aquatic organisms. The weighted average BCF is calculated by adjusting the mean normalized BCF (steady-state BCF corrected to 1 percent lipid content) to the 3 percent lipid content of consumed fish and shellfish. It should be noted that lipids of marine species differ in both structure and quantity from those of freshwater species. Although a BCF value calculated entirely from marine data would be more appropriate for this assessment, no such data are presently available.

e. **Average daily human dietary intake of pollutant (DI)** = 0 µg/day

Although no data are immediately available on DI, a value of 0 µg/day is assumed so that index values can be calculated.

f. **Cancer potency** = 1.98×10^{-2} $(mg/kg/day)^{-1}$

The cancer potency value is derived by U.S. EPA (1980) based on studies of hepatocellular carcinomas and adenomas developed in mice dosed with 2,4,6-trichlorophenol.

g. **Cancer risk-specific intake (RSI)** = 3.535 µg/day

The RSI is the pollutant intake value which results in an increase in cancer risk of 10^{-6} (1 per 1,000,000). The RSI is calculated from the cancer potency using the following formula:

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

4. **Index 4 Values**

Disposal Conditions and Site Characteristics	Sludge Concentration[a]	Seafood Intake[a,b]	Sludge Disposal Rate (mt DW/day) 0	825	1650
Typical	Typical	Typical	0.0	1.6×10^{-8}	3.1×10^{-8}
	Worst	Worst	0.0	0.00049	0.00097
Worst	Typical	Typical	0.0	0.000064	0.00013
	Worst	Worst	0.0	0.0016	0.0031

[a] All possible combinations of these values are not presented. Additional combinations may be calculated using the formulae in the Appendix.

[b] Refers to both the dietary consumption of seafood (QF) and the fraction of consumed seafood originating from the disposal site (FS). "Typical" indicates the use of the typical-case values for both of these parameters; "worst" indicates the use of the worst-case values for both.

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 mt/day indicates the degree to which any hazard is due to sludge disposal, as opposed to pre-existing dietary sources.

6. **Preliminary Conclusion** - Slight incremental increases related to human health were assessed for all the scenarios evaluated.

SECTION 4

PRELIMINARY DATA PROFILE FOR 2,4,6-TRICHLOROPHENOL IN MUNICIPAL SEWAGE SLUDGE

I. OCCURRENCE

2,4,6-Trichlorophenol is used as a bactericide and fungicide in the preservation of wood, leather, and glue and in the treatment of mildew on textile. It is also used as an ingredient in the preparation of insecticides and soap germicides. The primary use of 2,4,6-trichlorophenol is as an intermediate in the synthesis of pesticides including 2,4,6-trichlorophenoxy acetic acid (2,4,6-T) and Ronnel. U.S. EPA, 1979a (p. 465)

A. Sludge

1. Frequency of Detection

2,4,6-trichlorophenol was detected in 2 of 438 sludge samples (0.46 percent) from 40 POTWs. Not observed in sludge samples from additional 10 POTWs studied. U.S. EPA, 1982a (p. 42)

2. Concentration

11 and 16 µg/L from 2 samples from 40 POTWs. U.S. EPA, 1982a (p. 42)

2.3 and 4.6 mg/kg (mean and maximum, respectively) from 50 POTWs. CDM, 1984a (p. 14)

B. Soil - Unpolluted

Data not immediately available.

C. Water - Unpolluted

1. Frequency of Detection

2,4,6-trichlorophenol has been detected in finished drinking water. U.S. EPA, 1979b (p. 86-1)

"It is generally accepted that chlorinated phenols will undergo photolysis in aqueous solutions as a result of ultraviolet radiation and that photodegradation leads to the substitution of hydroxyl groups in place of the chlorine atoms with subsequent polymer formation." U.S. EPA, 1980 (p. A-8)

"Trichlorophenols disappear in a few days from aerated lagoons or activated sludge systems." — U.S. EPA, 1979a (p. 465)

2. **Concentration**

Data not immediately available.

D. **Air**

Data on levels of trichlorophenols in air are not available. — U.S. EPA, 1979a (p. 465)

E. **Food**

1. **Frequency of Detection**

"Exposure to other chemicals could result in exposure to trichlorophenols via metabolic degradation of the parent compound." — U.S. EPA, 1980 (p. C-51)

"Livestock have been shown to form trichlorophenol residues from the metabolism of a variety of chemicals including 2,4,6-T, Silvex, Ronnel, 1,3,5-trichlorobenzene, and hexachlorocylclohexane — U.S. EPA, 1980 (p. C-52)

Ingestion of food containing pesticides which degrade to chlorophenols could result in human exposure to trichlorophenol, though probably at very low levels. — U.S. EPA, 1979a (p. 465-6)

2. **Concentration**

Data not immediately available.

II. **HUMAN EFFECTS**

A. **Ingestion**

1. **Carcinogenicity**

Cancer potency = 1.98 x 10^{-2} $(mg/kg/day)^{-1}$ — U.S. EPA, 1980 (p. C-133)

Based on hepatocellular carcinoma and adenoma responses of male mice ingesting 650 to 1,300 mg/kg/day of 2,4,6-trichlorophenol.

2. **Chronic Toxicity**

Data not immediately available.

3. **Absorption Factor**

Data not immediately available.

4. **Existing Regulations**

Data not immediately available.

B. **Inhalation**

Data not immediately available.

III. PLANT EFFECTS

A. **Phytotoxicity**

"Information on effects, biotransformation, and elimination of trichlorophenols and tetrachlorophenols in plants is not available. No dose-response data have been reported for vascular plants."	U.S. EPA, 1979a (p. 468)
Corn and pea plants can metabolize pentachlorocyclohexane to the 2,4,6- 2,3,5-, and 2,4,5-trichlorophenol isomers.	U.S. EPA, 1980 (p. C-52)

B. **Uptake**

See Table 4-1.

IV. DOMESTIC ANIMAL AND WILDLIFE EFFECTS

A. **Toxicity**

See Table 4-2.

B. **Uptake**

See Table 4-3.

V. AQUATIC LIFE EFFECTS

A. **Toxicity**

1. **Freshwater**

52 µg/L of 2,4,6-trichlorophenol is the lowest concentration at which tainting of the flesh of the rainbow trout occurs.	CCHA, no date (p. 5)

Acute toxicity values for 2,4,6-trichlorophenol for fish and crustacean species range from 320 to 9,040 µg/L.	U.S. EPA, 1980 (p. B-6, 7)
Chronic toxicity values for 2,4,6-trichlorophenol range from 530 to 970 µg/L for early life stages of the fathead minnow.	U.S. EPA, 1980 (p. B-8)

2. **Seawater**

Data not immediately available.

B. Uptake

Bioconcentration factor = 150 L/kg

Based on the edible portion of all freshwater and estuarine aquatic organisms consumed by U.S. citizens.	U.S. EPA, 1980 (p. C-53)

VI. SOIL BIOTA EFFECTS

A. Toxicity

"Several genera of bacteria are capable of metabolizing chlorophenols. 2,4,5-trichlorophenol is more resistant to soil microbial degradation than is 2,4,6-trichlorophenol."	U.S. EPA, 1979a (p. 467)
2,4,5-Trichlorophenol inhibits growth of bacteria at concentrations of 10 to 400 mg/L. The test organism, Pseudomonas aeruginosa, was more resistant than other organisms tested. 2,4,5-Trichlorophenol also inhibits a number of fungal species at concentrations of 2 to 5 mg/L. Most fungi are inhibited at concentrations around 10 mg/L.	U.S. EPA, 1979a (p. 467)

B. Uptake

Under experimental conditions, 2,4,6-trichlorophenol inhibits O_2 uptake in mixed microbial populations at concentrations of 50 to 100 µg/g, but has no effect at 1 to 10 µg/g.	U.S. EPA, 1979a (p. 466)

VII. PHYSICOCHEMICAL DATA FOR ESTIMATING FATE AND TRANSPORT

Molecular weight:	197.5	
Melting point:	68°C (2,4,5-trichlorophenol) 69.5°C (2,4,6-trichlorophenol)	U.S. EPA, 1980
Boiling point:	Sublimes (2,4,5-trichlorophenol) 246°C (2,4,6-trichlorophenol)	(p. A-2)

Density: 1.4901 (2,4,6-trichlorophenol) Water solubility: 0.1 to 0.2 g/100 g Vapor pressure: 1 mm Hg/72.0°C (2,4,5-trichlorophenol) 1 mm Hg/76.5°C (2,4,6-trichlorophenol)	
Very soluble in organic solvents	U.S. EPA, 1979a (p. 466)
Microbial degradation appears to be a major elimination mechanism. Bacterial species capable of metabolizing 2,4,6-trichlorophenol have been isolated from soil and activated sludge	U.S. EPA, 1979a (p. 466)

TABLE 4-1. UPTAKE OF 2,4,6-TRICHLOROPHENOL BY PLANTS

Plant/Tissue	Chemical Form Applied	Soil Type	Soil Concentration (µg/g)	Control Tissue Concentration (µg/g DW)	Bioconcentration Factor[a]	References
Tomato/roots	2,4,6-trichlorophenol	Hydroponic	3.5	73.3	20.94	Fragiadakis et al., 1981 (p. 1317)
Tomato/stems & leaves	2,4,6-trichlorophenol	Hydroponic	3.5	1.4	0.4	Fragiadakis et al., 1981 (p. 1317)

[a] BCF = tissue concentration/solution concentration.

TABLE 4-2. TOXICITY OF 2,4,5-TRICHLOROPHENOL TO DOMESTIC ANIMALS AND WILDLIFE

Species	Chemical Form Fed	Feed Concentration (µg/g)	Water Concentration (mg/L)	Daily Intake (mg/kg)	Duration of Study	Effects	References
Cattle	2,4,5-T[a]	NR[b]	NR	18	78 days	No toxic effects	U.S. EPA, 1979a (p. 468)
Cattle	2,4,5-T	NR	NR	159	78 days	No toxic effects	U.S. EPA, 1979a (p. 468)
Cattle	2,4,5-T	NR	NR	53	154 days	No toxic effects	U.S. EPA, 1979a (p. 468)
Rats	2,4,5-T	NR	NR	820-2900		LD_{50}	U.S. EPA, 1979a (p. 469)
Rabbits	2,4,5-T	NR	NR	1-10	28 days	No toxic effects (20 doses)	U.S. EPA, 1979a (p. 469)
Rabbits	2,4,5-T	NR	NR	500	28 days	Slight kidney and liver changes	U.S. EPA, 1979a (p. 469)
Rats	2,4,5-T	NR	NR	10-100	NR	No toxic effects	U.S. EPA, 1979a (p. 469)
Rats	2,4,5-T	NR	NR	300-1000	NR	Minor histopathologic changes in kidney and liver	U.S. EPA, 1979a (p. 469)

[a] 2,4,5-Trichlorophenol.
[b] NR = Not reported.

TABLE 4-3. UPTAKE OF 2,4,6-TRICHLOROPHENOL BY DOMESTIC ANIMALS AND WILDLIFE

Species	Chemical Form Fed	Feed Concentration (µg/g)	Tissue Analyzed	Range of Tissue Concentration (µg/g)	Bioconcentration Factor[a]	References
Sheep	2,4,5-T[b] herbicide	2,000	muscle	0.13	<0.001	Clark et al., 1975 (p. 576)
			fat	<0.05	<0.001	
			liver	6.1	0.003	
			kidney	0.9	<0.001	
Cattle	2,4,5-T[b] herbicide	2,000	muscle	0.05	<0.001	Clark et al., 1975 (p. 575)
			fat	<0.05	<0.001	
			liver	0.42	<0.001	
			kidney	0.10	<0.001	
Cattle	2,4,5-T[b] herbicide	100	milk	0.05	<0.001	Bjerke et al., 1972 (p. 965)
		1,000	milk & cream	0.15-0.39	<0.001	

[a] BCF = tissue concentration/feed concentration.
[b] 2,4,5-trichlorophenol is a photodecomposition product of the herbicide 2,4,5-T.

SECTION 5

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APPENDIX

PRELIMINARY HAZARD INDEX CALCULATIONS FOR 2,4,6-TRICHLOROPHENOL 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. 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. EPA reserves the right to conduct such an assessment for this option in the future.

III. INCINERATION

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. EPA reserves the right to conduct such an assessment for this option in the future.

IV. OCEAN DISPOSAL

A. Index of Seawater Concentration Resulting from Initial Mixing of Sludge (Index 1)

1. Formula

$$\text{Index 1} = \frac{SC \times ST \times PS}{W \times D \times L}$$

where:

SC = Sludge concentration of pollutant (mg/kg DW)
ST = Sludge mass dumped by a single tanker (kg WW)
PS = Percent solids in sludge (kg DW/kg WW)
W = Width of initial plume dilution (m)
D = Depth to pycnocline or effective depth of mixing for shallow water site (m)
L = Length of tanker path (m)

2. **Sample Calculation**

$$0.0046\ \mu g/L = \frac{2.3\ mg/kg\ DW \times 1600000\ kg\ WW \times 0.04\ kg\ DW/kg\ WW \times 10^3\ \mu g/mg}{200\ m \times 20\ m \times 8000\ m \times 10^3\ L/m^3}$$

B. **Index of Seawater Concentration Representing a 24-Hour Dumping Cycle (Index 2)**

1. **Formula**

$$\text{Index 2} = \frac{SS \times SC}{V \times D \times L}$$

where:

SS = Daily sludge disposal rate (kg DW/day)
SC = Sludge concentration of pollutant (mg/kg DW)
V = Average current velocity at site (m/day)
D = Depth to pycnocline or effective depth of mixing for shallow water site (m)
L = Length of tanker path (m)

2. **Sample Calculation**

$$0.0012\ \mu g/L = \frac{825000\ kg\ DW/day \times 2.3\ mg/kg\ DW \times 10^3\ \mu g/mg}{9500\ m/day \times 20\ m \times 8000\ m \times 10^3\ L/m^3}$$

C. **Index of Toxicity to Aquatic Life (Index 3)**

1. **Formula**

$$\text{Index 3} = \frac{I_1}{AWQC}$$

where:

I_1 = Index 1 = Index of seawater concentration increment resulting from initial mixing after sludge disposal (µg/L)
AWQC = Criterion or other value expressed as an average concentration to protect marine organisms from acute and chronic toxic effects (µg/L)

2. **Sample Calculation** - Values were not calculated due to lack of data.

D. Index of Human Cancer Risk Resulting from Seafood Consumption (Index 4)

1. Formula

$$\text{Index 4} = \frac{(I_2 \times BCF \times 10^{-3}\ kg/g \times FS \times QF) + DI}{RSI}$$

where:

I_2 = Index 2 = Index of seawater concentration representing a 24-hour dumping cycle (µg/L)
QF = Dietary consumption of seafood (g WW/day)
FS = Fraction of consumed seafood originating from the disposal site (unitless)
BCF = Bioconcentration factor of pollutant (L/kg)
DI = Average daily human dietary intake of pollutant (µg/day)
RSI = Cancer risk-specific intake (µg/day)

2. Sample Calculation

$$1.6 \times 10^{-8} = \frac{(0.0012\ \mu g/L \times 150\ L/kg \times 10^{-3}\ kg/g \times 0.000021 \times 14.3\ g\ WW/day) + 0\ \mu g/day}{3.535\ \mu g/day}$$