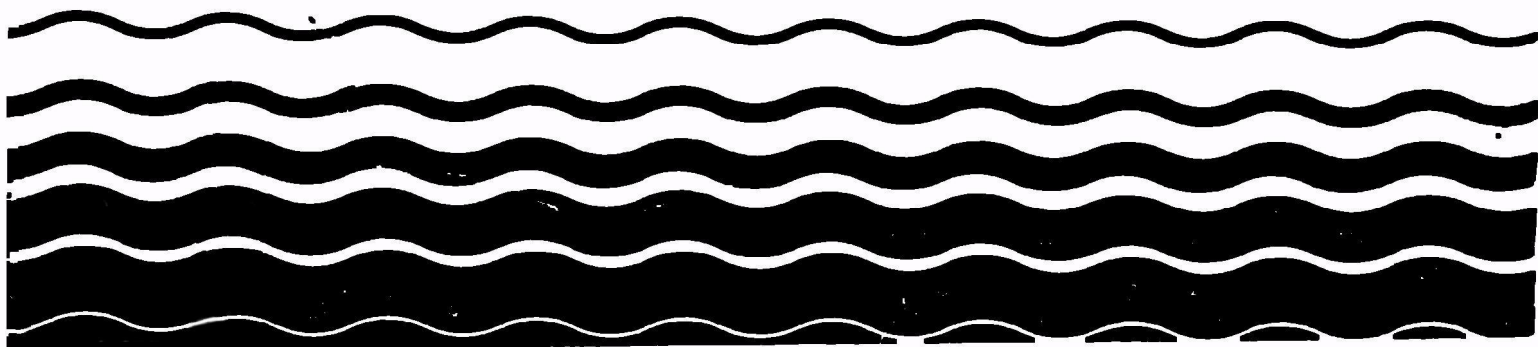




Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Methyl Ethyl Ketone



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.

TABLE OF CONTENTS

	<u>Page</u>
PREFACE	i
1. INTRODUCTION.....	1-1
2. PRELIMINARY CONCLUSIONS FOR METHYL ETHYL KETONE IN MUNICIPAL SEWAGE SLUDGE.....	2-1
Landspreading and Distribution-and-Marketing	2-1
Landfilling	2-1
Incineration	2-1
Ocean Disposal	2-1
3. PRELIMINARY HAZARD INDICES FOR METHYL ETHYL KETONE IN MUNICIPAL SEWAGE SLUDGE.....	3-1
Landspreading and Distribution-and-Marketing	3-1
Landfilling	3-1
Index of groundwater concentration resulting from landfilled sludge (Index 1)	3-1
Index of human toxicity resulting from groundwater contamination (Index 2)	3-8
Incineration	3-9
Ocean Disposal	3-9
4. PRELIMINARY DATA PROFILE FOR METHYL ETHYL KETONE IN MUNICIPAL SEWAGE SLUDGE.....	4-1
Occurrence	4-1
Sludge	4-1
Soil - Unpolluted	4-1
Water - Unpolluted	4-1
Air	4-2
Food	4-2
Human Effects	4-3
Ingestion	4-3
Inhalation	4-3

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
Plant Effects	4-4
Phytotoxicity	4-4
Uptake	4-4
Domestic Animal and Wildlife Effects	4-5
Toxicity	4-5
Uptake	4-5
Aquatic Life Effects	4-5
Toxicity	4-5
Uptake	4-5
Soil Biota Effects	4-6
Toxicity	4-6
Uptake	4-6
Physicochemical Data for Estimating Fate and Transport	4-6
5. REFERENCES.....	5-1
APPENDIX. PRELIMINARY HAZARD INDEX CALCULATIONS FOR METHYL ETHYL KETONE IN MUNICIPAL SEWAGE SLUDGE	A-1

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. Methyl ethyl ketone (MEK) was initially identified as being of potential concern when sludge is placed in a landfill.* This profile is a compilation of information that may be useful in determining whether MEK 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 → groundwater → 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 landfilling 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.

* 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 METHYL ETHYL KETONE 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

Conclusions were not drawn because index values could not be calculated due to lack of data.

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

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 METHYL ETHYL KETONE 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

A. Index of Groundwater Concentration Resulting from Landfilled Sludge (Index 1)

1. **Explanation** - Calculates groundwater contamination which could occur in a potable aquifer in the landfill vicinity. Uses U.S. EPA's Exposure Assessment Group (EAG) model, "Rapid Assessment of Potential Groundwater Contamination Under Emergency Response Conditions" (U.S. EPA, 1983). Treats landfill leachate as a pulse input, i.e., the application of a constant source concentration for a short time period relative to the time frame of the analysis. In order to predict pollutant movement in soils and groundwater, parameters regarding transport and fate, and boundary or source conditions are evaluated. Transport parameters include the interstitial pore water velocity and dispersion coefficient. Pollutant fate parameters include the degradation/decay coefficient and retardation factor. Retardation is primarily a function of the adsorption process, which is characterized by a linear, equilibrium partition coefficient representing the ratio of adsorbed and solution pollutant concentrations. This partition coefficient, along with soil bulk density and volumetric water content, are used to calculate the retardation factor. A computer program (in FORTRAN) was developed to facilitate computation of the analytical solution. The program predicts pollutant concentration as a function of time and location in both the unsaturated and saturated zone. Separate computations and parameter estimates are required for each zone. The prediction requires evaluations of four dimensionless input values and subsequent evaluation of the result, through use of the computer program.
2. **Assumptions/Limitations** - Conservatively assumes that the pollutant is 100 percent mobilized in the leachate and that all leachate leaks out of the landfill in a finite period and undiluted by precipitation. Assumes that all soil and aquifer properties are homogeneous and isotropic throughout each zone; steady, uniform flow occurs only in

the vertical direction throughout the unsaturated zone, and only in the horizontal (longitudinal) plane in the saturated zone; pollutant movement is considered only in direction of groundwater flow for the saturated zone; all pollutants exist in concentrations that do not significantly affect water movement; for organic chemicals, the background concentration in the soil profile or aquifer prior to release from the source is assumed to be zero; the pollutant source is a pulse input; no dilution of the plume occurs by recharge from outside the source area; the leachate is undiluted by aquifer flow within the saturated zone; concentration in the saturated zone is attenuated only by dispersion.

3. Data Used and Rationale

a. Unsaturated zone

i. Soil type and characteristics

(a) Soil type

Typical	Sandy loam
Worst	Sandy

These two soil types were used by Gerritse et al. (1982) to measure partitioning of elements between soil and a sewage sludge solution phase. They are used here since these partitioning measurements (i.e., K_d values) are considered the best available for analysis of metal transport from landfilled sludge. The same soil types are also used for nonmetals for convenience and consistency of analysis.

(b) Dry bulk density (P_{dry})

Typical	1.53 g/mL
Worst	1.925 g/mL

Bulk density is the dry mass per unit volume of the medium (soil), i.e., neglecting the mass of the water (Camp Dresser and McKee, Inc. (CDM), 1984).

(c) Volumetric water content (θ)

Typical	0.195 (unitless)
Worst	0.133 (unitless)

The volumetric water content is the volume of water in a given volume of media, usually expressed as a fraction or percent. It depends on properties of the media and the water flux

estimated by infiltration or net recharge. The volumetric water content is used in calculating the water movement through the unsaturated zone (pore water velocity) and the retardation coefficient. Values obtained from CDM, 1984.

(d) Fraction of organic carbon (f_{oc})

Typical 0.005 (unitless)
Worst 0.0001 (unitless)

Organic content of soils is described in terms of percent organic carbon, which is required in the estimation of partition coefficient, K_d . Values, obtained from R. Griffin (1984) are representative values for subsurface soils.

ii. Site parameters

(a) Landfill leaching time (LT) = 5 years

Sikora et al. (1982) monitored several sludge entrenchment sites throughout the United States and estimated time of landfill leaching to be 4 or 5 years. Other types of landfills may leach for longer periods of time; however, the use of a value for entrenchment sites is conservative because it results in a higher leachate generation rate.

(b) Leachate generation rate (Q)

Typical 0.8 m/year
Worst 1.6 m/year

It is conservatively assumed that sludge leachate enters the unsaturated zone undiluted by precipitation or other recharge, that the total volume of liquid in the sludge leaches out of the landfill, and that leaching is complete in 5 years. Landfilled sludge is assumed to be 20 percent solids by volume, and depth of sludge in the landfill is 5 m in the typical case and 10 m in the worst case. Thus, the initial depth of liquid is 4 and 8 m, and average yearly leachate generation is 0.8 and 1.6 m, respectively.

(c) Depth to groundwater (h)

Typical 5 m
Worst 0 m

Eight landfills were monitored throughout the United States and depths to groundwater below them were listed. A typical depth to groundwater of 5 m was observed (U.S. EPA, 1977). For the worst case, a value of 0 m is used to represent the situation where the bottom of the landfill is occasionally or regularly below the water table. The depth to groundwater must be estimated in order to evaluate the likelihood that pollutants moving through the unsaturated soil will reach the groundwater.

(d) Dispersivity coefficient (α)

Typical	0.5 m
Worst	Not applicable

The dispersion process is exceedingly complex and difficult to quantify, especially for the unsaturated zone. It is sometimes ignored in the unsaturated zone, with the reasoning that pore water velocities are usually large enough so that pollutant transport by convection, i.e., water movement, is paramount. As a rule of thumb, dispersivity may be set equal to 10 percent of the distance measurement of the analysis (Gelhar and Axness, 1981). Thus, based on depth to groundwater listed above, the value for the typical case is 0.5 and that for the worst case does not apply since leachate moves directly to the unsaturated zone.

iii. Chemical-specific parameters

(a) Sludge concentration of pollutant (SC) - Data not immediately available.

(b) Soil half-life of pollutant ($t_{1/2}$) = 3 days

Based on its relatively high water solubility and low octanol/water partition coefficient, MEK is expected to have a high soil mobility. Two processes that may account for significant loss of MEK from soil are volatilization and biodegradation. By analogy from aquatic media and lack of adequate data, the half-life of MEK in soils can be speculated to be about a few days (3 days chosen as a worst-case value) (U.S. EPA, 1984). (See Section 4, p. 4-1.)

(c) Degradation rate (μ) = 0.231 day^{-1}

The unsaturated zone can serve as an effective medium for reducing pollutant concentration

through a variety of chemical and biological decay mechanisms which transform or attenuate the pollutant. While these decay processes are usually complex, they are approximated here by a first-order rate constant. The degradation rate is calculated using the following formula:

$$\mu = \frac{0.693}{t_{\frac{1}{2}}}$$

- (d) Organic carbon partition coefficient (K_{OC}) = 4000 mL/g

The organic carbon partition coefficient is multiplied by the percent organic carbon content of soil (f_{OC}) to derive a partition coefficient (K_d), which represents the ratio of absorbed pollutant concentration to the dissolved (or solution) concentration. The equation ($K_{OC} \times f_{OC}$) assumes that organic carbon in the soil is the primary means of adsorbing organic compounds onto soils. This concept serves to reduce much of the variation in K_d values for different soil types. The value of K_{OC} is from Griffin (1984).

b. Saturated zone

i. Soil type and characteristics

(a) Soil type

Typical	Silty sand
Worst	Sand

A silty sand having the values of aquifer porosity and hydraulic conductivity defined below represents a typical aquifer material. A more conductive medium such as sand transports the plume more readily and with less dispersion and therefore represents a reasonable worst case.

(b) Aquifer porosity (\emptyset)

Typical	0.44 (unitless)
Worst	0.389 (unitless)

Porosity is that portion of the total volume of soil that is made up of voids (air) and water. Values corresponding to the above soil types are from Pettyjohn et al. (1982) as presented in U.S. EPA (1983).

(c) Hydraulic conductivity of the aquifer (K)

Typical	0.86 m/day
Worst	4.04 m/day

The hydraulic conductivity (or permeability) of the aquifer is needed to estimate flow velocity based on Darcy's Equation. It is a measure of the volume of liquid that can flow through a unit area or media with time; values can range over nine orders of magnitude depending on the nature of the media. Heterogenous conditions produce large spatial variation in hydraulic conductivity, making estimation of a single effective value extremely difficult. Values used are from Freeze and Cherry (1979) as presented in U.S. EPA (1983).

**(d) Fraction of organic carbon (f_{oc}) =
0.0 (unitless)**

Organic carbon content, and therefore adsorption, is assumed to be 0 in the saturated zone.

ii. Site parameters

(a) Average hydraulic gradient between landfill and well (i)

Typical	0.001 (unitless)
Worst	0.02 (unitless)

The hydraulic gradient is the slope of the water table in an unconfined aquifer, or the piezometric surface for a confined aquifer. The hydraulic gradient must be known to determine the magnitude and direction of groundwater flow. As gradient increases, dispersion is reduced. Estimates of typical and high gradient values were provided by Donigian (1985).

(b) Distance from well to landfill (ΔL)

Typical	100 m
Worst	50 m

This distance is the distance between a landfill and any functioning public or private water supply or livestock water supply.

(c) Dispersivity coefficient (α)

Typical 10 m
Worst 5 m

These values are 10 percent of the distance from well to landfill (Δl), which is 100 and 50 m, respectively, for typical and worst conditions.

(d) Minimum thickness of saturated zone (B) = 2 m

The minimum aquifer thickness represents the assumed thickness due to preexisting flow; i.e., in the absence of leachate. It is termed the minimum thickness because in the vicinity of the site it may be increased by leachate infiltration from the site. A value of 2 m represents a worst case assumption that preexisting flow is very limited and therefore dilution of the plume entering the saturated zone is negligible.

(e) Width of landfill (W) = 112.8 m

The landfill is arbitrarily assumed to be circular with an area of 10,000 m².

iii. Chemical-specific parameters

(a) Degradation rate (μ) = 0 day⁻¹

Degradation is assumed not to occur in the saturated zone.

(b) Background concentration of pollutant in groundwater (BC) = 0 μ g/L

It is assumed that no pollutant exists in the soil profile or aquifer prior to release from the source.

4. **Index Values** - Values were not calculated due to lack of data.
5. **Value Interpretation** - Value equals the maximum expected groundwater concentration of pollutant, in μ g/L, at the well.
6. **Preliminary Conclusion** - Conclusion was not drawn because index values could not be calculated.

B. Index of Human Toxicity Resulting from Groundwater Contamination (Index 2)

1. **Explanation** - Calculates human exposure which could result from groundwater contamination. Compares exposure with acceptable daily intake (ADI) of pollutant.

2. **Assumptions/Limitations** - Assumes long-term exposure to maximum concentration at well at a rate of 2 L/day.

3. **Data Used and Rationale**

a. **Index of groundwater concentration resulting from landfilled sludge (Index 1)** - Values were not calculated due to lack of data.

b. **Average human consumption of drinking water (AC)** = 2 L/day

The value of 2 L/day is a standard value used by U.S. EPA in most risk assessment studies.

c. **Average daily human dietary intake of pollutant (DI)** - Data not immediately available.

d. **Acceptable daily intake of pollutant (ADI)** = 7600 µg/day

The U.S. EPA (1984)-derived ADI of 7.6 mg/day is based on the inhalation MPIH, assuming respective absorption for ingestion and inhalation to be 100% and 50%. The inhalation MPIH is based on a study showing a no-observed-adverse-effects-level (NOAEL) (increased liver enzyme activity: fetal anomalies) in rats and assuming an uncertainty factor of 1000. (See Section 4, p. 4-3).

4. **Index 2 Values** - Values were not calculated due to lack of data.

5. **Value Interpretation** - Value equals factor due only to groundwater contamination by landfill by which expected intake exceeds ADI. The value does not account for the possible increase resulting from daily dietary intake of pollutant since DI data were not immediately available.

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

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

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 METHYL ETHYL KETONE IN MUNICIPAL SEWAGE SLUDGE

I. OCCURRENCE

A. Sludge

1. Frequency of Detection

Identified as one of the products of
activated sludge treatment of sewage and
as a component of the leachate from solid
waste. U.S. EPA, 1980
(p. 1)

2. Concentration

Data not immediately available.

B. Soil - Unpolluted

1. Frequency of Detection

Data not immediately available.

2. Concentration

Based on its relatively high water solu-
bility and low octanol/water partition
coefficient, MEK is expected to have a
high soil mobility. Two processes that
may account for the significant loss of
MEK from soil are volatilization and bio-
degradation. By analogy from aquatic
media, the half-life of MEK in soils can
be speculated to be about a few days. U.S. EPA, 1984
(p. 1)

Organic carbon partition coefficient =
4000 mL/g Griffin, 1984

C. Water - Unpolluted

1. Frequency of Detection

In most surface waters, MEK may bio-
degrade almost completely within 10 days.
The evaporative half-life from water was
calculated to be approximately 6 days
(in calculating the evaporative half-life,
the assumption that MEK is "slightly
soluble" remains questionable). U.S. EPA, 1984
(p. 1)

2. Concentration

a. Fresh water

Data not immediately available.

b. Seawater

Data not immediately available.

c. Drinking water

It is probable that some MEK is in municipal water supplies; however, there are insufficient data to estimate the amount.

U.S. EPA, 1980
(p. 1)

D. Air

1. Frequency of Detection

It is probable that all the MEK used as an industrial solvent is evaporated into the atmosphere along with the MEK produced by automobile exhaust.

U.S. EPA, 1980
(p. 2)

Half-life in air: 14 hours

U.S. EPA, 1984
(p. 1)

2. Concentration

Data not immediately available.

E. Food

1. Total Average Intake

MEK is a naturally occurring ketone present in many foods including cheeses, milk, cream, bread, honey, chicken, oranges, black tea, and rum. Thus the appearance in food appears to be ubiquitous.

U.S. EPA, 1980
(p. 1)

2. Concentration

In a variety of breads, MEK (1-Buta-none) levels ranged from 420 to 656 mg/100 g.

Sosulski and
Mahmoud, 1979
(p. 535)

II. HUMAN EFFECTS

A. Ingestion

1. Carcinogenicity

Data not immediately available.

2. Chronic Toxicity

a. ADI

The ADI of 7.6 mg/day was derived by the U.S. EPA from the MPIH, assuming respective absorption for ingestion and inhalation to be 100% and 50%. The derived ADI is based on a study showing a NOAEL (increased SGPT activity; fetal anomalies) in rats and an uncertainty factor of 1000. U.S. EPA, 1984

b. Effects

EPA has derived a short-term health advisory for a 10 kg child. The one-day and ten-day health advisories for MEK in drinking water are 7.5 mg/L and 0.75 mg/L respectively, and are based on hepatotoxicity observed in terms of increased serum enzyme activity and lipid accumulation in the livers of animals. U.S. EPA, 1981

3. Absorption Factor

Acute toxicity studies in animals indicate that MEK is absorbed from the gastrointestinal (GI) tract. U.S. EPA, 1980 (p. 2)

Quantitative data on the oral absorption of MEK are not available, but absorption from the GI tract can be inferred from systemic toxic effects seen after acute oral administration. U.S. EPA, 1984 (p. 2)

B. Inhalation

1. Carcinogenicity

Data not immediately available.

2. Chronic Toxicity

a. Inhalation Threshold or MPIH

The calculated maximum dose tolerated for subchronic exposure is 2.191 mg/kg/day or 153.4 mg/day for a 70 kg human. An MPIH of 15.3 mg/day was derived by the U.S. EPA based on studies showing a NOAEL (increased SGPT activity; fetal anomalies) in rats and an uncertainty factor of 1000. U.S. EPA, 1984 (p. 11)

b. Effects

Neurotoxic effects have been reported in a worker chronically exposed to MEK; however, total exposure to other compounds in the workplace was not determined. U.S. EPA, 1980 (p. 3)

3. Absorption Factor

Acute toxicity studies in animals indicate that MEK is absorbed from the respiratory tract. U.S. EPA, 1980 (p. 2)

Quantitative data on the pulmonary adsorption of MEK are not available, but adsorption from the lungs can be inferred from systemic toxic effects seen after acute and subchronic inhalation exposures. U.S. EPA, 1984 (p. 2)

4. Existing Regulations

The occupational exposure limit for MEK during a 10-hour workshift has been established at 200 ppm (590 mg/m³) (NIOSH, 1978) U.S. EPA, 1980 (p. 5)

III. PLANT EFFECTS

A. Phytotoxicity

No studies have been encountered concerning the effects of any of the ketonic solvents in plants. U.S. EPA, 1976 (p. 281)

B. Uptake

Because most ketonic solvents are fairly soluble, it appears unlikely that they will bioaccumulate in significant quantities in food chain organisms. Since they are also U.S. EPA, 1976 (p. 155-56)

rapidly attacked by microorganisms, it is unlikely that they will persist in the environment long enough to be taken up by organisms.

IV. DOMESTIC ANIMAL AND WILDLIFE EFFECTS

A. Toxicity

Attempts to induce neuropathy in rats by inhalation or subcutaneous administration have failed.

U.S. EPA, 1980
(p. 3)

Inhalation exposure of pregnant rats to MEK has been shown to produce teratogenic and fetotoxic effects.

U.S. EPA, 1980
(p. iii)

See Table 4-1.

B. Uptake

Data not immediately available.

V. AQUATIC LIFE EFFECTS

A. Toxicity

1. Freshwater

a. Acute

The observed 96-hour LC₅₀ values for the bluegill and mosquito fish are 5640 and 5600 ppm respectively. Inhibition of cell division of the bluegreen alga Microsystis aeruginosa, begins at 110 ppm.

U.S. EPA, 1980
(p. iii)

b. Chronic

Data not immediately available.

2. Saltwater

Data not immediately available.

B. Uptake

Data not immediately available.

VI. SOIL BIOTA EFFECTS

A. Toxicity

Using a mixed microbial culture, the mean tolerance level for MEK is 14 g/L. Many ketones have only a mild and apparently transient inhibitory effect on the growth of E. coli at ketone concentrations of 1×10^{-3} moles/L.

U.S. EPA, 1976
(p. 281)

B. Uptake

Data not immediately available.

VII. PHYSICOCHEMICAL DATA FOR ESTIMATING FATE AND TRANSPORT

Molecular weight: 72.11

U.S. EPA, 1980
(p. 1)

Melting point: -86.4°C

Boiling point: 79.6°C

Vapor pressure: 77.5 mm Hg

Solubility: Very soluble in water

Miscible in alcohol, ether, acetone,
and benzene

Solubility MEK in Water Weight Percent: 26.8

U.S. EPA, 1976
(p. 6)

Solubility Water in MEK Weight Percent: 11.8

Methyl ketones are known to be rapidly attacked by microorganisms, and therefore they are not likely to be around to be taken up by the other organisms.

U.S. EPA, 1976
(p. 155)

Log octanol/water partition coefficient: 0.26

U.S. EPA, 1984
(p. 1)

TABLE 4-1. TOXICITY OF METHYL ETHYL KETONE 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 (20)	MEK	NR ^b	NR	3,980	NR	LD ₅₀ 14 day	U.S. EPA, 1976 (p. 205)
Rat	MEK	NR	NR	3,300	NR	Lethal	
Rat (10)	MEK	NR	NR	5,530	NR	14 day LD ₅₀	
Rat	MEK	NR	NR	0	90 days	No effect	U.S. EPA, 1984 (p. 3)
	MEK	NR	NR	1,250	90 days	No effect	
	MEK	NR	NR	2,500	90 days	Elevated SGPT ^c activity	
	MEK	NR	NR	5,000	90 days	Depressed body weight	
Rat	MEK	NR	NR	200	24 weeks	Slight neurological effects	

^a N = Number of experimental animals when reported.

^b NR = Not reported.

^c SGPT = Liver enzyme.

SECTION 5

REFERENCES

- Abramowitz, M., and I. A. Stegun. 1972. Handbook of Mathematical Functions. Dover Publications, New York, NY.
- Camp Dresser and McKee, Inc. 1984. Development of Methodologies for Evaluating Permissible Contaminant Levels in Municipal Wastewater Sludges. Draft. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.
- Donigian, A. S., 1985. Personal Communication. Anderson-Nichols & Co., Inc., Palo Alto, CA. May.
- Freeze, R. A., and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, NJ.
- Gelhar, L. W., and G. J. Axness. 1981. Stochastic Analysis of Macrodispersion in 3-Dimensionally Heterogenous Aquifers. Report No. H-8. Hydrologic Research Program, New Mexico Institute of Mining and Technology, Socorro, NM.
- Gerritse, R. G., R. Vriesema, J. W. Dalenberg and H. P. DeRoos. 1982. Effect of Sewage Sludge on Trace Element Mobility in Soils. J. Environ. Qual. 2:359-363.
- Griffin, R. A. 1984. Personal Communication to U.S. Environmental Protection Agency, ECAO - Cincinnati, OH. Illinois State Geological Survey.
- Pettyjohn, W. A., D. C. Kent, T. A. Prickett, H. E. LeGrand, and F. E. Witz. 1982. Methods for the Prediction of Leachate Plume Migration and Mixing. U.S. EPA Municipal Environmental Research Laboratory, Cincinnati, OH.
- Sikora, L. J., W. D. Burge, and J. E. Jones. 1982. Monitoring of a Municipal Sludge Entrenchment Site. J. Environ. Qual. 2(2):321-325.
- Sosulski, F., and R. M. Mahmoud. 1979. Effect of Protein Supplement on Carbonyl Compounds and Flavor in Bread. Cereal Chemistry 56(6):533-536.
- U.S. Environmental Protection Agency. 1976. Investigation of Selected Potential Environmental Contaminants: Ketonic Solvents. EPA-560/2-76-003. Office of Toxic Substances, Washington, D.C.
- U.S. Environmental Protection Agency. 1977. Environmental Assessment of Subsurface Disposal of Municipal Sludge: Interim Report. EPA/530/SW-547. Municipal Environmental Research Laboratory, Cincinnati, OH.

- U.S. Environmental Protection Agency. 1980. Methyl Ethyl Ketone: Hazard Profile. Environmental Criteria and Assessment Office, Cincinnati, OH. April 15.
- U.S. Environmental Protection Agency. 1981. Advisory Opinion for Methyl Ethyl Ketone. U.S. Environmental Protection Agency. November 19.
- U.S. Environmental Protection Agency. 1983. Rapid Assessment of Potential Groundwater Contamination Under Emergency Response Conditions. EPA 600/8-83-030.
- U.S. Environmental Protection Agency. 1984. Health Effects Assessment for Methyl Ethyl Ketone. ECAO-CIN-H003. Environmental Criteria and Assessment Office, Cincinnati, OH. 18pp.

APPENDIX

PRELIMINARY HAZARD INDEX CALCULATIONS FOR METHYL ETHYL KETONE 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

A. Procedure

Using Equation 1, several values of C/C_0 for the unsaturated zone are calculated corresponding to increasing values of t until equilibrium is reached. Assuming a 5-year pulse input from the landfill, Equation 3 is employed to estimate the concentration vs. time data at the water table. The concentration vs. time curve is then transformed into a square pulse having a constant concentration equal to the peak concentration, C_u , from the unsaturated zone, and a duration, t_0 , chosen so that the total areas under the curve and the pulse are equal, as illustrated in Equation 3. This square pulse is then used as the input to the linkage assessment, Equation 2, which estimates initial dilution in the aquifer to give the initial concentration, C_0 , for the saturated zone assessment. (Conditions for B , minimum thickness of unsaturated zone, have been set such that dilution is actually negligible.) The saturated zone assessment procedure is nearly identical to that for the unsaturated zone except for the definition of certain parameters and choice of parameter values. The maximum concentration at the well, C_{max} , is used to calculate the index values given in Equations 4 and 5.

B. Equation 1: Transport Assessment

$$\frac{C(\chi, t)}{C_0} = \frac{1}{2} [\exp(A_1) \operatorname{erfc}(A_2) + \exp(B_1) \operatorname{erfc}(B_2)] = P(\chi, t)$$

Requires evaluations of four dimensionless input values and subsequent evaluation of the result. $\exp(A_1)$ denotes the exponential of A_1 , e^{A_1} , where $\operatorname{erfc}(A_2)$ denotes the complimentary error function of A_2 . $\operatorname{Erfc}(A_2)$ produces values between 0.0 and 2.0 (Abramowitz and Stegun, 1972).

where:

$$A_1 = \frac{\chi}{2D^*} [V^* - (V^{*2} + 4D^* \times \mu^*)^{\frac{1}{2}}]$$

$$A_2 = \frac{\chi - t (v^*^2 + 4D^* \times \mu^*)^{\frac{1}{2}}}{(4D^* \times t)^{\frac{1}{2}}}$$

$$B_1 = \frac{\chi}{2D^*} [v^* + (v^*^2 + 4D^* \times \mu^*)^{\frac{1}{2}}]$$

$$B_2 = \frac{\chi + t (v^*^2 + 4D^* \times \mu^*)^{\frac{1}{2}}}{(4D^* \times t)^{\frac{1}{2}}}$$

and where for the unsaturated zone:

C_o = SC x CF = Initial leachate concentration ($\mu\text{g/L}$)

SC = Sludge concentration of pollutant (mg/kg DW)

CF = 250 kg sludge solids/ m^3 leachate =

$$\frac{PS \times 10^3}{1 - PS}$$

PS = Percent solids (by weight) of landfilled sludge = 20%

t = Time (years)

χ = h = Depth to groundwater (m)

D^* = $\alpha \times v^*$ (m^2/year)

α = Dispersivity coefficient (m)

$$v^* = \frac{Q}{\theta \times R} \text{ (m/year)}$$

Q = Leachate generation rate (m/year)

θ = Volumetric water content (unitless)

$$R = 1 + \frac{P_{dry}}{\theta} \times K_d = \text{Retardation factor (unitless)}$$

P_{dry} = Dry bulk density (g/mL)

K_d = $f_{oc} \times K_{oc}$ (mL/g)

f_{oc} = Fraction of organic carbon (unitless)

K_{oc} = Organic carbon partition coefficient (mL/g)

$$\mu^* = \frac{365 \times \mu}{R} \text{ (years)}^{-1}$$

μ = Degradation rate (day^{-1})

and where for the saturated zone:

C_o = Initial concentration of pollutant in aquifer as determined by Equation 2 ($\mu\text{g/L}$)

t = Time (years)

χ = Δl = Distance from well to landfill (m)

D^* = $\alpha \times v^*$ (m^2/year)

α = Dispersivity coefficient (m)

$$v^* = \frac{K \times i}{\phi \times R} \text{ (m/year)}$$

K = Hydraulic conductivity of the aquifer (m/day)

i = Average hydraulic gradient between landfill and well (unitless)

ϕ = Aquifer porosity (unitless)

$$R = 1 + \frac{P_{dry}}{\phi} \times K_d = \text{Retardation factor} = 1 \text{ (unitless)}$$

since $K_d = f_{oc} \times K_{oc}$ and f_{oc} is assumed to be zero for the saturated zone.

C. Equation 2. Linkage Assessment

$$C_o = C_u \times \frac{Q \times W}{365 [(K \times i) \div \phi] \times B}$$

where:

C_o = Initial concentration of pollutant in the saturated zone as determined by Equation 1 ($\mu\text{g/L}$)

C_u = Maximum pulse concentration from the unsaturated zone ($\mu\text{g/L}$)

Q = Leachate generation rate (m/year)

W = Width of landfill (m)

K = Hydraulic conductivity of the aquifer (m/day)

i = Average hydraulic gradient between landfill and well (unitless)

ϕ = Aquifer porosity (unitless)

B = Thickness of saturated zone (m) where:

$$B \geq \frac{Q \times W \times \phi}{K \times i \times 365} \text{ and } B \geq 2$$

D. Equation 3. Pulse Assessment

$$\frac{C(\chi, t)}{C_o} = P(\chi, t) \text{ for } 0 \leq t \leq t_o$$

$$\frac{C(\chi, t)}{C_o} = P(\chi, t) - P(\chi, t - t_o) \text{ for } t > t_o$$

where:

t_o (for unsaturated zone) = LT = Landfill leaching time (years)

t_o (for saturated zone) = Pulse duration at the water table ($\chi = h$) as determined by the following equation:

$$t_o = \left[\int_0^\infty C \, dt \right] \div C_u$$

$$P(\chi, t) = \frac{C(\chi, t)}{C_o} \text{ as determined by Equation 1}$$

E. Equation 4. Index of Groundwater Concentration Resulting from Landfilled Sludge (Index 1)

1. Formula

$$\text{Index 1} = C_{\max}$$

where:

C_{\max} = Maximum concentration of pollutant at well = maximum of $C(\Delta l, t)$ calculated in Equation 1 ($\mu\text{g/L}$)

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

F. Equation 5. Index of Human Toxicity Resulting from Groundwater Contamination (Index 2)

1. Formula

$$\text{Index 2} = \frac{(I_1 \times AC) + DI}{RSI}$$

where:

I_1 = Index 1 = Index of groundwater concentration resulting from landfilled sludge ($\mu\text{g/L}$)

AC = Average human consumption of drinking water (L/day)

DI = Average daily human dietary intake of pollutant ($\mu\text{g/day}$)

ADI = Acceptable daily intake of pollutant ($\mu\text{g/day}$)

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

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

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.