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16. ABSTRACT

This report summarizes and evaluates information relevant to a preliminary interim assessment of adverse health effects associated with specific chemicals or compounds. The Office of Emergency and Remedial Response (Superfund) uses these documents in preparing cost-benefit analyses under Executive Order 12991 for decision-making under CERCLA. All estimates of acceptable intakes and carcinogenic potency presented in this document should be considered as preliminary and reflect limited resources allocated to this project. The intent in these assessments is to suggest acceptable exposure levels whenever sufficient data are available. The interim values presented reflect the relative degree of hazard associated with exposure or risk to the chemical(s) addressed. Whenever possible, two categories of values have been estimated for systemic toxicants (toxicants for which cancer is not the endpoint of concern). The first, RfD_S or subchronic reference dose, is an estimate of an exposure level that would not be expected to cause adverse effects when exposure occurs during a limited time interval. The RfD is an estimate of an exposure level that would not be expected to cause adverse effects when exposure occurs for a significant portion of the lifespan. For compounds for which there is sufficient evidence of carcinogenicity, q_1^*s have been computed, if appropriate, based on oral and inhalation data if available.

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HEALTH EFFECTS ASSESSMENT FOR CREOSOTE

ENVIRONMENTAL CRITERIA AND ASSESSMENT OFFICE
OFFICE OF HEALTH AND ENVIRONMENTAL ASSESSMENT
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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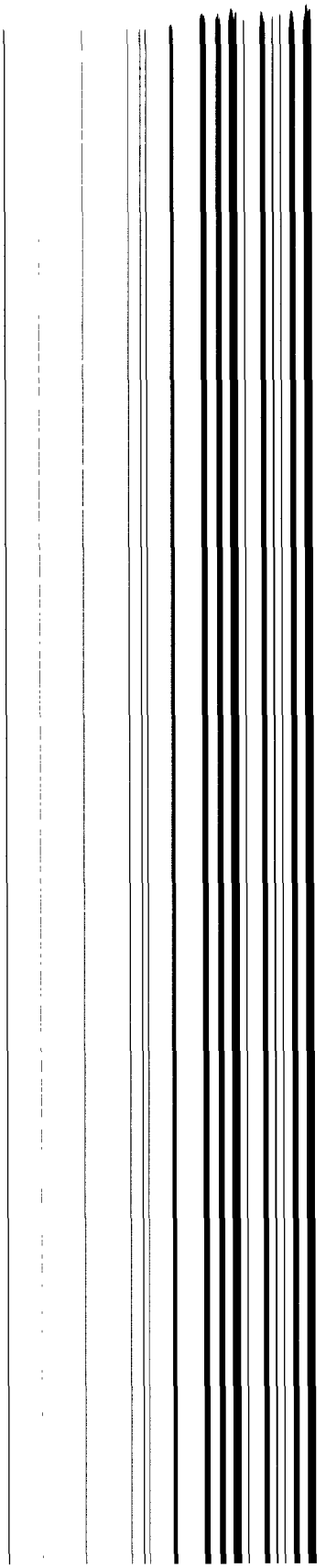
PREFACE

This report summarizes and evaluates information relevant to a preliminary interim assessment of adverse health effects associated with creosote and compounds. All estimates of acceptable intakes and carcinogenic potency presented in this document should be considered preliminary and reflect limited resources allocated to this project. Pertinent toxicologic and environmental data were located through on-line literature searches of the TOXLINE and the CHEMFATE/DATALOG data bases. The basic literature searched



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PREFACE

This report summarizes and evaluates information relevant to a preliminary interim assessment of adverse health effects associated with creosote and compounds. All estimates of acceptable intakes and carcinogenic potency presented in this document should be considered preliminary and reflect limited resources allocated to this project. Pertinent toxicologic and environmental data were located through on-line literature searches of the TOXLINE and the CHEMFATE/DATALOG data bases. The basic literature searched supporting this document is current up to May, 1986. Secondary sources of information have also been relied upon in the preparation of this report and represent large-scale health assessment efforts that entail extensive peer and Agency review. The following Office of Health and Environmental Assessment (OHEA) sources have been extensively utilized:

U.S. EPA. 1980a. Hazard Profile for Creosote. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste, Washington, DC.

U.S. EPA. 1980b. Ambient Water Quality Criteria Document for Polynuclear Aromatic Hydrocarbons. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Water Regulations and Standards, Washington, DC. EPA 440/5-80-069. NTIS PB 81-117806.

The intent in these assessments is to suggest acceptable exposure levels for noncarcinogens and risk cancer potency estimates for carcinogens whenever sufficient data were available. Values were not derived or larger uncertainty factors were employed when the variable data were limited in scope tending to generate conservative (i.e., protective) estimates. Nevertheless, the interim values presented reflect the relative degree of hazard or risk associated with exposure to the chemical(s) addressed.

Whenever possible, two categories of values have been estimated for systemic toxicants (toxicants for which cancer is not the endpoint of concern). The first, RfD_S (formerly AIS) or subchronic reference dose, is an estimate of an exposure level that would not be expected to cause adverse effects when exposure occurs during a limited time interval (i.e., for an interval that does not constitute a significant portion of the lifespan). This type of exposure estimate has not been extensively used, or rigorously defined, as previous risk assessment efforts have been primarily directed towards exposures from toxicants in ambient air or water where lifetime exposure is assumed. Animal data used for RFD_S estimates generally include exposures with durations of 30-90 days. Subchronic human data are rarely available. Reported exposures are usually from chronic occupational exposure situations or from reports of acute accidental exposure. These values are developed for both inhalation (RfD_{SI}) and oral (RfD_{SO}) exposures.

The RfD (formerly AIC) is similar in concept and addresses chronic exposure. It is an estimate of an exposure level that would not be expected to cause adverse effects when exposure occurs for a significant portion of the lifespan [see U.S. EPA (1980) for a discussion of this concept]. The RfD is route-specific and estimates acceptable exposure for either oral (RfD_O) or inhalation (RfD_I) with the implicit assumption that exposure by other routes is insignificant.

Composite scores (CSs) for noncarcinogens have also been calculated where data permitted. These values are used for identifying reportable quantities and the methodology for their development is explained in U.S. EPA (1983).

For compounds for which there is sufficient evidence of carcinogenicity RfD_S and RfD values are not derived. For a discussion of risk assessment methodology for carcinogens refer to U.S. EPA (1980). Since cancer is a process that is not characterized by a threshold, any exposure contributes an increment of risk. For carcinogens, q_1*s have been computed, if appropriate, based on oral and inhalation data if available.

ABSTRACT

In order to place the risk assessment evaluation in proper context, refer to the preface of this document. The preface outlines limitations applicable to all documents of this series as well as the appropriate interpretation and use of the quantitative estimates presented.

Creosote, a coal tar distillate containing a mixture of PAH, is considered to be a carcinogen by IARC (1985) and U.S. EPA (1978). Since dose-response data sufficient to calculate q_1^* values are not available, no risk assessment values could be derived. Risk estimates for carcinogenic PAHs, which are a component of creosote, are presented.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

CAS	Chemical Abstract Service
PAH	Polynuclear aromatic hydrocarbons
PEL	Permissable exposure level
ppm	Parts per million
RPAR	Rebuttable Presumption Against Registration
SMSA	Standard metropolitan statistical area
TLV	Threshold limit value
TWA	Time-weighted average

1. ENVIRONMENTAL CHEMISTRY AND FATE

The term creosote has been applied to two complex mixtures of organic compounds. CAS Registry number 8001-58-9 is applied to material derived from the distillation of coal tar. This product has had many uses and potential exists for the contamination of the environment. Its current use is restricted to the preservation of wood. CAS Registry number 8021-39-4 is applied to a wood-derived product. There are virtually no data available regarding the toxicity of the wood-derived product and it is not considered further in this document.

Creosote is an extremely complex mixture of compounds. The composition of this mixture varies depending upon the temperature during coal tar production and the source of the coal used (U.S. EPA, 1982). Most of the 200 or more compounds in creosote are PAH. The major PAH in creosote listed in Table 1-1 generally constitute at least 75% of creosote (Lorenz and Gjovik, 1972). In addition to the aromatic hydrocarbons, creosote also contains smaller amounts of phenolic constituents as well as nitrogen-, oxygen- and sulfur-containing heterocyclic ring compounds and aromatic amines (U.S. EPA, 1982). The physical properties of creosote vary depending on the method of distillation. The physical properties of a typical creosote are as follows:

Moisture content	trace
Benzene insoluble content	0.99%
Coke residue content	1.95%
Specific gravity at 38/15.5°C	1.102%
Distillation at 355°C	72.58%
Residue at >355°C	26.67%
Distillation loss at 355°C	0.75%

Creosote is immiscible in water (Hawley, 1981). The half-lives of creosote in air, water and soil could not be located in the available literature.

TABLE 1-1

Major Components in Creosote*

Component	Percentage of Whole Creosote (±0.07%)
Phenanthrene + anthracene	17.4-23.0
Fluoranthene	7.6-10.0
Fluorene	7.3-10.0
Acenaphthene	9.0-14.7
Pyrene	7.0-8.5
Dibenzofuran	5.0-7.5
Methyl anthracenes and methyl phenanthrenes	3.9-7.0
Naphthalene	1.3-3.0
Methylfluorenes	2.3-3.0
Chrysene	2.6-3.0
Dimethylnaphthalenes	2.0-2.3
Carbazole	1.2-2.0
Benzofluorenes	1.0-2.0
2-Methylnaphthalene	1.2-2.8
1-Methlynaphthalene	0.9-1.7
Biphenyl	0.8-1.6

*Source: Lorenz and Gjovik, 1972

It has been suggested that decomposition by microfaunal metabolism is a major factor in the degradation of creosote compounds in aquatic systems (Borthwick and Patrick, 1982). In addition, the high molecular weight PAH and azoarene constituents of creosote are expected to bioaccumulate in aquatic organisms and adsorb to suspended solids and sediments in water. In soil, these components are expected to be relatively immobile. In both water and soil, some of the high molecular weight components of creosote are expected to persist for a long time. The possibility of inhalation and dermal exposure to creosote for applicators of creosote and creosote/coal tar wood preservatives has been evaluated by U.S. EPA (1982). U.S. EPA (1982) concluded that there are no adequate quantitative inhalation or dermal exposure data available for the general population or those occupationally exposed to creosote.

2. ABSORPTION FACTORS IN HUMANS AND EXPERIMENTAL ANIMALS

Pertinent data regarding the quantitative absorption of creosote could not be located in the available literature. Specific PAH, such as benz(a)-anthracene, chrysene, 7,12-dimethylbenz(a)anthracene, benz(a)pyrene and 3-methylcholanthrene, that are found in creosote are absorbed by the lungs (Vainio et al., 1976) and from the gastrointestinal tract (Rees et al., 1971).

3. TOXICITY IN HUMANS AND EXPERIMENTAL ANIMALS

Pertinent data regarding the effects of creosote following subchronic or chronic exposure by oral or inhalation routes could not be located in the available literature. In addition, data regarding teratogenic or other reproductive effects following either route of exposure, or data regarding toxicant interactions could not be located in the available literature.

4. CARCINOGENICTY

4.1. HUMAN DATA

Individuals dermally exposed to creosote in occupational settings have developed cancer (Section 4.3.).

4.1.1. Oral. Dusich et al. (1980) found that the breast cancer rates for females in a Minneapolis suburb were significantly elevated ($p<0.0005$) over those in nearby municipalities and in the SMSA. Some of the wells supplying drinking water for the suburb were known to have been contaminated with creosote. The available information does not allow evaluation of the association between breast cancer and creosote exposure.

4.1.2. Inhalation. Pertinent data regarding the carcinogenic potential of creosote in humans following inhalation exposure could not be located in the available literature.

4.2. BIOASSAYS

Pertinent data regarding the carcinogenic potential of creosote in laboratory animals following oral or inhalation exposure could not be located in the available literature. Studies concerning carcinogenicity following dermal application of creosote are summarized in Section 4.3.

4.3. OTHER RELEVANT DATA

A number of cases of skin carcinoma in humans exposed chronically to creosote have been reported. These reports were summarized by NCI (1985) as follows:

> Mackenzie (1898) reported papillomas, which were "likely to become epitheliomatous," on the forearms and scrotum of a man who was employed for 30 years treating railway ties with creosote. O'Donovan (1920) described the cases of three men who treated wood with creosote and had subsequently developed skin cancer. Cookson (1924) reported a case of squamous cell carcinoma of the right hand in a 66-year-old man who had worked in a creosote factory handling treated lumber for 33 years. A post-mortem examination revealed apparent metastases in the lungs, liver, kidney, heart and axillary

lymph glands. A similar case of squamous papillomas on the hands, forearms, arms and thighs was reported in a man exposed to creosote during log impregnation (Haldin-Davis, 1935). Lenson (1956) reported carcinoma of the face and papillomas of the hands and neck in a man exposed to creosote while painting planks and scows in a shipyard. Exposure was for about 3 years and carcinoma developed about 5 years after exposure was terminated. This man was a painter for 41 years and was exposed to lead-based paints and paint solvents. Henry (1947) reported that 37 of 753 cases of dermal epithelioma could be linked to occupational creosote exposure. Fourteen cases occurred among lumber treaters, 9 among creosote storage workers, 10 among brick workers where creosote was used as a releasing agent, and one case each in workers exposed to creosote in a crucible furnace, disinfectant manufacture, a railway worker and a tar distillery chemist. Recent analytical epidemiologic data relating exposure levels and duration of exposure to creosote with skin or lung cancers are not available.

Creosote has also been shown to be carcinogenic in mice following repeated skin exposure. These studies are summarized in Table 4-1.

The NCI (1985) summary of mutagenicity studies of creosote is presented below:

Creosote was mutagenic in the Salmonella typhimurium assay in tester strains TA100, TA98, TA1538 and TA1537 (Bos et al., 1983). Strain TA1535 showed no increase in the number of revertants per plate. Creosote was an effective mutagen only when a rat liver microsomal preparation was supplied, thus indicating the requirement for metabolism to occur prior to expression of mutagenic activity. Creosote was also reported to be mutagenic in S. typhimurium strains TA1537, TA98 and TA100 and Escherichia coli WP2 strain (Simmon and Poole, 1978). Mitchell and Tajiri (1978) reported creosote to be mutagenic to mouse lymphoma cells (L5178Y) with increasing activity following metabolic activation. Bos et al. (1984) demonstrated the presence of mutagenic substances in the work environment of a creosote-wood treating facility. Despite the presence of creosote, the urine of workers showed no mutagenic activity during a 10-day test period. Environmental samples of creosote residues, liquid creosote, and the urine from rats exposed to creosote by intraperitoneal injection showed mutagenic activity in S. typhimurium strains TA98 and TA100 when a metabolic activation system was provided.

TABLE 4-1

Carcinogenicity of Creosote in Mice Following Dermal Application

Compound Tested	Strain/Sex	Dose	Duration of Study (weeks)	Tumor Type and Response*	Reference
Creosote and benzo(a)pyrene	strain A/NR	painted 3 times/week with B(a)P 0.05% and 1% creosote	51	accelerated tumor formation in 19/20 mice	Sall et al., 1940
#1 Creosote oil	Swiss/F	painted 2 times/week undiluted creosote oil	70	13/30 females developed skin tumors; majority were carcinomas	Lijinsky et al., 1957
Creosote	C57L/F	0.009 mℓ, 80 or 20% creosote, 3 days/week	≤44	skin tumors in all treated mice (8) at both doses; 7/8 tumors in both groups were epidermal cancer	Poel and Kammer, 1957
	C57L/M	0.009 mℓ, 50% creosote, 3 days/week	≤44	11/11 developed skin tumors	Poel and Kammer, 1957
Creosote	albino, random bred/NR	25 µℓ 2 times/week	28	skin tumors within 18 weeks affected 82% of treated mice	Boutwell and Bosch, 1958; U.S. EPA, 1980a; NCI, 1985
Creosote	NA	NA	NA	176 lung adenomas in 47 treated mice, 315 lung adenomas in 29 treated mice housed in creosote-treated cages	Roe et al., 1958; U.S. EPA, 1980a; NCI, 1985

*Control data were not presented for any of these experiments in the secondary sources from which these data were taken.

NA = Not available; NR = not reported

4.4. WEIGHT OF EVIDENCE

Adequate studies examining the carcinogenic potential of creosote by the oral or inhalation routes of exposure could not be located in the available literature. One study involving exposure of humans to creosote-contaminated well water was considered inadequate (Dusich et al., 1980). The only animal carcinogenicity studies on creosote available are dermal studies using mice; these studies indicate that creosote is a carcinogen. Also case reports of humans occupationally exposed to creosote also indicate that creosote is carcinogenic. In addition, some of the PAH components of creosote (e.g., benz(a)anthracene and benzo(a)pyrene) are known to be carcinogenic.

From this information, IARC (1985) stated that there is sufficient evidence for the carcinogenicity of creosote in laboratory animals and limited evidence for the carcinogenicity in humans. The evidence is sufficient to place creosote in Group B1, probable human carcinogen, according to the EPA (U.S. EPA, 1986) classification scheme.

5. REGULATORY STANDARDS AND CRITERIA

As a result of RPAR proceedings, U.S. EPA (1984a) published a proposed intent to cancel registration of creosote for all uses except as a wood preservative. Under this proposal, creosote cannot be used as a herbicide, fungicide (on canvas and rope), disinfectant, larvacide, insecticide or repellent. As stated in U.S. EPA (1984b), creosote can be used only by certified applicators, and a consumer awareness program recommends against the use of treated wood in contact with food, feed and drinking water. Creosote-coated products are also not to be used indoors.

No standards or criteria have been instituted for creosote. OSHA (1985) lists 0.2 mg/m^3 as the PEL for coal tar pitch volatiles (benzene soluble fraction), anthracene, benzo(a)pyrene, phenanthrene, acridine, chrysene and pyrene. These compounds are also found in creosote. ACGIH (1986) lists 0.2 mg/m^3 as the TLV-TWA for the benzene soluble fraction of coal tar pitch volatiles and lists the class as a recognized human carcinogen.

An ambient water quality criteria of 28 ng/ℓ for the 10^{-5} risk level for PAH compounds, based on the carcinogenic potential of benzo(a)pyrene, has been derived (U.S. EPA, 1980b). Because creosote contains a mixture of PAH compounds, this value could be applied to creosote contaminated water.

6. RECOMMENDATIONS

U.S. EPA (1984b) reported that creosote poses a significant risk of oncogenicity to humans and developed regulations to limit exposure. The dermal studies in mice and the human case reports that are available do not provide quantitative data by a relevant route of exposure. Because of the lack of quantitative data, q_1^* values for oral and inhalation exposure cannot be calculated.

Epidemiological studies of humans occupationally exposed to creosote may provide information about the carcinogenic potency of creosote; however, the exposure route and dose would be difficult to define in these studies.

Long-term cancer studies of creosote in laboratory animals would provide additional information that may be useful for quantitative risk assessment and permit promulgation of criteria and regulations. A large variable in these studies would be the high variability in the components of creosote. Studies of creosote from one source may not provide accurate risk estimates for creosote from a different source. The oral route of exposure should be the primary route investigated, although inhalation exposure also occurs, particularly in wood-treating facilities.

U.S. EPA (1980a) noted that creosote consists of liquid and solid cyclic hydrocarbons and "substantial" amounts of naphthalene and anthracene, 12-14% phenanthrene and 200 ppm benz(a)pyrene. U.S. EPA (1980b) based ambient water quality criteria for PAH on a q_1^* of 11.53 $(mg/kg/day)^{-1}$ for benz-(a)pyrene. Lacking more definitive quantitative data on the carcinogenic potency of creosote, the q_1^* of 11.53 $(mg/kg/day)^{-1}$ for PAH may be considered for creosote pending further testing with creosote itself.

U.S. EPA (1982) noted that creosote contains several known carcinogens as well as related chemicals that may act as cocarcinogens, initiators, promoters, potentiators or inhibitors of carcinogenesis. U.S. EPA (1982) concluded that analysis of the carcinogenic potency of individual components of creosote is not appropriate for predicting the carcinogenicity of creosote as a whole because of the possibility of synergism of the components.

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