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2.1 BACKGROUND AND ENVIRONMENTAL EXPOSURES TO CREOSOTE IN THE UNITED STATES

This profile addresses several substances: wood creosotes, coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles. Figure 2-1 shows how these substances are produced.

Creosote has been identified in at least 46 of the 1,613 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL). However, the number of sites evaluated for creosote is not known. Of these sites, all 46 are located within the United States.

2.1.1 Wood Creosotes

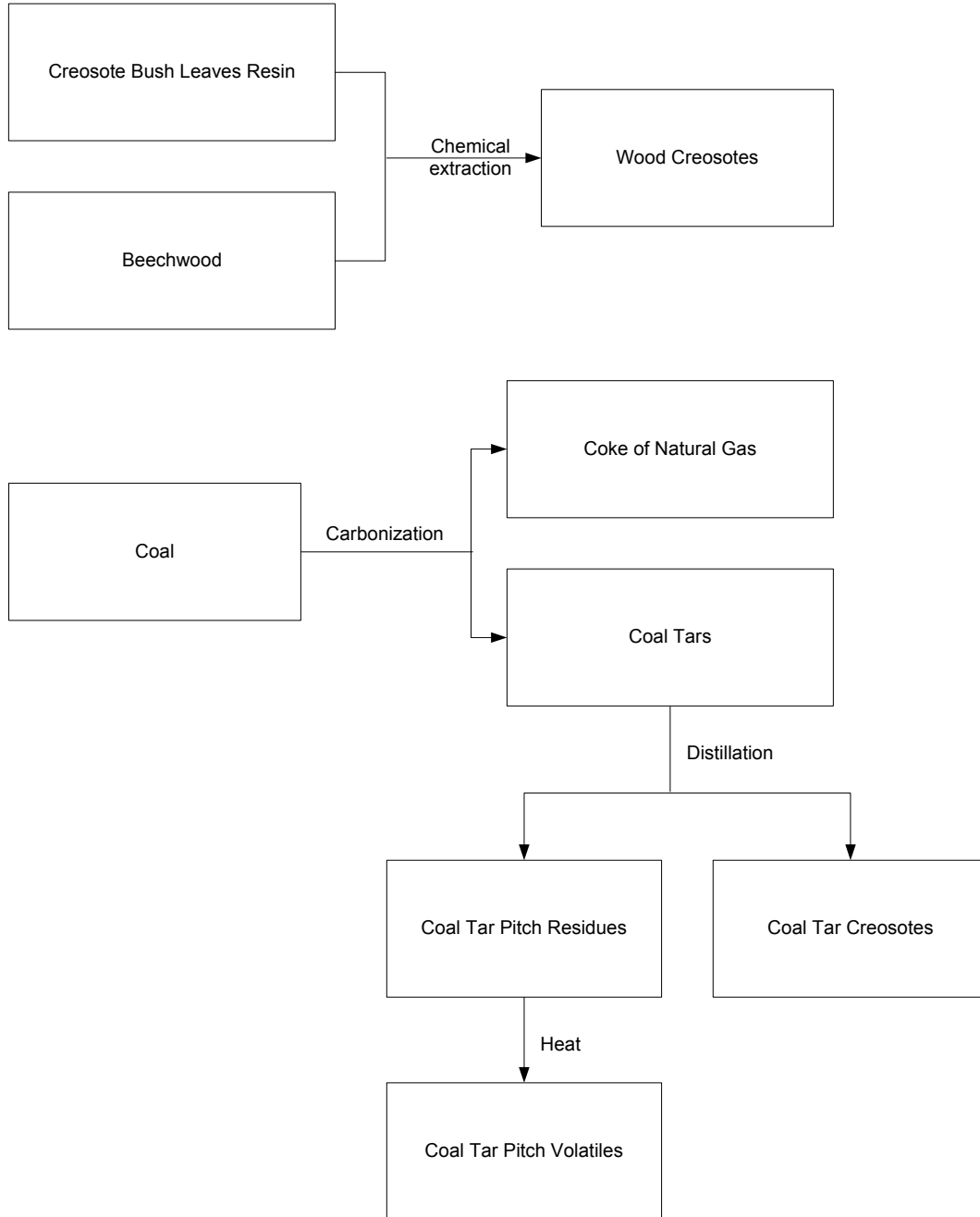
Wood creosotes are derived from the resin from leaves of the creosote bush (*Larrea*, referred to herein as creosote bush resin) and beechwood (*Fagus*, referred to herein as beechwood creosote). Creosote bush resin consists of phenolic (e.g., flavonoids and nordihydroguaiaretic acid), neutral (e.g., waxes), basic (e.g., alkaloids), and acidic (e.g., phenolic acids) compounds. The phenolic portion comprises 83–91% of the total resin, while nordihydroguaiaretic acid accounts for 5–10% of the dry weight of the leaves. Extracts of the creosote bush are used in homeopathic medicine, and the leaves are used to make an infusion called chaparral. Beechwood creosote consists mainly of phenol, cresols, guaiacol, xylanol, and cresol. It is a colorless or pale yellowish liquid, and has a characteristic smoky odor and burnt taste. It had therapeutic applications in the past as a disinfectant, laxative, and stimulating expectorant, but it is not a major pharmaceutical ingredient today in the United States. Exposure to wood creosotes appears to be confined to dermal contact with the plants and ingestion of plant extracts such as chaparral.

2.1.2 Coal Tar and Coal Tar Products

Coal tars are by-products of the carbonization of coal to produce coke and/or natural gas. Coal tar creosotes are distillation products of coal tar, while coal tar pitch is a residue produced during the distillation of coal tar. Coal tar pitch volatiles are compounds given off from coal tar pitch when it is heated. Coal tar creosotes, coal tar, coal tar pitch, and coal tar pitch volatiles are composed of many

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Figure 2-1. Origin of Wood Creosotes and Coal Tar Products



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individual compounds of varying physical and chemical characteristics. In addition, the composition of each, although referred to by specific name (e.g., coal tar creosote) is not consistent. For instance, the components and properties of the mixture depend on the temperature of the destructive distillation (carbonization) and on the nature of the carbon-containing material used as a feedstock for combustion.

Usually, coal tars are viscous liquids or semisolids that are black or dark brown with a naphthalene-like odor. Coal tars are complex combinations of polycyclic aromatic hydrocarbons (PAHs), phenols, heterocyclic oxygen, sulfur, and nitrogen compounds. PAH composition of coal tars is variable. Analyses of PAHs in four coal tar samples revealed 2- to 20-fold differences in concentration of selected PAHs among the samples. For example, benzo[a]pyrene ranged from nondetectable levels to 1.7, 3.9, and 6.4 g/kg of coal tar. By comparison, coal tar creosotes have an oily liquid consistency and range in color from yellowish-dark green to brown. The coal tar creosotes consist of PAHs and PAH derivatives. At least 75% of the coal tar creosote mixture is PAHs. Coal tar pitch is a shiny, dark brown-to-black residue that contains PAHs and their methyl and polymethyl derivatives, as well as heteronuclear compounds. Coal tar creosote, coal tar, and coal tar products are used as wood preservatives, herbicides, fungicides, insecticides, and disinfectants. Volatile components of the coal tar pitch can be given off during operations involving coal tar pitch, including transporting, and in the coke, aluminum, and steel industries.

There are no known natural sources of coal tar creosote. Coal tar creosote has been widely used as a wood-treatment pesticide since the turn of the 20th century, and workers in the wood-preserving industry have been exposed to coal tar creosote by the dermal and inhalation routes. Potential sources of non-occupational human exposure to coal tar creosote include contact with coal tar creosote-treated wood products (e.g., railroad ties used for landscaping), incineration of coal tar creosote-treated scrap lumber, contact with contaminated environmental media at hazardous waste sites (e.g., ingestion of contaminated groundwater), and the use of pharmaceutical products (e.g., shampoos) containing coal tar creosote. The EPA canceled all nonwood uses of coal tar creosote and restricted use of coal tar creosote products to certified applicators in January 1986. No information was found in the available literature regarding ambient atmospheric or water concentrations of coal tar creosote-derived components (i.e., PAHs) in the United States. PAHs have been measured in surface and subsurface soils around abandoned coal tar creosote wood treatment facilities at levels ranging from nondetectable to 1,000 ppm. Since coal tar creosotes are complex mixtures, techniques for relating apparent bioaccumulation or biomagnification in food chains to human health concerns are not well defined. Fish or shellfish directly exposed to coal tar creosote wastes will be tainted by offensive odors and tastes. In addition, fish and shellfish may

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accumulate coal tar creosote constituents at concentrations high enough to prompt public health officials to issue consumption advisories. The potential for human exposure to coal tar creosote is discussed in detail in Chapter 6 of this profile.

2.2 SUMMARY OF HEALTH EFFECTS

2.2.1 Wood Creosotes

Exposure to wood creosotes appears to be confined to ingestion of plant extracts and dermal contact with the plants. Most of the toxicity data for oral exposure to wood creosotes comes from reports of individuals who ingested plant extracts such as chaparral, an herbal extract prepared by grinding leaves of the creosote bush, or “seirogan”, a Japanese folk remedy made with wood creosote that is typically taken for stomachaches.

Several reports suggest that repeated exposure to chaparral is associated with adverse liver effects. There are isolated reports of renal failure, and of cystic renal disease and cystic adenocarcinoma of the kidney in individuals taking chaparral tea for periods ranging from 3 to 10 months. However, because of the limited amount of data, it is not possible to attribute the findings of renal effects to ingestion of chaparral tea. Cases of acute allergic dermatitis from dermal exposure to the creosote bush have been reported.

Information on health effects associated with the use of beechwood creosote is also very limited. It has been observed that the distribution of cancer cases in Japan coincided with “seirogan” production areas, but an association between cancer incidence in Japan and the use of “seirogan” cannot be made with the available data. It should be noted that beechwood creosote doses of up to 394 mg/kg/day in the diet for 96 weeks induced signs of toxicity in rats, but failed to produce treatment-related increases in the incidence of tumors. Organs examined for tumors include testis, ovary, pancreas, breast, thyroid and adrenal glands, lungs, and lymph nodes. Similar results were seen in a 52-week study with mice. In humans, dermal administration of beechwood tar for up to 8 weeks did not impair renal function or produce other adverse effects; however, animal studies suggest that long-term oral exposure to beechwood creosote has the potential to induce adverse effects in the kidney. The available data suggest that hepatic and dermal effects are the main adverse outcomes that result from oral or dermal exposure, respectively, to wood creosotes.

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Hepatic Effects. Icterus, jaundice, abdominal pain, liver failure, acute toxic hepatitis, and elevated serum liver enzymes were among the effects reported in four individuals who repeatedly ingested chaparral capsules (160–1,500 mg chaparral/day) over a period ranging from 6 weeks to 10 months. Liver transplant was required for one of the patients. Elevated liver enzymes returned to normal levels 3–6 weeks after exposure to chaparral was discontinued. Increased liver-to-body weight ratio has been observed in rats and mice orally exposed to beechwood creosote for as little as 3 months. The effect was generally seen at doses >143 mg/kg/day. However, no treatment-related liver histopathological alterations were observed in these animals. These findings are relevant for individuals in the general population who ingest chaparral capsules or chaparral tea.

Dermal Effects. There are reports of seven cases of acute allergic dermatitis following contact with the creosote bush. The patients presented erythematous and vesicular dermatitis of the face, the upper part of the neck, and the backs of the hands. An allergic component to these reactions was confirmed by patch tests. Beechwood creosote has been found to irritate the periapical tissue (the connective tissue surrounding the apex of the tooth) in dogs 7 days after its application. Localized inflammatory changes and occasional abscess formation were observed in these animals. Application of birch tar to the ear of rabbits for 3 weeks was associated with the formation of comedones on the ear. These findings show that members of the general population who come into contact with the creosote bush may develop acute allergic reactions of the skin.

2.2.2 Coal Tar and Coal Tar Products

Exposures to coal tar and coal tar products may take place in industrial and non-industrial settings and can occur through a number of different routes of exposure. Information regarding the adverse human health effects of coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles is available from occupational surveys and retrospective health studies. Unfortunately, the usefulness of many of the occupational studies is hampered by incomplete characterization of worker exposure and the difficulty in ascribing adverse effects to a particular exposure route. Additional health effects information is available from the use of coal tar products in the medical treatment of psoriasis patients. There are no reports of adverse reproductive or developmental outcomes in humans exposed to coal tar and coal tar products. Sperm counts and sperm characteristics were found to be unaffected in workers exposed to coal tar pitch volatiles. Women treated with coal tar for psoriasis or dermatitis (ages at treatment were 18–35 years) did not exhibit an increase in spontaneous abortions or congenital disorders in their offspring. There were no changes in reproductive outcomes, such as number of pregnancies, live, premature, and still births, or

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spontaneous abortions, among women who reside in a housing development built on contaminated land formerly occupied by a coal tar creosote wood treatment plant. Some studies have found adverse developmental effects in animals that were administered coal tar orally during gestation. There is, however, evidence of maternal toxicity in these studies. Estrogenic effects were not seen in mice orally administered coal tar creosote. The available information suggests that increased carcinogenicity risk and adverse dermal and respiratory effects are the most important health concerns related to exposure to coal tar and coal tar products.

Cancer. Studies of workers exposed to coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles in various industrial environments have found increased cancer risk involving a number of tissues including the respiratory tract, skin, lung, pancreas, kidney, scrotum, prostate, rectum, bladder, and central nervous system. Leukemia and lymphoma have also been diagnosed. These adverse effects are not apparent in patients undergoing coal tar therapy. Animal studies have demonstrated the carcinogenic potential of dermally-applied coal tar products. Less typical lesions include the development of cancer of the lip in a group of men involved in fishing net repair. These men typically held a creosote-laden wooden needle in their mouths during their work. Laboratory studies have found increases in mortality due to lung tumors in female Wistar rats exposed to coal tar pitch aerosol for 10 or 20 months. These findings are relevant to workers exposed to coal tar and coal tar products and individuals using coal tar therapeutically.

IARC has classified creosotes as a Group 2A mixture, probable human carcinogen, based on limited human evidence and sufficient animal evidence of carcinogenicity. IARC classified coal tar and coal tar pitches as Group 1 mixtures, carcinogenic to humans, based on sufficient evidence of human and animal carcinogenicity. EPA has classified creosote as a Group B1 probable human carcinogen, based on sufficient evidence from animal studies and limited evidence from human studies.

Dermal Effects. Dermal effects have been documented in populations occupationally and non-occupationally exposed to coal tar and coal tar products. In patients medically treated with 5% coal tar, dermal applications induced a photosensitizing effect in all patients within 30 minutes of treatment. The Texas Department of Health documented an increased incidence of skin rashes among residents of a housing development built on contaminated land formerly occupied by a coal tar creosote wood treatment plant. The rashes were associated with contact with the soil in the housing area. In workers exposed to coal tar and coal tar products, the observed dermal effects appear to be generally limited to unprotected areas such as the hands, face, and neck, including the posterior part of the neck. There is also a report of

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erythematous, papular, and vesicular eruptions seen in the ankle region of men that came in contact with coal tar creosote from freshly coated wood. Most of the chemical burns reported in workers who handled wood treated with coal tar creosote are mild; however, the remainder can lead to subsequent pigmentation and desquamation. Dermal irritation, burning, erythema, dry peeling skin on the face and neck with irritation, and folliculitis on the forearms have been reported in workers handling creosote-treated wood. The symptoms appeared to worsen on hot sunny days, which suggests a phototoxic effect. Similar effects were seen in workers exposed to coal tar pitch and coal tar. A skin lesion classified as a benign squamous cell papilloma was diagnosed in a man who was “heavily exposed” while dipping wood in coal tar creosote tanks. In laboratory animals, skin irritation and the formation of comedones have been observed following short-term dermal exposure to coal tar creosote.

Respiratory Effects. Workers using coal tar and coal tar creosote in wood preservative plants exhibited mild to moderate pulmonary restrictive and obstructive deficits. There did not appear to be large differences between smokers and nonsmokers in the prevalence of these conditions. Adverse respiratory symptoms, including increased morbidity from obstructive lung disease, have also been associated with long-term exposure of workers in an electrode manufacturing plant and in the aluminum industry. A residential survey conducted by the Texas Department of Health as part of a site surveillance program did not detect any adverse respiratory effects among residents of a housing development built on contaminated land formerly occupied by a coal tar creosote wood treatment plant. Studies with animals exposed to vapors of coal tar creosote or coal tar have shown lesions of the olfactory epithelium, histiocytosis of the lung tissue, and chronic fibrosing pneumonitis with peribronchial adenomatosis.

2.3 MINIMAL RISK LEVELS

Minimal Risk Levels (MRLs) for wood creosote, coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles cannot be determined because available data are insufficient for acute, intermediate, and chronic exposures via the oral and inhalation routes. In addition, coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles are extremely complex in their chemical compositions, thereby further complicating the MRL derivation process. The MRL is an estimate of the daily human exposure to a substance (noncarcinogenic) that is likely to be without an appreciable adverse risk over a specified duration of exposure. The primary limitation to deriving the MRL for these agents is that the MRL is, generally, based on measured biological effects of a single substance and not on the effects produced by mixtures of chemicals, which is the chemical nature of the wood creosotes, coal tar creosote, coal tar, and coal tar pitch. As stated in Section 1.1, creosote is a complex mixture originating from high temperature

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treatments of coal tar and beechwood or occurring in the resin of the creosote bush. About 300 chemicals have been identified in coal tar creosote, and there may be 10,000 other chemicals present in the mixture. Creosote derived from plants is composed of various organic compounds including phenols, cresols, and guaiacol.

The derivation of the MRL is further complicated by the variability of the mixture's composition among wood creosote and coal tar creosote samples and the differences in mode of action of the individual components. The mixtures' composition is dependent on the sources and preparation parameters of wood creosote and coal tar creosote and, as a result, the creosote components are rarely consistent in their type and concentration. Hence, toxicological evaluations of one creosote sample, for instance, are most likely inadequate for extrapolation to other creosote samples, unless their compositions are similar. An example of the composition variability among creosote samples was presented by Weyand et al. (1991). In that study, the concentrations of several PAHs were analyzed in four samples of manufactured gas plant (MGP) residue, a form of coal tar. All of the PAHs identified exhibited 2- to nearly 20-fold differences in concentration among the four samples. Benzo[a]pyrene, a component whose individual toxicity has been examined extensively, ranged from nondetectable levels (detection limit 0.3 g/kg) to 1.7, 6.4, and 3.9 g/kg of coal tar. Other studies that illustrate the variability of samples include Wrench and Britten (1975), Niemeier et al. (1988), and Emmett et al. (1981).

The risk assessment of mixtures on human and environmental health is complicated by the paucity of approaches to assess environmental exposures and biological effects of chemical mixtures. Furthermore, the use of single-compound toxicity data to predict the toxicity and health effects of complex mixtures is highly speculative. The difficulty of using single-compound toxicity data to estimate the toxicity of complex mixtures is illustrated by the considerable variation in carcinogenicity of PAHs depending on the components of the mixture (Warshawsky et al. 1993). For instance, when benzo[a]pyrene, a potent animal carcinogen, is added at noncarcinogenic levels to mixtures of carcinogenic or noncarcinogenic PAHs, the skin tumorigenicity of the mixture, as well as the latency of tumor incidence, is changed. Hence, unless the actual complex mixture is evaluated directly for toxicity, it is unlikely that its toxic potency can be interpreted from that of its isolated components.

While there are no MRLs for the mixtures discussed in this profile, the interested reader should refer to Table 8-1 for some regulations and guidelines applicable to coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles.

