8.2 General Toxicity of PAHs

PAHs can potentially cause adverse health effects to humans through several carcinogenic and noncarcinogenic modes of action, but the carcinogenicity of a subset of PAHs most influences human health risk at contaminated soil sites. PAHs can cause cancer not only through the mutagenic properties of their metabolites, which can initiate tumor formation by modifying DNA, but also through their parent compounds, which enhance tumor progression (USEPA 2017f).

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PAHs occur in soils as mixtures, and a relative potency factor (RPF) approach is used to determine the total cancer risk posed by the mixture (USEPA 1993). The RPF approach takes into consideration both the concentrations of the individual carcinogenic PAHs and their comparative cancer potency. Comparative cancer potency of the individual carcinogenic PAHs is expressed relative to an index chemical, which in the case of PAHs is BaP, and is termed its RPF. This approach is conceptually similar to the toxic equivalency factor (TEF) approach used for dioxins. The difference between RPFs and TEFs is that TEFs are intended to apply to all health endpoints, exposure routes, and exposure durations whereas RPFs for PAHs are currently limited to specific health endpoints, exposure routes, and exposure durations (USEPA 2000b). Generally, more data and greater certainty about the mode of action are required for TEFs than RPFs.

USEPA has published provisional guidance for the quantitative risk assessment of PAHs, and estimated the carcinogenic potency of seven potentially carcinogenic PAHs to within an order of magnitude; see Table 8-1 (USEPA 1993). USEPA published a review draft in (2010c) for the development of updated RPFs for PAHs, using more recent data and analysis of both tumorgenicity and genotoxicity for PAHs. The document is available for review purposes and is marked do not cite or quote. Total cancer risk for PAHs in a soil sample is derived by multiplying the concentration of each carcinogenic PAH by its respective RPF to derive its BaP equivalent concentration and then summing the BaP equivalent concentrations for each of the PAHs present to determine a total BaP equivalent concentration in the sample. This concentration can then be used, along with the BaP cancer slope factor and exposure factors appropriate to the exposure scenario of interest, to determine excess cancer risk from PAHs in soil.

In this approach, calculated cancer risk from oral exposure to PAH-contaminated soil is influenced by the bioavailabilities of several potentially carcinogenic PAHs. The bioavailabilities of these PAHs may or may not be the same, and the influence of the bioavailability of any one of these PAHs on risk depends upon how much it contributes to the total BaP-equivalent concentration in soil. Further adding to the complexity, a variety of factors can lead to differing bioavailabilities of these PAHs from site to site, or even from location to location, as discussed in the following section. Table 8-1 summarizes the relative potency factors available as of publication of this guidance. RPFs may be updated in the future, and alternative values may be used outside of the United States.

Table 8-1. PAH relative potency factors (USEPA 1993)

Chemical Name	CAS #	Relative Potency Factors (RPFs)
Benz(a)anthracene	56-55-3	0.1
Benzo(a)pyrene	50-32-8	1.0
Benzo(b)fluoranthene	205-99-2	0.1
Benzo(k)fluoranthene	207-08-9	0.01
Chrysene	218-01-9	0.001
Dibenz(a,h)anthracene	53-70-3	1.0
Indeno(1,2,3-c,d)pyrene	193-39-5	0.1