

Characterization of Contaminants, Environments, and Human Health

CHARACTERIZATION OF CONTAMINANTS

Concentration Units

In environmental science, confusion often arises from the use of the same or similar sounding terms that have different meanings in different contexts. This is especially true when considering the concentrations of air and water contaminants. Both are frequently expressed in terms of a ratio, such as parts per million (ppm) or parts per billion (ppb). However, when used for air contaminants, the units are molar or volume fractions, while when used for water contaminants, they are weight fractions. In order to avoid unnecessary confusion, the concentration units used in this book have appropriate subscripts: ppm_v to indicate parts per million parts of air, a volume ratio, and ppm_w, to indicate parts per million parts of water, a weight ratio. This problem is often avoided altogether by expressing all fluid contaminant concentrations as the weight of contaminant per unit volume (e.g., cubic meter, m³, or liter, L) of fluid. In air, the units generally used are mg/m³ or μg/m³, while in water they are most often mg/L or μg/L.

Air Contaminants

Chemical contaminants can be dispersed in air at normal temperatures and pressures in gaseous, liquid, and solid forms. The latter two represent suspensions of

particles in air, and were given the generic term *aerosols* by Gibbs¹ on the basis of analogy to the term hydrosol, a term already in use to describe disperse systems in water. On the other hand, gases and vapors, which are present as discrete molecules, form true solutions in air. Particles consisting of moderate to high vapor-pressure materials tend to evaporate rapidly, since those small enough to remain suspended in air for more than a few minutes (smaller than about 10 μm) have large surface-to-volume ratios. Evaporation is also enhanced by the Kelvin effect arising from the interaction of surface tension with the curvature of the droplet surface. Some materials with relatively low vapor pressures can have appreciable fractions in both the vapor and aerosol forms simultaneously, and are sometimes referred to as semivolatiles.

Gases and vapors

Once dispersed in air, contaminant gases and vapors generally form mixtures so dilute that their physical properties, such as density, viscosity, enthalpy, etc., are indistinguishable from those of clean air. Such mixtures may be considered to follow ideal gas-law relationships. There is no practical difference between a gas and a vapor, except that the latter is generally considered to be the gaseous phase of a substance that is normally a solid or liquid at room temperature. While dispersed in the air, all gaseous molecules of a given compound are essentially equivalent in their size and capture probabilities by ambient surfaces, respiratory tract surfaces, and contaminant collectors or samplers.

Aerosols

Aerosols, being dispersions of particles in air, have the very significant additional variable of particle size. Size affects particle motion and, hence, the probabilities for physical phenomena, such as coagulation, dispersion, sedimentation, impaction onto surfaces, interfacial phenomena, and light-scattering properties. It is not possible to characterize a given particle by a single size parameter. For example, a particle's aerodynamic properties depend on density and shape as well as linear dimensions, while the effective size for maximal light-scattering is dependent on refractive index and shape.

In some special cases, all of the particles within an aerosol are essentially the same in size. Such aerosols are considered to be monodisperse. Examples are natural pollens and some laboratory-generated aerosols. More typically, aerosols are composed of particles of many different sizes, and hence are called heterodisperse or polydisperse. Different aerosols have different degrees of size dispersion. It is, therefore, necessary to specify at least two parameters in characterizing aerosol size: a measure of central tendency, such as a mean or median, and a measure of dispersion, such as an arithmetic or geometric standard deviation.

Particles generated by a single source or process generally have diameters following a log-normal distribution, i.e., the logarithms of their individual diame-

