Dosages, Demands, and Residuals

The dosage is the amount of chlorine added, the demand is the amount used for oxidation of materials present, and the residual is the amount remaining after oxidation. The relationships between these are shown in Figure 17.5. The residual equals the dosage minus the demand.

Contact time is very important in the disinfection process. In chlorination, increased time of contact results not only in greater destruction of microorganisms but in an increased demand and, if appropriate precursors and free chlorine are present, in an increased amount of various chlorinated by-products.

Chlorine gas, hypochlorous acid, and the hypochlorite ion remaining after the demand is satisfied are collectively termed *free chlorine residuals*. The chloramines and other reactive chlorine forms remaining after the demand is satisfied are referred to as *combined chlorine residuals*. Free chlorine residuals are faster acting than combined residuals, and, for the same concentration and time, the free chlorine residuals have much greater disinfecting capacity than combined residuals, especially for viruses.

As depicted in Figure 17.5, an increase in chlorine dosage results in an equivalent increase in the residual up to a molar ratio of chlorine to ammonia nitrogen of 1:1. The residual formed is predominantly mono- and dichloramine. If the chlorine dosage is increased above this ratio, some nitrogen trichloride will be formed; however, as the dosage is increased, most of the chloramines will be oxidized to nitrogen gases. The oxidation reaction is essentially complete, for any particular point in time, at the minimum dip in the residual curve, which is termed the *breakpoint*. The breakpoint occurs at a chlorine dosage of about $1\frac{1}{2}$ to 2 moles of chlorine per 1 mole of ammonia nitrogen and represents the dosage when the chloramines have been converted to the nitrogen gases. Some of the gases have been identified as free nitrogen, nitrous oxide, and nitrogen trichloride, with free nitrogen being the most predominant. Continued addition of chlorine beyond the breakpoint gives a residual that is predominantly free chlorine.

The breakpoint dosage is very much dependent upon water quality, but for many drinking water supplies it ranges over 4 to 10 mg/ℓ. The desirable residual to be maintained at the farthest tap on the distribution system is at least 0.2 mg/ℓ, all free chlorine. The National Primary Drinking Water Regulations promote such a residual by allowing a reduction in the number of bacteriological samplings if that residual is maintained.

Wastewater chlorination practice will vary with states' policies. Some states utilize a fecal coliform criterion such as 200/100 mℓ. Other states specify a type of residual after a specific contact period. Texas specifies 1.0 mg/ℓ total residual after 20 minutes of contact. Breakpoint chlorination of wastewater is seldom practiced. Dosages of 50–70 mg/ℓ may be necessary to reach breakpoint in many wastewaters, and this renders the effluents highly toxic to much of the aquatic life (Brungs, W. A., 1973).

Chlorine Application

Gaseous chlorine may be dissolved in water using any one of a variety of proprietary chlorinators, and the concentrated solution is then piped to the water stream to be disinfected. Hypochlorites can be added using solution-type feeders. Dry hypochlorites are first dissolved in water in a plastic or clay vessel; the liquid is then decanted off by a solution-type feeder. Some hypochlorites are packaged in polymers to render them amenable to dry feed equipment, but for the usual size of installation these cannot compete economically with gaseous chlorine.

In water and wastewater treatment, prechlorination is the application of chlorine prior to any treatments, whereas postchlorination is chlorination after all treatments. Prechlorination is practiced to control undesirable growth such as might occur in a pipeline aqueduct. Similarly, prechlorination in wastewater treatment might be applied to sewers to control odors that develop as a result of undesirable growth. Postchlorination is sometimes called *terminal disinfection*.

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