

## Iron and Manganese Removal

Iron and manganese in concentrations greater than 0.3 mg/l of iron and 0.05 mg/l of manganese stain plumbing fixtures and laundered clothes. Although discoloration from precipitates is the most serious problem associated with water supplies having excessive iron and manganese, foul tastes and odors can be produced by growth of iron bacteria in water distribution mains. These filamentous bacteria, using reduced iron as an energy source, precipitate iron causing pipe incrustations. Decay of the accumulated bacterial slimes creates offensive tastes and odors.

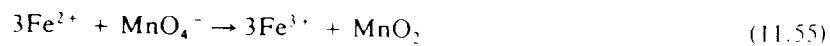
Dissolved iron and manganese are often found in groundwater from wells located in shale, sandstone, and alluvial deposits. Impounded surface-water supplies may also have troubles with iron and manganese. An anaerobic hypolimnion (stagnant bottom-water layer) in a reservoir dissolves precipitated iron and manganese from the bottom muds, and during periods of overturn these minerals are dispersed throughout the entire depth.

### CHEMISTRY OF IRON AND MANGANESE

Iron (II) ( $\text{Fe}^{2+}$ ) and manganese (II) ( $\text{Mn}^{2+}$ ) are chemically reduced, soluble forms that exist in a reducing environment (absence of dissolved oxygen and low pH). These conditions exist in groundwater and anaerobic reservoir water. When it is pumped from underground or an anaerobic hypolimnion, carbon dioxide and hydrogen sulfide are released, raising the pH. In addition, the water is exposed to air, creating an oxidizing environment. The reduced iron and manganese start transforming to their stable, oxidized, insoluble forms of iron (III) ( $\text{Fe}^{3+}$ ) and manganese (IV) ( $\text{Mn}^{4+}$ ).

The rate of oxidation of iron and manganese depends on the type and concentration of the oxidizing agent, pH, alkalinity, organic content, and presence of catalysts [10].

Oxygen, chlorine, and potassium permanganate are the most frequent oxidizing agents. The natural reaction by oxygen is enhanced in water treatment by using spray nozzles or waterfall-type aerators. Chlorine and potassium permanganate ( $\text{KMnO}_4$ ) are the chemicals commonly used in iron and manganese-removal plants. Oxidation reactions using potassium permanganate are



Rates of oxidation of the ions depend on the pH and bicarbonate ion concentration. The pH for oxidation of iron should be 7.5 or higher; manganese oxidizes readily at pH 9.5 or higher. Organic substances (i.e., humic or tannic acids) can create complexes with iron (II) and manganese (II) ions holding them in the soluble state to higher pH levels. If a large concentration