lationships in this section can be used to calculate the approximate stoichiometric quantities.

The most-used coagulant is aluminum sulfate ($Al_2(SO_4)_3 \cdot 14H_2O$). Filter alum is about 17% soluble material. The hydrolysis of the aluminum ion is complex. Assuming that the aluminum floc is $Al(OH)_3$ and the water pH is near neutral, then 1 mg/l of alum with a molecular weight of 600 removes the following quantities:

0.5 mg/l ($CaCO_3$) of natural alkalinity

0.39 mg/l of 95% hydrated lime ($Ca(OH)_2$)

0.33 mg/l of 85% quicklime (CaO)

0.53 mg/l of soda ash (Na_2CO_3)

If the alum has a molecular weight that is different than 600 (due to the variation in the number of waters of hydration), multiply the above quantities by (600/actual molecular weight).

Typical doses of alum are 5 to 50 mg/l, depending on turbidity. Alum flocculation is effective within pH limits of 5.5 to 8.0.

Ferrous sulfate ($FeSO_4 \cdot 7H_2O$), also known as *copperas*, reacts with lime ($Ca(OH)_2$) to flocculate ferric hydroxide ($Fe(OH)_3$). This is an effective method of clarifying turbid waters at higher pH, as in lime softening. 1 mg/l of ferrous sulfate with a molecular weight of 278 will react with 0.27 mg/l of lime.

Ferric sulfate ($Fe_2(SO_4)_3$) reacts with natural alkalinity or lime to create floc. 1 mg/l of ferric sulfate will react with

1.22 mg/l of $Ca(HCO_3)_2$

0.56 mg/l of $Ca(OH)_2$

0.62 mg/l of natural alkalinity (as $CaCO_3$)

Ferric sulfate can be used for color removal at low pH; at high pH, it is useful for iron and manganese removal, as well as a coagulant with precipitation softening.

K. TASTE AND ODOR CONTROL

- **Copper Sulfate Treatment**. This treatment is used in impounding reservoirs, lakes, storage reservoirs, and occasionally in settling basins or treated water, to prevent biological growths. Dosages may vary from 0.5 to 2.0 milligrams per liter; the lower dosage ordinarily suffices for soft water. For very hard water, a dosage above 2.0 milligrams per liter may be used after laboratory tests to determine the necessary algicidal dose. Effects on fish life should be monitored.

- **Aeration**. This process can be used to improve tastes and odors in water where the cause is hydrogen sulfide or the absence of dissolved oxygen. This method has little effect on most tastes and odors.

- **Activated Carbon**. This material removes most tastes and odors. Dosages may vary from 0 5 to 200 milligrams per liter, ordinarily ranging from 2 to 10 milligrams per liter.

- **Superchlorination and Dechlorination**. This treatment will improve tastes and odors caused by organic matter and industrial wastes, especially phenolic wastes. Normally, the dosage required will be several times greater than those for ordinary disinfection (as determined by testing). Provide chlorinating equipment capable of dosing at these high values; allow a minimum of 20 minutes contact time; furnish equipment for dechlorinating with sulfur dioxide or other reducing agent.

- **Chlorine-Ammonia Treatment**. Where chlorosubstitution products cause tastes and odors, the chlorine-ammonia treatment can be used to prevent them. It can also be used for maintaining the combined residual chlorine for an extended period as, for example, in reservoirs or distribution systems.
  - Chloramines are less active disinfectants than free chlorine and, therefore, may not be substituted where adequate disinfection requires free residual chlorine.
  - The ratio of chlorine to ammonia required for disinfection varies from 3:1 to 7:1.
  - Periodic laboratory tests should be conducted to determine the proper dosage. Apply chlorine after ammonia has been properly dispersed in the water.

- **Free Residual Chlorination**. Use this method before filtration to reduce tastes and odors caused by organic matter at locations where experience shows it to be effective and acceptable. Increase the chlorine dosage until the residual consists solely of free available chlorine.

- **Chlorine Dioxide**. In some cases, this chemical can be used to destroy phenolic and other organic tastes and odors in raw water. The dosage varies from 0.2 to 0.3 milligram per liter, as determined by testing.

- **Microstraining**. This method is used as a means of reducing the number of algae and other organisms in the water, and thus reduces the subsequent production of tastes and odors. The microstrainer