Chapter III

THEORETICAL CONSIDERATIONS

3.1 Mechanism of Color and Turbidity Removal.

Both iron and aluminum flocs form first as colloidal microcrystals bearing a positive charge and are capable of neutralizing and precipitating the negatively charged color colloid. In addition, the gelatinous flocs possess high adsorptive power. In the acid range, the positively charged trivalent ferric and aluminum ions are likewise highly effective in precipitating the negatively charged color colloid. This action gives rise to "color flocs" which may have absorptive properties far superior to the true iron and alum flocs just mentioned. In turbidity removal it is probable that the adsorptive capacity and specific gravity of the floc particles are the important factors, although colloidal precipitation undoubtedly plays a parts (BLACK 1934).

3.2 Results of Coagulation

The following are some of the results of coagulation :

3.2.1 Reduction of turbidity
3.2.2 Reduction of bacteria
3.2.3 Adjustment of the pH, alkalinity and hardness
3.2.4 Increased filter runs.

Reduction of turbidity : The water should be conditioned by coagulation so there will not be over 15 ppm of turbidity going into the filters. It is desirable, however, for a small amount of the floc to carry over to the filters. This floc forms a thin coating on the filter grains and aids in the filtering process. However, too much floc into the filter will reduce the time a filter will operate between washing.

Redution of bacteria : In the process of coagulation may of the bacteria present in the raw water are entrapped and removed by the floc.

Adjustment of the pH, alkalinity and hardness: In the coagulation process the operator may, in most cases, adjust the pH, hardness and alkalinity so as to obtain a stable water. Tests, pH and alkalinity, should be run to determine stability of the water, Jar tests may also be run to find the correct chemicals and the amounts which will give the desired results. By varying the amounts of chemicals applied in the coagulation basin the operator is able to obtain almost any desired pH, alkalinity or hardness.

Increased filter runs : Perhaps the most important result of effective coagulation is the increased time a filter may be left in operation. Increased filter runs mean less water used in the backwashing process. Proper coagulation will not only give longer filter runs but will protect the filter against "mud balls" and other filter troubles.

3.3 Variables in coagulation.

The variables involved in the coagulation treatment of a raw water are very numerous. They include **chemical** factors, such as the composition of the water and the nature of suspended and colloidal solids, the nature and concentration of coagulants and coagulant aids used, and physical factors such as the temperature of the water and the velocity gradients imparted during the flocculation state. Effective control of all of these variables can only be achieved under laboratory conditions using suspensions and solutions of known chemical composition.

The pH is well established as an important variable in the coagulation process and particular attention was paid in the present investigations to its control.

3.4 Coagulation Period.

The coagulation period, usually, though less accurately, termed "mixing period," includes both time of mixing and of flocculation, being defined as the time between the addition of the coagulant to the water and the end of agitation of the water at a velocity high enough to prevent settling of the flocculated matter. Most of the newer plants of conventional design provide for coagulation periods from 30 to 60 minutes, including preliminary flash or rapid mixing (AWWA 1951).

3.5 Coagulation Control.

The purpose, of course, is that of getting efficient coagulation, which in turn means getting a good floc with the lowest possible dose and at the same time leaving a minumum residual of the chemical in the filtered water. To get the most out of coagulation, an operator should have experience plus an ability to make and interpret laboratory tests. Some do fairly well on experience alone, but for the most part continuous efficiency is a product of laboratory control. It is therefore desirable that plants be equipped with facilities suitable for this purpose, and that operators be trained to interpret and apply their laboratory findings. The pH value of water has much effect upon the efficiency of coagulation. Operators may frequently depend upon pH tests for information as to the amount and character of the coagulant to be used.

3.6 Factors in Coagulation

For a more complete consideration of the various factors contributing to efficient coagulation it would be best to get a cross-sectional view of what actually happens in the mixing and coagulation basins and study these points in respect ot their effect on the plant.

Many factors influence the coagulation of turbid water are as the following :

3.6.1 Quantity and kind of coagulant.

3.6.2 Characteristics of the water, including suspended matter, temperature, and pH.

3.6.3 Time, violence and method of mixing.

3.6.4 Presence of nuclei.

It may be pointed out, too, that of all the factors influencing coagulation, only three-kind of coagulant, quantity of coagulant used and time of mixing generally subject to easy and close control. The operator, of course, determines the type and amount of coagulant, and the designer fixes the time of mixing in drawing the specifications of the coagulation basin.

A change in the alkalinity of raw water was generally accompanied by a variation in the temperature, turbidity, and pH and required adjustment of the coagulant dose. Usually a change in turbidity was of no particular importance except as further indication of the necessity of changing the coagulant dose, while an increase in turbidity resulted in a corresponding increase in coagulant being fed for a short time, the average dose, varied directly as the temperature and alkalinity, the period of maximum application being the period of lowest turbidities.

3.7 Factors in the Jar Test

There are several other points of importance. Once the jars are filled and in position, the stirring machine should be started before the coagulant solution is added. Many operaters have found that, if there is even a short lag between the addition of the chemical and the starting of the stirrer, the floc does not develop as effectively as when the chemical is added to an actively agitated sample (OCKERSHAUSEN 1945). This follows plant procedure, where the coagulant is always added to the water while it is in motion. Not only should the dosing of "still" samples be avoided, but the mixing of the sample should be done with care. A rapid initial mix of one or more minutes, as experience dictates, is highly desirable for quick dispersion of the coagulant in the wather. Dilute chemical solutions aid in obtaining immediate dispersion and enable accurate dosing. The rapid initial mix should be followed by 10 to 30 minutes of slow agitation just sufficient to keep the floc particles in suspension and permit them to grow in size. If desirable, this slow mixing period may be timed to conform with the mixing in the plant.

3.8 Effect of Stirring and Mixing

Proper mixing and flocculation go a long way in building up a heavy, well defind floc, and in keeping the floc particles, while forming, in contact with the material which it is possible for them to remove. Insufficient time and speed of mixing will cause a larger dosage to be required, thereby increasing cost of coagulants.

3.9 Effect of Temperature

The main influence of temperature upon coagulation is its effect upon the time required for good floc formation. Generally, the colder the water, the longer the time required to produce a good floc with a given amount of coagulant. Thus, in plants so designed that the coagulant for a given turbidity when the water is cold than when it is near the maximum temperature. And since temperature, like turbidity, is difficult to control, the temperature effect must usually be overcome by adjustment of other factors.

3.10 Quantity-Time Effects

With alkalinity and pH favorable to the formation of good floc, the most important factor influencing the time required for good floc formation is the quantity of coagulant use. In practice, coagulant dosage is based generally upon the rapidity with which the floc settles out in the basin. Once sufficient coagulant is added to produce a floc that will settle, the benefit to be obtained by adding more coagulant is a function of time, though not necessarily a straight-line function.

Generally speaking, use of the minimum quantity of chemical necessary for proper coagulation will necessitate the longest coagulation period for good floc formation. Thus, for example, use of 6 ppm. coagulant in the treatment of a water of 10 ppm. turbidity may involve a coagulation period of 60 minutes for good flocculation, while twice the amount of coagulant could produce the same result in half the time, and three times the amount in a still shorter period. It is largely this quantity-time factor which permits treatment plant operators to obtain fairly good results when coagulation periods must be limited.