Chapter I

INTRODUCTION

1.1 General Introduction

Water is one of the materials required to sustain life and have been suspected of being the source of many of the illnesses of man. It was not until a little over 100 years ago that definite proof of disease transmission through water was established. For many years following, the major consideration was to produce adequate supplied that were hygienically safe. The public has been more exacting in its demands as time has passed and to day sanitary engineers are expected to produce finished waters that are free of color, turbidity, taste, odor and harm-full metal ions. In addition, the public desires water which is low in hardness and total solids, noncorrosive, and non-scale-forming.

As populations increase, the demand for water grows accordingly and at a much more rapid rate if the population growth is accompanied by improved living standards. The combination of these two factors is placing greater and greater stress upon water engineers to find adequate supplies. With in adequate water for domestic needs, health condition may become serious. Surface waters becomes of great important as a valuable resource to furnish a supply of water.

Almost all surface water supplies are turbid, colored, and contain bacteria. The turbidity is due to finely divided matter held in suspen-sion, and may required long settling period. Color may be caused by dissolved organic material resulting from decayed vegetation and bacteria. Ordinarily the impurities may also be removed readily by the use of coagulants.

In the clarification of turbid and colored water by the process of rapid sand filtration, the first and most important step is that of proper conditioning or preparation of the raw water. Under ordinary conditions this is accomplished by chemically induced sedimentation, or in other words, by coagulation and sedimentation. Chemicals used for this purpose are referred to as coagulant or coagulating agents. When added to water they react with alkaline constituents to form an insoluble gelationous precipitate which absorbs or entraps bacteria, coloring matter, suspended mud, and other impurities. Gentle agitation of water thus treated results in the coalescence of small particles and finally in the formation of comparatively heavy aggregates which settle repidly during the usual period of sedimentation prior to filtration.

In the purification of surface waters for public supply the often stated advantages of chemical coagulation treatment over the biological process of slow sand filtration are the smaller area of land and the fewer operation personnel required. A third and perhaps most important advantage is the opportunity the chemical process provides of varying the treatment to meet changes in the composition of the raw water. The particles removed are either suspended or colloidal and are composed of clay and other inorganic materials, organic substances, bacteria, viruses, and even color. These particles usually carry a negative charge which can be changed in sign, depending on the pH and other characteristics of environment. Where particles maintain the same charge, negative or positive, they may remain permanently suspended by electromagnetic repulsion. Coagulation, by affecting the electrostatic charge may cause sedimentation.

Coagulation consists in mixing the coagulating chemicals with the water rapidly and in sufficient strength to produce the required precipitate. In mixing chemicals and in the formation of floc, turbulence is required with decreasing violence as floc is formed. In the settling basin, sometimes called the coagulation basin, water flows either horizontally or vertically upward through a sedimentation basin in which the coagulated solids settle to the bottom. The coagulation of water by the addition of chemicals involves chemical, physical-chemical, ionic, and physical reactions. The first action on the addition of a coagulant may be the neutralization of electric charges.

Sedimentation with coagulation is not commonly used as a complete method of treatment, but rather as a preliminary step in the preparation of water for filtration. In the design of a plant, provision should be made for the application of chemical at several points.

1.2 Appearance of Turbidity in Surface Water.

In natural waters used for public supplies, there are usually found both inorganic and organic matter which are not in solution, but which are in an extremely finely divided state. Some of this material does not readily settle out, even when the water is quiescent. Some of the organic matter appears to be in actual solution, although it has been discovered that this is not always the case. Such material will not precipitate unless the size of the particles of which it is composed is enlarged, or is trapped by other material which is collecting into larger masses and thus becomes capable of being deposited by sedimentation.

The impurities referred to in the above paragraph consist chiefly of inorganic compounds or mixtures commonly known as clay and silt, and of organic matter, both dead and living. Much of the inorganic material is in that finely divided condition known as the colloidal state of matter. The dead organic matter is usually in this condition, while the cells of the living organic matter may be always considered as in this form (ELLMS 1922).

Since a portion of the suspended impurities are, on account of their extraordinarily small size, not capable of settling out unaided, it becomes necessary to add something to the water which will cause these particles to come together. The aggregation of these particles into masses of such size that they may settle out is commonly known as coagulation. This process is usually effected through the agency of a chemical compound such as aluminum sulphate or ferrous sulphate, which, in reacting with the natural alkalinity of the water or with an alkalinity created by the addition of lime or soda ash, produces a colloidal precipitate. The latter by reason of the electrical charges upon its particles, which are of opposite sign from those on most of the natural colloidal impurities, brings about coagulation of the suspended matter, and subsequently is settled out under proper conditions.

1.3 Types of Suspended Solids.

The Suspended matter in turbid river water generally consists of finely divided silt, silica, and clay having specific gravities ranging from 2.65 for sand to 1.03 for flocculated mud particles containing 95 per cent water. Suspended vegetable matter will have a specific gravity from 1.0 to 1.5. Water treated by coagulants will contain particles of precipitated floc of Al_2O_3 or Fe_2O_3. These, with adsorbed water, will have specific gravities of 1.18 and 1.34, respectively. Large amounts of entrained water in the floc, however, will reduce the specific gravity to about 1.002. On the other hand, silt and clay enmeshed in the flocs will increase density. Floc particles range in size from submicroscopic to 1 mm. or more (STEEL 1960).

1.4 Purposes and Action of Coagulants.

The settling velocities of finely divided and colloidal clay are so small that removing them in a settling tank is impossible under ordinary conditions without very long detention periods. It has been necessary, therefore, to devise means to coagulate the very small particles into larger ones with higher settling values. Coagulation of water is a highly complex process involving physical chemistry which can only be indicated in simplified from here. It is done by adding to the water certain chemicals known as coagulants, the commonest being aluminum sulfate and forrous sulfate.

Coagulation proceeds in three steps. As the coagulant dissolves, positive aluminum or ferric ions become available to neutralize the negative charges on the particles of turbidity, including colloidal clay and color. This is the first stage of coagulation, and for the greatest efficiency a rapid mixture is necessary before secondary reactions take place. After the positively charged ions have neutralized a large part of the colloidal turbidity or color particles, the resulting flocs are still too small to be seen or to settle by gravity. Also, in the acid range of coagulation usually employed, they still retain positive charges, possible due to adsorption of positive ions from the water. In other words, the resulting positive flocs still have the property of neutralizing negative colloid. The treatment thereafter should be a slow stirring (sometimes called conditioning of flocculation) in order that the second step may occur, during which the very small flocs may agglomerate and grow in size until they are in proper condition for sedimentation. During this phase the third action, surface adsorption of particles, takes place on the large surface area provided by the floc particles. Entrapment of others, including bacteria, also takes place. Effective coagulation, and formation of a good floc, is aided by certain negative ions. The importance of ion concentrations with various coagulants is also indicated by varying optimum pH values. Floc formation is also aided by presence of turbidity as nuclei around which the floc will form. Effective coagulation also requires proper dosage of the coagulant and auxiliary chemicals when needed, adequate mixing of chemical and water, and suitable conditions for subsidence (STEEL 1960).

1.5 <u>Scope of Study</u>

The most common coagulant in use today for the removal of turbidity is aluminium sulphate. Especially, Metropolitan Water Works Authority treated the water from Klong Prapa with aluminum sulphate (or alum) as a coagulant.

The purpose of this research are :

1.5.1 To review very briefly the fundamental theory involved in the process of coagulation with ferrous sulphate.

1.5.2 To present results which are being obtained with ferrous sulphate as a coagulant in the treatment of various types of waters.

1.5.3 To summarize the advantages and disadvantages which may have resulted from the use of ferrous sulphate as a coagulant.

The surface water from Klong Prapa during winter was selected as the raw water for this study.