SURFACE WATER TREATMENT

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Abang Sapri Abang Raffae *Date*
Pejabat Kesihatan Daerah Betong,

Dedicated to my
beloved wife , Jaminah Yahya, my son, Abg Maizad Naqib and daughter, Dyg Nurmaizatul mahirah

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University of Malaysia Sarawak

Abstract

SURFACE WATER TREATMENT

by Abang Sapri Abang Raffae

Chairperson of the Supervisory Committee: Dr. Law Puong Ling

A surface Water Treatment is a study on water processing which includes a process of coagulation-flocculation-decantation and sand filtration. The study was done in the laboratory using a pilot plant, which consisted of two major parts; Coagulation-Flocculation-Decantation TE 600 and Sand Filtration TE 400. Untreated ssurface water contains minerals, inert solids, organisms, oxidized metals and other suspended materials. All these materials can inhibit disinfection, cause problems and leave the water cloudy. The study focused mainly on the removing of all the particles in the raw water sample and finally producing treated water which is suitable for human consumption.

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Chapter ONE
INTRODUCTION

1.1 INTRODUCTION

Provision of an adequate quantity of water has been a matter of concern since the beginning of civilisation. Even in ancient cities, local supplies were often inadequate and aqueducts were built to convey water from distant sources. Such supply systems did not distribute water to individual residences, but rather brought it to a few locations from which the citizens could carry it to their home. Until the middle of the seventeenth century, pipes that could withstand significant pressure were not available. The development of cast iron pipe and the gradual reduction in its cost, together with the development of improved pumps driven by steam, made it possible for even small communities to provide public supplies and deliver the water to individual residences.

Coagulants and filtration have been used in water treatment since at least 2000 B.C. although their application in municipal treatment in the United State was not common until about 1900. In 1906, slow sand filters was introduced in the treatment process and the reduction in number of cases occurred. Further improvement was also observed when disinfection with chlorine was introduced in 1913.

The positive progress in development also creates an effect to the environment especially to the sources of water supply. The contamination such as the chemical, physical and biological contamination of water supply can expose the consumers to several of diseases related with the water consumption.

Surface water, which is the main source for drinking water is also affected with this problem. The use of it as a source for drinking water should be given much emphasis and it is important to treat it in the very best way of treatment.

Water quality depends on agricultural practices in the watershed, location of municipal and industrial outfall sewers, river development such as dams, season of the year and climatic condition. Periods of high rainfall flush silt and organic matter from cultivated fields and forestland. Water quality control actually starts with management of the river basin to protect the source of water supply. Highly polluted waters are both difficult and costly to treat. The study of surface water treatment is very important in finding the economical and practical method of processing surface water.

1.2 The Statement of the Problem

This Surface Water Treatment is a study on how to treat a source from surface water. Raw water from surface water will be treated through a primary process such as chemical clarification by coagulation-flocculation, sedimentation and filtration. A suitable dosage of coagulant and flocculant will be added to remove taste and odour, colour and other chemical contains to produce quality treated water.

Untreated surface waters contain clay, minerals, bacteria, inert solids, microbiological organisms, oxidized metals, organic color producing particles, and other suspended materials. Some of the microbiological organisms can include Giardia cysts, pathogenic bacteria, and viruses. Oxidized metals include iron and manganese. All of these materials can inhibit disinfection, cause problems in the distribution system, and leave the water cloudy rather than clear.

Mainly the major concern of this study is to find out and evaluate the mechanisms of processing the surface water.

1.3 Objectives of the Study

1.3.1 General objectives

Generally, the objective of the study is to evaluate and analyse the processes in treating the surface water which involves the process of coagulation-flocculation, sedimentation and filtration.

1.3.2 Specific objectives

The specific objectives of the studies are to:

i. Determine the suitable and the effectiveness dosage of coagulant and flocculant used in destabilise suspended contaminants.
ii. Analyse and evaluate the process of coagulation-flocculation and sedimentation in removing the particle matter, chemical floc and precipitates from suspension through gravity settling.
iii. Evaluate the effectiveness of filtration process in removing the nonsettleable floc remaining after chemical coagulation and sedimentation

ii. To evaluate the effectiveness of processing by comparing the quality of raw and treated water.

1.4 Hyphotesis

The following hypotheses were put forward for the objectives in this study:

i. The water samples analyse after the coagulation-flocculation, sedimentation and filtration processes are more purified and quality.

ii. The result of the treated water analysed and obtained from the experiment follows the quality standard of the "Interim Drinking Water Standards Regulations" published by the United State Environment Protection Agency (EPA).

1.5 Scope of the Study

The study only focussing on the coagulation-flocculation, sedimentation and filtration process. The studies only concentrate on the physical and chemical aspects. The bacteriological parameters such as the total and faecal coliforms are not being analyses and assume to be zero because of the study excluded the process of disinfection.

Chapter TWO

LITERATURE RIVIEW

The objective of water treatment is to provide a potable supply-one that is chemically and microbiologically safe for human consumption. The primary process in surface water treatment is clarification by coagulation-flocculation, sedimentation and filtration. Lake and reservoir water has a more uniform year round quality and requires a lesser degree of treatment than river water. Natural purification results in reduction of turbidity, coliform bacteria, colour and elimination of day-to-day variations. On the other hand, growth of algae cause increased turbidity and may produce difficult to remove taste and odour.

River supplies normally require the most extensive treatment facilities with greatest operational flexibility to handle the day-to-day in raw water. The preliminary step is often pre-sedimentation to reduce silt and settleable organic matter prior to chemical treatment. Many river water treatment plants have too stages of chemical coagulation and sedimentation to provide greater depth and flexibility of treatment. The unit may be operated in series or by split treatment with softening in one stage and coagulation in the other.

2.1 Mixing and flocculation

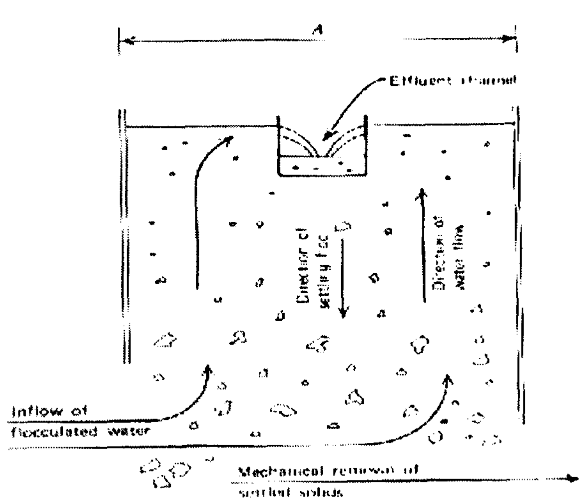
Chemical reactions in water treatment is designed as either completely mixed or plug flow basins. Applications of complete mixing in water treatment are rapid (flash or quick) mix tanks used to blend chemicals into raw water for coagulation and the mixing and reaction zone in flocculatior-clarifiers.

2.2 Sedimentation

Sedimentation, or clarification, is the removal of particulate matter, chemical floc, and precipitates from suspension through gravity settling. The common criteria for sizing settling basins are detention time, overflow rate, weir loading and, with rectangular tanks, horizontal velocity. Detention time, expressed in hours, is calculated by dividing the basin volume by average daily flow. The overflow rate (surface loading) is equal to the average daily flow divided by total surface area of the settling basin, expressed in units of gallons per day per square foot.

Most settling basins in water treatment are essentially up-flow clarifiers where the water rises vertically for discharge through effluent channels; hence, the ideal basin shown in Figure2.1 can be used for explanatory purposes.

Figure 2.1 : Ideal Sedimentation tank



Water entering a settling basin is forced to the bottom behind a baffle wall, and then rises vertically, overflowing the weir of a discharge channel at the tank surface. Flocculated particles settle downward, in a direction opposite to the flow of water, and are removed from the bottom by a continuous mechanical sludge apparatus. The particles with a settling velocity, v greater than the overflow rate Q/A are removed while lighter flocs, with settling velocities less than the overflow rate, are carried out in the basin effluent. Weir loading is computed by dividing the average daily quantity of flow by the total effluent weir length, and expressing the results in gallons per day per foot (cubic meters per meter per day).

Sedimentation basins may be rectangular, circular or square. They are designed for slow uniform movement with a minimum of short-circuiting. The rectangular tank contains partitioning baffles to guide the flow vertically to collecting troughs that extend across, and around the periphery, of the clarifier.

2.3 Filtration

The granular-media gravity filter is the most common type used in water treatment to remove nonsettleable floe remaining after chemical coagulation and sedimentation. A typical filter bed is placed in a concrete box with a depth of about 9 ft. The granular media, about 2 ft deep, are supported by a graded gravel layer over underdrains. During filtration, water passes downward through the filter bed by a combination of water pressure from above and suction from the bottom. Filters are cleaned by backwashing (reversing the flow) upward through the bed. Wash troughs suspended above the filter surface collect the backwash water and carry it out of the filter box.

Filtration rates following flocculation and sedimentation are in the range of 2 to 10 gpm/sq ft (1.4 to 6.8 $l/m^2.s$), with 5 gpm/sq ft (3.4 $l/m^2.s$) normally the maximum design value. Direct filtration, which does not include sedimentation, can be used to treat surface waters with low turbidity and colour. The typical flow scheme is rapid mixing for blending a coagulant into the raw water, flocculation for greater than 30 min, addition of a polymer coagulant aid, and filtration at a rate of 1 to 6 gpm/sq ft (0.7 to 4.1 $l/m^2.s$). Floc removed from the water is collected and stored in the filter, which is subsequently cleaned by backwashing. In general, the turbidity of the raw water should be less than 5 units and the colour below 40 units. Turbidity consistently over 15 units is likely to cause operational problems in direct nitration that could have been avoided by providing prior sedimentation. The success of direct filtration is based on use of a coarse-to-fine dual-media filter for a greater capacity to store the impurities removed, backwashing systems using mechanical or air agitation to clean the media, and selection of a suitable polymer coagulant aid.

2.4 Disinfection

The most common application of chlorination is disinfection of drinking water to destroy micro-organisms that cause diseases in humans. The bactericidal action of chlorine results from a chemical reaction between HOCl and the bacterial or viral cell structure, inactivating required life processes. Rate of disinfection depends on the concentration and form of available chlorine residual, time of contact, pH, temperature, and other factors. Hypochlorous acid is more effective than hypochlorite ion; therefore, the power of free chlorine residual decreases with increasing pH. Bactericida action of combined available chlorine is significantly less than that of free chlorine residual. Information is unavailable to provide specific application rates in chlorination to achieve 100 percent kill all microorganisms of sanitary significance for the variety of water supplies being treated for domestic use. The water source selected should, of course, be the least polluted available, and regulations should be set up to protect its quality. Current disinfection practice is based on establishing a given kind and amount of chlorine residual during treatment and, then, maintaining an adequate residual to the customer's faucet. Thus, a major part of quality control is testing water in the distribution system for chlorine residual. Effectiveness of the disinfection process is determined by testing for the coliform group as indicators of water quality. The sensitivity of bacteria to chlorination is well understood, while the effect on protozoa's and viruses has not been clearly delineated. Protozoa cysts and enteric viruses are more resistant to chlorine than are coliforms and other enteric bacteria. On the other hand, very little evidence exists to indicate that current water treatment practices are not adequate. No outbreaks of waterborne viral or protozoal infections have been documented in public water supplies after proper treatment by chemical coagulation, filtration, and chlorination.

These values are based on destruction of coliform bacteria at water temperatures between 20 and 25° C after 10-min contact for free chlorine and a 60-min contact for combined available chlorine. Minimum residuals for virus inactivation and protozoa cyst destruction are considerably greater.

Table 2.1 : Recommended Minimum Bactericidal Chlorine Residuals for Disinfection

pH value	Minimum Free Available Chlorine residual after 10 minutes contact (mg/l)	Minimum Combined Available Chlorine residual after 60 minutes contact (mg/l)
6	0.2	1.0
7	0.2	1.5
8	0.4	1.8
9	0.8	➢ 3.0
10	0.8	➢ 3.0

Therefore, recommended treatment of surface waters includes coagulation, sedimentation, and filtration to reduce the density of viruses and physically remove cysts, followed by chlorination to establish a free residual. With this water processing, establishing a free residual as recommended in Table 3.5.1 has proven to be satisfactory for protection of public water supplies. This requires breakpoint chlorinalion if the surface water contains dissolved ammonia.

Occasionally, a combined chlorine residual is established to control bacterial growths in treated water. Compared to free-residual chlorination, the advantages are that chloramines are less reactive and a residual can be maintained for a longer period of time without rechlorination. For instance, a combined residual can be applied to treat water before it is pumped through a fong pipeline to a municipal distribution system. If insufficient natural ammonia is present in the water, gaseous anhydrous ammonia is applied by feeding equipment similar to that used for chlorine.

Chapter THREE
METHODOLOGY

The water treatment process is run through a small-scale pilot plant in the laboratory. Mainly, the pilot plant consists of two major parts that is the Water Treatment Coagulation-Flocculation-Decantation TE 600 and Water Treatment Sand Filtration TE 400.

3.1 Water Treatment Coagulation-Flocculation- Decantation TE 600

Decantation is a unit operation by which some suspended solid particles move about in a liquid phase by gravity for the separation of these two phases and their elimination. Coagulation-flocculation-decantation is employed to separate suspended solids in a liquid phase (general water) when the natural sedimentation speeds are too small to obtain an efficient settling. Some suspended solids in a liquid phase do not settle by themselves because they are in a coloidal form and have the same electric charge: solid particles reject one another; for this reason no concentration of these solid particles is possible. It is necessary to eliminate the electric charges of the coloidal particles before sedimentation.

3.1.1 Liquid-Solid Mixtures

Suspended particles

There are three types of particles in an effluent; suspended materials, dissolved materials and suspended colloid particles.

-Suspended materials are materials of mineral origin or of organic origin.

These particles can be easily separated from the liquid using a simple sedimentation in a clarifier or a filter. The particles dimensions can vary from 10 mm to 0.1 mm diameter and it is big enough for the particles to settle by themselves with their own weight.

-Dissolved materials.

Generally consist in some salts and some organic material molecules resulting from the dissolution of ground.

-Colloid materials

The diameter of colloid materials is smaller than 1 mm diameter. These particles have the same origin than suspended materials but their diameter is so small that it take very long time for them to settle and