THE EFFECTIVENESS OF NATURAL SOIL AND KENAF FIBRE MIXTURE IN RIVERBANK FILTRATION SYSTEM

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Report submitted in fulfilment of the requirements
For the award of the degree of
B. ENG (HONS.). CIVIL ENGINEERING

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2014

ABSTRACT

Water is an essential resource that sustains life on earth. Clean and safe water supply is very demanding as the population are kept increasing as the years goes by. There are many methods to produce safe and clean water for daily purposes which might include a chemical reaction for the treatment. But most of the method involve a lot of procedures and definitely very costly. Recent study has found that riverbank filtration system is one of a new method that is naturally filtrate water at the river specifically without adding any chemicals. The soil properties might be different in each location so the standard water quality that needs to be achieved might be unsuccessful. The main objectives of this study are to identify the applicability of kenaf fibre and natural soil mixture as artificial barrier in riverbank filtration system and to determine the effectiveness of kenaf fibre and natural soil mixture in removing contaminants, organics and biological content. Riverbank filtration (RBF) systems are particularly well suited for providing better water quality than withdrawal directly from the surface water. Reliable RBF systems can remove microbial pathogens, organic contaminants, hormones, endocrine disruptors, turbidity, and other substances. The efficiency might vary from one location to another location because the efficiency of the system depends on the properties of the soil. So, modification is required in achieving reasonable treatment ability. In this study, natural soil from Chini Lake riverbank was considered and the effectiveness in improving the quality and appearance of water sample been investigated. New material which is kenaf fibre were used for this research where the effectiveness of the mixture of the natural soil and kenaf fibre were analysed to modify the soil. Several tests, namely adsorption test and filtration test was conducted in the laboratory to determine the effectiveness of both material as filtration medium. Result shows that the soil is clay soil with low plasticity. Parameter that been considered are Biochemical Oxygen Demand,Chemical Oxygen Demand, Turbidity, Total Suspended Solid and Total Dissolved Solid. Result had indicated that the mixture of natural soil and kenaf fibre are not effective enough as filtration medium to produce better water quality.

ABSTRAK

Air adalah keperluan asas di dalam dunia. Air adalah sumber penting yang mengekalkan kehidupan di bumi. Bekalan air yang bersih dan selamat mendapat permintaan yang sangat tinggi kerana kepadatan penduduk meningkat dari semasa ke semasa. Terdapat banyak kaedah untuk menghasilkan air yang bersih dan selamat di mana ia memerlukan tindak balas kimia untuk rawatan. Tetapi kebanyakan kaedah melibatkan banyak prosedur dan sangat mahal. Kajian terbaru telah mendapati bahawa sistem penapisan tebing sungai adalah salah satu kaedah baru secara semula jadi di mana air di tapis tanpa menambah sebarang bahan kimia. Sifat tanah mungkin berbeza di setiap lokasi maka kualiti air yang perlu dicapai mungkin tidak berjaya. Objektif utama kajian ini adalah untuk mengenalpasti kebolehan serat kenaf dan campuran tanah semula jadi sebagai bahan dalam sistem penapisan tebing sungai dan untuk menentukan keberkesanan serat kenaf dan campuran tanah semula jadi untuk menghapuskan bahan cemar, organik dan kandungan biologi. Sistem ini dipercayai boleh mengeluarkan patogen mikrobial, bahan pencemar organik, hormon, disruptors endokrin, kekeruhan, dan bahan-bahan lain. Kecekapan mungkin berbeza-beza dari satu lokasi ke lokasi yang lain kerana kecekapan sistem bergantung kepada sifat tanah. Jadi, pengubahsuaian diperlukan dalam mencapai keupayaan rawatan yang berkesan. Dalam kajian ini, tanah daripada Tasik Chini telah dipilih sebagai bahan kajian dan keberkesanannya dalam meningkatkan kualiti dan kebersihan air telah dikenalpasti. Bahan baru yang merupakan serat kenaf telah digunakan untuk kajian ini di mana keberkesanan campuran tanah semulajadi dan serat kenaf telah dianalisis untuk tujuan penapisan air. Ujian seperti ujian penyerapan dan ujian penapisan air telah dijalankan di makmal untuk menentukan keberkesanan kedua-dua bahan sebagai medium penapisan. Parameter yang dipertimbangkan adalah Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Total Dissolved Solid (TDS) dan ujian kekeruhan. Keputusan telah menunjukkan bahawa campuran tanah semulajadi dan serat kenaf tidak cukup berkesan sebagai medium penapisan untuk menghasilkan kualiti air yang lebih baik.

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RBF	Riverbank Filtration System
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solid
TDS	Total Dissolved Solid

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The water profile of Malaysia is dominated by a supply regime of copiously flowing rivers and widespread series of dams for surface water storage. The use of conventional water and wastewater treatment processes becomes increasingly challenged with the identification of more and more contaminants, rapid growth of population and industrial activities, and diminishing availability of water resources. Water qualities are very demanding as our body consist almost 70% of water(Chan, 2006). Water quality refers to the chemical, physical and biological characteristics of water. Water is the basic needs in the world that sustains life on earth. Clean and safe water supply is very demanding as the population are kept increasing as the years goes by. To determine a better water quality, scientists had measured and analyse on the characteristics of the water such as turbidity, dissolved mineral content and number of bacteria.

Urban and industrial development, farming, fossil fuels, stream-channel alteration, animal-feeding operations, and other human activities can change the quality of natural waters. The presence of bacteria and other microorganism in water are one of the signals that pathogens may be present. Each of the characteristic that had been analysed must achieved a standard result to classify the water is safe and suitable for particular use. There are many methods to produce safe and clean water for daily purposes which might include a chemical reaction for the treatment. But most of the method involve a lot of procedures and definitely very costly.

Riverbank filtration (RBF) systems are one of the system that are particularly cost-effective and natural pre-treatment technology that well suited for supplying better water quality than pumped out directly from the surface water(Weiss et al., 2003). It use the nature instead of adding chemicals to treat the surface water and groundwater supplies. Riverbank filtration systems are capable to remove microbial pathogens and organic contaminants which includes the taste and odour that causing turbidity and other substances.

Riverbank filtration system is one of the method that is not merely treating on existing raw surface water supplies but also developing new and sustainable water supplies. Riverbank filtration system uses the bed of a reservoir, lake or river and an adjacent sand and gravel aquifer as a natural filter (Gary, 2008). The technology can be applied directly to existing surface water reservoirs, streams, lakes and rivers, and now it is often a guiding factor in the hydrogeological investigation of new source supplies. (Gary, 2008).

1.2 PROBLEM STATEMENT

Water qualities at the selected areas are doubtful especially as drinking water for the community. The community are exposed to contagious diseases due to the condition of the water. The bacteria and microorganism in the water are considerably high. The lakes are very disappointing as the water is getting more polluted day by day. The ore mining and sediment from logging activities had given an enormous impact on the condition of the soil, the ecosystem and even the quality of the water. The beauty of the lake itself had been contaminated due to this inconsiderate situation. The locals had been suffered on receiving quality water for daily purposes.

The main problem that occurred in the conventional treatment is in term of the costing. The conventional water treatment involves many procedures to finally produce a better water quality. It also involves chemicals to treat the water and it often very expensive to construct and operate. As riverbank filtration system as one of the technology that will be imply to generate a better water quality, the tolerance of the advantages and disadvantages have to be considered thoroughly as the implication of the method either in a positive and negative ways will be used as a reference in a future.

1.3 RESEARCH OBJECTIVES

There are two objectives in accordance towards the study and the objectives are:

1. To identify the applicability of natural soil and kenaf fibre mixture as artificial barrier in riverbank filtration system

2. To determine the effectiveness of kenaf fibre and natural soil mixture in removing contaminants, organics and biological content.

1.4 SCOPE OF STUDY

In this study, Chini lake was selected for the area of research. The lakes had been detected as polluted based on the complaints from the locals and also the tourists. 10 litre of polluted water sample and 10 kg of natural soil will be collect and laboratory test will be carried out based on a few parameters that had been set. 5 parameters were considered , namely:

i. Apparent
   - Total Dissolved Solid
   - Total Suspended Solid
   - Turbidity

ii. Organic
   - Biochemical Oxygen Demand (BOD)
   - Chemical Oxygen Demand (COD)

Filtration test are to be conducted by using natural soil and kenaf fibre mixture as filtration medium. Based on the results of both two tests, a comparison will be made with the initial water parameter to identify whether the researcher manage to succeed the objectives.

This study is very important because it could help to implement a new filtration system without addition of any chemicals. Addition of kenaf fibre might increase the adsorption capacity of soil, thus improve the performance of RBF system. The use of RBF may be considered as a method to reduce contamination in Chini lakes.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

In this chapter, presents and summarizes the literature reviews pertaining to the study undertaken. This section will be divided into four main topics. The first topic will discussed about water demand and supply in general view. It comprises the source of water and parameters that had been selected will affect the water quality standard. The second topic is water treatment. The conventional water treatment and current water treatment will be discussed in this section.

2.1 WATER DEMAND AND SUPPLY

As population are increasing, the water is very demanding in our lives as it is an essential aspect in maintaining life. Our body consist almost 70% of water thus this need of water for every human are extremely important(Gullick, 2006). People may live without food for a several weeks, but cannot bear to have an insufficient amount of water even for three to five days. The needed of water are various. Every creature in the world wide needs water to continue their life.

The needed of water can be divided into four main parts, which are agriculture use, domestic use, recreational use and industrial use. In terms of agriculture need, it includes livestock husbandry, manages fisheries and forestry. It is estimated that almost 69% of worldwide has use water for irrigation and actually most of it provided directly by rainfall. As the increasing of population in worldwide, more food and livestock feed need to be produced in the future and automatically more water applied for this purpose. Approximately almost 40% of water withdrawn from rivers, lakes and aquifers for agriculture effectively contributes to crop production and the current global water withdrawals for irrigation are estimated to be about 2000 to 2500 km^3 per year (Howell *et. al*, 2001).

Every human required to at least drink two to three litres of water per day for the body to fully hydrate. It is estimated that almost 8% of worldwide water use is for household purposes. These include drinking water, bathing, cooking, sanitation, and gardening. The household water requirements have been estimated around 50 litres per person per day, not including for gardening purposes (Gleick, 2000). The water quality for drinking purpose must sufficiently high quality so that it can be consume without any risk or any disease in long term harm. Below is a picture showing more detailed information of water uses inside of a home.

Table 2.1 : Domestic Water Uses

Activity	Normal Use	Conservation Use
Flushing	Depends on Tank Size 5-7 gallons	Displacement bottles in tank 4 gallons
Showering	Water Running 25 gallons	Wet down; soap down 4 gallons
Bathing	Tub Full 40 gallons	Minimal water level 10-12 gallons
Washing Hands or Face	Tap Running 2 gallons	Plug and Fill Basin 1 gallon
Drinking	Run Water to Cool 1 gallon	Keep Water in Refrigerator 8 ounces
Cleaning Vegetables	Tap Running 3 gallons	Fill Pan with Water to Clean Vegetables 1/2 gallon
Dishwasher	Full Cycle 16 gallons	Short Cycle 7 gallons
Washing Clothes	Full Cycle, Top Water Level 60 gallons	Short Cycle, Minimal Water Level 27 gallons

Recreational water use is usually a very small of total water use. The participation in water- oriented outdoor recreation activities is growing at a spectacular rate. Recreational usage is usually non-consumptive. Recreational usage may reduce the availability of water for other users at specific times and places.

Water is also used in many large scales of industrial processes, such as thermoelectric power production, oil refining, fertilizer production and other chemical plant use. Industrial consumption of water is generally much lower than withdrawal, due to laws requiring industrial grey water to be treated and returned to the environment.

2.1.1 Source of water

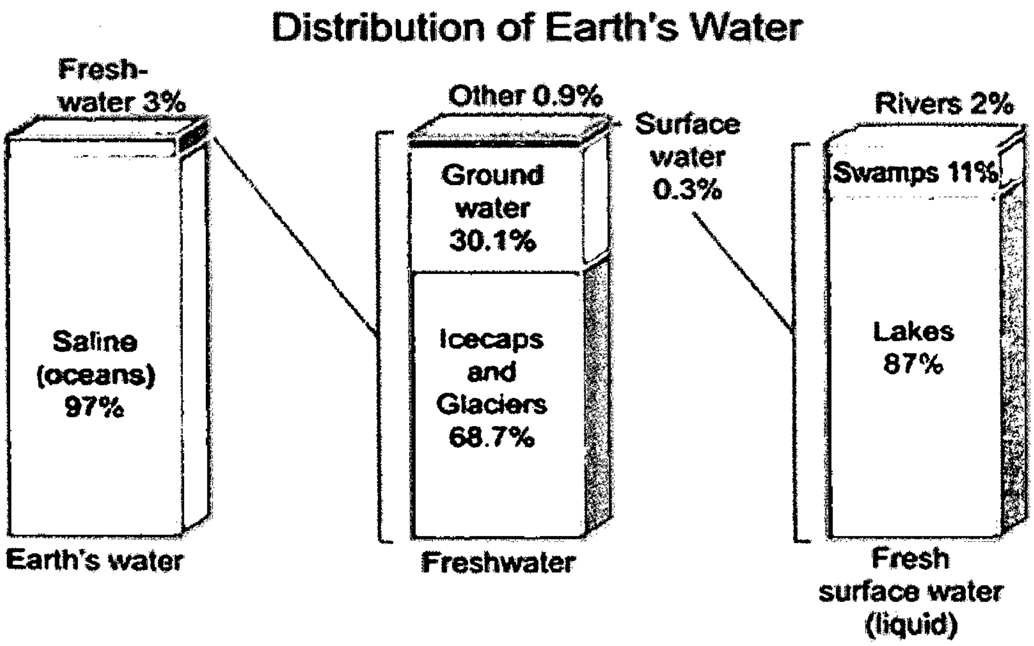

Figure 2.1 : Source of water

(Source: http://en.wikipedia.org/wiki/Water_resourceses)

Surfaces water resources have played an important function throughout the history in the development of human civilization. About one third of the drinking water requirement of the world is obtained from surface sources like rivers, canals and lakes (Das and Acharya, 2003). Water resources are sources of water that are very benefit or potentially useful

97% of the water on the earth consist of saline water are formally known as ocean and only 3% is fresh water; slightly over two thirds of this is frozen in glaciers and polar ice caps with percentage approximately 68.7%. The remaining unfrozen fresh surface water is found mainly as groundwater, with only a small fraction present above ground or in the air.

Basically, fresh water is a renewable resource. Meanwhile, surface water is water that can be found in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and has naturally lost through discharge to the oceans, evaporation, evatranspiration and sub-surface seepage(James, 2004).

The quantity of water in the system depends in a lot of factors. It covers storage capacity in lakes, wetlands and artificial reservoirs. These storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and even local evaporation rates.

Groundwater is fresh water located in the pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Groundwater can be thought of in the same terms as surface water in terms of the inputs, outputs and storage. The difference is due to its slow rate of turnover, groundwater storage is generally much larger compared to inputs than it is for surface water. This difference makes it easy for humans to use groundwater unsustainably for a long time without severe consequences. The groundwater source may become saline. In coastal areas, human use of a groundwater source may cause the direction of seepage to ocean to reverse which can also cause soil salinization. So, to increase the input of groundwater, humans can actually build reservoir or detention pond.

2.1.2 Water quality standard

To ensure that the water is particularly safe and clean to be use, it has to achieve the standard that had been provided by the expert. There are a few standards that can be referring such as Water Quality Index and Interim National Water Quality System. If the water quality manages to meet the standard, then the Ministry of Health (MOH) will give an approval that the water can be used as drinking water. But, if the water quality cannot reach the standard or did not follow the specification that had been provided, then the water is strictly not safe to be use, for drinking specifically. The Water Quality Index (WQI) was used as a basis for assessment of a watercourse in relation to pollution load categorization and designation of classes of beneficial uses as stipulated in the National Water Quality Standards for Malaysia (NWQS). The WQI was derived using Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH3-N), Suspended Solids (SS) and pH.

The water quality index (WQI) is a measurement used as a basis for assessing the level of pollution and categorizing it into classes as stipulated in the National Water Quality Standards for Malaysia (NWQS).

2.1.2.1 Total Dissolved Solid

Total dissolved solid refers to the total amount of all inorganic and organic substances including minerals, salts, metals, cations or anions that are dispersed within a volume of water. The solids must be small enough to be filtered through a sieve measuring 2 micrometres (Hayes, 2004). TDS concentrations are used to evaluate the quality of freshwater systems. TDS concentrations are equal to the sum of positively charged ions (cations) and negatively charged ions (anions) in the water. Sources for TDS include agricultural run-off, urban run-off, industrial wastewater, sewage, and natural sources such as leaves, silt, plankton, and rocks. Piping or plumbing may also release metals into the water.

The United States Environmental Protection Agency (EPA) recommends treatment when TDS concentrations exceed 500 mg/L, or 500 parts per million (ppm).

The TDS concentration is considered a Secondary Drinking Water Standard, which means that it is not a health hazard. Water with a high TDS concentration may indicate elevated levels of ions that do pose a health concern, such as aluminium, arsenic, copper, lead, nitrate and others (Singh, 1975).

2.1.2.2 Total Suspended Solid

Total suspended solids (TSS) are all particles that suspended in water which will not pass through a filter. Practically, they are defined as particles large enough to not pass through the filter used to separate them from the water. Suspended solids are present in sanitary wastewater and many types of industrial wastewater. There are also nonpoint sources of suspended solids, such as soil erosion from agricultural and construction sites. As levels of TSS increase, a water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, hence it increases water temperature and decrease the levels of dissolved oxygen. Some cold water species are very sensitive to changes in dissolved oxygen. Due to this condition, photosynthesis also decreases, since less light penetrates the water. There is a further drop in dissolved oxygen levels when the plants and algae cannot produce sufficient oxygen and result in the death of buried organisms.
The implications of the cause of TSS are:

i. High concentrations of suspended solids decrease the effectiveness of drinking water disinfection agents by allowing microorganisms to "hide" from disinfectants within solid aggregates.
ii. Many organic and inorganic pollutants sorb to soils, so that the pollutant concentrations on the solids are high.

Most people consider water with a TSS concentration less than 20 mg/l to be clear. Water with TSS levels between 40 and 80 mg/l tends to appear cloudy, while water with concentrations over 150 mg/l usually appears dirty. The nature of the particles that comprise the suspended solids may cause these numbers to vary.

2.1.2.3 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand is amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. The term also refers to a chemical procedure for determining this amount. The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a robust surrogate of the degree of organic pollution of water. BOD is similar in function to chemical oxygen demand (COD), in that both measure the amount of organic compounds in water. However, COD is less specific, since it measures everything that can be chemically oxidized, rather than just levels of biologically active organic matter.

There are many methods used to measure the amount of organic matter present, or the organic strength of wastewater. A high concentration of BOD is found in water bodies with excessive algal growth or a high level of organic matter. Low levels are associated with cleaner and clearer water bodies with a good level of decomposed material. BOD is the most important measurement that can be made in water quality analysis to determine the oxygen requirement in wastewaters, or polluted waters. It is used as a measure of organic pollution, as a basis for estimating the oxygen needed for biological processes, and as an indicator of process performance (Henry, 2005). There is one standard test called the 5-day BOD test. In order to measure the amount of biodegradable organic material present, a sample is tested by how much oxygen is required to completely oxidize the material into CO_2 and H_2O. The amount of oxygen required is equal to the amount of organic material (or BOD) that is present in the sample (Henry, 2005).

2.1.2.4 Chemical Oxygen Demand (COD)

In environmental chemistry, the chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. It is expressed in milligrams per liter (mg/L) also referred to as ppm (parts per million), which indicates the mass of oxygen consumed per liter of solution. The chemical oxygen demand (COD) is a measure of water and wastewater quality. The COD test is often used to monitor water treatment plant efficiency. This test is based on the fact that a strong oxidizing agent, under acidic conditions, can fully oxidize almost any organic compound to carbon dioxide. The COD is the amount of oxygen consumed to chemically oxidize organic water contaminants to inorganic end products.

The COD is often measured using a strong oxidant (e.g. potassium dichromate, potassium iodate, potassium permanganate) under acidic conditions. A known excess amount of the oxidant is added to the sample. Once oxidation is complete, the concentration of organics in the sample is calculated by measuring the amount of oxidant remaining in the solution. This is usually done by titration, using an indicator solution. COD is expressed in mg/L, which indicates the mass of oxygen consumed per litre of solution.

The COD test only requires 2 to 3 hours, while the Biochemical Oxygen Demand (BOD) test requires 5 days.

2.1.2.5 Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by individual particles that are generally invisible to the naked eye. In drinking water, the higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases. Contaminants like viruses or bacteria can become attached to the suspended solids. The suspended solids interfere with water disinfection with chlorine because the particles act as shields for the virus and bacteria. Similarly, suspended solids can protect bacteria from ultraviolet (UV) sterilization of water (Mann, *et. al*, 2007).

The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (NTU). Governments have set standards on the allowable turbidity in drinking water. In the United States, systems that use conventional or direct filtration methods turbidity cannot be higher than 1.0 nephelometric turbidity units (NTU) at the plant outlet and all samples for turbidity must be less than or equal to 0.3 NTU for at least 95% of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU. Many drinking water utilities strive to achieve levels as low as 0.1 NTU (EPA, 2009). Turbidity is commonly treated using either a settling or filtration process.

2.2 TREATMENT OF WATER

Competition for water has incredibly increased, and it has become more difficult to conciliate the need for water supply for human consumption, food production, ecosystems and other uses. Water administration is frequently involved in contradictory and complex problems (Boelens, 2009). Thus, the water treatments are very important and need to be provide for future uses.

2.2.1 Surface water

Many water treatments use a combination of coagulation, sedimentation, filtration and disinfection to provide clean, safe drinking water to the public. Worldwide, a combination of coagulation, sedimentation and filtration is the most widely applied water treatment technology, and has been used since the early 20^{th} century. The procedure on treating a surface water been divided into five main parts which are aeration, coagulation, flocculation, filtration and finally disinfection. Every step considered important because if the process cannot be done accordingly, the quality of the water might be affected.

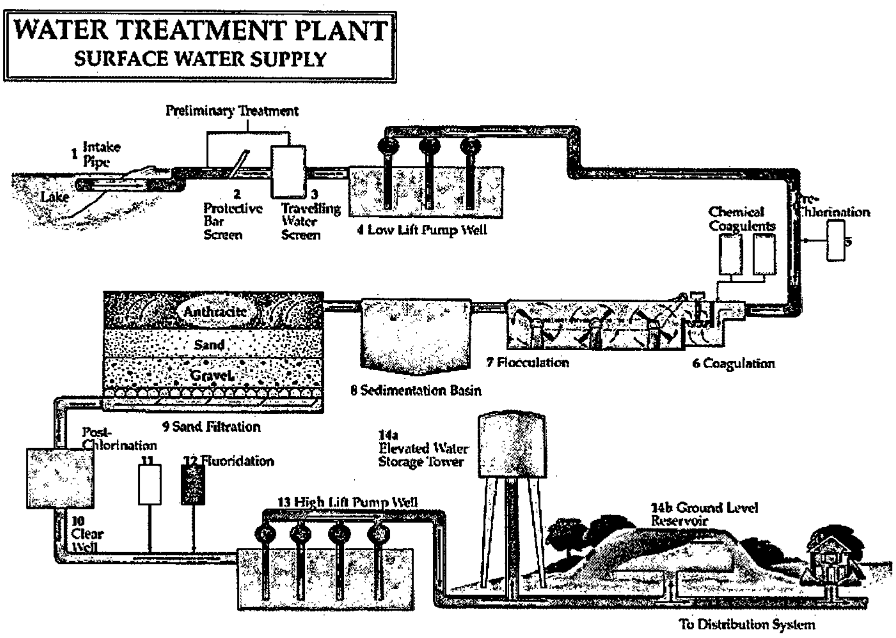

Figure 2.2: Water treatment flow diagram

(Source : http://cof-cof.ca/surface-water-treatment-plant-flow-diagram)

For the first step, raw water from a surface water lake or reservoir is drawn into the plant through intake structures. Then, the addition of chemicals will be done to assist in the removal of particles suspended in water. Inorganic and organic particles contribute to the turbidity and colour of water. The addition of inorganic coagulants such as aluminium sulphate (or alum) or iron (III) salts such as iron (III) chloride cause several simultaneous chemical and physical interactions on and among the particles. These precipitates combine into larger particles under natural processes such as Brownian motion and through induced mixing which is sometimes referred to as flocculation. The term most often used for the amorphous metal hydroxides is "floc." Particles been enmesh in suspension and facilitate the removal of particles by subsequent processes of sedimentation and filtration.

Coagulants, rapidly add electrochemical charges that attract the small particles in water to clump together as a "floc". The visible floc is kept in suspension until large enough to settle under the influence of gravity. Flocculated water is applied to large volume tanks where the flow speed slows down and the dense floc settles. Waters