USING POLYALUMINUM CHLORIDE IN WATER TREATMENT

A Thesis
Submitted to the Faculty of Engineering
Ain Shams University for the Fulfillment
of the Requirement of M.Sc. Degree
In Civil Engineering

PREPARED BY

ENG. MAHMOUD SAFWAT ABDELRADY TAHER

B.Sc. in Civil Engineering, June 2006
Faculty of Engineering, Ain Shams University

SUPERVISORS

PROF. DR. MOHAMED HASSAN ABDEL RAZIK

Prof. of Sanitary & Environmental Engineering
Faculty of Engineering, Ain Shams University, Cairo, EGYPT

DR. MOHAMED SOBHY ABDEL RAHMAN

Associate Prof. of Sanitary & Environmental Engineering
Faculty of Engineering, Ain Shams University, Cairo, EGYPT

DR. AISHA MAGED ZAKI

Associate Prof. of Sanitary & Environmental Engineering
Faculty of Engineering, Ain Shams University, Cairo, EGYPT

JANUARY 2013

USING POLYALUMINUM CHLORIDE IN WATER TREATMENT

A Thesis For
The M.Sc. Degree in Civil Engineering
(SANITARY ENGINEERING)

BY
ENG. MAHMOUD SAFWAT ABDELRADY TAHER
B.Sc. in Civil Engineering, June 2006
Faculty of Engineering, Ain Shams University

THESIS APPROVAL

EXAMINERS COMMITTEE	SIGNATURE
PROF. DR. HAZEM IBRAHIM SALEH Professor of Sanitary & Environmental Engineering Faculty of Engineering, Monofeia University	……….
PROF. DR. FEKRY HALIM GHOBRIAL Professor of Sanitary & Environmental Engineering Faculty of Engineering, Ain Shams University	……….
PROF. DR. MOHAMED HASSAN ABDEL RAZIK Professor of Sanitary & Environmental Engineering Faculty of Engineering, Ain Shams University	……….
DR. MOHAMED SOBHY ABDEL RAHMAN Associate Professor of Sanitary & Environmental Engineering Faculty of Engineering, Ain Shams University	……….

DATE: 14/01/2013

DEDICATION

I wish to dedicate this work to who suffered to educate, prepare, build capacity and help myself to be as I am,

TO

MY SOUL FATHER

(Dr. Mohamed Adel Ahmed Hussein)

&

MY MOTHER

(Allah May Bless Her Soul)

Also Thanks to

MY WIFE & MY SISTERS
For Their Encouragement and
Support to Complete This Work

STATEMENT

This dissertation is submitted to Ain Shams University, Faculty of Engineering for the degree of M.Sc. in Civil Engineering.

The work included in this thesis was carried out by the author in the department of Public Works, Faculty of Engineering, Ain Shams University, from October 2006 to September 2012.

No part of the thesis has been submitted for a degree or a qualification at any other University or Institution.

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others

Date: 14/01/2013

Signature: ………………..

Name: ***MAHMOUD SAFWAT ABDELRADY TAHER***

ACKNOWLEDGMENT

First and foremost I am thankful to Allah the Almighty God for his grace and mercy.

I am extremely grateful for ***Prof. Dr. Mohamed Hassan Abdel Raik****, Professor of Sanitary and Environmental Engineering, Faculty of Engineering, Ain Shams University, he has given me the chance for this research idea, his unfailing help, guidance, the very* capable assistance *and his sincere advices during this work.*

Also, my special thanks and gratitude is dedicated to ***Dr. Aisha Maged Zaki,*** *Professor of Sanitary and Environmental Engineering, Ain Shams University, for her unfailing help, guidance, keen insight, continuous encouragement, constructive suggestions and her invaluable advices during this work.*

Also my gratefulness is to ***Dr. Mohamed sobhy Abdel Rahman,*** *Professor of Sanitary and Environmental Engineering, Ain Shams University, for his help, enthusiasm and co-operation during the research.*

Also I owe special thanks and gratitude's for ***the operation staff of Al Fostat WTP*** *for their great help, making the experimental data available for me and their sincere support. Many thanks to all technicians and labors in Al-Fostat WTP laboratory and their assistance from the Holding Company of Water and Wastewater (HCWW) for their help.*

ABSTRACT

Name*:- *MAHMOUD SAFWAT ABDEL RADY TAHER

Title*:-* "*USING POLYALUMINUM CHLORIDE IN WATER TREATMENT*".

Faculty: Faculty of Engineering, Ain Shams University.

Specialty: Civil Eng., Public Works, Sanitary Engineering.

Summary:

Polyaluminium coagulants are finding increasing use in potable water treatment plants throughout Europe and USA, with polyaluminum chloride (PACl) in particular now having wide application.

This study examines the possibility of using Polyaluminum Chloride (PACl) instead of Aluminum Sulphate (Alum) as a coagulant in surface water treatment process and compares between both coagulants at actual parameters ranges (Turbidity, pH, Temperature, and Residual Chlorine).

The results indicated PACl is performing better than Alum.

Optimum dose for PACl was 20 mg/l for turbidity range of (5.5 – 22.5 NTU) and 40 mg/l for turbidity range of 88 NTU.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter One: INTRODUCTION

CHAPTER I: INTRODUCTION

1.1 BACKGROUND

Coagulation is a process for increasing the tendency of small particles in an aqueous suspension to attach to one another and to attach to surfaces such as the grains in a filter bed. It is also used to effect the removal of certain soluble materials by adsorption or precipitation. The coagulation process typically includes promoting the interaction of particles to form larger aggregates. It is an essential component of conventional water treatment systems in which the processes of coagulation, sedimentation, filtration, and disinfection are combined to clarify the water and remove and inactivate microbiological contaminants such as viruses, bacteria, and the pathogenic protozoa. Although the removal of microbiological contaminants continues to be an important reason for using coagulation, a newer objective, the removal of natural organic material (NOM) to reduce the formation of disinfection by-products, is growing in importance.

Aluminum and ferric iron salts have long been used to remove color caused by NOM. These organic substances are present in all surface waters and in many ground waters. They can be leached from soil, diffused from wetland sediments, and released by plankton and bacteria. Natural organic material adsorbs on natural particles and acts as a particle-stabilizing agent in surface water. It may be associated with toxic metals and synthetic organic chemicals (SOCs). Natural organic material includes precursor compounds that form health-related by-products when chlorine and other chemical disinfectants are used for disinfection and oxidation. For these reasons, considerable attention is being directed at the removal of NOM by coagulation in water treatment, even when color removal is not the principle objective. A treatment technique requirement in the U.S. Environmental Protection Agency's (USEPA's) Stage 1 Disinfection By-Products Rule requires NOM removal in conventional treatment systems by the practice of enhanced coagulation.

Coagulation has been an important component of high-rate filtration plants in the United States since the 1880s. Alum and iron (III) salts have been employed as coagulant chemicals since the beginning, with alum having the most widespread use.

In the 1930s, Baylis perfected activated silica as a “coagulant aid.” This material, formed on site, is an anionic polymer or a small, negatively charged colloid. Synthetic organic polymers were introduced in the 1960s, with cationic polymers having the greatest use. Natural starches were employed before the synthetic compounds.

Polymers have helped changing pretreatment and filtration practice, including the use of multimedia filters and filters with deep, uniform grain-size media, high-rate filtration, direct filtration (rapid mixing, flocculation, and filtration, but no sedimentation), and in-line filtration (rapid mixing and filtration only).

Coagulants are also being used to enhance the performance of membrane microfiltration systems and in pretreatment that prolongs the bed life of Granular Activated Carbon (GAC) contactors (Nowack and Cannon, 1996).

The development of new chemicals advances in floc removal process and filter design, and particle removal performance standards and goals have stimulated substantial diversity in the design and operation of the coagulation process, and change can be expected to continue in the future.

In evaluating high-rate filtration plants that were producing high-quality filtered water, (Cleasby - 1989) concluded; “Chemical pretreatment prior to filtration is more critical to success than the physical facilities at the plant.” their report recommends that plant staff uses a well-defined coagulant chemical control strategy that considers variable raw-water quality. There is no question that high-rate (rapid sand) filtration plants are coagulant-based systems that work only as well as the coagulants that are used.

Chemically, coagulant chemicals are either metallic salts (such as alum) or polymers. Polymers are man-made organic compounds made up of a long chain of smaller molecules. Polymers can be either cationic (positively charged), anionic (negatively charged), or nonionic (neutrally charged).

1.2 ALUM DISADVANTAGES

In reaction the aluminum hydroxide forms the insoluble flocculent precipitate that is desirable for purifying the water. It is to be noted that some calcium sulphate remains in solution when the natural alkalinity or the addition of lime is depended on to react with the alum. This increase the permanent hardness, expressed as calcium carbonate, resulting from this form of treatment is about 11 p.p.m., or about 0.6 grain per gallon for each grain of alum, $Al_2(SO_4)_3$ added. This amount is not objectionable in most water supplies. The increase of free carbon dioxide may be objectionable because of its corrosive nature. Unsatisfactory coagulation may result from the use of alum if sodium or potassium is present in the water. The presence of either of these substances spoils the precipitated aluminum hydroxide floc, causing it to appear in extremely fine particles which are almost colloidal. They will not settle, and they will pass through sand filters. The difficulty may be remedied by increasing the dose of alum.

If it becomes necessary to add alkalinity to improve coagulation, there is a danger of fixation of color of the water if the added alkali is too strong. The reaction is seldom fully completed, and high concentrations of colloidal matter sometimes further hinder the reaction, with a result that residual alum remains in the water that goes to the filters. It is difficult to adjust the coagulation through pH control, because the optimum range of pH values is narrow and application of alum depresses the pH.

1.2.1 Problem Definition

- ALUM is an acid salt and hence corrosive to most metals. It is readily soluble in water and is easily applied as a solution or as dry material. reactions between alum and the natural constituents of various waters are influenced by many factors.
- So it is impossible to determine accurately the amount of alum that will react with a given amount of natural alkalinity or of lime or soda ash added to the water, the addition of these materials are required with alum for the formation of aluminum hydroxide floc where the alkalinity of the treated water is not changed, that is, water treated with 1.0 p.p.m. alum and either 0.35