Cairo University

ENHANCED SETTLING OF ALUMINUM FROM LEAN SLUDGE IN DRINKING WATER TREATMENT PLANTS

By

Reham Samy Ahmed Ismail El Barawy

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Chemical Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

Prof. Dr. M. Hanafy Mahmoud

.....

Professor of chemical engineering
Chemical Eng. Department
Faculty of Engineering, Cairo University

Prof. Dr. Nabil Mahmoud Abdel Monem

.....

Professor of chemical engineering
Chemical Eng. Department
Faculty of Engineering, Cairo University

Dr. Mohamed M. El Bouraie

.....

Assistant Professor
At CLEQM
El Kanater, Egypt

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Approved by the
Examining Committee

_____
Prof. Dr. Mohamed Hanafy Mahmoud, Thesis Main Advisor
Faculty of Engineering, Cairo University

_____
Prof. Dr. Nabil Mahmoud Abd El-Monem, Advisor
Faculty of Engineering, Cairo University

_____
Prof. Dr. Hanem Sibak, Internal Examiner
Faculty of Engineering, Cairo University

_____
Prof. Dr. Mohamed Mokhtar, External Examiner
Head of Central Laboratories for Environmental Quality Monitoring, El Kanater

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2017

Engineer's Name:	Reham Samy Ahmed Ismail
Date of Birth:	18/3/1990.
Nationality:	Egyptian
E-mail:	reham_samy183@yahoo.com
Phone:	01017067775
Address:	New Maadi, Cairo
Registration Date:	1/10/2013
Awarding Date:	…./…./2017
Degree:	Master of Science
Department:	Chemical Engineering

Supervisors:

Prof. Dr. M. Hanafy Mahmoud
Prof. Dr. N. Mahmoud Abdel Monem
Prof. Dr. Mohamed M. El Bouraie, CLEQM, Kanater

Examiners:

Prof. Dr. Mohamed Mokhtar, CLEQM, Kanater (External Examiner)
Prof. Dr. Hanem Sibak (Internal Examiner)
Prof. Dr. M. Hanafy Mahmoud (Thesis Main Advisor)
Prof. Dr. Nabil Mahmoud Abdel Monem (Advisor)

Title of Thesis:

Enhanced Settling of Aluminum from Lean Sludge in Drinking Water Treatment Plants

Key Words:
Lean Sludge; Alum; Settling; Bentonite; Cationic Polymer.

Summary:

In the present thesis, sodium bentonite clay and combination of bentonite-cationic polymer were investigated to enhance settling of Aluminum from lean sludge of drinking water treatment plants and to dewater the sludge, increasing its solid content for better handling and reuse. Sodium bentonite as a natural material is usually a cheaper coagulant with high swelling mechanism, has high specific surface area with net negative charge, and can enhance its sorption capability.
Lean sludge was characterized using Inductively Coupled Plasma-Optical Emission Spectrum (ICP-OES), while, bentonite was characterized by using X-ray diffraction (XRD). Jar test experiments were performed at different pH, different volume dosages and concentration of bentonite and combination of bentonite-cationic polymer. A treatment compact unit was proposed and studied economically.

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Dedication

The thesis is dedicated to my family “God bless them” and the soul of my grandmother “Mercy of God on her”.

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Nomenclature

APHA	American Public Health Association
AWWA	American Water Works Association
BC	Before Christ
BCM/Year	Billion Cubic Meter / Year
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CWA	Clean Water Act
DOC	Dissolved Organic Carbon
EPA	Environmental Protection Agency
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectrum
L.O.I	Loss on Ignition
mm/year	Millimeter/Year
MC	Moisture Content
MCFA	Modified Coal Fly Ash
Mg/l	Milligram/Liter
MDR	Microwave Digestion Rotor
NTU	Nephelometry Turbidity Unit
P: B	Polymer to Bentonite mass ratio
R^2	Determination Coefficient
SS	Suspended Solids
SEM	Scanning Electron Microscopy
SRF	Specific Resistance to Filtration
SDWA	Safe Drinking Water Act
TDS	Total Dissolved Solids
TTN	Threshold Taste Number
TON	Threshold Odor Number
TOC	Total Organic Carbon
USN	Ultra Sonic Nebulizer
WHO	World Health Organization
XRD	X-Ray Diffraction
Y_N	Net Sludge Solids Yield

ABSTRACT

Abstract

Different cultures used various methods to treat water for improving its quality.

In Egypt, during water purification aluminum salt coagulants such as alum is used in the coagulation step to remove suspended solids but some of aluminum salt remains in the lean sludge. Most water treatment plants dispose the sludge without treatment directly to the nearest waterways. This in turn, causes lowering water depth and the need for dredging such sediments.

This research aims studying the feasibility of using natural clay such as “bentonite” known as montmorillonite clay and the combination of bentonite – cationic polymer as coagulants for aluminum salts removal from the lean sludge generated from drinking water treatment plants and consequently sludge dewatering increasing its solids content. Bentonite is characterized by a large specific surface area, good adsorption, ion exchange ability, and nontoxicity. Jar tests experiments were performed using a real alum lean sludge samples from El Khanka treatment plant, in Abu Zaabal. Different pH values, different dosage amounts of bentonite and different doses of cationic polymer were carried out. Then a proposed compact unit is designed and studied technically and economically.

Optimum results were analyzed using Inductively Coupled Plasma- Optical Emission Spectrometry (ICP-OES) using bentonite at concentration 30 mg/l, volume 10 ml and pH 11 aluminum salt removal efficiency was (98.79%).

While, for combination of bentonite with cationic polymer removal efficiency was (97.1%) obtained in case of using 0.49 gm of cationic polymer and 0.09 gm of bentonite (i.e. polymer to bentonite (P:B) mass ratio equals (5.4:1)) at pH 3, with 20 ml volume dosage, and 90 mg/l of bentonite at the optimum conditions. Therefore, bentonite usage is better than the combination of bentonite and polymer.

The thesis contains five chapters as follows, chapter one is introduction, chapter two is literature review about water treatment, sludge and bentonite. Chapter three starts the experimental work, tools and methodology, consequently, chapter four is the results and discussions. Chapter five is economic consideration and finally but not the end the conclusions and recommendations. Beside these main chapters there is the English and Arabic summary.

CHAPTER 1

INTRODUCTION