Ain Shams University
Faculty of Science
Chemistry Department

Utilization of Some Solid Wastes in the Field of Water Treatment

A Thesis

Submitted for Ph.D Degree in Chemistry

By

Sayed Ahmed Othman Abo El-Dahab

M.Sc. Chemistry, (2008)

Supervised by

Prof. Dr. Salah A. Abo-El-Enein (D.Sc.)

Professor of Physical Chemistry& Building Materials,
Faculty of Science, Ain Shams University

Prof. Dr. Fayza Sayed Mohamed Hashem

Professor of Physical Chemistry,
Faculty of Science, Ain Shams University

Dr. Safaa Mohamed Awwad El-Gamal

Associated Professor of Physical Chemistry,
Faculty of Science, Ain Shams University

Cairo - 2018

Ain Shams University
Faculty of Science
Chemistry Department

Utilization of Some Solid Wastes in the Field of Water Treatment

A Thesis

Submitted for Ph.D Degree in Chemistry

By

Sayed Ahmed Othman Abo El-Dahab

M.Sc. Chemistry, (2008)

Supervised by

Prof. Dr. Salah A. Abo-El-Enein (D.Sc.) ----------
Professor of Physical Chemistry& Building Materials,
Faculty of Science, Ain Shams University

Prof. Dr. Fayza Sayed Mohamed Hashem
Professor of Physical Chemistry, ----------
Faculty of Science, Ain Shams University

Dr. Safaa Mohamed Awwad El-Gamal ----------
Associated Professor of Physical Chemistry,
Faculty of Science, Ain Shams University

Head of Chemistry Department

Prof. Dr. Ibrahim H. A. Badr

Cairo - 2018

Ain Shams University
Faculty of Science
Chemistry Department

Utilization of Some Solid Wastes in the Field of Water Treatment

A Thesis

Submitted for Ph.D. Degree in Chemistry

By

Sayed Ahmed Othman Abo-El-Dahab

M.Sc. Chemistry, (2008)

Approved by

Prof. Dr. Salah A. Abo-El-Enein (D.Sc.) ----------
Professor of Physical Chemistry& Building Materials,
Faculty of Science, Ain Shams University

Prof. Dr. Mahmoud Ahmed Mohamed Mousa -------
Professor of Physical Chemistry & Materials Science,
Faculty of Science, Benha University

Prof. Dr. Ashraf Abd-El-Aziz El-Bendary ----------
Professor of Inorganic & Analytical Chemistry,
Faculty of Science, Damietta University

Head of Chemistry Department

Prof. Dr. Ibrahim H. A. Badr

Cairo – 2018


وعلمك ما لم تكن تعلم
وكان فضل الله عليك عظيما

ACKNOWLEDGEMENT

First and foremost, I would like to thank ***Allah*** *for giving me the opportunity and the strength to accomplish this work.*

I would like to express my deep gratitude to ***Prof. Dr. Salah A. Abo-El-Enein (D.Sc.)*** *Professor of Physical Chemistry& Building Materials, Faculty of Science, Ain Shams University.*

I would like to express my deep gratitude to ***Prof. Dr. Fayza Sayed Mohamed Hashem*** *Professor of physical chemistry, Faculty of Science, Ain Shams University, for her valuable supervision, advice, unlimited support and constructive suggestions throughout the thesis.*

I would like to express my deep gratitude to ***Dr. Safaa Mohamed Awwad El-Gamal*** *Associated Prof. of physical chemistry, Faculty of Science, Ain Shams University, for her valuable supervision, advice, unlimited support and constructive suggestions throughout the thesis.*

I owe great thanks and sincere love to my wife for her encouragement and support throughout my work.

Sayed Ahmed Othman Abo El-Dahab

List of Abbreviation

Symbol	Description
WHO	World health organization
TDS	Total dissolved salts
TSS	Total suspended solids
WTS	Water treatment sludge
PCB	Powder calcined brick
WBD	Waste brick dust
COD	Chemical oxygen demand
SMWW	Standard methods for the examination of water and wastewater
FA	Fly ash
DWTS	Drinking water treatment sludge
LWBW	Light white brick waste
HOMRA	Red brick waste
ICP	Inductive coupled plasma
XRD	X-ray diffraction
XRF	X-ray florescence
EDX	Energy Dispersive X-ray
SEM	Scanning electron microscope
CSH	Calcium silicate hydrates
CS	Calcium silicate

Applied Clay Science 146 (2017) 343–349

Contents lists available at ScienceDirect

Applied Clay Science

journal homepage: www.elsevier.com/locate/clay

Research paper

Drinking water treatment sludge as an efficient adsorbent for heavy metals removal

S.A. Abo-El-Enein[a], Ahmed Shebl[a,*], S.A. Abo El-Dahab[b]

[a] Chemistry Department, Faculty of Science, Ain Shams University, Abbassia 11566, Cairo, Egypt
[b] Holding Company for Water and Wastewater, Egypt

ARTICLE INFO

Keywords:
Drinking water treatment sludge
Lead cadmium nickel removals
Adsorption
Quartz
Illite
Albite

ABSTRACT

Green chemists paid much more attention towards the alternative ways to reutilize waste materials instead of its disposal in a non-ecofriendly manner. In this study, drinking-water treatment sludge (DWTS), which is a by-product resulted from drinking water treatment plants, was successfully applied as an adsorbent for Pb(II), Cd(II) and Ni(II) removal from wastewater. The physicochemical characteristics of DWTS were investigated using X-ray diffraction (XRD), X-ray fluorescence (XRF), scanning electron microscopy (SEM) and N_2 adsorption-desorption isotherms.

The XRD analysis revealed that the DWTS under study consists of quartz and illite phases which had been reported for their adsorption efficiency. Firing of DWTS at 500 °C causes the appearance of albite phase in addition to previous ones which enhances the adsorption capacity of these materials. The influence of different parameters such as firing temperature of DWTS, contact time, pH, DWTS dose and initial metal ions concentration on the adsorption of heavy metal ions and, consequently, on their removal were investigated. DWTS exhibit an adsorption efficiency towards Pb(II) > Cd(II) > Ni(II). The extremely high efficiency of DWTS towards Pb(II) adsorption can nominate it as a specific low-cost adsorbent for Pb ions.

1. Introduction

Drinking-water treatment sludge (DWTS) is a by-product from the coagulation-flocculation process using aluminum or iron based salts to precipitate clay, colloidal particles, algae and humic substances from water resources. Due to its high production rate and its environmentally unfavored disposal to landfill, several researchers paid a considerable attention for using this waste material in different applications especially those of low cost. The chemical composition of DWTS varies depending on the source of water under treatment as well as the type of coagulant used. These applications include utilization of DWTS for ceramic products (Zamora et al., 2008; Kizinievic et al., 2013; Mymrin et al., 2017), cement and concrete production (Rodríguez et al., 2010; Sales et al., 2011; Hwang et al., 2017) as well as wastewater treatment as an adsorbent for the removal of phenolic compounds (Fragoso and Duarte, 2012), phosphates (Razali et al., 2007; Piaskowski, 2013), dyes from textile industry discharge (Chu, 1999) and heavy metals (Ippolito et al., 2011; Siswoyo et al., 2014).

Pollution of water resources by heavy metals such as lead, cadmium and nickel which are continuously discharged in huge amounts from different growing industrial activities has been recognized (Ribeiro et al., 2012; Yang and Cui, 2013; Keränen et al., 2015). These heavy metals are considered as hazardous materials where their toxicity to living organisms comes from their tendency to accumulate in living tissues since they are not biodegradable causing several health hazards like kidney problems, anemia, lung cancer and dyspnoea (Ahmaruzzaman, 2011; Visa et al., 2012). Therefore, a tremendous number of researches deals with the removal of such heavy metals especially via adsorption process (Bailey et al., 1999; Babel and Kurniawan, 2003; Ngah and Hanafiah, 2008; Tofighy and Mohammadi, 2015; Castaldi et al., 2015; Isaac et al., 2015; Dobrowolski et al., 2017; Azimi et al., 2017).

The aim of this study is to get a beneficial use of DWTS as a low cost adsorbent for the removal of lead, cadmium and nickel metal ions from wastewater.

2. Experimental

2.1. Starting materials

The material used in this investigation is DWTS waste produced during 4 months from El-Fustat drinking water treatment plant (Egypt).

* Corresponding author.
E-mail address: a_ahmed@sci.asu.edu.eg (A. Shebl).

http://dx.doi.org/10.1016/j.clay.2017.06.027
Received 1 May 2017; Received in revised form 13 June 2017; Accepted 23 June 2017

ABSTRACT

The objective of this study is to investigate the efficiency of using drinking water treatment sludge (DWTS), light white brick (LWBW) and red brick (HOMRA) wastes as solid adsorbents for the removal of heavy metal ions like lead, cadmium and nickel from their aqueous solution. The physicochemical characteristics of each solid waste were investigated using X-ray diffraction (XRD), X-ray fluorescence (XRF), scanning electron microscopy (SEM) and N_2 adsorption-desorption isotherms. Besides, the effect of different parameters such as contact time, initial pH, initial metal ion concentrations, adsorbent dose and competition of metal ions on the adsorption of heavy metal ions was studied by using batch experiments. In addition, the effect of firing temperatures on the removal efficiency of these heavy metal ions from their solutions was investigated in case of DWTS. The removal efficiency at optimum conditions was approximately 100% for Pb^{+2}, Cd^{+2} and Ni^{+2} using DWTS and LWBW and 100, 20 and 9.7%, respectively using HOMRA. The adsorption kinetics of ions was followed the pseudo-second-order model based on the amounts of metal sorbed at various time intervals.

Keywords: Solid waste, heavy metals, wastewater, sludge, brick waste, low cost adsorbent.

List of Contents

List of Figures