MANAGEMENT OF SEWAGE SLUDGE IN THE CERAMIC TILE INDUSTRY

By

Eman Mohamed Abd El–Hamid Ramadan

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
GIZA, EGYPT

2015

MANAGEMENT OF SEWAGE SLUDGE IN THE CERAMIC TILE INDUSTRY

By
Eman Mohamed Abd El–Hamid Ramadan

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

Under the Supervision of

Prof. Magdi Fouad Abadir

……..

Chemical Engineering Department
Faculty of Engineering, Cairo University

Prof. Hanem Abd El–Rahman Sibak

……..

Chemical Engineering Department
Faculty of Engineering, Cairo University

Ass. Prof. Shakinaz Ali El–Sherbiny

……

Chemical Engineering Department
Faculty of Engineering, Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT

2015

MANAGEMENT OF SEWAGE SLUDGE IN THE CERAMIC TILE INDUSTRY

By
Eman Mohamed Abd El–Hamid Ramadan

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

Approved by the
Examining Committee

_____
Prof. Magdi Fouad Abadir, Thesis Main Advisor,
Faculty of Engineering, Cairo University

_____
Prof. Mai Kamal El–Deen El–Said, Internal Examiner,
Faculty of Engineering, Cairo University

_____
Prof. Mohamed El–Menshawy Shalaby, External Examiner,
Central Metallurgical Research Institute (CMRDI)

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT

2015

Engineer: Eman Mohamed Abd El Hamid Ramadan
Date of Birth : 7 / 2 / 1990
Nationality : Egyptian
E-mail : iman_abdelhamid_90@hotmail.com
Phone. : 01015769123
Address : 25 - Moawia Abn Abo Sofian - Ard El Gamaia- Embaba

Registration Date : 1 / 10 /2012
Awarding Date : / /
Degree : Master of Science
Department : Chemical Engineering Department

Supervisors : **Prof. Dr.** Magdi Fouad Abadir
Prof. Dr Hanem Abd El–Rahman Sibak
Ass. Prof. Shakinaz Ali El–Sherbiny

Examiners : **Prof. Dr.** Magdi Fouad Abadir
Prof. Dr. Mai Kamal El–Deen El–Said
Prof. Dr. Mohamed El–Menshawy Shalaby (Professor in Central Metallurgical Research Institute)

Title of Thesis : **Management of Sewage Sludge in the Ceramic Tile Industry**

Key Words: Ceramic–Tiles–Sewage–Sludge

Summary :

The sewage sludge produced from the waste water treatment plant was tested for chemical and mineralogical composition. It was gradually added to standard wall and floor tiles mix in proportions ranging from 0% to 35%. The samples were pressed, dried and then fired at temperature from 1050 to 1150 °C. The vitrification parameters, which are linear firing shrinkage, loss on ignition, water absorption, apparent porosity, bulk density, closed porosity, and mechanical properties, were determined and compared ISO standards. Fired samples of the proposed mixtures were investigated by scanning electron microscope (SEM).

Sewage sludge can be used in ceramic tiles of thicknesses < 7.5 mm for wall tiles with water absorption > 10 % at temperature 1150 °C and percentage 7 %, while for floor tiles with water absorption 6 % < E ≤ 10 %, 7 % waste addition can be used at 1150 °C, and for floor tiles with water absorption > 10 %, 14 % waste addition can be used at temperature 1150 °C, which are recommended for both its economic and environmental benefits.

ACKNOWLEDGEMENTS

The author's special thanks and gratitude go to God for his mercy, kindness, and support.

The author wishes to express her deep thanks and gratitude to her main supervisor Prof. M.F. Abadir, at the Chemical Engineering Department, Faculty of Engineering, Cairo University, for suggesting the research point, supervising the experimental work, in addition to his continuous encouragement.

The author also thanks both of Prof. H.A. Sibak and Dr. S.A. El–Sherbiny, at the Chemical Engineering Department, Faculty of Engineering, Cairo University, for her supervision and help.

Deepest gratitude is also due to Dr. Sh.K. Amin, Assistant Professor, at the Chemical Engineering and Pilot Plant Department, National Research Centre, for supervising and following up the experimental research work. Her efforts in solving the practical problems that faced the author are deeply appreciated.

The author deep thanks also due to Eng. Ahmed Samir, Quality Manager of the Royal Company for Ceramic Tiles (CERAMICA ROYAL), and to the staff of the Quality Control Laboratory in this factory, for helping the author to perform the experimental work and the required tests in both factories.

Finally, the author expresses her gratitude to her mum for her encouragement to do her best, believing in her and supporting her dreams and also thanks her dad, and all her family members, for their continuous encouragement and help.

Table of Contents

Page

List of Tables

Page

CHAPTER (2): LITERATURE REVIEW

CHAPTER (3): EXPERIMENTAL WORK

CHAPTER (4): RESULTS AND DISCUSSION

List of Figures

Page

CHAPTER (1): INTRODUCTION

CHAPTER (2): LITERATURE REVIEW

CHAPTER (3): EXPERIMENTAL WORK

CHAPTER (4): RESULT AND DISCUSSION

List of Abbreviations

B.S	: Breaking Strength
DTA	: Differential Thermal Analysis
GB	: Glazed, Apparent Change in Appearance
GLB	: Glazed, Low Concentration, Apparent Change in Appearance
I.S.S.A	: Incinerated Sewage Sludge
L.D.S	: Linear Drying Shrinkage
L.F.S	: Linear Firing Shrinkage
L.O.I	: Loss on Ignition
MOR	: Modulus of Rupture
S.S	: Sewage Sludge
SEM	: Scanning Electron Microscope
T.L.S	: Total Linear Shrinkage
TGA	: Thermal Gravimetric Analysis
UB	: Unglazed, Apparent Change at the Cut Edge
ULB	: Unglazed, Low Concentration, Apparent Change at the Cut Edge
W.A.	: Water Absorption
WWTP	: Waste Water Treatment Plant
XRD	: X – Ray Diffraction
XRF	: X – Ray Fluorescence

List of Symbols

P	: Apparent Porosity
E	: Water Absorption
B	: Bulk Density
T	: Apparent Specific Gravity
L	: Distance between Two Supports
b	: Width of the Tested Sample
d	: The Minimum Thickness of the Tested Sample
L_i	: Tile Length after Drying
L_f	: Tile Length after Firing
D	: Dry mass
S	: Suspended Mass
M	: Saturated Mass
σ	: Mechanical Strength

ABSTRACT

Sewage sludge is produced from WWTPs after the primary and the secondary treatment of municipal waste water, the daily production of dry sewage sludge in Egypt is estimated to be 5.8×10^3 tons. Sewage sludge represents an extremely high ecological hazard to the environment.

The main aim of this thesis is to show the possibility of management of this hazardous waste in wall and floor ceramic tiles industry.

The experimental program includes assessment of raw materials by performing the required analysis, which are XRF, XRD, DTA and TGA. The fine waste was used to partially replacement for wall and floor ceramic tiles basic mixtures from Egyptian raw materials. The replacement ratios varied from zero % to 35 % by weight. Screen analysis, powder density, and plasticity of different mixes were determined.

Rectangular tile specimens of dimensions $110.4 \times 55.4 \times 8$ mm^3 were molded by dry pressing under uniaxial pressure of 200 MPa, then dried overnight at 135 °C. Wall tiles samples were fired at temperatures 1050 °C, 1100 °C and 1150 °C, while the floor tiles samples were fired at temperatures 1050 °C, 1100 °C, 1120 °C and 1150 °C. The vitrification parameters, which are linear firing shrinkage, loss on ignition, water absorption, apparent porosity, bulk density, closed porosity, and mechanical properties, were determined and compared to the ISO standards. Fired samples of the proposed mixtures were investigated by scanning electron microscope (SEM).

Sewage sludge can be used in the ceramic tile industry according to the ISO standard limits: for wall tiles 7% waste addition can be used at temperature 1150 °C, while for floor tiles 7 % and 14% waste addition can be used at 1150 °C, which are recommended for both their economic and environmental benefits.

Chapter One