



Cairo University

# 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

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**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.

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## **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 <sub>i</sub>	: Tile Length after Drying
L <sub>f</sub>	: Tile Length after Firing
D	: Dry mass
S	: Suspended Mass
M	: Saturated Mass
$\sigma$	: 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  $5.8 \times 10^3$  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  $110.4 \times 55.4 \times 8 \text{ mm}^3$  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***