



# **Studies on microbial deterioration of some limestones monuments**

Thesis

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By

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# Comtent

Subject	Page
<b>List of figures</b> .....	VI
<b>List of tables</b> .....	VIII
<b>Abbreviations</b> .....	X
<b>Aim of work</b> .....	X I
<b>Abstract</b> .....	XII
<b>Introduction</b> .....	1
1 <b>Review of literature</b> .....	4
1.1    Monuments and microbes.....	6
1.2    Stone.....	8
1.3    Microbial diversity of stone monuments.....	10
1.3.1    Bacteria and actinobacteria.....	10
1.3.2    Fungi.....	13
1.3.3    Cyanobacteria.....	14
1. 4    Other biological deteriorating agents.....	16
1.4.1    Lichens.....	16
1.4.2    Lower plants and weeds .....	16
1.5    Mechanism of microbial biodetririation.....	17
1.5.1.    Biofilm formation .....	17
1.5.2    Discoloration.....	18
1.5.3    Salting.....	20

1.5.4	Physical damage .....	21
1.5.5	Inorganic acids .....	22
1.5.6.	Organic acids.....	23
1.5.7	Redox processes on cations from the mineral lattice.....	23
1.6	Methods of Intervention.....	24
1.6.1	Mechanical methods	25
1.6. 2	Physical methods .....	26
1.6.3	Biological methods .....	27
1.6. 4	Biochemical methods.....	28
1.6.5	Chemical methods...	30
1.6.6	Natural methods.....	33
<b>2</b>	<b>Material and methods.....</b>	<b>35</b>
<b>2.1</b>	<b>Material.....</b>	<b>35</b>
2.1.1	Samples of different sites.....	35
2.1.2	Culture media.....	37
2.1.3	Chemicals.....	42
2.1.4	Reagents and solution .....	42
<b>2.2</b>	<b>Methods.....</b>	<b>45</b>
2.2.1	Sampling and culturing .....	45
2.2.2	Isolation and purification .....	48
2.2.3	Qualitative evaluation of microbial limestone degradation.....	49

2.2.4	Quantitative evaluation of microbial limestone degradation.....	50
2.2.4.1	Standard curve for evaluating the acidolytic activity of microbial isolates.....	51
2.2.5	Acid and melanin production ability of the most potent isolates.....	53
2.2.6	Characterization of microbial isolates.....	54
2.2.6.1	Cultural and microscopic examination.....	54
2.2.6.2	Molecular characterization.....	56
2.2.6.2.1	PCR amplification of 16S-rRNA genes using direct colony PCR.....	56
2.2.6.2.2	Sequencing 16S-rRNA genes.....	57
2.2.7	Antimicrobial activity of some synthetic and natural substances and their minimum inhibitory concentration (MIC).....	57
2.2.8	Evaluation of the effect of antimicrobial agents on limestone using Fourier transform infrared spectroscopy (ATR-FTIR).....	58
2.2.9	Simulation experiment.....	59
2.2.9.1	Physical characters evaluation of artificial inoculated limestone.....	60
2.2.9.2	Morphological character evaluation of artificial inoculated limestone.....	61
2.2.9.3	Chemical evaluation of artificial infected limestone.....	61
2.2.9.4	Simulation of treatment and conservation of microbial degraded limestone by the most potent isolates.....	62
2.2.10	Statistical analysis.....	62
<b>3</b>	<b>Results.....</b>	<b>63</b>
3.1	Isolation and counting .....	63
3.1.1	Isolation by swabbing method. ....	63

3.1.2	Isolation using serial dilution of solid deteriorated samples	66
3.2	Qualitative evaluation of microbial limestone degradation.....	68
3.3	Distribution percentages of microbial isolates among archeological sites.....	72
3.3.1	Distribution percentages of actinobacterial isolates among archeological sites.....	72
3.3.2	Distribution percentages of bacterial isolates among archeological sites.....	73
3.3.3	Distribution percentages of fungal isolates among archeological sites.....	74
3.4	Quantitative evaluation of microbial limestone degradation.....	75
3.5	Acid and melanin production ability of the most potent isolates.....	80
3.6	Characterization of microbial isolates .....	82
3.6.1	Characterization of actinobacteria.....	82
3.6.1.1	Cultural characteristics of actinobacteria .....	82
3.6.1.2	Microscopic characteristics of actinobacteria.....	91
3.6.1.3	Molecular identification of the most potent actinobacterial isolate.....	91
3.6.2	Characterization of bacterial isolates.....	92
3.6.2.1	Cultural characteristics of bacterial isolates.....	92
3.6.2.2	Microscopic characteristics of bacteria isolates.....	92
3.6.2.3	Molecular identification of the most potent bacterial isolates.....	94
3.6.3	Characterization of fungal isolates.....	95
3.6.3.1	Cultural characteristics of fungal isolates.....	95
3.6.3.2	Microscopic characteristics of fungal isolates.....	95

3.7	Antimicrobial activity of some synthetic and natural substances and their minimum inhibitory concentration	104
3.8	Evaluation of antimicrobial agents effect on limestone using ATR-FTIR analysis.....	121
3.9	Simulation of deterioration experiment.....	123
3.9.1	Physical changes evaluation of artificial inoculated limestone.....	125
3.9.2	Morphological change evaluation of artificial inoculated limestone.....	128
3.9.3	Chemical change evaluation of artificial inoculated limestone.....	131
3.9.4	Simulation of treatment experiment of limestone	135
<b>4</b>	<b>Discussion.....</b>	<b>137</b>
<b>5</b>	<b>Conclusion.....</b>	<b>150</b>
<b>6</b>	<b>Recommendation.....</b>	<b>151</b>
<b>7</b>	<b>Summary.....</b>	<b>152</b>
<b>8</b>	<b>References.....</b>	<b>155</b>

## List of figures

	Subject	Page
<b>Figure 1</b>	Microbial deterioration of stone monuments.....	20
<b>Figure 2</b>	Salting causing physical damage and dark discoloration of walls at Seti I tomb at Luxor.....	21
<b>Figure 3</b>	Deteriorated surfaces of stone monuments.....	46
<b>Figure 4</b>	Methods of sampling.....	47
<b>Figure 5</b>	Standard curve of CaCO <sub>3</sub> weights (g) and volume of titrant (NaOH) (ml).....	52
<b>Figure 6</b>	Total count of solid deteriorated stone scratches from different archeological sites.....	67
<b>Figure 7</b>	Percentage of bacterial limestone degraders.....	70
<b>Figure 8</b>	Percentage of fungal limestone degraders.....	71
<b>Figure 9</b>	Distribution percentage of common actinobacteria among archeological sites.....	72
<b>Figure 10</b>	Distribution of common bacterial isolates among archeological sites.....	73
<b>Figure 11</b>	Distribution of common fungi among archeological sites.....	74
<b>Figure 12</b>	Quantitative evaluation of actinobacterial limestone degradation percentage.....	77
<b>Figure 13</b>	Quantitative evaluation of bacterial limestone degradation percentage.....	78
<b>Figure 14</b>	Quantitative evaluation of fungal limestone degradation percentage.....	79
<b>Figure 15</b>	Cultural characteristics of some selected actinobacteria.....	90
<b>Figure 16</b>	Light microscope image of isolates 37 and 45.....	91
<b>Figure 17</b>	Minimum inhibitory concentrations of different antimicrobial agents against actinobacterial isolates.....	118



<b>Figure 18</b>	Inhibition percentage of different concentrations of antimicrobials on actinobacterial isolates.....	118
<b>Figure 19</b>	Minimum inhibitory concentrations of antimicrobials against bacterial isolates.....	119
<b>Figure 20</b>	Inhibition percentage of different concentrations of antimicrobials on bacterial isolates.....	119
<b>Figure 21</b>	Minimum inhibitory concentrations of antimicrobials against fungal isolates.....	120
<b>Figure 22</b>	Inhibition percentage of different concentrations of antimicrobials on fungal isolates.....	120
<b>Figure 23</b>	FTIR analysis of treated and control limestone cubes.....	122
<b>Figure 24</b>	Sealed limestone cubes inoculated with the most potent isolates...	123
<b>Figure 25</b>	Microbial deterioration visual signs after inoculation with the most potent isolates.....	124
<b>Figure 26</b>	Reduction percentage of compressive strength and porosity due to microbial deterioration.....	127
<b>Figure 27</b>	Morphological change evaluation of artificial inoculated limestone cubes using ESEM.....	130
<b>Figure 28</b>	EDX analysis of control and inoculates limestone.....	133

## List of plate

<b>Plate 1</b>	Macromorphological and micromorphological characterization of fungal isolates.....	99
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## List of tables

Number	Subject	Page
<b>Table 1</b>	Total pooled swabs and samples from different archeological sites.....	35
<b>Table 2</b>	Mean count of pooled collected swabs from different sites.....	64
<b>Table 3</b>	Total count of solid deteriorated stone samples from different archeological sites.....	67
<b>Table 4</b>	Total number and percentage of actinobacterial limestone degraders.....	69
<b>Table 5</b>	Total number and percentage of bacterial limestone degraders.....	70
<b>Table 6</b>	Total number and percentage of fungal limestone degraders.....	71
<b>Table 7</b>	Quantitative evaluation of actinobacterial limestone degradation percentage.....	76
<b>Table 8</b>	Quantitative evaluation of bacterial limestone degradation percentage.....	78
<b>Table 9</b>	Quantitative evaluation of fungal limestone degradation percentage.....	79
<b>Table 10</b>	Acid and melanin production of microbial isolates.....	81
<b>Table 11</b>	Cultural characteristics of actinobacterial isolates.....	83
<b>Table 12</b>	Microscopic characterization of bacterial isolates.....	93
<b>Table 13</b>	Cultural and microscopic identification of fungal isolates.....	96
<b>Table 14</b>	Antimicrobial agents against the most potent actinobacterial isolates.....	106
<b>Table 15</b>	Antimicrobial agents against the most potent bacterial isolates.....	109
<b>Table 16</b>	Antimicrobial agents against the most potent fungal isolates.....	115
<b>Table 17</b>	Physical changes of artificially inoculated limestone.....	126

<b>Table 18</b>	Reduction percentage of compressive strength and porosity due to microbial deterioration.....	127
<b>Table 19</b>	EDX mineral microanalysis of uninoculated and artificially inoculated limestone.....	134
<b>Table 20</b>	Inhibition percentage of active antimicrobials inside deteriorated limestone model.....	136

## ABBREVIATIONS

<b>ATR-FTIR</b>	Attenuated total reflection-Fourier transform infrared spectroscopy
<b>bp</b>	Base pair
<b>CFU</b>	Colony forming unit
<b>cm</b>	Centimeter
<b>DNA</b>	Deoxyribose nucleic acid
<b>dNTP</b>	Deoxyribose nucleotide triphosphate
<b>EDTA</b>	Ethylene diamine tetra acetic acid
<b>g</b>	Gram
<b>Kb</b>	Kilo base
<b>M</b>	Molar
<b>mg</b>	Milligram
<b>MIC</b>	Minimum inhibitory concentration
<b>min</b>	Minute
<b>ml</b>	Milliliter
<b>MPa</b>	Mega Pascal
<b>NCBI</b>	National Center for Biotechnology Information
<b>PCR</b>	Polymerase chain reaction
<b>RPM</b>	Rotation per minute
<b>rRNA</b>	Ribosomal ribonucleic acid
<b>sp.</b>	Species (singular)
<b>TBE</b>	Tris-Borate-EDTA
<b>TE</b>	Tris-EDTA
<b>v/v</b>	Volume/volume
<b>w/v</b>	Weight/volume

## **Introduction**

Cultural Heritage plays very important role in our life since it keeps us attached to our traditions and beliefs. Egypt has played an important role through thousands of years. Ancient monuments indicates Egypt's role in most of the world's historic events, where some of the first written words of civilization were found in Egypt.

Ancient Egypt was regarded as the “state out of stone” because stone was the most important raw material used during different periods of pharaonic Egypt until Greco-Roman and Arab times. Much of what remains of ancient Egypt are from stones. There are building stones for temples, pyramids and tombs. In addition, ornamental stones for vessels, sarcophagi, shrines, statues, sculptures, gemstones for jewelry, weapons, tools and others.

There are many factors that contribute in the deterioration of stones. These factors include: the environmental conditions; temperature, relative humidity, light condition, wind and rainfall, nature

and properties of stones, texture, mineral constituents, pH and moisture content and finally pollutants including microorganisms (Urzi, 2004 and Steiger et al.,2011 )

Many groups of microorganisms; bacteria, actinobacteria and fungi co-existed at the same time and in the same place. Any biodeterioration occurring is probably the result of complex microbial interactions. This complexity has to be taken into account during the control of biodeterioration phase for each historic stone (Warscheid et al., 1996). Some microorganisms can grow only on stone surfaces (epilithic), others prefer more protected habitats like small crevices and fissures (chasmolithic) or inside the stone structure (endolithic). The metabolic activities of these organisms such as the production of extra cellular polymers, the liberation of mineral chelating compounds and organic/inorganic acids, together with the presence of colored pigments and the mechanical pressure exerted by growing

structures act together to cause stone decay (Ortega et al., 1993).

When considering solutions for stone biodeterioration problem, three factors must be considered; stone nature, environmental conditions and biodeteriogens. Actions against microbial growth can be divided into two major categories: indirect control by altering environmental conditions and direct control by mechanical removal of biodeteriogens, application of biocides (natural or chemical) and physical eradication methods (Warscheid and Braams, 2000).

Caring about the Egyptian cultural heritage requires constant monitoring, protection and maintenance. This work was carried out to protect and preserve monuments, as originally as possible, in their existing substance and to pass them on to future generations as “genuine” cultural heritage.