Studies on microbial deterioration of some limestones monuments

Thesis
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Comtent

List of figures

List of plate

List of tables

ABBREVIATIONS

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