

Biodeterioration of stone monuments and remediation strategies

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Stone monuments are exposed to abiotic and biotic factors that endanger their conservation. In particular, the exposure to natural or artificial light promotes the growth of phototrophic biofilms on the lithic surfaces, a process known as biodeterioration. These biofilms are composed of photoautotrophic cyanobacteria, sometimes associated with microalgae, chemoautotrophic bacteria and fungi and cause aesthetic and structural problems to the valuable surfaces that need periodic restoration. The standard protocols carried out to restore and conserve stone monuments, are based on the use of mechanical interventions coupled with the employment of chemicals, that often result invasive for the substratum and dangerous for humans and the environment.

Studies were undertaken in order to characterize the phototrophic communities that develop in different Roman Catacombs causing the discoloration of exposed surfaces some of them with frescoes. Non-invasive and non-destructive sampling techniques were used to collect samples, that resulted formed by cyanobacteria after the observation at the light microscope. Some species of cyanobacteria found in these sites appeared as particularly biodeteriogenic due to the ability to mobilise minerals from the lithic substrata.

In order to develop new non-invasive conservation strategies different compounds were tested: nanomaterials based on graphene oxide and essential oils were evaluated as new biocompatible, eco-sustainable compounds alternative to the classical biocides. The tests were carried out on phototrophic biofilms collected *in situ* and grown on agarized medium and the effect evaluated as the ability to inhibit the growth and to reduce the photosynthetic activity. These new biocides were also evaluated in relation to the effect on different types of stone materials.