

Executive Summary of

BIODAM

Technology of the Future for the Conservation of our Past

INHIBITORS OF BIOFILM DAMAGE ON MINERAL MATERIALS

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The objective of BIODAM was to evaluate different apoptosis signals, pigment inhibitors, exopolysaccharide inhibitors, permeabilizers and photodynamic treatments for their "in vitro" effectiveness against bacteria, fungi and algae commonly found in deteriorated stone materials. Model organisms were selected from those commonly found on deteriorated stone and plaster substrates. Selected photodynamic treatments were screened for effectiveness against algae/cyanobacteria both *in vitro* and in the field on stone and painted mortar substrates. Compounds were selected showing a correct behaviour from the environmental point of view, and to take into account their toxicity (animal model), ecotoxicity (environmental model) and biodegradability (test with microorganisms). These compounds were further tested in subsequent work of BIODAM after some other laboratory tests screened for unwanted development of crystal deposits or stains on sensitive materials. A joint laboratory workshop at VTT, Finland by four of the partners was dedicated to in vitro testing of compounds on artificial biofilms on rock slabs. Later exposure sites in Scotland, Germany and Spain were chosen for detailed field experimentation. Two sandstones (Scottish, German) and one limestone (Spanish) were chosen, cut and exposed at the 5 experimental sites. The rock specimens were exposed to the selected exposure site environment, inoculated with selected strains and/or natural biofilm development was allowed for. Then the slabs were treated with the polyphasic treatment including biocides against growth, polysaccharide formation and development of ugly dark pigments. The simultaneous photodynamic treatment enabled a considerable reduction of applications of poisonous chemical compounds. Initially a light beam sensitizer was planned. Later it was shown in laboratory experiments and field assays, that sun light exposure during treatment sufficiently activates the photosensitizer compounds. The combined polyphasic treatment developed in the course of the project was effected with zero value sampling and subsequent sampling and measurement also in the field assay.

The field assay results will be monitored also beyond the operative time of three years.

Main Scientific achievements:

Bacteria, cyanobacteria, algae, and fungi were selected and taken into culture. A literature survey was done on biofilms, biocides, permeabilizers and application techniques. Permeabilizers, biocides and photodynamic treatments were chosen and tested on laboratory scale. Two sandstones, one limestone and one plaster have been chosen for further experimentation in field assays in Scotland, Germany, and Spain. A Web - Site was established and a brochure prepared. Most important results were represented at congresses and published in Journals, books, and Congress Proceedings. A suitable reaction of some of the strains selected to the permeabilizers and biocides was documented as well as the effects of photosensitizers. The data are given in the detailed report and in the published output. The materials were presented at several European Conferences on Innovative Technologies and Materials for the Protection of Cultural heritage. The project ended within the time frame and deliveries were yielded on schedule.

One main and most important result is the feasibility of the polyphasic approach in biofilm inhibition under laboratory and field conditions. The combination of biocides, permeabilizers and photosensitizers considerably reduces the amounts of biocides needed in order to eliminate damaging biofilms. This in turn will reduce environmental hazards as well as health risks for restorers applying the treatments.

The field data were collected and scientific articles on the results were prepared, submitted and published. The final report is published and distributed in the form of a report of Historic Scotland, an institution of conservation of cultural heritage with a reputation on publishing reports of scientific developments applicable for restorers and conservators. This book can be ordered at Historic Scotland or downloaded from the Website!

Socio-economic relevance and policy implications:

The socio-economic relevance of the findings is evident in view of minimizing toxicity hazards of treatments and yielding a better evaluation of biofilm damage on architectural and other material surfaces under different and often difficult climatic outdoor conditions. Visits to sites in Cambodia, Greece, Japan, Russia and Thailand made it clear that EU derived techniques and experiences are acknowledged also outside of the Common Market. The involvement of SME's (BIOGEMA) and end users (Historic Scotland) improves the transfer potential and political impact of BIODAM. Close cooperation with the overlapping COALITION team also helped and enabled further distribution of BIODAM results. The Web-Site in its final shape will again serve for further distribution of the results.

Conclusions and dissemination of results:

The concept of a polyphasic approach to inhibiting detrimental growth of biodeteriorative and or unaesthetic biofilms turned out to be extremely valid after the BIODAM experimental laboratory and field polyphasic 3-years approach. The literature reviews have shown clearly a necessity to analyse for and to inhibit biofilm growth on monument mineral materials. The selection of a few non-toxic or low toxic compounds for combating detrimental biofilms was in urgent need. The combination of biocides with permeabilizers and photodynamic treatments turned out as a very promising tool, which now is in the extended field test phase with the first readings being quite satisfactory. Special compounds, combined with photodynamic activation treatments turned out as a very attractive alternative to costly and environmentally hazardous treatments effected until now in many monuments worldwide. The dissemination of the results is organised via the participating institutions organized especially by brochures from Historic Scotland and the Website hosted by BIOGEMA. A brochure and courses as well as conference communications are planned also for the future.

BIODAM thus truly developed

Technologies of the Future for the Preservation of our Past.

Keywords:

Cultural heritage, biofilm, patina, biodeterioration, permeabilizers, photodynamic treatment, microcolonial fungi, detrimental bacteria, sandstones, plaster, polyphasic protection of building and other material surfaces, environmental protection.