

The use of ultraviolet irradiation to control microbiological growths on mosaic pavements

The growth of micro-organisms is common on archaeological mosaics in damp and shaded conditions. They prevent the aesthetic appreciation of mosaic pavements. More seriously, pioneer micro-organisms (such as algae) encourage the colonisation and succession of more damaging plant species (such as moss). Therefore the control of micro-organisms is essential for good maintenance.

Since 2008 Historic England in conjunction with the Isle of Wight Heritage Service have been conducting experiments at Newport Roman Villa to develop a cost-effective method for treatment of micro-organisms on mosaics - by a means that can be repeated as part of a regular cycle of maintenance. The chosen method of treatment is the use of Ultra-violet light using light boxes and equipment developed and constructed by Historic England and utilised on areas of mosaic and areas within the hypocaust at Newport Roman Villa. Ultraviolet radiation is commonly used to control micro-organisms such as bacteria, viruses, moulds or algae in industrial applications but has rarely been used on heritage sites.



Fig.1 Showing the effect of Ultraviolet radiation on a portion of the mosaic in the kitchen area at Newport Roman Villa

The initial results were extremely encouraging and led to the continuation and expansion of the project. Experiments are continuing with the addition of a new partner The University of Portsmouth. Two university departments are partnered with Historic England the micro-

biology department and the department of geography. The proposals for upcoming research are set out below:

1. Short-term on-site experiments and analysis at Newport (March 2019)

The experiments will focus on two specific objectives using new methodologies to analyse changes arising from UV treatment: (a) to assess the long-term effects **on the hypocaust** irradiated in the 2018 trial by measuring spectral reflectance using an mobile ASD spectrometer contact probe, and (b) to carry out further trials **on the kitchen mosaic** using the mobile light box following by detailed on-site photography using a high-resolution, wavelength specific, visible-Near-Infrared camera and associated quantitative image analysis. This latter technique requires space for lighting and camera equipment but can be left *in situ* until the experiment is completed.

2. Laboratory experiments on mosaic tiles using UV box (April–September)

Experiments will be undertaken in the laboratory to establish the effects of UV light on the mosaic surface using pristine tesserae and those that have been impregnated with algal suspensions to simulate field populations and conditions. Analysis will be done using the same techniques as described above in the short-term experiments in (1) above. These would involve visible-NIR camera imaging, ASD probe and XRD analysis.

Potential Masters Studentship (September onwards)

The Masters project will be in the School of Biological Sciences and build upon the past collaboration whereby previously, the microbial community in different areas of the Newport Roman Villas has been examined and key microbial species have been identified. The next phase in this project will support a Masters student to determine the effectiveness of UV treatment in directly controlling bacterial and algal isolated species growth from the Newport Roman Villa culture collection. The Masters student will examine the effectiveness of different UV light treatment regimens on the isolated species; including different UV frequency exposure. The student will also be involved in examining NIR spectra from the Newport Villa and determining if chlorophyll and accessory pigment profiles can be used as a signature marker for rapid evaluation of site contamination.



Fig 2. Portsmouth University scientists sampling algae from the mosaic at Newport Roman Villa

3. Improved Technology (Beyond 2019)

The two visible-Near-InfraRed instruments proposed for use are operated by the UoP Centre for Applied Geoscience, both are non-destructive and operate with no surface preparation. 'Probe' experiments will be carried out using an ASD Labspec4, a newer version of the equipment used in Newport in 2016. A 20mm wide light emitting probe would be placed gently against the target surface for 0.5 seconds. The spectrometer would measure the intensity of light reflected back at each wavelength in the range 450-2500 and present this as a spectrum. Spectra can be calibrated against library or experimental data to determine mineralogy, pigment, moisture or organic components. Spectral 'image' experiments will utilise a Gilden Photonics imager. The scanner is mounted on a motorised tripod that rotates the imager, enabling the capture of an image of the target scene. This requires that the scene is illuminated using photographic lamps for the measurement time of 10-30 seconds. An image typically contains 200000 pixels, each of which contains measurements of spectral intensity in 200-400 channels between 400 and 1000nm. As with the probe data, images can be calibrated to experimental data to determine spatial patterns of mineralogy, pigment, moisture or organic contents.

Later aspects of the project may evolve to include the development of an automated system to deliver UV light to problem areas. Discussions with the 'Future and Emerging Technologies' would be the next step in this process, as funding streams would be available for applied projects.