Making historic plant collections safe to handle through the development of a simple and cost-effective screening tool

1. Summary of the impact

- Mercury has been used to preserve plants in museum collections since the 18th century. This has led to severe mercury contamination in historic plant collections across the world, which is today a global health concern.
- The research involved development of a rapid, cost-effective and non-destructive screening method for identifying mercury-based biocide residues in historic plant collections.
- The impact of this research is two-fold: on professional conservation and curatorial practice; and on the health and safety of the collection users (the public) when handling the collections.
- The National Museum of Wales (NMW) has used the methodology to identify severely contaminated specimen sheets in its 800,000+ specimen collection and to prioritise which collections required immediate re-mounting. The NMW used the methodology to ensure the implementation of safe, standard procedures to protect personnel and visitors when handling the collections. The methodology has enabled the museum to remove a large amount of hazardous chemical from the herbarium environment.
- More widely, the methodology is now being adopted by museums and institutions across the UK
- There is also international interest in the methodology, which is being disseminated via international conferences.

2. Underpinning research

Context

Although it was generally known within the museum community that plant collections were historically conserved using toxic compounds of mercury and arsenic, it was not known that residues of these compounds still remained in significant quantities today. Master's research at De Montfort University (1996-98) determined that the NMW herbarium was severely contaminated with mercuric chloride and naphthalene residues - two of the most common biocides used historically and ubiquitous in many collections across the world - and could not be handled safely. As museum plant collections are unique research resources, access to them is essential – from both conservator and user perspectives. Due to the vast size of these collections (800,000+ specimens at the NMW) removal of the contaminated backing sheet was not an option (in terms of the time it would take), and routine chemical analysis to inform a rolling remounting programme was neither feasible in terms of time, nor economically viable.

Aims

To develop a simple, cheap and rapid screening method to identify the presence of mercury on plant specimen backing sheets. Since a significant proportion of backing sheets have historic significance, a non- or micro-destructive method was preferable.

The research

- PhD research, in collaboration with the NMW, was carried out at the University of Lincoln (2003-2012).
- During the initial Master's research (at De Montfort University), fluorescent spots, over a range of emission wavelengths, were observed on all of the backing sheets.
- Particle induced X-ray emission, using the linear accelerator at the Centre de Recherche et de Restauration des Musées de France, the Louvre (Paris) with funding from the EUArtech programme, determined the elemental compositional differences between the fluorescent and non-fluorescent areas on over 200 historic backing sheets from the NMW collection.
- X-ray photoelectron spectroscopy was carried out at the EPSRC facility at Cardiff University to determine the mercury speciation for both fluorescent and non-fluorescent areas.

- Laboratory simulations and accelerated aging experiments were carried out using modern materials to validate the research hypotheses.

Key findings that led to impact

- It has been demonstrated that the development of the fluorescence is directly linked to the presence of mercury.
- There is compelling evidence to support the hypothesis that the observed fluorescence within the herbarium collection is due to the reduction of Hg(II) to Hg(I) during the oxidative degradation of cellulose, occurring as part of the natural aging process.
- Both accelerated aging tests, and empirical observations, indicate that the fluorescence takes at least 30 years to develop, as the degradation of cellulose has to progress sufficiently to propagate the production of the fluorescent Hg(I) species.
- The application of naphthalene as a biocide is very common, and is likely to be present in the majority of herbaria in Britain and abroad. The presence of naphthalene increases the rate of fluorescence development on specimen sheets that have also been treated with mercuric chloride. The oxidative decomposition of naphthalene is a source of additional hydroperoxyl radicals, also produced during the oxidative degradation of cellulose. These hydroperoxyl radicals are responsible for the reduction of Hg(II).
- A hand-held UV-A lamp provides a rapid and effective method of identifying those samples within the collection that have been highly contaminated with mercuric chloride, and provides a means to prioritise which collections require immediate re-mounting. Furthermore, this will inform the implementation of standard procedures to protect personnel and visitors handling the collections, and enable the removal of a large amount of hazardous chemical from the herbarium environment.

3. References to the research

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- COLSTON, B. AND PUREWAL, V. (2008). Development of a novel approach to the identification of historic herbarium biocides. *Conservation Science Annual* at the *2008 Eastern Analytical Symposium*, November 2008, New Jersey, USA (INVITED).
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- PUREWAL, V. AND COLSTON, B. (2006). OLD POISONS – New Approaches (2006). *Society for the Preservation of Natural History Collections Annual Conference* Albuquerque, New Mexico, May 2006.
- PUREWAL, V. (2012) – Novel detection and removal of hazardous biocide residues historically applied to herbaria. PhD Thesis, University of Lincoln.
- PUREWAL, V. AND COLSTON, B. (2005).The Identification of Hazardous Pesticide and Fungicide Residues Present on Herbarium Mount Paper. *Metals in Paper*, Rome, February 2005.

4. Details of the impact

The presence of large amounts of hazardous pesticide residues within historic plant collections is a legacy from past conservation treatments affecting many museums and institutions across the world. It was common practice from the 18th Century until the late 20th Century to regularly apply highly toxic compounds of mercury and arsenic

to plant collections to prevent insect and fungal damage. Regrettably, it was not common practice to record the treatments that were applied, and identifying contaminated specimens within collections today is impossible without chemical analysis. For an institution legally required to protect its staff, visitors, volunteers and researchers, the detection and removal of hazardous material from the herbarium environment is a top priority. Unfortunately, many museum plant collections are vast, often containing hundreds of thousands of specimens, making such a task difficult – both costly and time-consuming – and impossible to achieve in many museums. Nevertheless, historic plant collections are primary research resources and access to them has to be maintained if they are to fulfil their role.

This research has led to the development of a simple screening method for identifying mercury-contaminated specimen sheets within a collection. It requires the use of a hand-held UV-A lamp, which is an accessible and affordable item for the majority of museums across the world.

The initial impact of this research is on practitioners. It has changed professional conservation and curatorial practice, offering a means to address a serious problem that could not previously be solved. Subsequently, the research has impacted on the end-users of the collection, by removing the risk of exposure to toxic chemicals, allowing them to be handled safely, and to ensure that collections remain available as a research resource.

Impact at the National Museum of Wales

The research, carried out in collaboration with the National Museum of Wales, was driven by the Museum's need to find a solution to a problem. A number of its conservation and curatorial staff were becoming ill after spending extended periods of time working on the museum's plant collections. It was common for staff members and some visitors to work in close contact with the collections, handling numerous specimens every day, as well as close identification work using hand lenses. The observed symptoms were associated with exposure to the mercury and naphthalene that had previously been identified in the collection during the Masters research carried out by their botanical conservator (De Montfort University, 1996-98). The herbarium was closed to the public and staff for 3 months in 2001, and reopened with the introduction of changes in working practice, to reduce the risk of exposure to staff and visitors. This was seen only as a short-term measure, allowing the collection to remain accessible, whilst the Museum searched for a means to ensure its collection was safe to handle in the long-term.

From 2005-2009, the NMW has used the methodology to:

- identify severely contaminated specimen sheets in its 800,000+ specimen collection, and to prioritise which collections required immediate re-mounting;
- ensure the implementation of safe, standard procedures to protect personnel and visitors when handling the collections; and
- enable the removal of a large amount of hazardous chemical from the herbarium environment.

National impact

More widely, the methodology is now being adopted by museums and institutions across the UK. The NMW is actively engaged in training other museums to utilise the methodology in their plant collections. To date, this has included the Natural History Museum, The Royal Botanical Gardens at Kew, and the Royal College of Physicians. All have identified mercury in their collections using the methodology and have been able to determine whether specimens are safe to handle or need re-mounting.

International impact

There is also international interest in the methodology, which is being disseminated via international conferences: Rome (2005); New Mexico (2006); Mexico (2007); Berlin (2008) and Leiden (2009).