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Access to Collections

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Keeping and Accessing a Hazardous Collection

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Natural science and anthropological curators are becoming aware of the potential hazards that their collections in particular are presenting. These collections have been treated with various mixtures of organic and inorganic pesticides and/or fungicides to prevent pest and mould attack. Invariably the information relating to identity, concentration and date of the application is not present. The problem associated with this material is whether to keep it as discrete collections that cannot be accessed, or to continue using the collections by implementing safety measures that will allow the collections to be handled without the risk of contamination. The aim of this project was to identify and quantify the residues present on the herbarium sheets within the NMW herbarium and establish whether handling the collections could pose a risk to health. Mercury, arsenic and barium were identified and the research established that contamination could occur through handling material containing these residues.

Introduction

It is unlikely that many historical natural science collections have managed to survive this long without being exposed to pesticides or fungicides during their lifetime. As the date, amount and nature of the chemical were invariably not recorded, it has been easy to overlook potential 'invisible' health risks. The botanical collection within the NMW herbarium as with other natural science collections, had not been considered a health risk because it was believed that pesticide/fungicide applications made many years ago would have dissipated by the present day (Merrill, 1948). The NMW herbarium has no documentation accompanying collections that have been donated to the museum, or regarding its own methods of preservation, although senior curator's can recall specimens being fumigated with carbon disulphide up until 1975. From about 1930 it is thought that paradichlorobenzene was applied to the zoological specimens and naphthalene was placed within botanical cabinets. Drione a silica aerogel, desiccant, dust and Constrain a permethrin based micro-emulsion have been applied to the insides of the botanical cabinets since 1995.

Brown and yellow tide marks present on the herbarium sheets did not relate to the methods previously described and so a research project was undertaken to identify this discoloration. The aim of the project was to determine whether the collections housed within the NMW herbarium had been subjected to other chemical applications, and if so whether the chemicals were hazardous.

No information was available with regards to analysing residues on paper and so a literature search was carried out to find information relating to:

(i) standard techniques in residue analysis and
(ii) general pesticides/fungicides applied to herbaria.

A questionnaire was sent to key institutions abroad and in Britain, from which 15 main pesticides were identified (See table 1).

Table 1: Chemicals known to have been applied in botanical institutions.

Chemical applied
1 Arsenic trioxide
2 Barium fluorosilicate
3 Carbon disulphide
4 Carbon tetrachloride
5 DDT
6 Ethylene oxide
7. Lauryl pentachlorophenate
8 Mercuric chloride
9 Methyl Bromide
10 Naphthalene
11 Paradichlorobenzene
12 Phosphine
13 Pyrethrum
14 Hydrogen cyanide
15 Vapona/ Dichlorvos/DDVP

Method and Results

Several different analytical instruments were employed for this research, as it was not known which would be the most sensitive technique for residues on paper. 85 samples were taken from the mount sheet below the specimen. The paper was then digested in nitric acid, diluted with distilled water and centrifuged. The most successful methods were achieved with Inductively Coupled Plasma Mass spectrometry (ICP-MS), Cold vapour flow injection mercury system (FIMS) and Atomic Absorption Spectrophotometry (AAS).

The analytical results indicated that the majority of the NMW herbarium had been treated with mercuric chloride (corrosive sublimate) arsenic trioxide and barium fluorosilicate (these being the most common applications to natural history specimens). From table 2 it can be seen that the concentration of mercuric chloride remaining on the herbarium sheet varied considerably form zero readings to as much as 424 ppm (parts per million).

Arsenic had not previously been strongly associated with botanical collections, however the concentrations found were substantial and the number of sheets that showed positive for arsenic were considerable. High concentrations of barium were also identified. This was most probably derived from barium fluorosilicate, a bait for silverfish recommended for application by Kew.

The results of this project are calculated in ppm as the concentration in the paper is related to the concentration that can be absorbed through the skin. The LD50 in rats for mercury absorption through the skin was 41 ppm (41 ppm killed 50 out of 100 rats) (Ellenhorn et al, 1997).

The Health and Safety Executive (HSE) have produced guidelines on working with toxic chemicals and the occupational exposure limits (OEL). These are based on a time-weighted average (TWA) of 8 hours, which are calculated in mg of vapour to a metre cubed of air (EH/40 1997).

These levels have been produced by the HSE because mercury and arsenic in particular are extremely toxic (See table 3).

Table 2: Results of AAS analysis of 9 samples for arsenic, barium and mercury.

Sample No.	sample	wt g	dil	**As µg/g**	**Ba µg/g**	**Hg µg/g**	As µg/ml	Ba µg/ml	Hg µg/ml
2	paper	0.0730	10	**26.160**	**330.80**	**423.69**	0.191	2.4150	3.0930
14	paper	0.0640	10	**15.250**	**4.9280**	**0**	0.097	0.0310	0.0110
23	paper	0.0620	12	**11.516**	**4.9930**	**0**	0.059	0.0260	0.0180
50	paper	0.0600	10	**3.6330**	**3.8000**	**0**	0.0218	0.0230	0.0590
51	paper	0.0660	10	**17.257**	**19.242**	**0**	0.1139	0.1270	0.0660
52	paper	0.0810	10	**6.2460**	**359.506**	**49.74**	0.0510	2.9120	0.4030
82	sp of 50	0.1200	10	**0**	**1.5000**	**0**	0.0060	0.0100	0.0200
83	sp of 51	0.0800	10	**0.6400**	**8.7300**	**0**	0.0050	0.0100	0.0700
84	sp of 51	0.0100	10	**0.5900**	**5.8300**	**0**	0.0010	0	0.0700
blank 1		0.1200	10	**0**	**0.0500**	**0**	0.0050	0.0100	0
blank 2		0.0700	10	**0.4500**	**0**	**0**	0.0030	0.0030	0
blank 3		0	0	**0**	**0**	**0**	0	0	0

Results in bold relate to actual amount of metal in PPM in the paper sample. This is a sample of the main results.

Table 3: Toxicology results for arsenic, barium and mercury

	Mercuric chloride Mg/m^3	Arsenic trioxide Mg/m^3	Barium fluorosilicate Mg/m^3
STEL	0.015	_____	_____
LTEL	0.025	0.1	0.5
Routes of entry into system	Absorption through skin Inhalation Ingestion	Absorption through skin Inhalation Ingestion	_____
Short term effects	Eye contact = irritation, burns, even permanent damage. Breathing = lung irritation, coughing possible pulmonary oedema	Hoarse voice, irritation of nose, eyes skin and throat. Nausea, vomiting, diarrhoea, loss of appetite, coughing, chest pain, giddiness, headache, breathing difficulty.	Barium poisoning results in a rapid onset of paralysis, gastrointestinal symptoms, cardiac dysrhythmias, hypertension, and often severe hypokalemia. The acute syndrome can be fatal. *
Long term effects	Sore gums, shakes, loss of memory, teeth and appetite, weakness, kidney and brain damage. Possible Carcinogen	Damages the heart, brain, lungs, gastrointestinal tract and kidneys. Eventual skin, bone marrow and peripheral nervous system damage.	Repeated or chronic exposures have been reported to cause osteosclerosis, as with fluoride.
Carcinogen	Possible	Yes Class A Oncogen	_____
Reproductive problems	Foetal damage and genetic mutations	Malformations of mice/rat off-spring	_____

All of the information received on Toxicology came courtesy of the Welsh National Poisons Unit, Llandough Hospital, Cardiff.

STEL stands for short term exposure levels usually within a fifteen minute period. (HSE, 1997)

LTEL long term ---, 8 hour dose 5 days a week (HSE 1997)

No information available at present

*Little * Ellenhorn et al*

The NMW herbarium is an extremely important resource and is one of the largest herbaria in Britain. To make a collection such as this inaccessible would be mortifying but necessary, if the health of staff and visitors was put at risk.
The first precautionary steps taken were to close the herbarium to staff and the public. Air quality control was carried out on both lower and higher plant herbaria. Fortunately, due to the air-conditioning within the lower plant herbarium and the open layout of the higher plant herbarium, the air quality was not registering levels of mercuric chloride vapour above 0.0001 mg/m^3, which are well within the recommended HSE guidelines of 0.025mg/m^3 (EH/40,1997). Further tests have been carried out on the vapour emitted from highly contaminated sheets. Controlled conditions gave results of ca.0.1mg/m^3 for sample 2. Sheets holding concentrations ca.1000 ppm were producing mercury vapour 28 times greater than the recommended HSE guidelines. Sheets with very high concentrations of mercury generally had yellow/brown discoloration around the specimen. It may be possible to determine highly contaminated sheets through the colour of the residue and this could be a topic for further research.

Once the over all air quality had been deemed safe, the herbarium was re-opened for staff use only.
Base line measurements had to be taken through biological monitoring to determine whether arsenic or

mercury had accumulated in the blood and urine of staff. Urine tests give accurate information relating to the exposure to contamination that has occurred in the last 3 months. Blood tests will only give information relating to the past 5 days, and if fish has been eaten within this period then the blood test will not be accurate as fish are extremely adept at storing heavy metals within the flesh and the liver.
One problem was that it took too long to actually implement the tests. By the time the staff had been sent for tests they had not been in contact with the main herbarium for at least 3 months which could have rendered the biological monitoring fruitless. However, even after this delay two members of staff did show slightly higher than normal mercury and arsenic levels at the first test.

Safe Standard Procedures Employed
Precautions were taken immediately and this included:
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Informing all visitors to the collections of the possible problems of contamination.

- Ensuring work was only carried out in well-ventilated areas.
- Wearing powder free, nitrile gloves (Fisher Scientific, UK) whenever accessing the collections. (These are thrown away after single use).
- Washing hands after handling collections, particularly before eating, drinking or smoking.

One year after these precautions were implemented, staff returned for their health surveillance and within this time all staff members' contamination levels had returned to normal.

Conclusion

The conclusive analysis on this collection singled it out as a hazard in its entirety, however its removal would not have provided a means to an end as the numerous other collections within the museum may well have been contaminated too. Until conclusive analysis has been done all historic natural history collections should be treated as potentially hazardous. If suitable precautions are carried out then maintaining and accessing the collection should continue as normal.

Future research has been initiated on the identification of organic residues present on the collections. The very number that may have been applied and the hazards they may pose should never be under estimated!

Bibliography

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HSE (1997) Guidance notes EH/40. Occupational Exposure Limits. Contains the list of maximum exposure limits and occupational exposure standards for the use with the Control of Substances Hazardous to Health regulations 1994. Crown copyright, Norwich. pp 20-33.

Study Trip

Royal Botanic Gardens - Kew

Mike Palmer, Buckinghamshire County Museum

On the 19th June, one of the hottest days of the summer, a small band of seven curators congregated in the main reception of the Herbarium Building. We were met by Lourdes Rico of the Leguminosae Section who began with a brief introduction.

The main herbarium comprises some 7,000,000 specimens including at least 250,000 Types. What was previously a small botanical collection was substantially enlarged in 1866 by the purchase of Sir William Hooker's herbarium and library followed by the bequest of George Bentham's collection. The original purpose built herbarium building was brought into use in 1877. As the collections grew subsequent wings were added (1902, 1932 and 1960) eventually forming an enclosed quadrangle. Further storage space was completed under the quadrangle in 1989. Despite the recent addition of a further floor to the rear wing the annual addition of some 30,000 specimens to the collections means that a fifth wing will soon be required.

The collections are arranged broadly in the Family order of Bentham and Hooker (Genera Planetarium, 1862-1883) with some modifications. Within Families the arrangement follows the most recent major work while within genera specimens are arranged geographically.

Collecting is mainly from the tropics concentrating on poorly collected areas and areas of current research interests. Attempts are also made to avoid overlap with the Natural History Museum and the Royal Botanic Garden, Edinburgh. The main collecting areas are Tropical Africa, particularly East and South-Central