Control of Health Hazards from HgCl Treated Botanical Specimens

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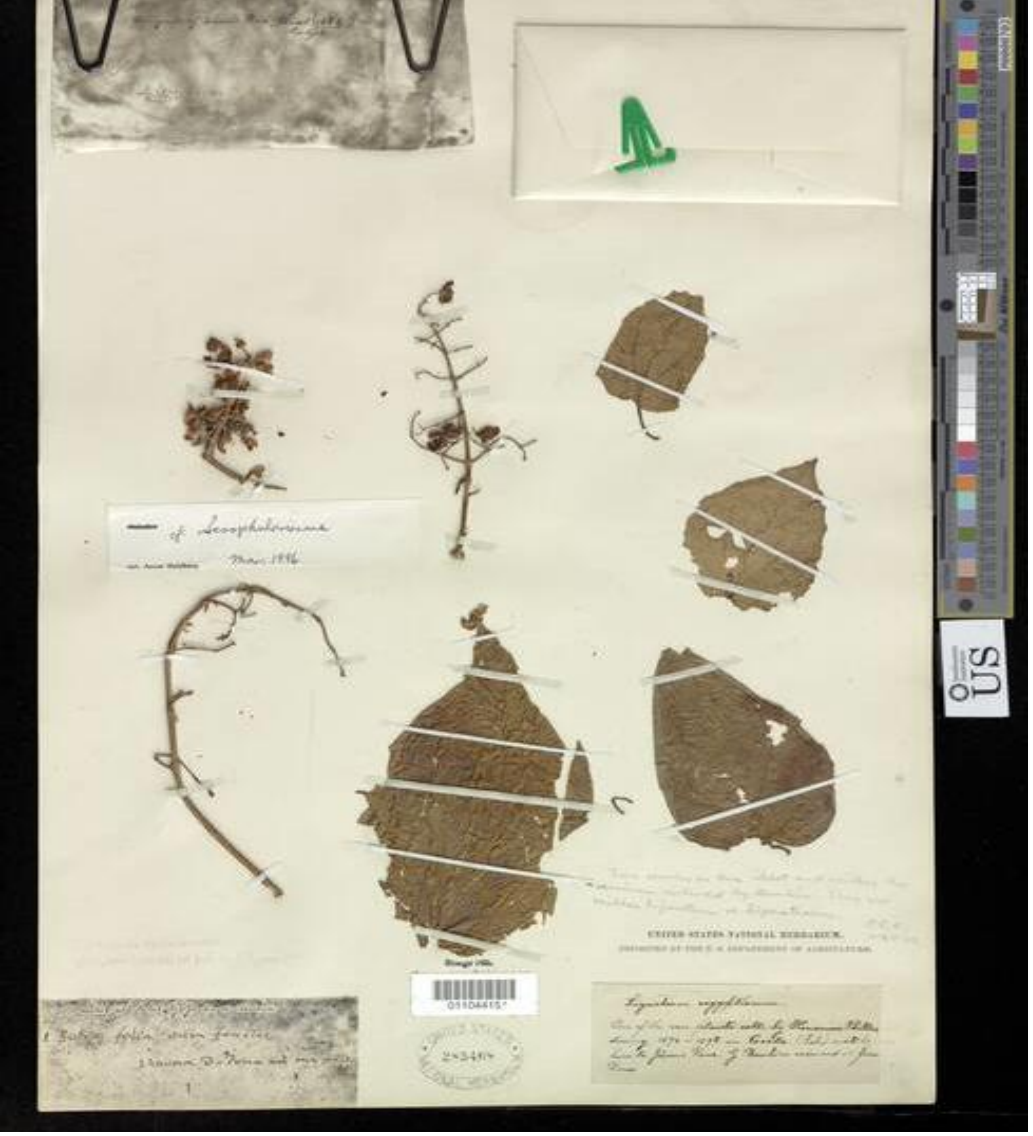
Retired: Smithsonian Institution National Museum of Natural History and Office of Safety, Health and Environmental Management



Smithsonian NMNH Botany Collection & Use of Mercury Salts

- No evidence that mercuric chloride treatments were used at the museum; however:
  - Specimens treated in the field during collecting expeditions by NMNH staff to limit mold and pests
  - Specimens treated by non-NMNH staff during field collecting or subsequent preparation, then transferred to NMNH Botany
  - Specimen sheets exposed to cross-contamination via storage in closed cabinets with sheets off-gassing mercury vapor

NMNH oldest specimen.

Collection contains approximately 5.2 million specimens dating from ca. 1598 to present

Nature of Contamination

- Processed cellulose (e.g., paper) and many old adhesives seem to react with mercuric chloride and in the presence of sulfur and light, undergo reactions that lead to metallic mercury, various mercury compounds, and mercury vapor.

- **ABSENCE OF STAINS DOES NOT EQUAL ABSENCE OF CONTAMINATION.**

- Reactions not always readily apparent - contamination may be present but not readily visible if other factors that stimulate dark compounds or metallic mercury are not present.

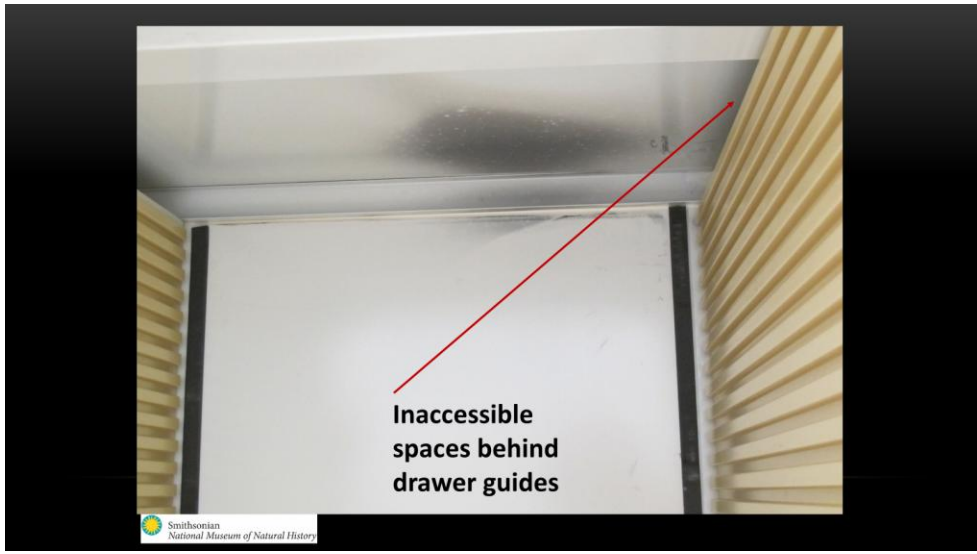
Dark stains are often mistaken for mold.

Fluorescence Signaling in Historic Herbaria: Detecting Mercury-based Biocides in Museum Collections. V. Purewal & B. Colston. https://cpb-eu-w2.wpmucdn.com/blogs.lincoln.ac.uk/dist/3/1966/files/2013/06/Vicky-Purewal-research.pdf

Cabinet Contamination: Continual Source of Hg Vapor

Storage furniture can become contaminated with mercury in various forms, either through adsorption or absorption and can re-emit vapor.

Powder-coated, metal storage cabinets



Source Sampling – Case Interiors

Kathy Makos sampling Botany cabinets with **Jerome 431-X . Model no longer sold but still used by many IH offices.**

Direct-Reading Instrumentation:

Jerome Mercury Vapor Analyzers

- Gold film sensor, stable & selective for Hg.
- 13-16 sec sample time - Detection Range: 0.003-0.999 mg/M3

https://www.brookfieldengineering.com/products/toxic-gas-analyzers/mercury-vapor-analyzers

Lumex: Detection Range much lower, but instrument easily overloaded in botany case situations

Passive Qualitative Indicator:

Mercury vapor respirator cartridges with end-of-service life indicators can serve as an alert for presence of accumulated vapor.

Important Distinction Underscoring Need to Work with a Health & Safety Professional:

- **Source Samples** capture a moment in time (e.g., high-to-low case concentrations in cases) or a general area concentration over time (e.g. assessing IAQ).

- **Only Personal (Breathing Zone) Monitoring** can assess your actual time-weighted average exposure from your interaction with a hazard source.

Personal Exposure Monitoring – Botany Collection Tasks (1999-2014)

- *Case Pest Inspections*
- *Inspecting/Sorting unprocessed material*
- *Hg Surveys*
- *Filing/Identifying*
- *Retrieval and Research*

Media: SKC 226-17-1A (200 Anasorb C3)

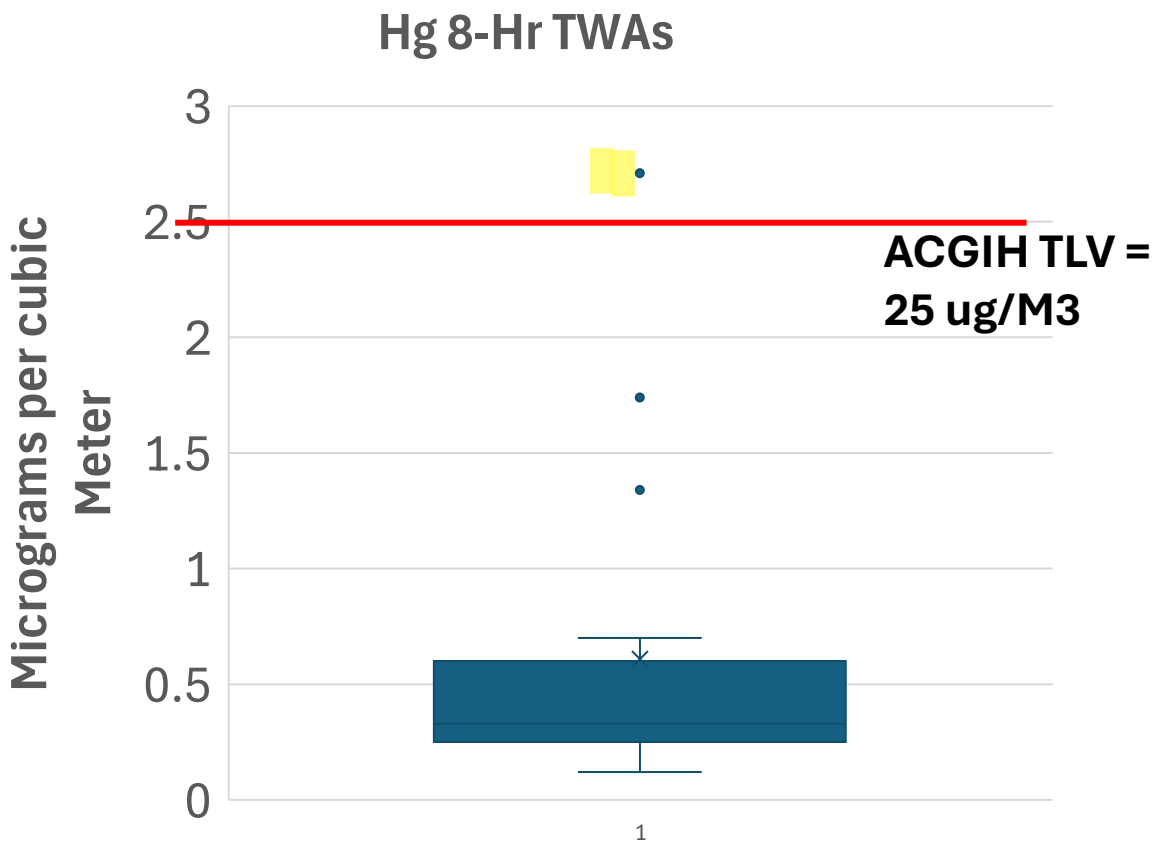
Method: NIOSH 6009

27 Samples

8-hr TWA Range: 0.12 – 2.73 micrograms/M3

ACGIH TLV, Mercury (Elemental & Inorganic Forms) = 25 micrograms/M3

Value of Analyzing Exposure Data



Statistical analysis indicates that there is less than 2.69e-05 % that any future exposures > TLV.

Inspecting cases with unprocessed specimens (high hazard source) = 2 outliers (2.73 and 2.71).

Personal exposure surveys help to & prioritize where to spend time/resources on control measures.

2001, 2009, 2012 Case Surveys of Interior Hg Vapor Levels

Approx 2500 cases re-surveyed for Hg vapor levels.

Sweeping motion, bottom to top of case 4 x15 sec intervals.

Goals:

- 1) determine rate of case aeration,
- 2) identify which required respirators to safely open.
- 3) prioritize cases for remediation.

	2000-01 Samples (Hollenberg/Makos)					June/July 2009 Samples (Hollenberg/Makos)					July/August 2012 Samples (Hollenberg/Bell/Makos/Carlberg)			
CASE ID	Initial 12-15 sec	2nd 30 sec	3rd 45 sec	4th 60 sec		Initial 12-15 sec	2nd 30 sec	3rd 45 sec	4th 60 sec		Initial 12-15 sec	2nd 30 sec	3rd 45 sec	4th 60 sec
	(ug/M3)	(ug/M3)	(ug/M3)	(ug/M3)		**(mg/M3)**	**(mg/M3)**	**(mg/M3)**	**(mg/M3)**		**(mg/M3)**	**(mg/M3)**	**(mg/M3)**	**(mg/M3)**
2-1-18C	163	78				0.133	0.096				0.659	0.222		
2-1-18D	7										0.003			
2-1-18E	173	18				0.115	0.018				0.423	0.324		
2-1-18F	6	7				Dept presumes no change				→	0.006	0.007		
2-1-18G	5	7				Dept presumes no change				→	0.005	0.007		
2-1-18H	0	0									(empty)			
2-1-18I	0	0				0.183 (month later: 0.073, 0.113)					0.549	0.469	New interleaving experiment.	
2-1-18J	737	(South American grasses)				0.272 (month later: 0.160, 0.139)					0.055	0.029		
2-1-18K	36	33				0.084 (month later: 0.016, 0.0156)					0.174	0.127		
2-1-18L						0.197 (month later: 0.134, 0.113)					0.413	0.386		

Case Aeration Study on Impact of Browsing in Front of Contaminated Cases

- Low exposure profiles justified exploring case aeration as a work practice method along with good ventilation, PPE, hazard awareness outreach.

- Random sampling of 184 (of 4000) collections cases was statistically analyzed per Jerome sample time interval.

- **The TLV was met after 1 min. 15-30 minute aeration ensures significant dilution. (aisle area samples <0.003 mg/M3)**

Time Interval	*AM*	*95% LCL*	*95% UCL*	*95/95 GUTL*
15 sec.	0.0161	0.0145	0.0178	0.0760
30 sec.	0.0088	0.0085	0.0092	0.0360
45 sec.	0.0076	0.0072	0.0080	0.0340
60 sec.	0.0050	0.0046	0.0054	*0.0220* *(TLV:0.0250)*

ACGIH TLV (8-hr TWA) = 0.025 mg/M3

Risk Reduction: Absorbent Source Removal

- Replacing field papers and stained sheets or other absorbent materials to reduce mercury load *(while retaining labels and other data);*

- ANY mounting paper will absorb Hg. Concentrations may be reduced, but not all sources will be eliminated.

- *Other methods include Surface Cleaning and Scavengers*

Risk Reduction: Adsorbent Surface Cleaning

- Clean hard-surfaced (**ad**sorbent) storage furniture with dilute **Lugol's Iodine Solution or Hg Absorb Sponges** where feasible (i.e., no damage to furniture finish)

- Both effective for removing stains but extremely time-consuming.

- **Isopropanol Wipes** to remove residual Lugol's

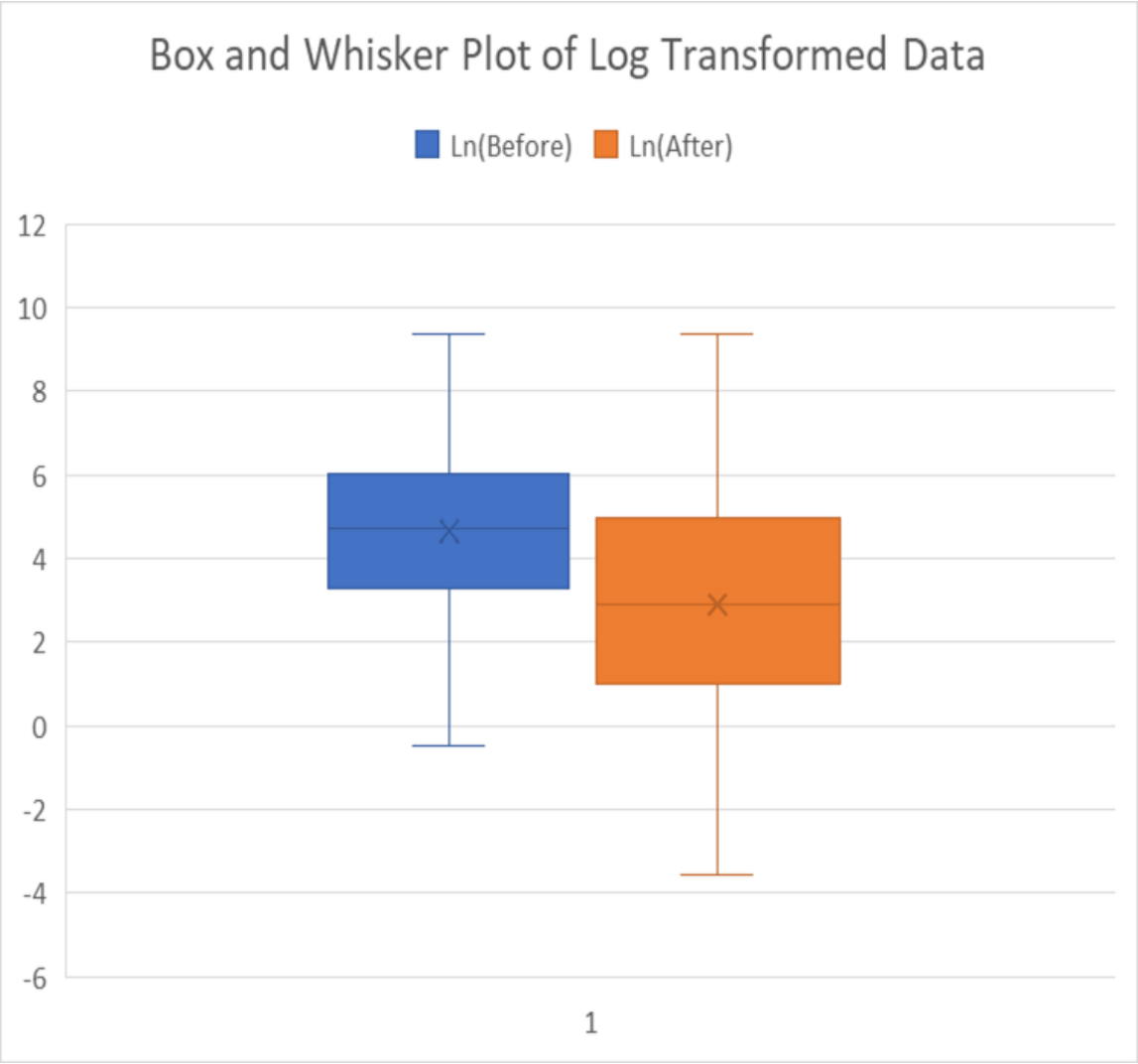
- **Ethanol** to remove Hg stain (minimally effective)

Cautionary Tale:
2013-2020
Contaminated Sheet Replacement & Case Interior Cleaning

- Project involved the 120 cases with highest Hg vapor concentrations.

- Statistical analysis comparing the highest Hg level in 2013 with the 2020, post remediation Hg level.

Conclusion: Measures not fully effective.



Risk Reduction: Scavenger Materials

- MicroChamber™ folders
  - Rehousing Wilkes collections at National Herbarium
  - One Wilkes cabinet originally 0.139 mg/M3
  - 3 months after refiling in MicroChamber: 0 mg/M3

- Use of museum pollutant scavengers, alkaline buffers + dispersed molecular traps are not always effective and require frequent changes.

TCLP: Toxicity Characteristic Leaching Procedure

- Assume HEPA vacuum bags & filters are Hazardous Waste.

- Test for misc. materials: contaminated gloves, interleaving papers, swabs, contaminated drawers.

Listed Metal Waste	Bulk sample of gloves from week-long conservation work	Bulk composite sample of waste materials associated with work on objects (e.g., gloves, blotters, application tips, sheeting and acid-free paper)	Regulatory Level (mg/L) USEPA 40 CFR 261.24 Table 1
	Results (milligrams per liter, mg/L)		
Arsenic	< RL of 0.500	< RL of 0.500	5.0
Barium	< RL of 10.0	< RL of 10.0	100
Cadmium	< RL of 0.100	< RL of 0.100	1.0
Chromium	< RL of 0.500	< RL of 0.500	5.0
Lead	< RL of 0.500	< RL of 0.500	5.0
Mercury	0.00263	< RL of 0.00200	0.2
Selenium	< RL of 0.100	< RL of 0.100	1.0
Silver	< RL of 0.500	< RL of 0.500	5.0

Managing the Risks

Access Control Procedures

- Keys maintained by collection manager
- High air exchange rate in storage area
- Open door, walk away, allow cabinet to vent (15-30 min recommended) prior to access
    - Monitoring indicated aisles <0.003 mg/M3 after doors opened, vented.
- Remove specimens to well-ventilated worktable or lab.
- Use of Nilfisk mercury abatement vacuum to fully evacuate known high hazard cases.

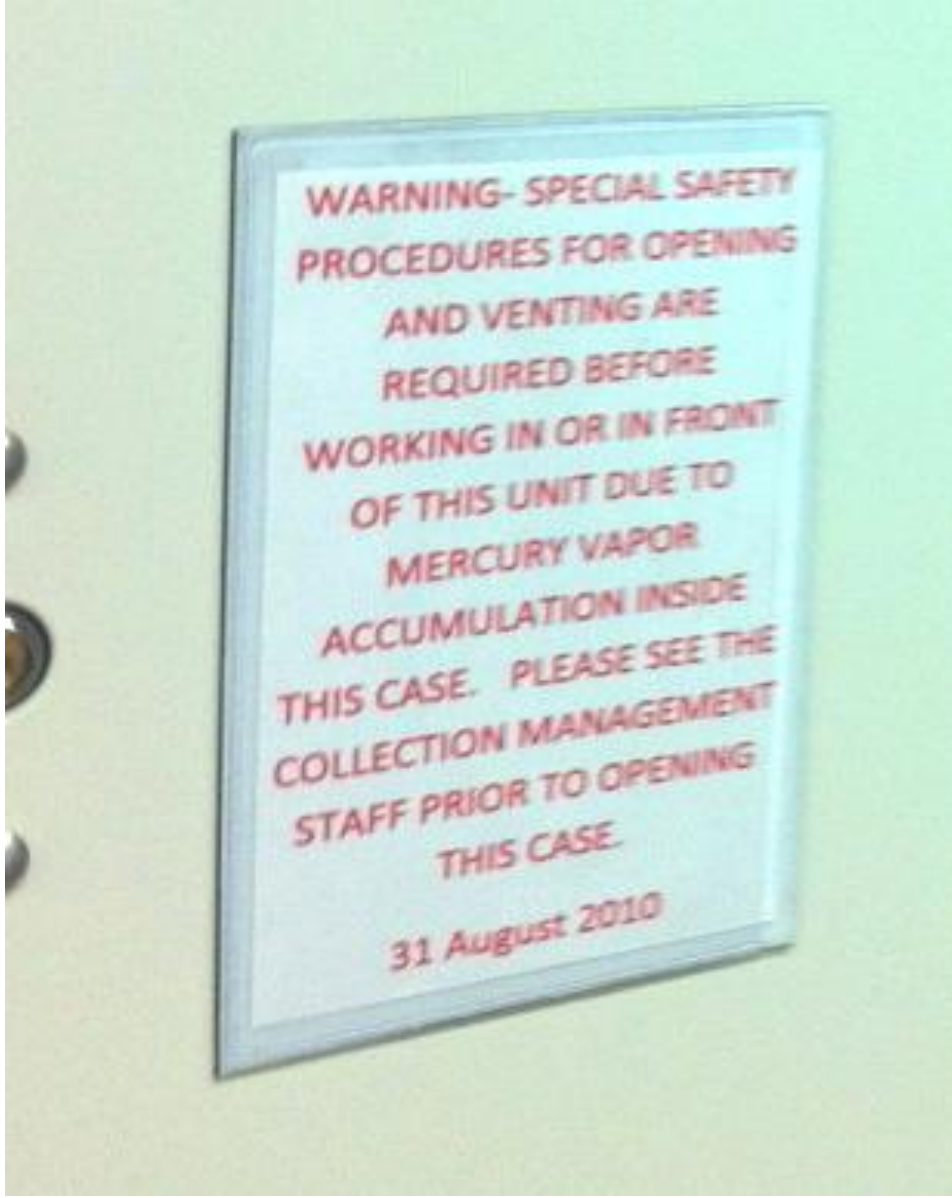
Managing the Risks

Hazard Awareness

- Fact sheets for staff, visiting researchers, interns (online and on site)
- Object/shelf labelling + storage area signage
- Hazards documented in accession/catalogue records, collection information system.
- Disclosure documentation for shipping and receiving

Personal Protective Equipment

- Disposable glove supplies in study/storage areas, frequent changes, discarded after use.
- Respirators for all collection managerial staff.
- Frequent washing of hands (after glove removal), exposed skin.



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