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Pesticides in Museums

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A very wide range of chemicals is available for use as pesticides (see Cornhill 1973). In museums, a large number of different preparations are used and it appears that no two institutions have adopted the same protection strategy.

Information is accumulating all the time concerning the dangers presented to human health by many of these chemical preparations, and it is becoming apparent that a different approach to the problems of collection protection may be needed.

"Even when approved for application to collections, however the multitude of health problems caused by these chemicals forces one to reconsider their use at all, but particularly when used as the sole, continually applied means of pest control. Some of the approved pesticides are potential hazards to the specimens or the storage equipment.
This book makes it abundantly clear that means other than chemical must be developed to control pests in museums. One that is mentioned as being in use in some institutions is temperature and humidity control. Creative thought should produce other methods." - Curator Vol 25/3 1982

- Extract from a review of 'Pest Control in Museums: a Status Report' 1980

The following chemicals are listed in this book:-

1. Pesticides recommended and registered for "Museum Use", USA

DOWFUME 75 (70% ethylene dichloride and 30% carbon tetrachloride). Recommended use: in a fumigation chamber. Threshold Limit Values*: Time Weighted Average = 23 ppm (proposed to be reduced to 8 ppm); Short Term Exposure Limit = 41 ppm (proposed to be reduced to 16 ppm). Reactivity to Materials: May soften plastics; appears to accumulate in fatty materials which must be well aerated after exposure. Effectiveness: as fumigant, chamber only. Organs affected: Central nervous system, kidneys, liver, skin. Carcinogenic effects. Liver cancer in animals, suspect in humans.

NAPHTHALENE (Moth flakes, Moth balls)
Recommended use: repellent in storage cases. Threshold Limit Values: Time Weighted Average = 10 ppm 50 mg/m^{-3}; Short Term Exposure Limit = 15 ppm. Reactivity to Materials: Can recrystallize on specimens. Effectiveness: as repellent. Organs affected: Liver, kidneys, blood, central nervous system, skin and eyes. Suspect carcinogen - see Wolf 1976 and Wolf 1978 for reference to cancer diseases amongst Napthalene cleaners.

*Time Weighted Average - Threshold Limit Value (TLV) = average concentration for an 8 hour day, 40 hour week, to which nearly all workers may be repeatedly exposed.

Short Term Exposure Limit (STL) maximum concentration to which workers may be exposed for a period of 15 minutes with no more than 4 exposures per day with one hour intervals.

EPA - Environmental Protection Agency of USA.

2. Pesticides recommended and registered for use in "Public Buildings/Institutions". USA

PYRETHRUM (Pyrethrin)
Recommended use: in storage cases.Threshold Limit Values: Time Weighted Average = 5 mg/m^3; Short Term Exposure Limit = 10 mg/m^3. Reactivity to Materials: Unknown. Effectiveness:in storage cases, as contact pesticide. Organs affected: Skin, respiratory system, central nervous system. Carcinogenic effects: Unknown.
Plant flower extract. Very effective insecticide rapidly decomposed by light and inactivated in air. Rapid knock down and repellent capability. No toxic residues. Considered safe in the presence of food stuffs.

VAPONA STRIPS (A13-20,738,DDVP, Dimethyl dichlorovinyl phosphate, Dichlorvos, Harkol, no-pest strip, Nuvan, Vaponite)
Recommended use: in storage cases and sealed display cases. Threshold Limit Values: Time Weighted Average = 0.1 ppm; Short Term Exposure Limit = 0.3 ppm. Reactivity to Materials: Forms an acid in humid situations, may corrode metals, may "bleed" onto specimens. May bleach some specimens - see Scoble 1983. Effectiveness: for maintenance and fumigation in storage cases. Organs affected:Central nervous system, eyes, respiratory system, cardiovascular system. Carcinogenic effects: National Cancer Institute tests are negative. Reproductive effects: suspect.

VIKANE (Sulfuryl fluoride)
Recommended use: highly promising, requires research. Threshold Limit Values: Time Weighted Average = 5 ppm; Short Term Exposure Limit = 10 ppm. Reactivity to Materials: Unknown. Effectiveness: as fumigant. Organs affected: Eyes, respiratory system, central nervous system, kidneys. Carcinogenic effects: Unknown.

3. Pesticides recommended and registered for use in fumigation chambers. USA

ETHYLENE OXIDE (Carboxide, epoxyethane, ETO (in pure state), Oxyfume, Oxirane, Penngas).
Recommended use: in chambers by trained personnel. Threshold Limit Values: Time Weighted Average = 50 ppm (proposed for reduction to 10 ppm); Short Term Exposure Limit = 75 ppm. Reactivity to Materials: Settles in rubber, fatty materials of leather etc. Such specimens should be aired thoroughly. Effectiveness: as fumigant, in chamber only. Organs affected: Skin and eyes, respiratory system, central nervous system, blood. Carcinogenic effects: May cause leukemia in humans. Lethal, highly flammable, vapour explosive.

METHYL BROMIDE (Brom-O-Gas, Brozone, MeBr, Meth-O-Gas, Terr-O-Gas)
Recommended use: Only by Certified Applicator. Threshold Limit Values: Time Weighted Average = 15 ppm (proposed to be reduced to 5 ppm); Short Term Exposure Limit = (proposed to be set at 15 ppm). Reactivity to Materials: Do not use with proteins or other materials containing sulphur (rubber, fur, feathers, leather, some paper, wool). Do not use with metal, cinder blocks, charcoal, mixed concrete, mixtures of mortar and soil. Effectiveness: as fumigant, in chamber only. Organs affected: Central nervous system, respiratory system, skin and eyes.Carcinogenic effects: Unknown.

4. Pesticides not registered for use in Museums, Institutions or Public Buildings. USA

EDOLAN-U (Eulan CN, Mitin FF)
Recommended use: possibly for moth proofing. Threshold Limit Values: Not established; however, LD_{50} = 600 mg/kg. Reactivity to Materials: Bonds with keratin in hair, hides and certain horns; may affect colour of specimens. Effectiveness: as contact pesticide. For maintenance, as permanent "moth proofing". Organs affected: Skin, eyes. Carcinogenic effects: Unknown.

METHOXYCHLOR (Chemform, Marlate, Moxie, biodegradable form of DDT)
Recommended use: possibly in storage cases, requires investigation. Threshold Limit Values: Time Weighted Average = 10 mg/m^3. Reactivity to Materials: Unknown. Effectiveness: as contact pesticide and for maintenance in storage cases. Organs affected: Possibly liver; in animals central nervous system, liver and kidneys. Carcinogenic effects: National Cancer Institute studies negative; International Agency for Research on Cancer studies indefinite.

PARADICHLOROBENZENE (p-dichlorobenzene, Di-Chlorocide, PDB, PARA, Para-Di, Paracide, Paradow)
Recommended use: probably, in storage cases. Requires minor usage registration. Threshold Limit Values: Time Weighted Average = 75 ppm; Short Term Exposure Limit = 110 ppm. Reactivity to Materials: Softens some plastics, resins and tar paper; and affects some pigments on leather. Forms chlorine gas in closed containers that may bleach specimens. Effectiveness: as fumigant and for maintenance in storage cases. Organs affected: Liver, kidneys, respiratory system, skin and eyes, central nervous sustem. Carcinogenic effects: Currently being tested by EPA.

5. Pesticides not recommended for use in Museums, USA

ALDRIN
Recommended use: None. Threshold Limit Values: Time Weighted Average = 0.25 mg/m^3; Short Term Exposure Limit = 0.75 mg/m^3. Reactivity to Materials: Bonds with keratin and other proteins. Effectiveness: as contact pesticide and for maintenance. Organs affected: Liver, kidneys, central nervous system, skin. Carcinogenic effects: Both Aldrin and its breakdown product, dieldrin, are suspected human liver carcinogens.

CARBON DISULPHIDE
Recommended use: None. Threshold Limit Values: Time Weighted Average = 20 ppm (proposed to be reduced to 10 ppm); Short Term Exposure Limit = 30 ppm. Reactivity to Materials: Tarnishes metals. Effectiveness: as fumigant. Organs affected: Central nervous system, peripheral nervous system, cardiovascular system, kidneys, liver, skin, eyes. Carcinogenic effects: Unknown. Reproductive effect: Suspect.

CARBON TETRACHLORIDE (Carbon-Tet)
Recommended use: None.Threshold Limit Values: Time Weighted Average = 10 ppm (proposed to be reduced to 5 ppm); Short Term Exposure Limit = 20 ppm. Reactivity to Materials: softens and dissolves lacquers, waxes, rubber; corrodes metals. Effectiveness: as fumigant. Organs affected: Central nervous system, kidneys, liver, skin. Carcinogenic effects: Causes liver cancer in animals, suspect in humans.

DIELDRIN (Dieldrite, Octalox, Panoram D31)
Recommended use: None. Threshold Limit Values: Time Weighted Average = 0.25 mg/m^3; Short Term Exposure Limit = 0.75 mg/m^3. Reactivity to Materials: Bonds with keratin and other proteins. Effectiveness: contact pesticide, and for maintenance. Organs affected: see ALDRIN. Carcinogenic effects: as ALDRIN.

ETHYLENE DICHLORIDE (1,2-dichloroethane)Recommended use: None. Threshold Limit Values: Time Weighted Average = 50 ppm (proposed to be reduced to 10 ppm); Short Term Exposure Limit = 75 ppm (proposed to be reduced to 15 ppm. Reactivity to Materials: softens or dissolves waxes, and fatty substances. Effectiveness: as fumigant. Organs affected: Skin and eyes, liver, kidneys, lungs, central nervous system, cardiovascular system. Carcinogenic effects: Suspect.

HYDROGEN CYANIDE (Aeor Discoids, Cyanogas, Cyclon, HCN, hydrocyanic acid, prussic acid)
Recommended use: None. Extremely dangerous. Threshold Limit Values: Time Weighted Average = 10 ppm (proposed to establish 10 ppm ceiling); Short Term Exposure Limit = 15 ppm. Reactivity to Materials: Very slight odour remains on ethnographic materials. Effectiveness: as fumigant. Organs affected: Central nervous system, respiratory system, skin. Carcinogenic effects: Unknown. Human toxin.

To this list may be added other chemicals in use in the UK.

CHLORDANE An organochlorine forming a resinous film. May be absorbed through skin.

DDT and ARSENIC Both formerly used in UK collections and likely to be still used in museums abroad. (see UNESCO 1968).

LETHANE Organic thiocyanate. Used to improve the knockdown capabilities of chlorinated hydrocarbon and organophosphorus insecticides in household sprays.

LINDANE - Gamma BHC. Benzehexachloride.

MALATHION Organophosphorus - corrosive to iron - moderate persistence and low mammalian toxicity.

MERCURIC CHLORIDE Widely used to poison herbarium material.

PENTACHLOROPHENOL (Mystox). Principally used in mould and insect proofing of herbaria.

PHOSPHINE (Aluminium phosphide). Inflammable fumigant with a TLV of 0.1 ppm (2000 ppm LD_{50} human). May be chosen as alternative to Methyl Bromide (see Horie 1983).

ROTENONE (Derris) Plant root extract. Short persistence. Low mammalian toxicity. Used as a dust.

From the above lists it may be clearly seen that difficulties exist in terms of the safe application of pesticides in the Museum context.These are summarised as follows:

A. In store areas where people are working, opening sealed units, browsing over collections, and where staff may be permanently stationed amongst collections.

B. The difficulties of applying constantly evolving safety controls, as TLV's and STL's move ever downwards.

C. The problems regarding the provision and use of safety facilities and equipment, and procedures. Masks, coats, gloves, fume cupboards, building ventilation and general pesticide containment.

D. The high cost of fumigation chambers and choice of fumigant.

E. The choice of insecticide.

It would appear that in view of these difficulties maximum use should be made of all non-chemical means of pest control. In the long term this must be safer and more economical considering also the damage which may be caused to objects by countless applications of different chemicals over the years.

The non chemical strategy that em erges is along the following lines:-

i) Clean, sound, building interiors and case structure. Double glazed windows, well sealed units.

ii) Good maintenance, regular cleaning.

iii) Regular inspection.

iv) Tight control over the input of material.

v) Steady medium humidity, ca 55% and Low temperature. (Many store rooms appear to be overheated for the comfort of personnel, whilst low temperature can be a major factor in reducing pest activity.)

vi) Properly screened ventilation.

vii) Alternative fumigation strategies. This is an area where much constructive work remains to be done. Workers in herbaria have demonstrated the viability of alternatives to chemical methods, and have shown freezing to be more consistently effective than Methyl Bromide. Very promising claims have been made regarding the killing of all stages of certain pest species. (Crisafulli 1980) and (Edwards 1981).

In the author's own preliminary control experiments using a conventional deep freezer, 48 hours at -20°C has proved lethal to all stages of *Anthrenus verbasci L.* (The Beautiful Carpet Beetle), infesting a bird corpse.

There are a variety of other techniques which may prove to be useful in terms of alternatives to dangerous chemicals.These include freeze dry and related vacuum techniques, pressure, heat and humidity combinations, as well as developments along the lines of relatively mild insecticide used in combination with dessicants (Edwards 1981 and Schofield 1980).

It would seem clear that the full potential of the preventative approach has not yet been realised.

Chemical fumigation.

At present a bewildering number of different strategies are in use in museums in the UK. Institutions may clearly need to carry out emergency fumigation of buildings, stores or objects. Some have fumigation chambers, and may circulate collections through the chamber on a continued basis. The careful fumigation of all incoming material may also be undertaken. There is disquiet regarding the choice of fumigant however, and urgent work is needed to resolve questions concerning reactions between fumigants and objects. (Methyl bromide versus Phosphine for example.)

Chemical protection.

Within stores, storage units and displays, almost every combination of the following approaches may be encountered -

a) Prior poisoning (Eulan, Merchuric chloride etc).

b) Vapona strip. Hung in cupboards, rooms, or cut into strips and pinned into drawers. Sealed into displays.

c) Vapona strip. Circulated on a systematic basis.

d) Naphthalene. As a repellent in trays, bags and in drawer cells.

e) Paradichlorbenzene. In trays, bags and drawer cells.

f) Mixtures of the above.

g) None. Regular checking, periodic fumigation of store, and environmental controls.

This is an area of such importance to the long term welfare of our collections and the health of museum workers that systematic study is urgently required in the formulation of strategies for wide adoption by institutions and professional groups.

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Editor. While this paper was being prepared numerous museum biology curators were approached to obtain some idea of their views and experiences with what turned out to be a bewilderingly varied selection of pest control strategies.

Naphthalene, one of the most widely used chemicals was reported by several people to produce a wide range of symptoms related to periods of exposure to very high levels. These include nausea, stomach pains and upsets, chest constriction and pain, headaches, sore throats and migraine onset. In one unusual example first one and, some weeks later another, small mammal died when left overnight in a room containing entomological collections with naphthalene.

There were also reports of allergic reactions amongst workers, although these are notoriously difficult to attribute to a specific source in any situation. In one case both staff and volunteers developed allergic sensitivity when working for any sustained time in a certain stora ge area. No pesticide is used at present in the collections which are protected by periodic fumigation of the building. Methyl bromide is used and residues of this could be responsible. Alternatively it could be traces of other materials (or combinations). However, despite extensive tests, the cause has not been traced.

If you have other observations concerning these chemicals, or constructive comments about pest control I would welcome them for inclusion in the Newsletter.