OCCUPATIONAL HEALTH AND SAFETY … THE CARING CLIENT?

Full Paper

TOXIC MOULD AND ITS EFFECT ON CLIENTS.

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ABSTRACT

Evidence now suggests that the mould, Stachybotrys chartarum (S. atra), is not only damaging property but causing health problems and may become the asbestos of the 21st century. Buro Happold (2004) warned recently that councils and social landlords are particularly at risk when attempting to deal with this problem. Research at Salford University supports the belief that landlords may be ignorant of the extent of this problem within their properties and are running the risk of massive claims for damage to health following incorrect diagnosis or delay in eradication of this type of mould growth.
Litigation following health damage said to have been caused by S.atra (more commonly known as 'toxic mould') in the US has already reached billions of dollars (CIOB; *Construction Manager*; March 2004) and contractors, clients, consultants and (in particular) landlords are warned that ignorance of the facts relating to this mould and the consequential delays in its eradication from their property will not protect them from severe financial penalties.
HSE statistics (2003) show that asbestos related mesothelioma claims are still rising and insurance companies in the UK are studying the US 'toxic mould' experiences and considering how they can best protect themselves (and their clients) from possible long-term financial damage.
The virulence of S.atra and its associated micotoxin is especially harmful to humans and in particular those with asthma; of particular concern is evidence that such toxins also form part of the arsenal of biological warfare weaponry. Maintenance contractors must be especially careful when exposing their surveyors and operatives to housing affected by damp induced mould growth.
This paper outlines the current situation in the north-west of England regarding S atra and in particular considers the impact of damp housing conditions on personal health and upon a large regional public housing client.

Keywords: toxic mould; mycotoxins; mycotoxicosis; Stachybotrys; T2 Toxins, toxigenic fungi

GENERAL INTRODUCTION AND BACKGROUND

MOULD IN BUILDINGS

A characteristic *'mouldy'* or musty odour encountered when entering some older buildings comes from volatile organic compounds (VOC's) such as pentane, heptanes, octane, 2 hexanone, and undecane exuded by mould organisms established within the structure. The smell is probably one of the first indicators of the ultimate condition of the building. Further critical examination of the building often reveals a lack of investment in routine maintenance, and in the worst cases some elements of the structure may be in the final stages of decay and possible collapse.

Building Surveyors and Facilities Managers surveying 'old-stock' buildings might expect to find both superficial and structural damage caused by fungal growth; especially from the Conifora puteana (cerebella) or '*wet-rot*' and Serpula (Merulius) lacrymans – '*dry-rot*' varieties. The latter is generally perceived as being the most dangerous variety and presents to the surveyor with large and often active soft hyphal growth similar in appearance to cotton wool:

Fig 1. S.atra on glass slide. 2000x mag. Source Harvard Univ'y.

Mould spores are present in the atmosphere in abundance and poor environmental conditions in some areas of buildings allow spores to establish and grow rapidly, establishing usually within dark and damp basements or other closed areas such as sub-floors, roof spaces and built-in cupboards. Mould typically obtains sustenance from condensation and bio-degradable organic building components and some sources mistakenly attribute growth mould across inorganic substances and components as a sign of its ability to live off virtually anything – more careful examination however, reveals an underlying organic contamination providing the fungus with sustenance – e.g. dust, grease and oil contamination on (say) steel, iron and glass (Fig. 1).

Until comparatively recently it was not considered too much of a health risk to enter and survey an existing building (other than perhaps when the building was structurally unstable). However, health and safety risk assessments now identify the need for suitable protective clothing and high quality breathing masks (filters) when surveying or working in buildings affected with dry or wet rot.

Evidence, particularly from the United States, describes the threat from a previously little known mould that is creating a new genre of litigation and proving to fit the definition of a 'litogen' (substances inducing more litigation than injury). It has also received the media-created name: *'Toxic Mould'* but carries the correct name of Stachybotrys chartarum (synonyms: S.atra & S.alternans). S.atra is common in soils

and plant debris but is also been found (along with other 'toxic' moulds) in cereal animal feedstuff. It is considered to be the cause of many animal deaths in Eastern Europe due to mouldy straw feed and more recently implicated by Flappan et.al. (1999) in numerous cases (and deaths) of Infant Pulmonary Haemorrhage (IPH) in the United States (Cleveland, Ohio) dating back to 1993. In addition, Elidemir et.al. (1999) '*confirms'* one case in which S.atra was isolated from the bronchoalveolar lavage fluid of a child with IPH. S.atra was later recovered from the child's water-damaged home and happily, in this instance, the child recovered following medical care and eradication of the source of contamination. However, the current situation regarding S.atra causing IPH is still uncertain due to a lack of rigorous scientific investigation, although there is now a body of anecdotal (and some investigative) evidence leading to logical hypotheses in this context.

The two most common pathways for exposure to moulds are through inhalation and dermal contact. Personal sensitivity will affect the human response time varying between almost immediate (6 minutes), to somewhat delayed (several weeks). Infants under 6 months of age seem to be more at risk as do the elderly; those with an immune deficiency; asthmatics; those with a genetic disposition; and those undergoing chemotherapy or suffering long-term illness.
S.atra forms a greenish-black mould on material with high cellulose and low nitrogen content, such as wallpaper, fibreboard, gypsum board, paper, dust, and lint. Growth occurs when there is, or has been, a very high moisture level from water damage e.g. excessive humidity, water leaks, condensation, water infiltration, or flooding. S.atra is present in the soil and is freely carried into properties during the course of a flood.

In the United States mould related lawsuits are now affecting all members of the construction community including home builders, real estate agents, prior owners, landlords, housing associations, local authorities or just about anyone connected with the construction and maintenance of a structure. They have been held responsible for negligent design, construction or mismanagement of buildings that can be shown as promoting conditions favourable for mould growth above background levels. Examples of such conditions include: enclosed areas with insufficient air flow; recurrent moisture sources; defective damp proof coursing; leaking pipes or HVAC contamination. Poor construction practices are particularly targeted, e.g. the inadvertent creation of an environment favourable to mould initiation by failing to give interior woodwork or other absorbent material time to dry before being sealed up.

MOULD TYPES AND INDOOR CONDITIONS

Modern construction methods produce airtight indoor environments that are positively welcoming to the rapid growth of mould. Previously, draughty buildings with many air-changes per hour diluted the concentrations of mould spores and mycotoxins in the internal air. Nowadays, the move towards more environmentally friendly and sustainable methods of construction (e.g. timber-frame) provides a ready source of food for the mould spores – this is especially the case when sloppy production methods are allowed (or overlooked) and parts of the building are sealed up before they are fully dry. Leakey & Lewin (1996) estimate there are approximately 1.8 million species of fungi, some of which we choose to consume without injury or other ill effects and most of which we have yet to identify (or even discover!). Like plants, fungi take root, but unlike plants fungi cannot photosynthesise and therefore have no chlorophyll (thus are not green). They generally grow directly on their food source, hence their appearance on timber or any other organic substrate and they can '*eat*' the sulphur off concrete walls. When suffering from depleted resources fungi may

escape by aggregating hyphal structures (called strands or rhizomorphs) and grow beyond the zone of depletion, crossing great distances and in so doing, locate further food and water resources. Spore sizes of airborne fungi range between 3 – 60 μm and they cannot be seen without a good microscope; instead they appear as a cloud of 'smoke' when discharged or disturbed. In Europe the most common fungal species appear to be Penicillium chrysogenum and Aspergillus versicolor. (Cole and Cox 1981). Some Aspergillus and Penicillium spores although appearing dormant may remain viable for 12 years or more before activating when moisture becomes available.

Normally, builders and surveyors would be concerned with the effects of mould upon timber and its removal prior to general repairs, however, given sustenance, moulds can grow on virtually any substrate, e.g. kerosene (including jet-fuel), petrol, paint, rubber, textiles, insulation lagging, electrical equipment, glass and stainless steel.
Inadequate kiln drying or seasoning of timber leaves sap within the structure which whilst not affecting the strength of components does encourage the growth of mould, subsequently leaving it susceptible to further attack by more vigorous mould strains.

Wood-rotting Basidiomycetes are perceived to be the only group of fungi of special significance in wood deterioration; however the potential for damage to human health caused by the S.artra fungal strains cannot now be overlooked. Metabolic activity of most fungi occurs at about 75%RH although S.atra generally requires approximately 93%RH and 25^0 C (Kuhn and Ghannoum 2003):
In this context mould growth and damage will readily occur in properties suffering the after-effects of flooding. A report from the Building Research Establishment (Sanders and Cornish 1982) established that 12% of UK housing stock, equating to approximately 2.5 million dwellings, suffered from serious dampness but this was mostly (60%) due to condensation rather than flood damage. This contrasts with the Royal Institution of Chartered Surveyors (RICS) current estimate of 3 million properties suffering from *(incorrectly named)* '…mildew'. (The Move Channel - News Report 2002).

Geographical location also plays a part and in the UK the number of properties built on flood plains should be a cause for concern by building users and owners. Insurance companies may wish to review their risk exposure not only because of the potential for damage to property from flooding but from the consequential personal injury claims resulting from exposure to toxic substances resulting from the negligence of the construction and property community. In November 2001, in a written answer to a Members question in the House of Commons, the Secretary of State for Transport, Local Government and the Regions (Ms Keeble) stated:

> '…*some 14500 (11%) new houses built during 1998 were built on flood plains…'* and '…*for the 10 years from 1989–98, 9% of the land changing to residential use and 10% of the almost 1.4 million new dwellings built were within the indicative flood plains. This compares to the 12% of all land in England that is within the indicative flood plains.'*

The difficulties in isolating and identifying mould spores from inside buildings cannot be over-emphasised. Several studies have shown that the

> *'…indoor environment contains a wide range of microrganisms, including bacteria (e.g. legionella); mycobacteria; and moulds, as well as their products, including endotoxins and mycotoxins...*' (Kuhn and Ghannoum 2003).

Following exposure to mould spores persons exhibit upper airway symptoms similar to those exhibited by persons allergic to dust mites and thus, because of a lack of

understanding and investigation, symptoms may not be correctly ascribed to mould exposure. Any resulting misdiagnosis may be contributing to a distortion in statistical findings.

McCrady (1999) explains that the normal ideal mould environment ranges between 0°- 40°C, pH 3 to 8 although some fungi can flourish at temperatures below freezing and as high as 50°C. These wide ranging temperatures, humidity and pH create a dilemma for building managers, users and owners. Environmental responses to building management require high quality relatively 'tight' structures and inappropriate construction solutions may be out-of-balance with the requirement to keep the inside air quality healthy – preferably without the use of forced air-conditioning/handling systems. Keeping buildings warm may be desirable but the ventilation requirements for the maintenance of a healthy 'mould-free' zone may be at odds with this.

MYCOTOXINS AND S.ATRA

A mycotoxin is a poison. In the context of fungi it is a metabolite (by product) of the growth of moulds. Mycotoxins have very real toxic side-effects on plants, animals and humans and when moulds are shocked by sudden fluctuations in temperature (freezes or hot spells) they exude mycotoxins. They are generally less selective of the hosts they attack and are shown to cross plant species. Some mycotoxins are able to suppress the human immune system. (McCrady 1999).

There are hundreds of known or suspected mycotoxins, but mycologists suggest the list may turn out to be in the thousands. Several mycotoxins have gained some notoriety e.g. Aflatoxin B1 (potential carcinogen) and Satratoxin H (see below) and trichothecenes. The five most important mycotoxins to human health are aflotoxin (produced by Aspergillus); ochratoxin (produced by Penicillium); fumonisins; trichothecenes (as produced by Stachybotrys) and, zearalenone. The species of any given genus may produce few toxins (e.g. Aspergillus species), or they may produce many e.g., Penicillium species, which produce more than 100 – some of which are beneficial. However, trichothecene may be a different proposition:

> '*Trichothecene mycotoxin (T2) can theoretically be used in aerosol form (yellow rain) to produce lethal and nonlethal casualties. T2 is one of the more stable toxins, retaining its bioactivity even when heated to very high temperatures. T2 can enter the body through the skin and aerodigestive epithelium, without being inhaled, and quickly inhibit protein and nucleic acid synthesis* (Texas Department of Health. 2004), (Office of the Special Assistant for Gulf War Illnesses. 2003)

The use of mycotoxins as an agent in bioterrorism is by no means a trivial assertion and the use of 'Aflatoxin B1' by Iraq are a documented part of their weapons of mass destruction programme (UNSCOM 1998) however, there is some conflict as to the toxicity of this particular Aspergillus mould derived mycotoxin and while The Physical and Theoretical Chemistry Laboratory at Oxford University produce data sheets stating that this mycotoxin is '…*extremely hazardous*…' and '…*may be fatal if even very small amounts are absorbed through the skin*…' (Oxford University 2003), (See website: http://physchem.ox.ac.uk/MSDS/AF/aflatoxin_B1.html) other US sites suggest the quantities required to successfully deliver a lethal dose to a population make its use improbable if not impractical. (See website: http://www.gulflink.osd.mil/bw_ii/bw_tabf.htm)

The RICS warned surveyors to exercise vigilance when conducting surveys of buildings and be particularly watchful for S.atra. They estimate that with almost 3 million affected UK homes there may be serious consequential damage to owners and tenant's health who present with cold-like symptoms, rashes, and aggravated asthma. They go on to describe the dangers to operatives involved in building work where widespread fungal contamination exists, stating that they '…*could also be at risk from developing Organic Dust Toxic Syndrome (ODTS)*...'. (The Move Channel 2002)

ODTS is also known as Pulmonary Mycotoxicosis; Silo Unloader's Syndrome (SUS) or *Atypical* Farmers Lung. Although OTDS is not considered as serious as Farmers Lung it is more common and generally occurs after a delay following high-level exposure to various dusts (mouldy grain, grain dusts, mouldy silage, wood chips, foul dust, swine dust) and a call for assistance in preventing OTDS has gone out from the Centers for Disease Control and Prevention in Atlanta, Georgia, USA. CDC (2004). The common link here is the reference to mouldy grain, symbolising some of the first reported instances of S.arta affecting animals in the Ukraine in Eastern Europe in the 1930's. (Nelson 2001).

Considerable argument exists between researchers on the subject of S.atra being especially harmful to humans. The debate relates to the identification and levels of the harmful species in the bioaerosol. Many species of fungi spores are present when samples are taken: particularly the Penicillium, Cladosporium and Aspergillus species. (Hunter et.al. 1988; Grant et.al. 1989). Indeed, over 66 different fungi and yeasts were found to be present in 94% of properties in a US survey. (Kuhn and Ghannoum 2003).

Penicillium and Aspergillus are already well known as mycotoxin producers having a serious effect on humans, while S.atra produces the mycotoxin Satratoxin H which at best, produces cold and flu-like symptoms, headaches, sore-throats, and diarrhoea but is further cited in many areas as suppressing the immune system affecting the lymphoid tissue and the bone marrow. Animals injected with Satratoxin H exhibited the following symptoms: necrosis and haemorrhage within the brain, thymus, spleen, intestine, lung, heart, lymph node, liver, and kidney. Effects by absorption of the toxin in the human lung are known as pneumomycosis. (UMN 2004) Table 1 (overleaf) gives a breakdown of the human response of exposure to mycotoxins.

Table 1. Measuring Toxigenic Mould Exposure and Health: Adapted from: Univ of Minnesota study (2004)

Agent in Environment	Human Exposure	Molecular Response	Symptoms - Disease
• Possible to determine, typically not measured until after onset of illness. Later measurements may not be reflective of the environmental conditions present at the time illness was developing (changes in moisture, temperature, food sources, or other growing microorganisms can all affect mould growth. • Inconvenient for typical consumer • Can vary depending on measurement methods used. Can make comparisons difficult between studies using different testing methods.	Often measured via self-reported mould and/or moisture problems at home or workplace as a proxy for mould-specific indicators of exposure and dose. • Results of environmental testing in the home or workplace are also used as a proxy for indoor mould exposure. • Both measures are very crude measures of dose. • Not yet possible to measure mycotoxins in human or animal tissue.	Few toxicological studies have been performed using inhalation as a route of exposure. • Most of what is known about the physiological response to mycotoxin/ mould exposure is derived from animal studies using ingestion as a route of exposure; respiratory defence mechanisms differ from those present in the digestive system. • The limited numbers of inhalational in-vitro studies suggest that some moulds produce haemolysins and other iron-scavenging substances that result in the destruction of RBCs. • Also implicated in allergic responses and cytotoxicity.	• No effects are specific to either indoor moulds or particular toxigenic species of mould. • Makes establishing associations with indoor mould exposure more difficult. • Three categories of effects: 1) Infection (only applicable to susceptible populations (e.g. immunosuppressed people) 2)Sensory Irritation 3)Allergy 4) Immune effects (e.g. inflammatory response, immunosuppressant) • Suspicion of toxins produced by Stachybotrys chartarum as a possible cause of infant pulmonary haemorrhage has existed since the early 1990s. Only recently has this mould been isolated from the lung of an infant suffering from this condition (Elidemir O. et al. *Paediatrics* 1999).

THE UNIVERSITY OF SALFORD STUDY

The objective of the Salford University exercise was to discover the levels of knowledge and experience of S.atra among housing professionals within the Salford and Wigan areas of north-western England. There is much social housing in this

region and it might normally be expected that local construction professionals would have a high level of understanding of mould infestation criteria. In addition, given the climate and socio-economic status of the region many of their tenants would find it difficult to cope with moisture levels following a flood or deal with the very high internal levels of condensation during a very cold winter when the drying of clothes outside was not possible.

Fifty persons in six target groups connected with the design, management or surveying of housing were initially contacted and thirty firm responses were obtained. From the thirty responses, twenty-four finally agreed to be interviewed and also responded to a brief questionnaire. This small sample population included: architects; facilities managers; general practice (GP) surveyors; housing managers; housing surveyors and maintenance managers who between them had responsibility for over 25000 properties. The survey drew general conclusions but identified the direction the wider investigation will take to ascertain the real picture among the industry's professionals. It is however a pointer to levels of understanding within the construction community.

The following is a synopsis of the survey from what may be termed as the professional housing sector in two large authorities. The targeted groups were asked a series of questions ranging from: practice area; building category; witness to internal dampness; causation and, user complaints from tenants and owners. The latter part of the questionnaire deduced knowledge of the term '*toxic mould*' and the respondent's profession.

Causes of and witness to internal dampness:
All members of all target groups had witnessed internal dampness in property that had been caused by most of the common conditions including: defective DPC's, sewer damage and defective rainwater goods, condensation, leaking appliances and pipe-work etc. This produced a baseline of understanding from which the remaining questions were examined.

Experiences of mould growth:
Some 92% of the respondents indicated that they had experienced or seen mould growth within properties – this includes all of the GP surveyors, maintenance managers and housing managers. However, only 33% of architects had witnessed it. One inference that might be drawn from this response may be that architects neither get onto site nor do they get involved in maintenance works often enough; another may be that within large housing organisations maintenance and repair work is often handled by internal 'works departments, who are left to deal with the damage and restore elements of the structure without reference to a design professional.
The worst and most consistent cases of mould growth were seen in Residential Care Homes for the elderly, where on a regular basis, the normal internal daily temperatures exceeded 25^0C with 95% RH values; often as a result of limited ventilation in an (damaging) attempt to conserve fuel and power by extensive draught-stripping and sealing of openings in the structure. In addition, most of these premises undertook extensive food preparation and washing, daily generating high humidity levels.

Flood damage:
Only 38% of all respondents had dealt with or witnessed flood damage, two of whom (housing surveyor and housing manager) stated they, '…dealt with flooding issues on

a yearly basis…'. However, the bulk of respondents had never had to react to floodwater inundations within properties in their charge.
S.atra growth is particularly prevalent in these circumstances as it is expected that it will be carried into the property by floodwaters. There is a natural reaction on the part of the landlord or owner to get tenants back into the property as quickly as possible and this may lead to shortcuts being taken during the restoration process and, the property being handed over before it is fully dried out. Social housing owners (in particular) have a responsibility to ensure that their property is safe, both to hand over and to occupy.

Client complaints concerning mould:
When questioned about their experiences with clients, all of the housing managers, housing surveyors, and 60% of GP surveyors had suffered complaints from clients about mould in their property following exposure to damp conditions. It is of no surprise to find that maintenance managers had little (40%) experience of client's dissatisfaction – this may be due to their arrival on the scene after the event - usually to rectify the damage.
In a similar vein, none of the architects had experienced client dissatisfaction. There may be a case for architects to re-visit their clients following some years of building use – this could form part of their design-feedback loop, enabling them to witness the problems of poor or over simplistic specification and construction techniques.

Client complaints of ill-health:
When clients complained about ill-health they did so to all housing surveyors and GP surveyors. None of the other professionals had experienced this issue. It was found that the first port of call for all clients was their 'landlord' in the case of tenanted accommodation - they then passed the complaint on to the housing surveyor to determine the cause of the complaint. In the case of owner-occupied dwellings the normal route was to contact a GP surveyor, who then determined the cause of the mould infestation.
The alarming situation regarding temperatures and humidity levels in care homes for the elderly leads to a number of speculations as to the well-being of the inhabitants, many of who are too infirm or possibly disabled to easily 'get out' into the fresh air. The surveyors/managers responsible for these homes were not requested to record their concerns about these premises although it is clear that a comprehensive and dedicated survey of such premises may yield some difficult and challenging results.

'Toxic mould' knowledge:
This is perhaps the most surprising result of all. Only 38% of the targeted group had heard of the term '*Toxic mould'*. The media coverage during (particularly) the last two years has been considerable, with most of the professional journals carrying considered and reflective reports of the fungus. At the same time there have also been 'scaremonger' reports in the daily press, likening S.atra to Asbestos and stating that UK insurance companies were about to face massive and very long term claims from mycotoxin affected claimants. Some US insurance companies will no longer hold cover on S.atra infected or asbestos contaminated properties. When asked (during a follow-up telephone interview) to describe, *in one word*, what 'Asbestos' meant to them – the overwhelming responses from all interviewees were the words: 'deadly'; 'lethal'; and 'cancer'. The message has clearly got through about the effects of asbestos on the human body however; issues surrounding the body's reaction to mycotoxins emanating from mould infestation in property have not – yet.

Facilities management:
Most disturbingly, the group of professionals consistently unable to produce a knowledgeable answer to most of the questions were the facilities managers. If this trend is reliable, there are many issues for this growing and relatively new profession to resolve in respect of their understanding of buildings, particularly those that may be classified as 'sick buildings'.

CONCLUSIONS

The study concludes that there is a growing body of evidence suggesting S.atra and its mycotoxins of Satratoxin H and trichothecenes have a harmful effect on human tissue especially among those with immune deficiencies or who are 'weak' e.g. infants, the infirm and the elderly. The isolation of S.atra spores from the many fungal spores present in any building due to natural environmental conditions is especially difficult and further work needs to be done in this respect. The use of forced-air collection systems rather than passive (e.g. agar slides) is preferred when collecting evidence of mould spores within properties.

Humans are exposed to mould spores in the natural environment all the time and most of us are immune, normally not suffering any ill or side-effects. However, some of the Stachybotrys mycotoxins (particularly the T2 strains) have a severe and debilitating effect on human tissue and because of this the procedures for removal of moulds from within property should be speedy and precise; operatives must be well trained and given protective 'all-over' Hazardous Materials (HAZMAT) suiting containing complex breathing filtration systems that are robust enough to enabling operatives to safely handle and dispose of contaminated building products.

With the exception of one case in the US (Elidemir et.al. 1999) the link between the presence of agents in the environment to human exposure data and subsequently to molecular alterations and disease still leaves many researchers unconvinced of the connection between damage to human lung, intestinal, brain and other vital organs in the body following exposure to the singular S.atra mould and its mycotoxin – however, the evidence is growing and litigation (particularly in the US) is driving forward the body of knowledge relating to this quiet menace.

The best way of dealing with mould is still to deny it any moisture. This simple action will stop mould growth and underpins the assertion that adequate, unobstructed ventilation is still paramount as is the need to fully dry properties subsequent to flood inundations. Similarly, sloppy construction practices that allow damp timber or other construction elements to be enclosed (sealed) during the construction phase must be condemned. Speedy identification and removal of dampness problems must be given a higher priority by social housing landlords not only to reduce their potential for exposure to litigation but also to improve the health and well-being of their clients. A recognition that the removal of mould growth from properties can be an extremely costly, time consuming, hazardous and difficult exercise – it may seem very extreme but in difficult cases the outcome may be to burn the dwelling to the ground in order to totally eradicate the presence of mould and the potential for human suffering. (Mold Reporter 2002).

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