Review Article

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Mould in building disputes

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Abstract

Background: Indoor air quality and water damaged buildings are increasingly a focus of civil litigation and public health concern. This paper reviews the science and practice of dealing with damp and mould in the built environment. The focus is on education for solicitors, barristers and arbitrators, builders and building consultants, architects, engineers and real estate personnel who have a common interest in dispute resolution within the property law space. In Australia, there is currently no consistent consensus regarding how and what to measure when buildings get wet or there are adverse health claims. Possible reasons include commercial self-interest from groups within the remediation industry and uneven response to claims from the insurance, residential and commercial tenancy or landlord and building sectors due to a lack of policy or professional conduct guidelines. Ignorance of basic biology and infection control are also salient factors. In the absence of defined expectations and thresholds for both the assessment and remediation stages, the occupant may be left inside a building that remains contaminated or where inappropriate resources have been applied or misapplied without justification or based on flawed reasoning. This could result in liability for key stakeholders or result in disproportionate allocation of funds that could create an unequal public health care response. The recent announcement of the Inquiry into Biotoxin-related Illnesses in Australia is likely to shine a spotlight on the need for objective evidence collection and analysis during all stages of decision-making about human exposure and remediation of fungi within diverse building structures. To illustrate, I review the AustLII database of the Victorian Civil and Administrative Tribunal between 1998-2018 for all cases about mould. Both the number and frequency of cases is trending up with a dominance of disputes within residential tenancy at 50%, followed by 31% for building. These results reveal issues concerning minimum housing standards and difficulties dealing with unexpected outcomes caused by newer building practices as well as dispute over contract terms, costs or health status. Compliance principles are suggested with reference to key citation and consensus methods or documents that can be used to improve the assessment and practical cleanup of indoor water damage.

Keywords: mould, water damaged buildings, building and property law, sick building syndrome, mould assessment, mould remediation, public health, inflammatory response syndrome, biotoxin-related illness

Introduction

There is overwhelming evidence that air pollution from environmental sources compromises human health across all age groups[1] and is responsible for one in nine deaths annually.[2] In turn, much attention is now focusing on indoor sources of pollution and how building factors and conditions shape microbial communities (the microbiome).[3,4] For example, introducing a dog into a home has been associated with a reduced allergic disease risk[5] and is hypothesized to alter the indoor microbial population dynamics which in turn modifies the human gut microbiome. Research shows that dog introduction immediately introduces new microbes and over 12-months leads to large relative abundance shifts. Now consider what happens when an unexpected flood, storm event, plumbing or building defect, human error in judgement or dilapidation event results in water ingress and property damage? Mould growth indoors is an ancient unwanted problem and dates back to biblical times[6] where it was seen as an unclean phenomenon.[7] In the 16th century the theory of contagion developed around the notion of infection through transferrable seeds directly and through indirect contact with a contaminant although they were not considered to be alive. By the mid 19th century there was support for a new theory that microorganisms were the cause of disease[8] and that their reproduction in or on a suitable host leads to infection. This has been refined ever since.

Water damaged buildings

Indoor dampness is known to affect between 10-50% of the built environment depending on house type and condition and climate factors.[9] It's also widely reported that up to 80-90% of our time is spent indoors[10] and the Department of Public Health and other Government agencies have previously claimed that up to 50% of illness is due to indoor pollution (cited in Hope. 2013).[11] The microbiome of a water damaged building is complex and quickly shows species selection towards those fungi, bacteria and yeasts that exploit the food source in the various building elements and products and take advantage of the excess available water to reproduce. When conditions like this occur, this promotes luxuriant growth and normal background levels of these microorganisms quickly get out of control.[12] In new buildings, there is also some concern that gypsum wallboard may already contain toxic moulds that are introduced during manufacture and therefore become active if inadvertently wetted.[13] A study from 2012[14] in Australia showed that for strata housing, water leaks were the most common building defect with 42% experiencing internal water leaks, 40% water ingress from outside-in, 25% due to guttering problems, 23% from defective roofing and 22% through plumbing defects. In turn, confirmation of moisture damage in homes is associated with subclinical inflammation[15] in children; while aspects of this inflammatory response syndrome in adults has been previously elaborated on by others.[16,17]

Social justice and legal context

In my own lab and consultancy many of the buildings we inspect and report on are the subject of intense litigation and other civil disputes between different stakeholders that for whatever reason are now locked in battle regarding the health and safety of their indoor living environments. In principle, the arguments put forward by opposing sides reduce towards weight of evidence[18] to determine if something is more likely to be true or false. However, the 'yes-no-maybe' cycle of teasing apart each component of an argument is not in practice an idealistic or linear logic pursuit. In my opinion, the relevance and reliability of an expert witness response to any matters contained in mould and water damage property disputes don't adequately assess the scientific facts at hand. This is the crux of the experts' job who champion the cause-in-fact but where additional non-scientific arguments[19] are raised that invoke aspects of *Daubert v Merrell Dow Pharmaceuticals*. This famous case and others such as *General Electric Co v Joiner* are decisions aimed towards ensuring a closer relationship between the law and the sciences.[20] Mould cases therefore present with aspects of causal inference, mixed scientific evidence, a lack of information on potential toxicants and many avenues for vigorous scientific disagreement. There is much elegant reasoning about cause and causality and how evidence can be used to increase or decrease confidence in some factor being causally related to adverse hardship or disease, which is the foundation of so many mould disputes.[21] Notably a recent Senate inquiry into Australian Lyme Disease highlighted a failure of evidence-based medicine to influence patients and policy.[22] Lyme disease[23] flaring is often linked to mould exposure, although the former is more likely a primary bacterial or parasite infection rather than fungal although co-infection is likely. My own interest in environmental justice[24] is an attempt to help people through useful and practical interventions. Mould is something which affects people in different ways depending on one's position. For example, a tenant claiming loss of amenity on the grounds of sick building syndrome is arguing from a different base to the managing agent who may equally vigorously be claiming to have discharged responsibility under the Estate Agents Act 1980 or the Residential Tenancies Act 1997. In this paper, I have reviewed all the Victorian Civil and Administrative Tribunal (VCAT) 1998- (AustLII) decisions from 1998-2018[25] (June) containing the term "mould" spanning an almost 20-year period. VCAT enables claims to be made according to type of dispute and are assigned to one of several available law lists. Table 1 shows the case breakdown.

Table 1 Case distribution according to law list containing reference to the term "mould" between 1998-2018

% Occurrence	Law list	n, Cases (111)
50%	Residential Tenancy	56
31%	Building and property, Domestic Building, Real Property	34
6%	Retail Tenancy	7
13%	Civil Claims, Planning and Environment, Owners Corporation, Administrative Appeals,	14

The distribution shows that half of the cases involve residential tenancy while ~30% are building related matters. This is important information that also informs the weighting of influence of social and economic policies on population health. What I mean by this is that we can infer that more buildings used for residential tenancy have mould and water damage problems. Therefore, the VCAT data for the built environment suggest that any strategic initiative or changes that promote a Health in All Policies[26] could help address inequality, and disadvantage and offer improved social protections[27] within the Australian housing market. There is increasing public media awareness about toxic mould. In 2011 the mother of deceased actress Brittany Murphy filed a law suit against the builder of the home claiming her daughter died of mould.[28] Other famous people who have been unsuspectingly caught up by mould-affected homes include: Oz et al.[29–32]. A search for the search query "toxic mold" on Google Trends worldwide does not reveal an increasing trend in interest across any category. Contrast this with the breakdown of VCAT cases over time where the number of mould and water damage civil claims is increasing (Figure 1). It should be noted that data was only available for the first 6-months of 2018.

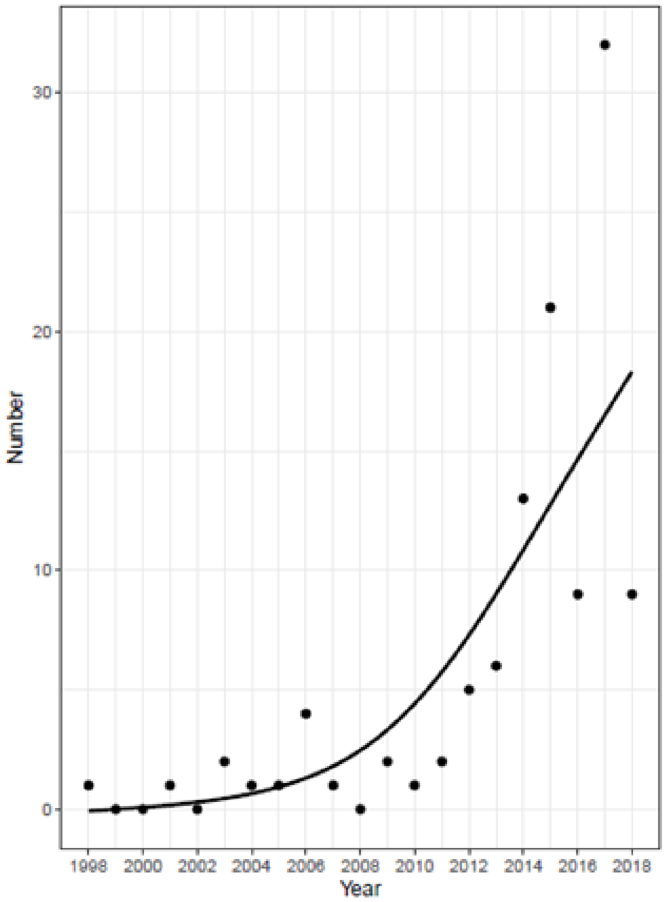

Figure 1 Time series distribution for VCAT cases referencing the term "mould" between 1998-2018. A positive increase in the volume of cases is seen, particularly from 2012 onwards. Data summary showing the overall trend uses a generalized additive model plotted in R (RStudio Version 1.1.453).

Particular attention was then given to only those cases that were heard under either the: Building and Property; Domestic Building; Real Property list. A subset of typical cases is given in Table 2. An analysis of this data (and all the other cases back to 1998) shows there are approximately ten main issues that are repeated time and again:

Table 2 Example of mould claim and issue at test for the last seven cases published in 2018 on AustLII

Building and property case document	Mould claim	Issues
24th April 2018, VCAT Reference: BP84312017	Assessment of damages for defects in silicon applied at top to vanity basin leading to discolouration and mould.	Visible damage
17th April 2018, VCAT Reference: R227 /2013	Allegation of works not completed and cracked walls, foul smell and humidity issues making some commercial motel rooms not presentable and a possible health Issue for guests	Allegation of mould smell, health risk
29th March 2018.VCAT Reference: BP790 /2017	Damp smell but no visual evidence daily leak or mould or water damage. Denial of any roof leak.	Allegation of mould smell
10th January 2018, VCAT Reference: 13F5375 /2017	Defects apparent within two months of laying floating timber floor with mould discovered underneath.	Visible damage
27th October 2017, VCAT Reference: BP985/2017	Painting over defects including mould. Other areas of metal framing found to be mould affected and in need of treatment prior to painting.	Concealment/coverup, visible damage, defective work
12th September 2017, VCAT Reference: BP640 /2015	Complaint raised about defects, including mould and water ingress Primary claim against builder for partial fix that did not address the primary underlying defects which were causing water ingress from the balconies.	Concealment/coverup, visible damage, defective work
6th September 2017, VCAT Reference: BP690/2016	Damage to wooden floor and suo-floor of premises by tenant from unchecked water leaks from retrigerator/freezer equipment into an area lacking ventilation and with elevated humidity. Concerns raised for possible health issues.	Visible damage, health risk

a. Allegations of mould or water damage

b. Visible signs of mould or water damage

c. Smells

d. Unhappy with workmanship/warranty

e. Unhappy about problems being covered up

f. Worried about health risks

g. Get out of lease or dispute terms

h. Get out of building contract or dispute terms

i. Methods to remediate/clean mould

j. Discussion over costs

What are fungi?

Fungi are the third most abundant taxonomic group in terms of weight after plants and bacteria making up 12 gigaton (Gt) versus all humans that only weigh 0.06 Gt.[33] Mould is the common term for filamentous fungi. Mould colonies form from spores which germinate like tiny seeds and form a radially symmetric colony called the mycelium. The individual mould cells are long filaments called hyphae that are symmetrical and increase in length from the tips. The size of the individual mould spores range from 2-10µm while some are as large as 30µm and still others have diameters up to 100µm. Mould spores germinate when conditions are favorable. Once the spore germinates a single hypha grows outwards and then begins to branch and then branches again and again in a fractal pattern until it turns into a macroscopic colony. Fungi are eukaryotic, meaning they have a nuclear membrane surrounding the nucleus containing the genetic material. They are more complex than bacteria, archaea, protists and algae. There are between 2.2 and 3.8 million species of fungi and only 3-8% of them have been named.[34] It is entirely normal for fungi to be found inside buildings as well as outside. Problems occur when fungi find suitable ecological niches inside a home which allows them to proliferate. This can easily occur when a building becomes water damaged or building elements containing a suitable carbon source like cellulose or lignin containing timbers or plasterboard or even the glue used for wallpaper become wet and in turn become colonized by any of the fungi that are found in the normal airspace within the home or are introduced through human movement creating aerosolized bio-plumes into the airspace.[35]

How do they cause problems?

Fungal growth is completely dependent on access to nutrients, available moisture, the right pH and temperature and oxygen in the air. The moisture content or water activity of the underlying materials including dwell time is the key factor and species diversity is a result of the fact that different fungi have different temperature and water activity preferences. Heating ventilation and air-conditioning all affect the indoor environment which in many cases is completely artificial and can lead to a lack of natural ventilation. In general, a normal building indoors will show a lower number of fungi compared to the outdoor air. The outdoor area should also show a range of different fungal species which is considered diverse. Compare this with water damaged and mould affected building that tend to show an increase in the overall numbers of indoor fungi as well as showing species selection towards certain groups of fungi. The health effects from exposure to mould comes about through a reaction to

a. volatiles liberated from fungal growth,

b. mycotoxins in the spores and

c. Respiratory illness or distress caused by inhalation of spores or cell wall fragments.

For example, mould smells are known to cause headache, fatigue and eye, nose and throat irritation. Since fungi reproduce through spores, mycotoxins are chemicals produced by the fungus which help them survive. However, these mycotoxins are known to have adverse immune consequences and can elicit reactions such as cold and flu like symptoms, skin irritations/allergy, burning or sore throat, headaches, fatigue, diarrhea and compromised immune function. Dermatitis is also a risk factor for some individuals. Asthma, bronchitis and respiratory issues including pneumonia have been widely reported in the literature. Many fungi such as *Aspergillus fumigatus* also opportunistic pathogens and can grow inside the lungs and nosocomial pathogens can colonize open wounds. Hence persons who are already immune compromised such as those undergoing surgery or recovering from unexpected accidents are particularly at risk.

A short bullet list[7] of typical mould exposure symptoms is provided below.

a. Brain fog
b. Chest tightening
c. Coughing
d. Dizziness
e. Fatigue
f. Headaches
g. Irritability
h. Muscle aches
i. Paresthesia (tingling or prickling sensation)
j. Sneezing

Other risks

Much of the health-related research literature focuses on the physical health impacts of living in a cold, damp and mould affected house.[36] However, the mental health aspects of these situational problems cannot be underestimated. I want to briefly review this area and highlight some of the emerging literatures on this topic which broadly report on mental health impacts as opposed to mental health disorders. For example, living in a cold and damp house has been shown to contribute to different mental health stressors including persistent worry about debt and affordability, thermal discomfort and worry about the consequences of living in a cold and damp building. Improving the energy efficiency has been shown to improve mental well-being.[37] As well, some groups are known to suffer social isolation and other mental health costs due to inadequate rental housing and there is a need for minimum tenancy housing standards.[38] Interesting there is strong evidence that mycotoxin toxicity is associated with autism spectrum disorder in children.[39] The infectious disease literature also reports on individual cases of delusional infestation. This is the perception of being infested by animate or inanimate objects that cause distress.[40] Referred to as delusional parasitosis, less than 1% are fungi related, yet nevertheless this condition can result in serious skin disorders. More recent research,[41] shows that many of these complex skin disorders may in fact have a solid microbiological basis. For example, Morgellan's disease alsopresents with ulcerated skin and protruding fibers. Multiple detection methods have confirmed this to be a true illness caused by *Borrelia* spirochaetes that also cause Lyme disease. Notably, it's not uncommon for some mould exposure clients to also claim to be suffering from Lyme disease, although this remains a scientifically and politically controversial topic (Brown, 2018).[22] New and alarming research shows that the brains of Alzheimer's disease patients show clear signs of fungal infection;[42] while the elderly (without Alzheimer's) also showed signs of unusual fungal infection and bacterial infection.[43] Other research suggests that Alzheimer's disease is caused by inhalation of biotoxins and mycotoxins from fungi which manifests as chronic inflammatory response syndrome.[44] Therefore, we shouldn't underestimate the role that fungi play in the aetiology of a diverse range of unwanted illness events.

How and what do we measure?

So therefore, how should buildings is assessed to collect suitable evidence on which to make a determination regarding both indoor air quality and the potential for water damage and mould to impact on the occupants? A range of different documents[45] are available that explain how to perform a building inspection for mould. Normally this task will be performed by an occupational hygienist or someone qualified in microbiology, mycology or environmental health. A more liberal interpretation of the skillset needed for mould assessment is provided by the IICRC R520-2015 that defines this role to be provided by an Indoor Environmental Professional (IEP). Different approaches for different buildings have been written about in both the citation and consensus literature which seek to encompass most aspects of the different options available for remediation. In all cases a walk-through to collect visual and easily acquired observations is the first step. It is important that all investigations develop a suitable sampling strategy to acquire quantitative data. This fall into three main types: air sampling, surface sampling, and bulk sampling. Air samples usually take a known volume of air and collect this into a spore trap in order to count and speciate the different mould spores present in the sample. Other air sampling methods again take a known volume of air and pass this across the exposed side of a Petri dish to see what will grow using mechanical pumps or sedimentation directly from the air. Optical techniques include measuring the cumulative particle number concentration (particulate matter size distribution) based on size[46] rather than mass using an optical particle counter[47] since it has recently been found that large fungal fragments (>1µm) are under-sampled by traditional monitoring approaches, thereby underestimating actual fungal exposure.[48] Regardless of methodology, it is very important to collect suitable controls for the outdoor area as well as from the complaint/region of interest areas as well as those immediately adjacent to such areas. Suitable indoor controls which include non-complaint rooms or regions should be collected. Surface sampling as its name suggests involves taking samples from visibly contaminated surfaces or from surfaces that might be contaminated through for example settled spores. Methods include sticky tape-type transfer slides or swabs to Petri plate or RODAC contact press plates. Bulk sampling refers to collecting samples of actual building material such as insulation within walls, dust samples or water from air handling units. It is very important that the units used to quantify mould levels are consistent and that there is an effort towards report harmonization between different laboratories. As well, the sampling strategy used to assess the building conditions at the first inspection (ingoing assessment) should be well-matched with subsequent inspections. There is no point collecting a random set of data or under-sampling a building or worse yet, omitting appropriate controls. The aim of the initial inspection is to provide comprehensive data for the building as a whole. If the inspection relates to a residential property, and there are health and safety concerns, it is recommended to sample all habitable rooms. This makes it straightforward to compare like-with-like after cleaning and remediation and data sets should allow for easy comparison (at a glance) between the ingoing and outgoing condition. Because each sampling method measures different aspect of the fungal life cycle, more than one method should always be used, and care should be exercised in the taking of controls and matching sample locations. Table 3 details the main testing methods that have well documented standards or guidelines.

Table 3 Published Standards and Guidelines for performing inspections, sampling and data analysis

Test Type	Standard or Guideline
Visual Inspection/environmental surveillance	-Standard D7338-14 which is the ASTM Standard Guide for Assessment of Fungal Growth in Buildings
-Quality control approach	-Kemp, P. et al.[54] Australian Mould Guideline. 2nd ed. The Enviro Trust
-Collect information using visual or olfactory queues for the purpose of making accept/reject or pass/fail/borderline decisions	-Standard Test Method for Categorization and Quantification of Airborne Fungal Structures in an Inertial Impaction Sample by Optical Microscopy. ASTM International. Designation: ASTM D7391 – 17e1.
- Involves pattern recognition and clustering	
Spore Traps	
-Compare indoor mould levels to outdoors as well as the inter-room variability	- Kemp, P. et al.[54] Australian Mould Guideline. 2nd ed. The Enviro Trust
-Captures standardized volume of air to a sticky microscope slide	-Standard Test Method for Direct Microscopy of Fungal Structures from Tape. ASTM International. Designation: D7658-17.
-Captures ever type of particulate matter in each sample	
-Units of: spores/m^3 of air	
-Allows Speciation to Genus level	
-Samples can be archived for re-analysis by other labs	
Tape Lifts	
-A sticky slide is pressed against a suspect/target surface region of interest	- Kemp, P. et al.[54] Australian Mould Guideline. 2nd Ed. The Enviro Trust
-Examined microscopically	-ASTM D7789-12. Standard Practice for Collection of Fungal Material from Surfaces by Swab.
-Biased method since difficult to standardize region of interest	
-Easy to test known-clean surfaces or known-contaminated surfaces and cherry pick samples to suit conclusions made a priori	
-Units of: spores/hyphae/biological matter/non-biological matter/biofilm classified semi-quantitatively or often as a percentage of the sample trace	
-No easy ability to Speciate to Genus unless very heavy fungal growth is transferred	
-Likely damage to delicate fungal structures used for classification from tape shear forces	
Surface Swabs -A swab is used to transfer a streak sample from a suspect/target surface region of interest onto either a Petri plate or into an enrichment broth for culture -Captures only what can grow and depends on the petri plate medium composition	- Kemp, P. et al.[54] Australian Mould Guideline. 2nd Ed. The Enviro Trust
-Much less bias and negative controls can be used	
-Ability to classify to Genus and Species	
-Ability to perform other tests or PCR from mixed or pure cultures	
-Units of: colony forming units, CFU per cm^2 or raw counts per plate, CFU per plate	
RODAC Contact Plates	-Cleanrooms and associated controlled environments: biocontamination control. Part 1: general principles and methods. Document ISO 14698-1:2003. 2014, ISO
-A smaller Petri plate having a raised convex surface is directly pressed onto a suspect/target surface region of interest	- Kemp, P. et al.[54] Australian Mould Guideline. 2nd Ed. The Enviro Trust
-Squares on the reverse side of the plate allow for easy counting of colonies	
-Any differential medium can be poured to test for a wide range of bacteria, fungi or yeasts	
-Much less bias and negative controls can be used	

Table continued.....

Test Type	Standard or Guideline
-Ability to classify to Genus and Species	
-Ability to perform other tests or PCR from mixed or pure cultures	
-Units of: colony forming units, CFU per cm2 or raw counts per plate, CFU per plate	
Active & Passive Air Sampling	-ISO 16000-17:2008, Indoor air Part 17: Detection and enumeration of moulds - Culture-based method
-Defined approach to using classical microbiological technique for viable fungal sampling	-ISO 16000-18:2011, Indoor air Part 18: Detection and enumeration of moulds - Sampling by impaction
-Active sampling uses a pump to collect standardized volumes of air	-Cleanrooms and associated controlled environments: biocontamination control. Part 1: general principles and methods. Document ISO 14698-1:2003. 2014, ISO
-Passive air sampling relies on gravity sedimentation in a defined window or time to fall onto an open Petri plate.	
-Units of: raw counts per plate, CFU which can be transformed using a formula into CFU/m3	
Airborne Particle Counting	-ISO 21501-4:2018, Determination of particle size distribution -- Single particle light interaction methods -- Part 4: Light scattering airborne particle counter for clean spaces
-Method for using a light scattering airborne particle counter to measure the size distribution and particle number concentration of particles suspended in air. Typical size range of particles measured by this method is between 0.1µm and 10µm in particle size.	
Dealing with Statistical Uncertainty	-ASTM D 7440-08 Standard Practice for Characterizing Uncertainty in Air Quality Measurements. (2015)
-Dealing with uncertainty during air quality assessments for both airborne and settled materials and characterizing measurements as to uncertainty.	

Is there a safe level of mould?

Safe levels of indoor mould occur when there are no building defects that could result in overt water ingress or hidden moisture accumulation. A safe indoor mould level exists when the microbiome and mycobiome of the indoors is not dominated by one or more clusters of water-loving fungi that are known irritants. A safe level of indoor mould occurs when adequate ventilation and insulation for thermal comfort and heating are provided. Contrary to the popular mantra that there aren't established safe levels of mould, I will briefly revise those published thresholds that have been formed through consensus and citation research and that do in fact define objective thresholds. In most cases, there is a need to compare the outdoor air to the indoor air. The outdoor air is usually considered to be normal and acts like a reference control. The aim is to find where indoors, there may be evidence of a change in the statistics for whatever set of tests are applied. Any significant difference between the indoor and outdoor air in any room or region of interest is then red flagged for follow-up. Because mould does not need to be visible to be of concern, a visual inspection only is not sufficient when mould exposure health concerns are raised or are potentially foreseeable. Quantitative data must be obtained in these situations. The WHO Guidelines (2009) for Indoor Air Quality, Dampness and Mould make recommendations and review other Standards and Guides and although they fall short of explicitly defining a cut-off, they do conclude that a limit value of 500CFU/m^3 for airborne fungal spores indicates a dwelling without moisture problems. Interestingly, these values re-emerge[49,50] when the Omeliansky equation is applied to the CFU on Petri plates and converted back to CFU/m^3. The total fungal count is also part of the Polish Standard PN 89/Z-04008/08 and is in accord with the American Industrial Hygiene Association (AIHA) guideline limit; all of which have been catalogued and exhaustively reviewed.[51] The AMG 2010 also applies these thresholds covering all of the practical testing methods.

In practice provided adequate outdoor controls are taken for every building and (as required) suitable indoor controls for non-contaminated areas, then the quantitative nature of most methods will produce sufficient data on which to make an evidence-based comparison between indoor and outdoor air quality. The ultimate threshold should therefore be set by a minimum of duplicate or triplicate sets of outdoor controls defining the 'normal mould level' on a building-specific basis and compared with documented reference metrics listed above on a case-by-case basis. This would introduce a logical flexibility into interpretation where data is compared based on site-specific environmental factors measured on the day to reveal the overall outdoor/indoor ratio as well as fine-detail about inter-room variability. The IICRC S520 specifies three levels of mould contamination but these should not be misunderstood as meaning they are quantitative mould thresholds. They are only qualitative conditional categories applied by the restoration and remediation industry. Condition 1 is normal fungal ecology, Condition 2 is settled spores and fungal fragments, while Condition 3 is actual growth. This three-level classification is used as a guide for the restorer to sensibly approach the manual cleanup operation. Unfortunately, this subjective scale all too often appears during post remediation verification with extremely limited quantitative data as support. For this reason, the conditional scale should be limited to describing the remediation task, while superior and verifiable methods are used for the indoor/outdoor ratio and inter-room variability assessments that map back to the above-mentioned consensus or citation documents.

How to remediate?

In order to manage indoor air quality and mould problems indoors it is necessary to do two things. The first is to eliminate the source of moisture and the second is to perform source removal of all contaminated areas. This usually involves strip out and partial demolition under containment and adherence to wearing of appropriate personal protective equipment and exclusion of other persons until clearance has been achieved. Cleanup controls are similar to those used for asbestos abatement:

a. ANSI/IICRC S500 Standard and Reference Guide for Professional Water Damage Restoration, 4th Edition, 2015.

b. ANSI/IICRC S520 Standard for Professional Mold Remediation, 3rd Edition, 2015.

c. ANSII/IICRC R520 Reference Guide for Professional Mold Remediation, 3rd Edition, 2015.

d. Kemp, P. & Neumeister-Kemp, H. (2010). Australian Mould Guideline. 2nd Ed. The Enviro Trust (AMG 2010)

e. Kemp, P. & Neumeister-Kemp, H. (2010). The Mould Worker's Handbook–A Practical Guide for Remediation. 2nd Ed.The Enviro Trust.

A Call for Improvement?

Recently Federal Member of Parliament Lucy Wicks has called for a National Inquiry into mould due to her own experience dealing with illness following storm damage to her home.[52] She recounts the difficulty in finding suitable scientifically literate medical practitioners. She also recommends changes to building codes around mould and water damage and development of a national guideline for mould remediation. In turn, an inquiry into biotoxin-related illnesses in Australia was initiated for public comment on 21st June 2018.[53] At this point in time, Table 3 shows which Standards already exist for the practice of mould assessment, while the AMG 2010[54] and the IICRC[55] mould documents definitely provide the methodology for the remediation component and parts of the assessment process. In a sense the documents already exist yet need further input. What is needed is development of more comprehensive guidelines that extend on this information byexplicitly defining

a. minimum testing and threshold criteria for both the 'ingoing' initial assessment and

b. The 'outgoing' final assessment (called post remediation verification).

It is important that these guidelines be based on scientific principles of data collection[56] to promote ethical conduct and prevent bias and concealment that is unfortunately rife within the remediation industry. Some reasons for this include opportunistic financial gain through deception or implementation of practices that are not matched to the scale of the problem. From personal experience, it is not unheard of for unscrupulous trades to perform mould remediation in a haphazard, cavalier way and then have their work rubber stamped at the end. This occurs because of the ease of fabrication without appropriate legal oversight. In turn, the Insurance sector also needs to address these points of misconduct, since in many cases, they are the ones paying the cleanup bill. As has already been discussed in the academic literature, building inspections for mould are very useful if done well.[57] Independent testing needs to be rigorous at both the beginning, during and end, and should serve as a wake-up call to the unregulated remediation industry. Again, I see far too many examples of the Insurers and claimants being regularly deceived through deceptive practices at both the assessment and remediation stages. For these reasons, scientists, doctors, other health professionals, qualified builders and other building professionals as well as Insurers should form the balance of any group charged with the task of preparing such guidelines. This is important so as not to be unreasonably undermined by the self-interests of industry groups, dominated by actors who in many cases have no more training than a 4-day short course. Such training is hardly capable of matching appropriate infection control methods to individualized site-specific building factors and should be more appropriately addressed by development of Vocational Education and Training (VET) accredited courses. A national set of guidelines would also put Australia on a path that has already been followed to a large extent in Canada.[58,59] As well, such an approach will better involve citizens in their own health by encouraging routine surveillance in the home for mould and dampness that is in fact a 2018 Census question in New Zealand[60] and maps back into their emerging Warrant of Fitness[61–63] rating scheme for minimum housing standards. Similarly, in the United Kingdom, the Homes (Fitness for Human Habitation and Liability for Housing Standards) Bill 2017-19[64] is currently being read[65] and if passed will establish mould and dampness as a statutory nuisance in rented dwellings.

Treatments and building interventions

In closing this article, I want to review why early diagnosis of mould and appropriate treatment to the building and the client/patient remains the goal. Mould avoidance followed by therapeutic interventions such as antigen treatment and detoxification has been reported to have been successful in the treatment of over 10,000 patients[66] with some treatment modalities yielding an up to a 95% success rate with a return to normal function outcome.[67] Therefore, from a property and building law perspective, there is a very strong expectation of positivity surrounding being able to effect successful mould interventions[68] that dramatically influence the health and wellbeing of occupants.[69] I am hopeful that improved awareness of mould and damp buildings and those practical tasks such as performance of comprehensive assessments, adherence to consensus and citation Standards and Guidelines and attention to scientific validity will in turn result in positive public health outcomes.

Conclusion

This paper has reviewed the climate in Australia with regard to water damage assessment and remediation as this relates to the Victorian AustLII civil claims list between 1998-2018. There is a dominance of residential tenancy claims followed by general building in a 50:30% ratio. The volume of cases has steadily increased since 2012. An introduction to basic fungal biology is described along with a review of the key symptoms commonly described by persons exposed to water damaged building environments. Comment is also made regarding the mental health impacts of living in a mould and damp affected house and the emerging bacterial and parasite pathogen threats apart from mould that are appearing in the literature. Those Standards and Guidelines used in Australia and elsewhere for assessment and remediation of mould are reviewed along with comment on how these should be extended or collected together to address existing failures in sampling, remediation or post remediation verification. These are matters of environmental public health that can influence social and economic policy at the population health level.

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Conflict of interest

Author declares that there is no conflict of interest.

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