MYCOTOXINS IN THE BUILT ENVIRONMENT:
ARE THEY A POTENTIAL HAZARD?

by 21st Global Pty Ltd
Research Department

21st Global Pty Ltd is a privately-owned and -funded company. With a long association with both the remediation and Indoor Air Quality industries, we set out to find the truth about the "much talked about" mycotoxins.

HISTORY

Mycotoxins, by definition, are any toxic substances produced by a fungus. Mycotoxins have a very long history, having first been documented in 600BC. They have been responsible for many deaths through ergotism, or Saint Anthony's Fire. It was documented that the ingestion of infected rye grains by a fungus called claviceps caused the condition. Ergotism symptoms can include nausea, vomiting, skin irritation, disruption to the heartbeat (either slowing it, or speeding it up), numbness, muscle weakness, and pain. It can progress to such conditions as gangrene, psychological effects, convulsions, spasms, impairment of sight, and death. Since 1952, the term *mycotoxicosis* has been used to describe diseases in animals and humans as a result of consumption of fungal contaminated foods, skin contact with fungal infested substrates, and inhalation of mycotoxins. Additional health impacts have been identified in recent times and include, but are not limited to, kidney and liver damage (including cancer).

OVERVIEW

Two years ago, our research team earnestly began investigating mycotoxins within the built environment, as opposed to the agricultural sector. Most of the previous research on this subject within the built environment was lacking in its findings, which could lead the reader to the conclusion that mycotoxins were not really a problem within the built environment. One of the resounding outcomes was the need for more research. We set out to find out whether or not they could be found and, if so, in what numbers.

CHALLENGES

The first challenge that presented itself was that much of the existing sampling was being conducted on fungal colonies themselves. We know that many fungal varieties are capable of producing one or more mycotoxins. Even though they are capable of producing mycotoxins, they do not always do so – making sampling of the fungal colony a not-so-reliable indicator of the mycotoxins that would potentially be inhaled by the occupants of built environments.

This led us to establish the need to source equipment that would be able to collect samples from within the breathing zone of humans, with a flow rate to mimic the quantity of air that would normally be inhaled by humans. In addition, we needed to capture particles much finer than dust and spores, which meant sourcing a capture medium to suit. We have now achieved this.

The next challenge was to find a group of representative water damage and fungal-affected homes that would have experienced similar environmental conditions (such as rainfall, temperature, and humidity), so as to maintain consistency of outside factors. To achieve this, we partnered with a remediation company to sample a group of homes located geographically in a relatively small area, and sampled over a 2-day period.

Our final challenge was to source a laboratory that was capable of the sample analysis. During our research phase, we discovered that, unquestionably, the agricultural sector has led mycotoxin analysis and quantification. Mycotoxins are controlled within our crop and food production industries, with established global limits which are reviewed regularly. We have now established a relationship with an appropriate laboratory.

THE FINDINGS ARE IN

As previously mentioned, we collected 1-hour samples from 4 homes, over a 2-day period, and in a geographically-comparable area. The samples were collected from within the breathing zone. All homes had experienced a water damage event and had visible fungal growth. Samples were analysed for the presence of aflatoxins and ochratoxin A (OTA). All properties showed the presence of OTA; however, only one home showed the presence of aflatoxins. The home in which the aflatoxins were detected was the only home where the water damage was identified as historical, with the damage occurring approximately 3 years prior where ground water had intruded into the space. This home had been remediated by an unknown company after the original water damage incident; yet, fungal growth had returned.

***Note**: We have conducted many random samples since these original 4; however, we have used only the examples above due to their comparable ambient weather conditions and locations. Greater than 90% of the additional properties showed background levels of OTA – not all of which would be considered hazardous.*

HOW DO WE INTERPRET THE RESULTS?

For the purposes of this section of our presentation, we will focus on ochratoxin A (OTA). The range of OTA among our 4 samples mentioned above was 1.4ppb (parts per billion) to 2.6ppb. The acceptable level of OTA within agricultural commodities is 2ppb. OTA has been identified in humans to affect the kidneys. In addition, whilst studies in humans are very rare, in animal studies there is also relationship between OTA and foetal development, as well as damage to the immune system. *(WHO fact sheet on Mycotoxins)*

It is noteworthy that the FDA "Chemical Hazards" fact sheet states, of OTA, "Although the FDA has placed limitations on the quantity allowed in animal food, there are still complications because of its heat tolerance. Most fungi would be destroyed when properly cooked, avoiding the adverse effects in animals and humans upon consumption; but Ochratoxin A is resistant to these techniques."

There are questions that we must ask ourselves. If it is acceptable to have a level of 2ppb in, say, spices (which are then diluted out in cooking because they are an additive) and we take the lowest number detected in our samples above of the air that we are inhaling (1.4ppb) and multiply it by the number of hours we spend within that environment, say 8 hours, we would have a total exposure of 11.2ppb. Why do we not have PELs (permissible exposure limits) in place?

In the context of the built environment, OTA is a mycotoxin produced by some varieties of penicillium and aspergillus, although these mold species can also produce several other varieties of mycotoxins as well. Mycotoxins are chemical in nature and, as such, once produced, they can survive independently of active fungal growth.

You cannot be sure that active fungal growth is producing mycotoxins without testing for their presence in the air that the occupants are breathing. You also cannot be sure about whether mycotoxins are still present where fungal growth has been removed, without testing the air.

OBSERVATIONS

We have made several observations during the course of our research. Before and after mycotoxin sampling showed that there could be an increase in mycotoxins present in the **after** samples. We repeated different methods of remediation and continued to sample before and after. We identified that all of the current remediation methods were incorrect for the removal of mycotoxins. There are three primary reasons that this occurs. The first is that activity within the space will aerosolize particulates that may have mycotoxins attached. The second is that mycotoxins are smaller than the particulate size that HEPA filtration captures. The third reason is that mycotoxins are chemical in nature, with remediation methods treating what is essentially fungal in nature.

We determined that there was a need to create protocols for remediation that would eliminate both the mycotoxins and the fungal growth. This has now been achieved by both research and practical demonstration, with repeatability, in the field in conjunction with our remediation partner. Remediation protocols will be the subject of a separate presentation.

CONCLUSIONS

We have proven that there is indeed the need for concern in relation to mycotoxins in both fungal-affected built environments and those that may have experienced a historical water damage event.

The sample collection method developed must be used to maintain global consistency in sample collection and analysis. Without consistency in protocols, you cannot achieve a baseline control point. It is also vital that only a limited number of laboratories be authorised so as to also maintain consistency of analysis. It is unfortunate that the +/- factors in current processing of other types of samples are too great between different laboratories on samples known to be the same at collection.

Mycotoxins are chemical in nature and toxic by definition. Global occupational health authorities, including OSHA, have protocols for chemical hazards and toxic substances. As such, hazard identification and critical control point protocols must be adhered to. You cannot exclude the presence of mycotoxins without sampling for the mycotoxins. We have established that you must sample the air – not the fungal colony – using the protocol developed. You cannot know what, if any, mycotoxins are being produced by knowing the species of fungi.

It is well recognised that mycotoxicosis can occur through exposure via ingestion of mycotoxins. Knowing the exposure within the built environment is not only vital information to the occupants of a home or workspace but also essential for clearance following remediation projects as part of a duty of care by the remediation company.

In mid 2020, we added additional mycotoxins to the analysis suite. **This sampling and analysis is known as M-MTX™.** All samples will be analysed for:

Aflatoxins B1, B2, G1, G2
Generated by several species of *Aspergillus* including, but not limited, to *Aspergillus flavus* and *Aspergillus paraciticus.*
Health concerns: include carcinogenic and mutinagenic (mutagenic), particularly affecting the liver, immune toxicity, neurotoxicity.
Hazard Classification: 1B carcinogenic

Ochratoxin A
Generated by several species of *Aspergillus* and *Penicillium* including, but not limited to, *Aspergillus niger, Aspergillus ochraceus, Penicillium verrucosum.*
Health concerns: include immunosuppression, lung disease, nephropathology.
Hazard Classification: 2 (carcinogenic, toxic to reproduction)

Fumonisin
Mostly associated with several of the *Fusarium* fungal varieties.
Whilst currently inconclusive, limited studies in humans have flagged concerns of a possible contribution to cancer and birth defects.
Hazard Classification: B1 (possibly carcinogenic)

Vomitoxin (DON)
Is a type B trichothecene. It is produced by some *Fusarium* fungal varieties, including *Fusarium graminearum.*
Health concerns: vomiting, diarrhea, headaches, dizziness, fever, immunological issues.

Zearalenone
Generated by several of the *Fusarium* fungal varieties.
Health concerns: generally has low toxicity. In high concentrations, or prolonged exposure at low levels, there have been reports of reproductive disorders and estrogenic effects.

T2 & HT2
Part of the trichothecene family and mainly generated by several of the *Fusarium* fungal varieties.
Health concerns: immunodepressants, mutagenic, gastrointestinal haemorrhaging, neurotoxic.
Classified as hazardous.

Please note: *The descriptions provided above are not meant to be a complete list of all fungi varieties and associated mycotoxins. As we have previously established, many fungi produce more than one mycotoxin, or may not be producing at all, highlighting the necessity to sample for mycotoxins. Health concerns may not be a complete list and may also not be experienced by occupants. M-MTX™ sampling and analysis is designed to identify the mycotoxins, if present, and aid the occupants in both environmental and health investigations.*

Mycotoxins in the built environment, are they a potential hazard?
YES, all toxic substances are hazardous.