MMAD aboμt moμld spores

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I HAVE RECEIVED a lot of off-list questions and comments regarding my last post discussing units of expression ("Express Yourself!") Some of the answers are too long to post in a reply, and one individual, Mr. JS, posed several questions, each worthy of a separate post. So here we go:

In my post "Express Yourself!" I noted that CFUs/m3 was not a legitimate expression of concentration. Mr. JS writes and asks:

> *A couple of quick questions. What is the proper unit of measure for concentrations of mold spores?*

Answer: There are several appropriate units that can be used depending on one's *a priori* data quality objectives (DQOs). A quantifiable unit of expression, albeit one that is almost always used incorrectly, is "spores per cubic meter of air" (spore/m3).

The reason why this unit is almost always used incorrectly lies with the sample collection technique and the poor training of the of the individual collecting the sample. Whereas a "spore/m3" is quantifiable, a laboratory result of "spore/m3" for a sample collected by a common spore trap method (usually a product similar to a slit impactor) is not a quantifiable concentration. I will use the Zefon Air-O-Cell (TM) product as an example since I happen to like the Zefon product, and I have used it hundreds upon hundreds of times.

I'm going to keep this simple, so all you Stokes Law fanatics, and Ludwig guys, just keep your hair on because I'm not going there, it's already complicated enough!

Many spore traps exhibit a "cut-size" commonly called the "d50" and expressed as a mass median aerodynamic diameter (MMAD) in micrometers (μm). If a device has a "d50" of 2.5 μm, a particle of unit density with an MMAD of 2.5 μm, has a 50% probability of being trapped and retained, when the device is operated at a specified air flow, specific temperature, and specific altitude. If the device has a d25 of 2.5 μm, then the same particle has a 25% chance of being trapped and retained, and so forth. If a device has a "d50" of 1.0 μm, a particle of unit density with an MMAD of 1.0 μm, has a 50% probability of being trapped and retained, when the device is operated at a specified air flow, specific temperature, and specific altitude, and so forth.

Now, to make matters easy, consider that you are in a magical atmosphere containing an homogeneous distribution of monodispersed mould spores of unit density whose MMAD is exactly 2.5 and there is exactly 1,000 spore/m3 and you have used a spore trap with a d50 as described above to collect ten air samples at the specified sampling parameters of temperature, altitude, flow rate etc.

You submit all ten samples to an imaginary laboratory that can magically enumerate the spore counts without error and with 100% precision. The laboratory will kick back ten results that tell you the atmosphere contains approximately 500 spores/m3. Well, you knew that didn't you? After all, you knew the atmosphere actually contains 1,000 spores/m3 and you knew the MMAD of your unit density spores was 2.5 µm and you knew your spore trap had a d50 of 2.5 µm therefore, you should have known that your sample result would be about 500 spores/m3.

Now, unfortunately, there is a nonlinear relationship between capture characteristics and particle size. As such, a spore whose MMAD is 3.0 µm may have a capture probability of 99%; a spores with an MMAD of 2.2µm may have a capture probability of 35% and a spore of MMAD 1.9 µm may have a capture probability of 5%. One really doesn't know the capture characteristic of their mixture, once one deviates from the ideal parameters. Therefore, what will the laboratory report be if the atmosphere of 1,000 spores/m3 has the following distribution profile:

7% of the spores have a MMAD of 0.9 µm

23% of the spores have a MMAD of 1.5 µm

4% of the spores have a MMAD of 2 µm

54% of the spores have a MMAD of 2.5 µm

12% of the spores have a MMAD of 3.7 µm

Well – the actual laboratory report will be anyone's guess, but it will probably be in the neighborhood of about 325 spores/m3. If the investigator is untrained (i.e. 99.999999% of "Certified Mould Inspectors" and "Certified Microbial Consultants," etc), with a straight face, they are going to erroneously report to their client the atmosphere contains 325 spores/m3 (or whatever the laboratory report says).

So, what is the d50 for the (wonderful) Zefon product? Good question… if you are an investigator collecting a sample at 70F in a residence near the Dead Sea in Israel (altitude of 1,350 feet below sea level) at 15 lpm it is about 1.7 µm (ish) and if you are with me collecting a sample in a residence in Alma Colorado (altitude 10,678 feet above sea level), also at 70F, it will be about 2.6 µm (ish).

Well, what if you are collecting all your samples in Boston, Massachusetts? Well, that makes it easier, the d50 for that sample you collected inside that warm office is about 2.3

µm and (ignoring "bounce") the same location sample you took outside (for "comparison"… HA!), where the air temp is 5F, the d50 is about 2.1 µm.

Now, consider this:

Cladosporium cladosporioides has a MMAD of about 2.1 µm

Aspergillus versicolor has a MMAD of about 2.4 µm

Penicillium brevicompactum has a MMAD of about 2.2 µm

Is that significant? I would say that is very significant. Also, what happens if the flow rate is off? As the flow rate increases, the d50 decreases. Is that important?

The next time you look at a spore-trap sample result, ignore the fact that the spatial distribution makes the "result" virtually useless anyway, and ignore the fact that the temporal distribution makes the "result" virtually useless anyway, and ignore the fact that the inter and intra-laboratory variability makes the "result" useless anyway… ignore all that and just ask yourself this:

What does a laboratory report of, say 550 spores/m3 (or 3,500 spores/m3) tell you anyway?

After all, you now have a laboratory report, from a valid lab, using a very good sampling device but still haven't got a clue what the spore count is in the study area.

Food for thought.

With thanks to Mr. JS for being such a trouble maker.