The recent outbreak of Legionnaires' Disease in New York highlights the vulnerability of cooling systems to pathogens. We are Christine McInnis and Ian Tomlinson. Ask Us Anything!

Christine McInnis[1]

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Abstract

Hi Reddit! Like many of you, we've been watching the events unfold in New York as the city works to combat the outbreak of Legionnaires Disease. This case provides a vivid example of how even in a mature, developed country, we still have a lot we can do to protect human health, and highlights the importance of water chemistry in our everyday lives. We are researching sustainable ways to control microbial growth in water systems –which provide an ideal environment for various pathogenic and resistant bacteria that lead to health and safety issues. Christine McInnis: I am a Ph.D. organic chemist with a background in biology and am responsible for developing breakthrough solutions for microbial control in water applications globally. I am passionate about responsible use of water, reduction of energy used in water-related processes, and preventing diseases spread through water systems. I have authored more than 20 papers and hold a patent. I also hold leadership positions within the Association of Water Technologies, Cooling Tower Institute and the American Chemical Society. Ian Tomlinson: I am a Ph.D. organic chemist and Research Fellow at Dow. During the last 3 decades my research has covered a wide variety of fields from contract manufacturing and biotechnology to pharmaceuticals and drug research, to water purification and microbial control. Solving complex issues such as the incidence of Legionnaires disease requires understanding the root cause. Using this knowledge to help develop new solutions to address important human problems is what makes the life of a scientist exciting. I hold 30 US patents and have a dozen more pending; I have authored 8 papers in peer reviewed journals and I am a member of the Royal Society of Chemistry and the American Chemistry Society. We'll be back at 1 pm ET (5 pm UTC, 10 am PT) So, please, Ask Us Anything! There has been a lot of great discussion on this topic. Thank you for your questions and comments! We will try to answer a few more questions as time allows in the next few days. Feel free to find us on LinkedIn if you want to continue the discussion.

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ABSTRACT

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CORRESPONDENCE:

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I'm a commercial HVAC technician (I also help mod /r/HVAC). Is there anything we heating & cooling guys should be made immediately aware of that may not be obvious or common sense? Or perhaps something to be on the lookout for?

relic2279
Hi relic 2279, this is Christie. Folks like you, who work in a fairly small region of the country and have experience are generally well equipped to handle many of the challenges in water treatment. Since I don't know your background, it is always good to remember the water treatment triangle--that scale, corrosion, and microbial growth are integrally related and you should have an active control program to address each aspect. Common sense is often your best tool. If you are interested in a specific list of things to consider, I recommend that you look at the new ASHRAE 188-2015 guideline.

Science AMA Series: The recent outbreak of Legionnaires' Disease in New York highlights the vulnerability of cooling systems to pathogens. At Dow Microbial Control, we study ways to control this kind o, *The Winnower* 2:e144041.18014 , 2015 , DOI: 10.15200/winn.144041.18014

I used to be a cooling tower technician and also worked with chemical and non chemical water treatment systems, I only encountered 1 tower with legionaire bacteria that I knew about out of the thousands or so that I serviced. Where does the bacteria come from and are more regions susceptible than others for growing it? Which treatment systems work best for controlling growth?

melokay
Hi melokay, this is Christie. Great question! Many times people don't know if they have Legionella in their cooling water systems because they aren't testing for it. Do you test all your towers for Legionella? It is unknown how many Legionella bacteria are required to make someone sick, so it is very likely that a tower will have Legionella but not make anyone sick.

Some regions definitely seem to be more susceptible than others. For example, Pennsylvania and Wisconsin seem to have somewhat higher incidences than other regions of the US. As noted below, Legionella is ubiquitous and there could be an outbreak in any region.

There has been a lot of discussion around the best treatment programs. In general preventing biofilm will reduce the ability of Legionella to reproduce in the system.

I read about a paint that dries with nano-sized stippling (points) that pierces the membrane of a microbe landing on it, causing the microbe's death.

Have you worked with it? Is it practical to use inside cooling systems?

DJLinFL
Hi this is Ian: We have not worked with this particular technology but also saw the same article. In our experience, surface antimicrobials are effective in clean environments, however, if the environment has the tendency to foul with dirt or scale etc. which is very possible in a cooling tower, then the bacteria are not able to access the surface and hence the efficacy goes down.

Hello Dr.'s McInnis and Tomlinson! I'm interested in joining the R&D side of pharmaceuticals and therapeutics for microbes but not sure whether to go for industry, academia or government. My current long-term goal would be to become a PI.

With regards to your research at Dow Microbial Control, how would you compare your overall research process with a university academic approach of the same process? Are there greater/fewer funding constraints? Can you take the research in any direction you'd like as the PI?

Also, what would you say the overall research atmosphere is like in private industry? How is it similar or different to academia or government?

Thanks for doing the AMA!

ZergAreGMO
Christie here. This is a great question. I work with a lot of younger chemists through the American Chemical Society's Younger Chemist Committee with the same question. There are a lot of resources available to help you make your decision.

In my personal experience, there is getting to be less and less of a difference between industry and academia as many partnerships between industry and universities are forming. I feel that I have a lot of flexibility in my research areas at Dow, as long as they are relevant to microbial control in industrial water systems. Some of my friends who are new professors find that they are also somewhat limited in their research topics based on what they can find funding for. I really appreciate that I don't have to write grants and can work with really experienced coworkers. While there is certainly some budget

constraints, I feel like I can get the resources I need for projects that are important.

Government is an interesting option too. I have a few friends that work in government labs. It seems to be very similar to my experiences in industry, but they have to worry about the political atmosphere a lot more than I have to.

Hello Dr.'s McInnis and Tomlinson! I'm interested in joining the R&D side of pharmaceuticals and therapeutics for microbes but not sure whether to go for industry, academia or government. My current long-term goal would be to become a PI.

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ZergAreGMO
Ian here: I agree this is a great question. Working in industry is very rewarding because we work on problems that are important to our customers and consumers and when we are successful lead to new commercial products.

When I compare our research activities to academia I typically think that we frequently work on more targeted opportunities. We find the research in Universities to be essential to help us understand the fundamentals and the range of approaches that might be used to solve the problem. We frequently fund research programs at universities to help accelerate our programs and to perform developments which are much longer to fruition. We will then use all the information available to us to try to drive to a viable solution as quickly as possible.

As Christie said below, in private industry we need to seek support for a project which involves both marketing and research objectives, once we receive support then provided the project hits the milestones and continues to move towards a commercial solution the funding will grow as required for success. In academia, a Professor spends a lot of time applying for grants to fund their students.

How effective is ultraviolet light as an antibacterial strategy, and is it applicable to cooling systems?

redcolumbine
Ultraviolet light can be used as a useful antimicrobial, however, it is best used in clean systems because sediment or organic matter in the water can also be uv active. One of the areas that I am most familiar with the use of uv is in purified water systems, where the water has been purified to remove salts and other contaminants and then the uv source is used to kill very small numbers of bacteria that might have leaked through the initial treatment methods.

I work as a mechanical engineer working on building systems. The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has a couple documents (Guidline 12, 2000 and Standard 188, 2015) that seem comprehensive enough to combat Legionellosis in both cooling and potable water systems from both a design and operations perspective.

How are these ASHRAE practices insufficient to address Legionellosis in building systems today? It seems to me that big deal in NYC was lack of maintenance and user error (criminal or

otherwise). If people are going to ignore best practices, it seems that they're going to ignore the fine science performed at DOW.

GreatGreenGeek
Hi, Christie here. I am so glad that you are familiar with the new ASHRAE guidelines. They are a great start to helping water treatment professionals think about some of the risks associated with Legionella and control points. However, there is very little actual guidance in ASHRAE 188-2015. I expect that other associations will be coming out with additional guidelines that will offer more specific information in the near future--at least for the cooling water side.

Your question about having best practices and people following those best practices being two different things is spot on. I think the recent outbreak in NYC will help make people more aware of best practices. I also work with several industry associations that work hard to educate water treatment professionals and building owners. Hopefully, that will help bridge the gap in the future.

Is it possible for our individual AC units (like in bedroom window) to create legionnaires?

HandfullofMouse
Hi, this is Christie. It would be very difficult for you to get Legionnaires' Disease from your bedroom window AC unit. One of the reasons open cooling towers can be a source of Legionnaire's Disease is that the Legionella bacteria can get caught in the mist that is released and inhaled by people. That is very unlikely to happen in your home because your home system is not an open system--you don't have to refill it with water.

Is it possible for our individual AC units (like in bedroom window) to create legionnaires?

HandfullofMouse
Hi this is Ian: No it is extremely unlikely that individual AC units are going to be a good area for legionella to grow and create any risk of legionnaires disease.

Can you talk some about what biofilms are, and the difficulties they present in water systems?

kerovon
Hi this is Ian: Good question and I will try to be brief because this is a topic we spend a lot of time discussing. Biofilms are formed by bacteria as a way to create a habitat for survival. When a bacteria contacts a surface which has a conditioning layer "thick as food" they will settle and produce an excess of a polymer which we call EPS and which acts as a great adhesive. The bacteria will continue to produce this EPS, multiply and even send out other signal molecules that will attract other bacteria. Rapidly a biofilm will develop which will contain a variety of bacterial species and will result in a stable ecosystem. The bacteria will express enzymes which will break down proteins and other organics which are filtered out of the water to provide food. Another benefit of the biofilm for the bacteria is that it will help protect the bacteria from antibiotics or biocides that are fed into the system to try to kill them. This makes it much more difficult to kill and remove the bacteria from the system. Common examples of biofilm are slime that forms when water is continuously dripping or dental plaque.

Biofilm creates difficulties in water systems because it protects the bacteria inside the biofilm, they can also easily concentrate minerals from the water resulting in scaling which can eventually block pipes forcing expensive replacement.

Can you talk some about what biofilms are, and the difficulties they present in water systems?

kerovon
Christie here. In addition to some of the problems with potentially blocking pipes and facilitating scale formation, biofilms can create Microbially Influenced Corrosion (MIC). This leads to deep pitting in

metals which can cause leaks.

However, probably the single most important problem that biofilms cause in cooling water systems is a lack of efficiency. We all want to use as little energy as possible, so having biofilm in the system is a major problem. They can grown on heat exchangers, insulating them and reducing efficiency. Biofilm can form on spray nozzles, affecting the spray pattern and reducing efficiency. Biofilm can form on fill (which helps the water splash as much as possible and get the greatest cooling possible), causing something called sheeting and reducing efficiency.

Hi! I took a disease class in college taught by Dr. McDade, who I believe identified the cause of Legionnaires after the Philadelphia outbreak in the 70s.

I was just wondering why Legionnaires outbreaks always seem to be connected with Air Conditioning systems rather than, like, water fountains or those produce misters at the grocery store. Is there something about HVAC systems that make them more susceptible to bacterial growth? Or are they just better at infecting people?

eLexlibris
Hi this is Ian: Legionnaires outbreaks are not only connected to air conditioning systems although these are what we hear about the most because they usually involve many people coming down with the disease and hence get more media attention. Legionella can occur anywhere in the environment and it is possible for transmission whenever there is the potential for aerosol or mist formation. Legionella is also mostly found in heated water systems because they thrive better at warmer temperatures.

Provided fountains and other spray systems are well maintained and the water treated with an antimicrobial such as chlorine or ozone, then the risks of exposure to legionella is very low.

Do homeowners need to worry about Legionella? If yes then what are some preventable measures that can be taken. Thank you

subzilovesme
Hi this is Christie here. I see that there is quite a lot of interest on this particular point. I think the reply I gave for another thread can address your question. Check it out here.
https://www.reddit.com/r/science/comments/3i6xvm/science_ama_series_the_recent_outbreak_of/cue44i1

Hi there! What is it about the cooling/water systems that makes them idea for bacterial growth? And what'd be your optimal method (that may or may not exist yet) for getting rid of them? Questions for both of you! And thanks in advance!!

pauliopop
Hi this is Ian: Anywhere where there is water and nutrients, bacteria will flourish. A cooling tower fits this criterion, there is copious amounts of warm water and since they are not closed systems there is the potential for nutrients to enter the system. The bacteria will also readily form biofilms which provide protection for the bacteria and also allows for the nutrients to be filtered out of the water making them more available to the bacteria.

The best method to prevent bacteria building up in the cooling tower is to keep the tower clean and to treat with an adequate level of biocides. There are a lot of very good service companies who manage cooling towers for their customers, they use a variety of additives such as antiscalants and biocides to keep the cooling towers clean and maintain the level of bacteria as low as possible.

Ian: i am a recent graduate with a bachelors in biochemical engineering and I am looking to start my career in biotechnology or pharmaceuticals. Your career path seems one that i am

very interested in myself. Do you have any advice on going back to school for a masters/phd or advice on breaking into the biotechnology field? Im having a bit of trouble starting out.

thebody10
Hi this is Ian: If you are interested in a research career I would personally recommend that you get a Ph.D. in an area that you find really interesting and exciting. There are a lot of good positions that you can get with a BS or MS but if you want to lead major research projects then the Ph.D. is preferred.

Is home use air conditioning unit just as vulnerable? Since similar conditions can be found in any AC unit. If so I guess it could be less reported because it's not cooling a mall filled with people.

Singleservingfriendx
Hi Singleservingfriendx. Christie here. This is a pretty popular question. I think I was able to address that here:
https://www.reddit.com/r/science/comments/3i6xvm/science_ama_series_the_recent_outbreak_of/cue44i1

Hope that helps.

How much commercial experience is there with the isothiazolone test kit in the field for cooling? Is there an accurate way to measure lower levels for discharge purposes?

formulate
This is Christie. Many people have used the isothiazolone test kit for verifying that they have dosed their cooling water system correctly. I am looking forward to a paper at the upcoming Association of Water Technologies (AWT) conference in September on this topic. The lower limit for the test kit is 0.75 ppm active. This level is probably better to verify dosing rather than for discharge purposes.

I work in cooling towers pretty regularly, we have the engineer get their treatment company to shock the tower to loosen the scale before we do repairs or cleaning, does a chemical shock do anything for legionnaires?

f_bastiat
This is Christie. Nice question. We do have something called a "shock" or "slug" dose for controlling microbes in the cooling tower. This is basically a fairly high dose of a biocide. It is common to use a very high dose of a biocide to help remediate cooling towers when Legionella is discovered in the tower.

PLEASE get the word out about Legionnaire's Disease.

Cooling towers are NOT the only source of these nasty bugs.
My wife contracted Legionnaire's Disease from a hot tub in a hotel.
She was in an induced coma and on a vent for eight days and in the hospital for two months.

OK, I know the rules. Here is the question:
How about genetically modifying the legionella bug into something harmless to humans?

SecondhandUsername
Christie here. I am so sorry to hear about your wife!! Hot tubs are definitely a major source of Legionella. Your shower head can be too.

Genetically modifying Legionella is an interesting concept. It might be a little hard to do that with wild strains. Do you have ideas on how to practically do that?

I am currently an hvac technician, i was wondering are you looking to change the disease itself by introducing something to it or changeing something about the units to make it less likely to harbor the disease?

HotShItGG
Hi, this is Christie. This is a great question that comes up a lot. It is very difficult to change something with the Legionella bacteria itself because the Legionella grow in the wild. No one is purposely adding Legionella to cooling towers. This makes changing the biology of Legionella really hard. It is a much more practical approach to make cooling towers less likely to grow Legionella through either chemical or mechanical methods.

Firstly, nice job Dow for letting your scientists speak.

Secondly, the ?s:

Are you discussing known products or future products?

I've read that copper and blue led light are good at antibiotic applications, but I think they both have to do with bacterial metabolism, which suggests to me that neither can be antiviral - how widely can copper and blue led light be used?

What's the difference between attacking air handlers and say reservoir ponds or such? I think my question is a bit beyond your expertise, but maybe you'd like to comment on how you see the US prepared for these NBC (minus the N) avenues of attack?

LawHelmet
Hi LawHelmet, this is Christie. It is awesome that we can participate in something like this! :)

Copper is a great biocide. Copper Sulfate is even an EPA registered biocide. Unfortunately, there are very limited applications for a copper based biocide in cooling water applications. This is mostly due to discharge regulations. Copper is such a good biocide that we need to be really careful about how much of it makes its way into our lakes and streams. Unlike organic biocides or oxidizing biocides like bleach, copper is not going to break down in the environment over time.

I am not familiar with blue LED light, but UV light is not often used in cooling water systems because the turbidity of the water is generally too high to make them effective.

Your last question is outside of my area of expertise. If you mean reservoir ponds like we can get drinking water from, the main difference is that you don't get aersolization of water droplets that can be inhaled leading to Legionnaires' Disease.