

Flagstaff City Manager's Compounds of Emerging Concern Advisory Panel – Interim Report

The City Manager's Advisory Panel on Compounds of Emerging Concern (CEC) met several times in the first half of 2013. The result was some helpful advice regarding the management of CECs in the City's drinking, wastewater and reclaimed water.

Background

As a precursor to those results, it should be noted that solving a scientific problem in a political environment is a very challenging merger of practices and perspectives. To start, the science associated with water, wastewater and reclaimed water utilities is extremely detailed and complex. No single study, investigation or finding can provide enough data to make an informed business decision. Politics and media coverage often look for the single discovery as evidence of a conclusion or the sole motivation for action. Science is based upon multiple replicated, controlled studies. And even after that string of investigations and results, the decisions implemented must be regularly tested, reviewed and analyzed. With that as a background, the panel of distinguished experts felt comfortable providing the City Manager the following advice.

As a framework, the Panel divided CECs into three categories: pharmaceuticals, endocrine disrupters, and antibiotic resistance genes (ARG). Upon further discussion, the Panel also categorized CECs into chemical and microbial – pharmaceuticals and endocrine disrupters being the former and antibiotic resistant genes and any associated bacteria (ARB) being the latter.

Further, the universe of research is enormous and the City Manager had to prioritize what was most critical to addressing the concerns raised by the utility operation. To that extent, he asked the Panel to focus on "human health effects" as opposed to animal, aquatic or environmental impacts. All are important and not necessarily mutually exclusive, but this work required a starting point.

Findings/Advice

Drinking Water

From a chemical standpoint, we learned that the U.S. EPA, with advice from various scientific panels and previous analytical studies, has developed a list of CECs (both chemical and microbial) that may warrant further consideration for possible regulation in US water. This list of contaminants is referred to as the Contaminant Candidate List (CCL) and considers only

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human impacts. Antibiotic resistant genes and antibiotic resistant microbes have not been listed on the CCL as of yet. Inclusion on the CCL generally requires a demonstration of potential occurrence in drinking water and potential for human health effects. On the third iteration of the CCL (CCL3), many pharmaceuticals, hormones, and endocrine disruptors were evaluated, yet only nine hormones and one antibiotic made the list. Further, there has been no documented study from around the world of a human health effect linked to any of these 10 chemicals through exposure from drinking water. Lastly, the U.S. EPA has an unregulated contaminant monitoring rule (UCMR) which dictates which unregulated contaminants US utilities must monitor on a periodic basis. Because of these, the panel advised:

Monitoring of any CECs on the CCL3, beyond the UCMR, in Flagstaff drinking water at this time is unnecessary.

However, City of Flagstaff Utilities Division staff may want to consider evaluating which contaminants within the CCL that are likely being utilized or prescribed for use in the Flagstaff community as background information in preparation for the potential of future regulation.

Reclaimed Water

Additionally, we learned that there are three CCL3 chemicals that reveal themselves in reclaimed water that deserve noting—17-beta estradiol (estradiol), triclosan, and NDMA. Specifically, caffeine and triclosan were detected in a 2010 sample of Flagstaff reclaimed water. We learned that caffeine and estradiol are both removed when chlorine is added. The Flagstaff treatment process adds chlorine. Therefore, the panel advised:

Monitoring of caffeine and 17-beta estradiol in reclaimed water is appropriate, but treatment beyond adding free chlorine is not warranted at this time.

An important caveat to this recommendation is that the reference dose for caffeine and 17-beta estradiol established in the CCL3 list are for drinking water. No limit has been set for reclaimed water used for irrigation or snowmaking. Moreover, the health effect findings for these chemicals were exclusive to drinking water. However, in the absence of this information, CCL3 limits provide a context to any quantities detected in City reclaimed water.

The amounts of triclosan detected in reclaimed water are significantly less than the amounts found in shampoo and antimicrobial soaps. In other words, Flagstaff residents are exposed to far more triclosan in much higher quantities in their personal environment (unless residents are using all natural soap products) than they would encounter from coming into contact with reclaimed water. Therefore, the panel advised that:

Monitoring for triclosan in reclaimed water is appropriate, but no treatment is advised.

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This left NDMA.

According to the U.S. EPA Technical Fact Sheet, NDMA (N-Nitroso-dimethylamine) is an unintended byproduct of chlorination of wastewater, particularly at wastewater treatment plants that use chloramines for disinfection. It is important to note that NDMA does not fall within the Panel's definition of CECs that includes the following three categories: pharmaceuticals, endocrine disrupters, or antibiotic resistance genes. The City of Flagstaff's Wildcat Wastewater Treatment Plant disinfects with free chlorine, while the City's Rio de Flag Reclamation Plant uses ultraviolet light. Both plants then use free chlorine in the reclaimed distribution system, which is different than chloramine, for disinfection. Further, the City has never tested its reclaimed water for this chemical. NDMA is highly biodegradable and has been shown over and over to degrade rapidly in soil during infiltration or turf application. It is also present in various food products and endogenously formed in the human body from nitrite. The U.S. EPA notes that "it is reasonably anticipated to be a human carcinogen." Although Flagstaff uses free chlorine to disinfect, the panel advised:

Commence testing of reclaimed water for NDMA; however, be cautious that NDMA is notorious for false positives at levels below approximately 5 ng/L. Bring results back to the panel for analysis and next steps.

Antibiotic Resistant Bacteria (ARB) and Antibiotic Resistant Genes (ARG)

Background: Antibiotic resistance in human pathogenic (i.e., disease causing) microbes is an ongoing public health threat, as the number of available antibiotics is limited and infections are becoming harder to treat. Antibiotic resistance in microbes, such as bacteria, occurs through a number of mechanisms, including natural mutations in certain genes or other portions microbial DNA, and the spread of antibiotic resistance genes (ARGs) between microbes. Resistance is "selected" by the inappropriate use of antibiotics in medicine, agriculture, and manufacturing of household products. Antibiotic resistance is both a man-made phenomenon and a naturally occurring microbial defense mechanism in the environment. Given the importance of antibiotics to human health, scientists are interested in understanding all possible ways by which antibiotic resistance might become prevalent among bacteria. Because they receive disposed and excreted antibiotics, water reclamation plants are one area of research interest among scientists.

Amy Pruden, Ph.D and Robin Silver M.D. conducted an independent study of Flagstaff reclaimed water from various sprinkler heads at selected parks. In these water samples, they detected markers of antibiotic resistant genes. The presence of these genetic markers indicates the presence of the DNA for different, potentially pathogenic, bacteria, but such a finding does not indicate if the DNA is from live or dead bacteria. Such DNA could be remnant material from bacteria that were treated, and killed, at the treatment plant, or the DNA maybe from live bacteria originating from pre- or post-treatment sources in the water system. However, Drs. Pruden and Silver found ARG's that were detected at the distribution point that were not

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detected at the treatment plant. This could imply that there is growth and/or recovery of bacteria in the delivery pipes. The Panel was asked to provide the City Manager with advice regarding how to use this information and how to proceed.

The panel expressed caution in any furtherance of this study as any findings had significant limitations on conclusions that could be drawn. Specific complicating factors to be considered included:

- Is Flagstaff exhibiting any public health issues associated with antibiotic resistant bacteria (ARB) from reclaimed water?
 - Dr. Ritland, the pathologist at Flagstaff Medical Center (FMC), indicated that antibiotic resistant bacteria are a challenge in every American hospital and FMC is no different. He further indicated that there is the sense that there are no abnormal increased levels of infections associated with antibiotic resistant bacteria at FMC.
 - David Engelthaler, Director of Programs and Operations at TGEN North and former Arizona State Epidemiologist, advocated that understanding the public health implications of these findings is an important first step. In other words, one must understand what ARB's are present in the local human population, and which species and strains of ARBs are causing what health problems, if any, before looking for the source. This is why scientists and health officials conduct epidemiological studies.
- Can one draw a nexus between ARB public health issues and reclaimed water as the source?
 - ARB's are all around us. They can be found on food at the supermarket. They can be found on playground equipment. They can be naturally occurring and found in soil. Therefore, any study identifying ARB's must understand the background they exist within. Connecting ARB infections to reclaimed water is challenging and less likely given the degree of exposure to reclaim water versus other exposures in the environment.
 - There are many ARBs and antibiotics to which they might be resistant. An epidemiology study is necessary to understand what particular ARB species and strains are present in Flagstaff residents, if these species and strains are found in Flagstaff reclaimed water, and if these species and strains are found locally in Flagstaff in other sources.
 - Reclaimed water has been in use in Flagstaff for over 20 years. Therefore, it is hard to control for reclaimed water as a variable in an epidemiological study ARB infection prevalence in Flagstaff.
- The cost of these sorts of studies is extremely expensive and likely beyond the capacity of the Flagstaff utility.

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Interim Recommendation – Priorities

Given these concerns, the Panel advised that a comprehensive and careful study would be required to understand the public health implications of detecting ARGs in reclaimed water. Because such a study would be beyond the financial resources of the City, part of the work would be developing the study, and then looking for an outside agency to fund it. The City could contribute its system as a sort of lab to any study. Therefore the panel recommended:

A subgroup of the CEC Panel outlined an epidemiological and microbial study to better understand the public health implications of ARGs in reclaimed water. The subgroup will help identify potential individuals or agencies to complete the study, potential funding sources, and potential uses or conclusions that the studies would provide to the business operation of reclaimed water in Flagstaff. The Panel will also review studies that have already been undertaken involving reclaimed water exposure.

A parallel study that might be of interest is the comparison of the effects of water treatment technologies (e.g., chlorination, UV, UV-peroxide, membranes) on ARBs and ARGs. A cautionary note here is that it would not be beneficial to recommend expensive changes to the treatment process that would not be guaranteed to have a benefit. However, if existing water treatments could be modified at little or no cost to remove ARBs and ARGs, this would be attractive. Research in this area could be pursued if outside funding sources are available, but could not be supported solely by the City.

Advisory Panel Interim Priority Recommendation: There are no data at present time to suggest that the continued use of reclaimed water provides undue risk to human health. In fact, other national panels, such as the National Research Council which reports to the U.S. Congress, have concluded the same. The panel recommends applying the best science available and that the above outlined studies be pursued, as future positive ARB results from randomly collected environmental samples, or evidence of ARB infections in persons who may have been exposed to reclaim water, are possible and even likely. However, such results will not provide scientifically or epidemiologically significant evidence to reverse such a recommendation.

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