COLORADO
Water Quality Control Division
Department of Public Health & Environment

MEMORANDUM

DATE: October 19, 2017

TO: Water Quality Control Division

FROM: Christopher A. Czaja, MD MPH, Antimicrobial Stewardship Medical Epidemiologist

RE: Antibiotic Resistance in Reclaimed Water

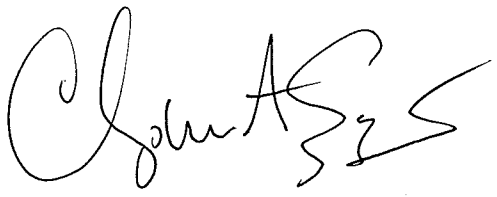
To Whom It May Concern:

Lillian Gonzales and Brandi Honeycutt asked me to offer my opinion regarding antibiotic resistant bacteria and the proposed new uses of reclaimed water. The proposed uses of reclaimed water include toilet and urinal flushing and irrigation of cannabis. While I am only somewhat familiar with reclaimed water, Lillian and Brandi provided a good explanation of the process of treatment, distribution, and the exposure pathways for the proposed uses. I also reviewed several peer-reviewed articles regarding antibiotic resistance and water, attended a presentation of a Water Research Foundation study, and informally spoke with an environmental antimicrobial resistance researcher at Colorado State University. In my review, I considered two questions.

The first question was whether reclaimed water amplifies antimicrobial resistance. Conceptually, reclaimed water could amplify antimicrobial resistance if horizontal transfer of resistance genes between bacteria occurred in reclaimed water storage and distribution systems, or, perhaps, if persistent bacteria were exposed to antibiotics in water. Existing studies demonstrate that antibiotic resistant genes are prevalent in, and occasionally enriched in, reclaimed water, spray irrigation sites that use reclaimed water, and soil in urban parks irrigated with reclaimed water (1-5). Investigators have also detected antibiotic resistant bacteria at the point of use of reclaimed water (2). In a controlled study set in Arizona, the prevalence of antibiotic resistant *Enterococcus* species was similar in sediment from water storage basins containing reclaimed water and ground water (6). This latter research implies that antimicrobial resistance found in reclaimed water represented environmental levels rather than amplification. Given there are multiple studies that vary in methods and that do not present definitive findings, the potential for reclaimed water to amplify antibiotic resistance remains unknown. My impression is that amplification of antimicrobial resistance, if it occurs, is more likely to occur upstream in the wastewater treatment plant, where concentrations of bacteria are higher (7-8).

The second question I considered was whether reclaimed water could cause antibiotic resistant infection in humans. Potential exposure pathways include the contamination of crops or other food products later ingested by humans or direct occupational exposure of workers handling reclaimed water, although the actual risk of infection is not clear (2, 9). Currently, there are no documented risk assessments that allow us to assess the risk of antibiotic resistant infection from the proposed uses of reclaimed water. Regardless, according to the potential exposure pathways, the risk for any bacterial infection, whether or not associated with antimicrobial resistance, should be of concern. Any regulation should consider current standards for human exposure to bacteria in water, and proposed uses of reclaimed water should meet these standards.

Antibiotic resistant bacteria present a clear public health threat. However, at this time, I find there is no definitive evidence to indicate that reclaimed water amplifies antimicrobial resistance or specifically poses a risk of antimicrobial resistant infections in humans when used as proposed. I did not complete a formal systematic review of all published research. In the absence of further data, I recommend that water safety measures established to prevent bacterial infection in humans be applied when considering the newly proposed uses of reclaimed water.



References

1. Pruden A, Pei R, Storteboom H, Carlson KH. Antibiotic resistance genes as emerging contaminants: studies in Norther Colorado. Environ Sci Technol 2006; 40: 7445-50.
2. Carey SA, Rosenberg Goldstein RE, Gibbs SG, Claye E, He X, Sapkota AR. Occurrence of vancomycin-resistant and -susceptible *Enterococcus* spp. In reclaimed water used for spray irrigation. Environmental Research 2016; 147: 350-55.
3. Fahrenfeld N, Ma Yanjun, O'Brien M, Pruden A. Reclaimed water as a reservoir of antibiotic resistance genes: distribution system and irrigation implications. Frontier Microbiol 2013; 4: 130.
4. Han XM, Hu HW, Shi XZ, et al. The impacts of reclaimed water irrigation on soil antibiotic resistome in urban parks of Victoria, Australia. Environ Pollut 2016; 211: 48-57.
5. Barker-Reid Fiona, Fox EM, Faggian R. Occurrence of antibiotic resistance genes in reclaimed water and river water in the Werribee Basin, Australia. J Water Health 2010; 8: 521-31.
6. McLain JE, Williams C. Sustainability of water reclamation: long-term recharge with reclaimed wastewater does not enhance antibiotic resistance in sediment bacteria. Sustainability 2014; 6: 1313-1327.
7. Rosenberg GE, Micallef SA, Gibbs SG. Mithicillin-resistant Staphylococcus aureus (MRSA) detected at four U.S. water treatment plants. Environ Health Perspect 2012; 120: 1551-8.
8. Rosenberg GE. Micallef, Gibbs SG, et al. Detection of vancomycin-resistant enterococci (VRE) at four U.S. wastewater treatment plants that provide effluent for reuse. Sci Total Environ 2014; 466-7: 404-11.
9. Rosenberg Goldstein RE, Micallef, SA, Gibbs SG, et al. Occupational exposure to Staphylococcus aureus and Enterococcus spp. among spray irrigation workers using reclaimed water. Int J Environ Res Public Health 2014; 11: 4340-55.