

STATE WATER RESOURCES CONTROL BOARD
Recycled Water Research Needs Workshop
October 29, 2014

Thematic Topic #1: Water Quality and Human Health

Definition of the Topic:

Wastewater has been introduced into drinking water supply sources for centuries. For instance, treated wastewater is discharged into river systems that contribute to downstream drinking water supplies all throughout the U.S. (this practice is referred to as *de facto* water reuse). Public health risks associated with drinking water supplies (including supplies affected by *de facto* water reuse) have been virtually eliminated due to advances in filtration and disinfection. As an example, indirect potable reuse (IPR) has been successfully practiced in California for more than 50 years, with studies verifying the safety of using recycled water to recharge groundwater supplies.

Direct potable reuse (DPR) could provide the State with greater flexibility in using recycled water by enhancing existing reuse strategies aimed at augmenting water supplies. Because DPR reduces the need for environmental buffers (i.e. storage prior to reuse), it may require additional treatment, operational control, and monitoring, including real-time (or near real-time) monitoring, to ensure the performance of the treatment systems and quality of the treated water. Two classes of constituents are of particular interest due to their potential effects on human health: pathogens and residual chemicals (such as disinfection byproducts and constituents of emerging concern [CECs]). Recent requirements established for IPR in California call for the log reduction of viruses and protozoa between raw sewage and the final product water distributed to consumers. Furthermore, a select number of chemicals and process control surrogates have been identified for monitoring recycled water. These requirements are in addition to the need to comply with drinking water Maximum Contaminant Levels (MCLs) for substances with a defined risk level.

Summary of the Issue:

Current regulatory and monitoring paradigms for drinking water have proven effective in preventing acute human health impacts due to pathogens. Risks due to microorganisms are well-characterized by considering human dose-response data for target microbes (e.g., *Cryptosporidium* and norovirus) so that treatment techniques that control these targets can be reasonably applied to a wider group of related pathogens. Because monitoring methods for many pathogens can be slow, insensitive, and/or imprecise, surrogates are routinely used to demonstrate the operational integrity of treatment barriers and ensure acceptable water quality. For DPR, additional monitoring schemes and approaches would be beneficial for validating treatment performance and water quality.

Chemicals can be measured at low concentrations, including well below levels of human health concern, although advanced instrumentation and expertise are required. Full advanced treatment (i.e., microfiltration, reverse osmosis, and advanced oxidation processes) for recycled water is effective in reducing trace organic compounds, as shown through direct chemical analyses and total organic carbon (TOC) concentrations in treated water. The performance of these treatment processes are validated using online and real-time surrogate measures.

Developing conventional dose-response relationships for chemicals using animal models to assign risk thresholds is slow, cumbersome, and expensive. The addition of a risk framework for assessing large numbers of trace organic compounds could help improve the evaluation of the human health significance of chemicals. In addition, evaluating possible impacts of mixtures of chemicals, including unknowns and metabolites (for which we do not yet have analytical methods), is an area of research interest.

State of the Knowledge:

DPR monitoring can be enhanced to improve the operational integrity of treatment barriers, which would result in water quality with an acceptable risk for chemicals and pathogens. Doing so would involve the following advancements:

- Development of better indicators and surrogates.
- Use of Critical Control Points for process control for validating the operations of treatment processes.

Pathogen monitoring may also be enhanced through the use of molecular methods for pathogen measurements. The state of pathogen measurement using molecular methods, such as polymerase chain reaction (PCR) based technologies, is expanding rapidly. These methods may shorten the response time from days to hours. They also provide the potential opportunity for analytical automation and incorporating such technology into a continuous-flow measurement system. However, these technologies are still being developed for many pathogens of potential interest and are not sensitive enough to ensure the detection of pathogens that are of concern at very low concentrations. PCR-based techniques do not provide information about the infectivity of pathogens, indicators detected, or the level of risk for the population.

For chemicals, detection methods are continually being developed and/or improved to measure new chemicals or existing chemicals at lower levels of detection. Bioanalytical tools that screen for biological activity are being developed to complement the analysis of individual chemical measurements. These tools, however, have their challenges: they are still in their early stages of development for many potential biological endpoints of interest; can only measure the activity of certain chemicals; may be unable to assess activity at low concentrations; and cannot address all biological endpoints of interest. In addition, they would require a set of accompanying diagnostic tools and a new interpretive framework to make bioassay outputs useful. For instance, a screening response could be used to trigger a more detailed analysis, including chemical analysis for specific chemicals or chemical groups that are causing the screening response.

Research Needs:

- Evaluate the efficacy of current monitoring tools for DPR to address the following questions:
 - Are indicators and surrogate measures adequate to represent the effectiveness of treatment processes to control microbial and chemical risks?
 - Could additional indicators and surrogate measures be employed to better define risk and, therefore, better optimize the application of treatment and monitoring resources?
 - What are appropriate Critical Control Points, and how effective is this monitoring strategy?

- Verify the performance of multiple barriers in reducing chemical and microbial hazards to levels that are protective of human health. Are these barriers sufficiently robust and timely to divert off-spec water so that it does not pose a health risk to consumers? Can pathogen log removal credits for treatment barriers be better characterized?

- Develop a strategy for assessing the usefulness of PCR-based techniques in a DPR scheme to address the following:
 - Automated large volume method for PCR detection of pathogens of interest (especially viruses and protozoa).
 - Validation of pathogen methods with inter-laboratory evaluations and different water matrices.
 - Validation of unit processes and surrogates for pathogen and CEC removal.

- While bioassays may present an opportunity to assess the presence of chemicals in recycled water, they are in the initial stages of development. One possible next step could be to further investigate bioassays for use as indicators of initial triggers in toxicity pathways. If research advances are made, future efforts may involve:
 - Developing a chemical risk paradigm to interpret bioassay monitoring data.
 - Developing and validating bioanalytical tools (screening level) and non-targeted analytical methods (diagnostics) to inform the CEC risk paradigm and verify treatment performance.