

Effectiveness of Advanced Water Treatment for the Pure Water Monterey Project – Constituents of Emerging Concern

Overview of Constituents of Emerging Concern

Among the perceived risks of using purified recycled water for groundwater replenishment is the presence of trace concentrations of pharmaceuticals (e.g., antibiotics and antidepressants), ingredients in personal care products (e.g., sun-screen and fragrances), and chemicals that can affect the human endocrine system in terms of growth, reproduction, and sexual behavior (e.g., synthetic hormones). These chemicals are often grouped together and are called constituents of emerging concern (CECs).

Many of the CECs listed in the 2013 *Chemosphere* article “Pharmaceuticals as emerging contaminants and their removal from water. A review¹,” have been found in municipal wastewater, drinking water, and groundwater. This is not a new occurrence—these chemicals are pervasive, and many people use them in their daily lives. CECs are also being detected more frequently because laboratory methods and analytical capability have rapidly evolved over the past 20 years. Molecules can be detected down to very, very low levels - nanograms per liter (ng/L)². Simply detecting a compound, however, does not mean that its presence is of health significance. Understanding the health significance to humans of exposure to ultra-low concentrations of CECs has been the subject of many research studies, leading the Environmental Protection Agency (EPA) to adopt very conservative “safe” levels in drinking water, which are called Drinking Water Equivalent Levels (DWELs). In other words, a DWEL is the lifetime exposure level that is still safe and is not expected to cause adverse health effects. DWELs are defined in microgram per liter ($\mu\text{g/L}$)³.

To put the DWELs into understandable terms, they can be compared to the number of 8-ounce glasses of water containing a detected concentration of a CEC that a person would have to drink *per day* to reach the DWEL. Some examples of DWELs and water consumption rates to reach the DWEL are presented in the following table.

¹ J. Rivera-Utrilla, M. Sanchez-Polo, M. Ferro-Garcia, G. Prados-Joya, and R. Ocampo-Perez, 2013. “Pharmaceuticals as emerging contaminants and their removal from water. A review.” *Chemosphere*. October

² Where a ng/L, or part per trillion, is the equivalent of one twentieth of a drop of water in an Olympic sized swimming pool.

³ Where a $\mu\text{g/L}$, or part per billion, is equivalent to half a teaspoon of water in an Olympic sized swimming pool.

Examples of Daily Water Consumption Equal to the Drinking Water Equivalent Level for Commonly Used CECs^a

Compound	Type of Compound	DWEL (µg/L)	Water Consumption Rate Required to Equal DWEL (8-ounce Glasses/Day)
Alprazolam	Anti-anxiety medication	0.083	39
Ciprofloxacin	Antibiotic	17	4,800
Clonidine	Blood pressure medication	0.028	>99
DEET	Insecticide	81	3,500
Ibuprofen	Anti-inflammatory	34	290
Morphine	Analgesic	1.0	42
Primidone	Anticonvulsant	0.85	55
Salicylic acid	Skin care product ingredient	54	420
TCEP ^b	Flame retardant	4.4	84
Di- <i>n</i> -butyl phthalate	Plasticizer	14	200

- a. Source: Bruce, G. M., Pleus, R. C. Peterson, M. K., Nellor, M. H., Soller, J. A. (2010) *Development and Application of Tools to Assess and Understand the Relative Risks of Drugs and Other Chemicals in Indirect Potable Reuse*; Tools to Assess and Understand the Relative Risks of Indirect Potable Reuse and Aquifer Storage and Recovery Projects, Vol. 2; WaterReuse Foundation: Alexandria, VA. Bruce et al., 2010.
- b. TCEP - Tris(2-chloroethyl)phosphate.

In general, for the CECs studied by Bruce, et al., (2010) that were evaluated in recycled water, drinking water, or other water sources, CECs were many times lower than the acceptable concentrations based on the DWELs, thus showing no evidence of human health risk.

Pure Water Monterey CEC Study

CECs and their removal through advanced treatment were a subject of intensive study as part of the Environmental Impact Report for the Pure Water Monterey Project. The Pure Water Monterey Project will take secondary effluent from the Regional Treatment Plant and produce purified water at an Advanced Water Purification Facility (AWPF). The advanced treatment processes at the AWPF will include ozone oxidation, membrane filtration (MF), reverse osmosis (RO), advanced oxidation (AOP) using ultraviolet light and hydrogen peroxide, and post-treatment stabilization. A pilot study was conducted to evaluate the treatment effectiveness of the ozone, MF, and RO portions of the AWPF. To determine the removal of CECs through these processes, samples were collected at various points in the treatment process to measure the concentrations of CECs in the pilot plant influent (secondary effluent from the Regional Treatment Plant), the water after ozonation treatment, and the water after RO treatment. Over 90 CECs were evaluated using industry standard equipment and sensitive analytical methods⁴.

⁴ Liquid Chromatography Tandem Mass Spectrometry (LC-MS-MS) method

Only four CECs were detected in the water following RO treatment: caffeine (a simulant), iohexol (an imaging contrast agent), albuterol (an asthma medication), and N-nitrosodimethylamine (NDMA - a byproduct of water disinfection). Caffeine, iohexol and albuterol were detected at concentrations near their analytical detection limits—many orders of magnitude below any demonstrated health related maximum levels⁵ even prior to the final AOP treatment step. In addition, recommendations of a Science Advisory Panel convened by the California State Water Resources Control Board stated “[...] the very small percentage of CECs that are recommended for health-based monitoring (3 of 489 or < 1%) reinforces the inherent low potential risk of CECs in recycled water to human health currently attributable to water reuse applications that include most Title 22 non-potable uses and potable reuse via groundwater and surface water augmentation under current regulatory practices⁶.”

NDMA was found in the water after RO treatment at concentrations in the low ng/L range; however, AOP will reduce NDMA to levels below its DWEL and/or below the analytical detection level in the final purified water to be used for groundwater replenishment. The AOP system at the AWPf is specifically designed to achieve 1.5-log removal (96.8% removal) of NDMA, and this removal will be demonstrated at the facility prior to the production of water for injection into the aquifer⁷. Similar advanced treatment processes are being used for approved groundwater replenishment projects elsewhere in California, such as Orange County Water District’s Groundwater Replenishment System. These projects have shown that the purified water produced surpasses all drinking water standards and other health and water quality requirements.

The California Division of Drinking Water (DDW) and the Central Coast Regional Water Quality Control Board (Regional Board) reviewed all aspects of the Pure Water Monterey Project, including the advanced treatment processes. The Engineering Report submitted to DDW by Monterey One Water, formerly MRWPCA, demonstrates the safety of the Pure Water Monterey Project. The Regional Board issued a permit to M1W on March 9, 2017 that authorized treatment of recycled water at the full-scale AWPf and injection of the treated water for groundwater replenishment. The permit is available at: www.waterboards.ca.gov/centralcoast/board_decisions/adopted_orders/2017/monterey_pure/pwm_order_and_mrp.pdf.

⁵ Caffeine was detected at 12 ng/L compared to the 2018 CEC Science Advisory Panel Report benchmark of 350 ng/L, based on Australia’s drinking water goal; iohexol was detected at 16 ng/L compared to the 2018 CEC Science Advisory Panel Report benchmark of 720,000 ng/L, based on Australia’s drinking water goal; and albuterol was detected at 31 ng/L compared to the 2018 CEC Science Advisory Panel Report benchmark of 20,000 ng/L based on Minnesota Department of Health’s screening level for pharmaceuticals in water

⁶ J. E. Drewes et al., 2018. “Monitoring Strategies for Constituents of Emerging Concern (CECs) in Recycled Water. Recommendations of a Science Advisory Panel.” *SCCWRP Technical Report 1032*. April

⁷ NDMA was detected at 32 ng/L, while the AOP was designed to reduce the concentration to 1 ng/L, compared to the DDW Notification Level of 10 ng/L; for more information see the AWPf Engineering Report