



Testing CECs for Potable Reuse

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Testing for CECs

- What are CECs?
- Health risks of CECs
- Which CECs should we test?
- Analytical methods, QA/QC
- Sensitivity of CEC testing
- Testing for GWRS
- Findings in purified (FAT) recycled water
- Research needs for CECs



What Are CECs?

- Chemicals, compounds, constituents, contaminants of emerging concern
- Principally organic compounds
- Unregulated – No California or US EPA MCL
- Some have Notification Levels
- Emerging concern from research community or regulatory scrutiny (UCMR, CCL)
- Some are actually chemicals of emerging publicity rather than health concern
- No standard testing methods



Health Risks with CECs

- Many CECs are included because of endocrine disruption potential or carcinogenicity risk
- Toxicity data is limited (MCHM West Virginia example)
- Toxicity evaluations indicate that most CECs are below levels of health concern prior to advanced treatment
- Exceptions include NDMA and 1,4-dioxane
- NDMA is found in some industrial chemicals and is formed by chloramination or ozonation of precursors
- 1,4-Dioxane occurs in household products and has industrial chemical uses



Which CECs Should We Test?

- SWRCB list (2013 Recycled Water Policy)
- Notification Levels – notification required if found above NL in drinking water sources
- UCMR lists - based on concerns with risk of CECs in drinking water
- Compounds resistant to degradation/removal
- Wastewater indicator compounds
- Public and media interest
- Available testing methods



Analytical Methods for CECs

- Automated solid phase extraction reduces solvent use and labor
- GC/MS/MS – for volatile compounds
- LC/MS/MS – for semi-volatiles
- IC/MS – separate perchlorate from pCBSA
- Isotopic dilution - expensive, time consuming
- Methods development at OCWD
 - 5 methods, 47 CECs, 29 excluding phenols and hormones
 - Rigorous QA/QC essential for data reliability



Sensitivity of CEC Testing

- Ideally sensitivity based on health risk level in drinking water
- Actual sensitivity based on
 - UCMR requirements for national drinking water occurrence testing
 - Other US EPA specified DLR
 - Or research lab testing capability
- Significant investment in equipment and time
- Analytical arms race – we test lower because others have and we can



Scope of CEC Testing for GWRS

- CEC testing guided by IAP for GWRS
- Focus on testing Final Product Water
- Quarterly testing of CECs in FPW
- Occasional testing across GWRS treatment processes (6 times in 2010)
- ROF and ROP now twice annually
- Source water testing if indicated by findings in GWRS – confer with OCSD
- Groundwater - CEC testing annually at 35 monitoring wells (Forebay and barrier)



CEC Findings in Purified (FAT) Recycled Water

2014 WBMWD & OCWD Indirect Potable Reuse Projects - Final Product Water Monitoring Results for Constituents of Emerging Concern (CECs)

CECs

Endocrine Disrupting Compounds						
Constituent	Common Use	SWRCB Required Monitoring ¹	Reporting Limit (ng/L) WBMWD / OCWD	WBMWD Result ² (ng/L)	OCWD Results ³ (ng/L)	SWRCB Monitoring Trigger Level ¹ or other health screening level ⁴ (ng/L)
17α-estradiol	Synthetic Hormone	No	1.0 / 1.0	ND	ND	350
17β-estradiol	Natural Steroid Hormone	Yes	1.0 / 1.0	ND	ND	0.9
17α-ethynylestradiol	Contraceptive	No	1.0 / 2.0	ND	ND	280
Diethylstilbestrol	Synthetic Estrogen	No	1.0 / 2.0	ND	ND	NA
Epitestosterone	Natural Steroid Hormone	No	1.0 / 1.0	ND	ND	NA
Estril	Natural Steroid Hormone	No	1.0 / 2.0	ND	ND	350
Estrone	Natural Steroid Hormone	No	1.0 / 2.0	ND	ND	350
Progesterone	Natural Steroid Hormone	No	1.0 / 1.0	ND	ND	110,000
Testosterone	Natural Steroid Hormone	No	1.0 / 1.0	ND	ND	7,000
Bisphenol A	Plasticizer	No	1.0 / 200 ⁵	140	ND ⁵	35,000
Nonylphenol	Industrial Chemical	No	0.9 / 200	ND	ND	500,000 ⁶
Octylphenol	Industrial Chemical	No	0.2 / 200	ND	ND	5,300,000
Pharmaceuticals						
Constituent	Common Use	SWRCB Required Monitoring ¹	Reporting Limit (ng/L) WBMWD / OCWD	WBMWD Result ² (ng/L)	OCWD Results ³ (ng/L)	SWRCB Monitoring Trigger Level ¹ or other health screening level ⁴ (ng/L)
Acetaminophen	Analgesic	No	20 / 5.0	ND	ND	350,000
Atenolol	Beta Blocker	No	1.0 / 5.0	ND	ND	70,000
Azithromycin	Antibiotic	No	10 / 10	ND	ND	3,900
Carbamazepine	Anti-convulsant	No	1.0 / 1.0	ND	ND	1,000
Diclofenac	Anti-inflammatory	No	1.0 / 5.0	ND	ND	1,800
Gemfibrozil	Anti-cholesterol	Yes	1.0 / 1.0	ND	ND	45,000
Ibuprofen	Anti-inflammatory	No	1.0 / 1.0	ND	ND	40,000
Iohexol	Contrast Media	No	10 / 20	ND	ND	720,000
Iopromide	Contrast Media	Yes	5.0 / 10	ND	ND	750,000
Meprobamate	Anti-anxiety	No	1.0 / 5.0	ND	ND	260,000
Naproxen	Anti-inflammatory	No	1.0 / 5.0	ND	ND	220,000
Primidone	Anti-convulsant	No	1.0 / 1.0	ND	ND	840 ⁷
Sulfamethoxazole	Antibiotic	No	1.0 / 1.0	8.0	ND	35,000
Triclosan	Anti-microbial	Yes	2.0 / 1.0	ND	ND	350
Food Additives, Personal Care Products, Other						
Constituent	Common Use	SWRCB Required Monitoring ¹	Reporting Limit (ng/L) WBMWD / OCWD	WBMWD Result ² (ng/L)	OCWD Results ³ (ng/L)	SWRCB Monitoring Trigger Level ¹ or other health screening level ⁴ (ng/L)
Caffeine	Stimulant/Additive	Yes	1.0 / 3.0	16	ND	350
DEET	Insect Repellent	Yes	1.0 / 1.0	1.3	ND	2,500
TCEP	Flame Retardant	No	1.0 / 5.0	3.7	ND	2,500

ND = not detected above the reporting limit

NA = health-based screening level not readily available

¹2013 Amended Recycled Water Policy for both surface spreading and groundwater injection projects

²based on 2014 annual sample result (n=1)

³based on average of 2014 quarterly sample results (n=4)

⁴Other health-based screening levels from 2010 SWRCB Recycled Water CEC Science Advisory Panel Final report (Appendix J) if available; otherwise alternative source referenced

⁵OCWD 2014 reporting limit = 200 ng/L, previously all ND results with OCWD 2010-11 RL of 10 ng/L

⁶2008 Australian Water Recycling Guidelines

⁷Drinking Water Equivalent Level (DWEL) developed by Intertox, Inc. (2009) for OCWD



CEC Findings Across GWRS Processes

2010 OCWD GWRS Influent and Effluent Monitoring Results for Constituents of Emerging Concern

June 24 2010 - 24 Hour Composite Samples

Parameter	RDL	Units	GWRS-Q1	GWRS-MFE	GWRS-ROP	GWRS-UVP	GWRS-FPW
			GWRS Influent	MF Effluent	RO Product	UV-AOP Product	Final Product
17a-Estradiol	1	ng/L	ND	ND	ND	ND	ND
17a-ethynylestradiol	2	ng/L	ND	ND	ND	ND	ND
17b-Estradiol	2	ng/L	2.5	ND	ND	ND	ND
4-Nonylphenol	100	ng/L	ND	ND	ND	ND	ND
Acetaminophen	5	ng/L	78.4	205	15	ND	ND
Atenolol	5	ng/L	555	548	ND	ND	ND
Atrazine	1	ng/L	1	1	ND	ND	ND
Azithromycin	1	ng/L	391	332	ND	ND	ND
Bisphenol A	100	ng/L	ND	ND	ND	ND	ND
Caffeine	3	ng/L	1060	1050	5.2	ND	ND
Carbamazepine	1	ng/L	263	265	ND	ND	ND
Diclofenac	5	ng/L	300	260	ND	ND	ND
Diethylstilbestrol	1	ng/L	ND	ND	ND	ND	ND
Dilantin	10	ng/L	197	173	ND	ND	ND
Diuron	5	ng/L	66	72	ND	ND	ND
Epitestosterone (cis-testosterone)	1	ng/L	ND	ND	ND	ND	ND
Erythromycin	1	ng/L	148	139	ND	ND	ND
Estriol	1	ng/L	3.9	1.3	ND	ND	ND
Estrone	1	ng/L	41	22	ND	ND	ND
Fluoxetine	5	ng/L	25	19	ND	ND	ND
Gemfibrozil	1	ng/L	802	678	ND	ND	ND
Ibuprofen	1	ng/L	280	292	ND	ND	ND
Linuron	5	ng/L	ND	ND	ND	ND	ND
Meprobamate	5	ng/L	401	389	ND	ND	ND
N,N-diethyl-m-toluamide (DEET)	1	ng/L	528	501	4.0	ND	ND
Naproxen	5	ng/L	872	705	ND	ND	ND
Primidone	1	ng/L	100	103	ND	ND	ND
Progesterone	1	ng/L	ND	ND	ND	ND	ND
Simazine	5	ng/L	10	11	ND	ND	ND
Sulfamethoxazole	1	ng/L	2130	1500	1.2	ND	ND
Testosterone (trans-)	2	ng/L	ND	ND	ND	ND	ND
Triclosan	1	ng/L	324	113	6.2	ND	ND
Trimethoprim	5	ng/L	424	320	ND	ND	ND
Tris-2-chloroethyl phosphate (TCEP)	5	ng/L	338	347	ND	ND	ND



2014 GWRS Water Quality: Select CECs

Constituent	Common Use	Average GWRS Influent (ng/L)	Average GWRS Final Product (ng/L)
17 α -estradiol	Synthetic Hormone	NS	ND < (0.4 - 2)
Caffeine	Stimulant/Additive	450	ND < 3
Carbamazepine	Anti-convulsant	250	ND < 1
DEET	Insect Repellent	120	ND < 1
Gemfibrozil	Anti-cholesterol	420	ND < 1
Iopromide	Contrast Media	99.4	ND < 10
Primidone	Anti-convulsant	110	ND < 1
Triclosan	Anti-microbial	110	ND < 1



What CEC Data Show

- Testing at GWRS indicates:
 - Low levels most CECs in 2ndary effluent
 - RO is main CEC barrier in FAT processes
 - AOP provides additional CEC barrier
 - UV/AOP main barrier to NDMA
 - Reformation of NDMA after AOP
 - Membrane aging affects RO performance



Research Needs for CECs

- **Toxicological assessments for CECs**
 - Levels of health concern in drinking water
- **Evaluate CEC transformation products for potential risks**
 - Oxidation, BAC and SAT transformation products
- **Determine appropriate sensitivity for testing**
 - Based on health risk with margin of safety
- **Identify indicator compounds that correlate with removal of CECs of health concern**
 - Performance verification indicators
- **Correlate CEC removal with on line sensor systems**
 - Detection of significant excursions
- **RO membrane end of life assessment**
 - Trend analysis for predicted replacement need