What are the Contaminants of Emerging Concern?

Exist in recycled water?

Impact the soil and groundwater?
Outline

Projects at SoCal

- Palmdale Water Reclamation Plant
- Effluents of 5 Wastewater Treatment Plants (WWTPs) in SoCal
- Turf-grass study at UCR

Review

Summary
California has been a pioneer in water recycling.

- Low seasonal rainfall,
- Large population centers,
- Strong agricultural demands,

Reclaimed water has been utilized within the state of California for almost a century and is an important resource in this area.
Uses of Municipal Recycled Water in the 2015 Survey

- *2015 GRAND TOTAL*: 714,000 acre-feet per year

**Uses of Water**
- **Golf Course Irrigation**: 30%
- **Landscape Irrigation**: 17%
- **Agriculture Irrigation**: 8%
- **Seawater Intrusion Barrier**: 8%
- **Industrial Irrigation**: 9%
- **Geothermal Energy Production**: 3%
- **Natural Sys. Restoration, Wetlands, Wildlife Habitat**: 3%
- **Groundwater Recharge**: 16%
- **Recreational Impoundment**: 4%
- **Other**: 1%

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Guidelines for Water Reuse (EPA, 2012)

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
<th>Filtration and Disinfection</th>
<th>Advanced</th>
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<tbody>
<tr>
<td>Sedimentation</td>
<td>Biological oxidation and disinfection</td>
<td>Chemical coagulation, biological or chemical nutrient removal, filtration, and disinfection</td>
<td>Activated carbon, reverse osmosis, advanced oxidation processes, soil aquifer treatment, etc.</td>
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<td>No Uses Recommended</td>
<td>Surface irrigation of orchards and vineyards</td>
<td>Landscape and golf course irrigation</td>
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<td>Non-food crop irrigation</td>
<td>Toilet flushing</td>
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<td>Restricted landscape impoundments</td>
<td>Vehicle washing</td>
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<td>Groundwater recharge of nonpotable aquifer</td>
<td>Food crop irrigation</td>
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<td>Wetlands, wildlife habitat, stream augmentation</td>
<td>Unrestricted recreational impoundment</td>
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<td>Industrial cooling processes</td>
<td>Industrial systems</td>
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Impurities and Potential Negative Effects of Recycled Water

Pathogens and indicator organisms

Contaminants of emerging concern (CECs)

Dissolved minerals (salinity)

Nutrients (N and P)

Other potentially toxic substances
Contaminants of Emerging Concern (CEC)

- Pharmaceuticals (P)
  Antibiotics, Birth control pills, Neuronal stabilizers, Over the counter pharmaceuticals, etc.

- Personal care products (PCPs)
  Fragrances, Surfactants, Preservatives, Small plastics

- Endocrine disrupting chemicals (EDCs)
  Pesticides; may alter normal function of hormones, cause tumors and birth defects
Municipal wastewater treatment plants are not designed to specifically remove CECs from wastewater (EPA, 2010).
Factors affecting CECs concentration in soil

- Sorption to soil
- Degradation in soil by microbes
- Uptake by crops
- Leaching to ground water

CECs in water may cause a series of adverse effects for aquatic species and ecosystem.
Reclaimed water and soil parameters

Physiochemical properties

- pH
- Organic matter
- Salinity
- Nutrient
- Contaminants
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Outline
- Review
- Summary
Seasonal variations of CECs in samples from Waste Water Treatment Plants (WWTPs)

The occurrence of 14 EDCs and PPCPs were investigated for the samples from 5 WWTPs in southern California in 2 seasons.
4-n-nonylphenol (NP), 4-tert-octylphenol (OP), aspirin (ASP), bisphenol A (BPA), carbamazepine (CBZ), clofibric acid (CFA), diclofenac (DCF), estrone (ETR), gemfibrozil (GFB), ibuprofen (IBP), ketoprofen (KTP), naproxen (NPX), paracetamol (PCM), triclosan (TCS)
- Faster degradation of the compounds in summer.
- More human consumption of pharmaceuticals during winter.

Compounds include:
- 4-n-nonylphenol (NP),
- 4-tert-octylphenol (OP),
- aspirin (ASP),
- bisphenol A (BPA),
- carbamazepine (CBZ),
- clofibric acid (CFA),
- diclofenac (DCF),
- estrone (ETR),
- gemfibrozil (GFB),
- ibuprofen (IBP),
- ketoprofen (KTP),
- naproxen (NPX),
- paracetamol (PCM),
- triclosan (TCS)
Performance of treatment processes were more effective in warmer temperature of summer.
Results

**Effluents**: RQs were less than unity for all the compounds except for Estrone, (not an immediate risk)

**Sludge**: RQs were higher than unity for 3 compounds, (high risk of contamination).

Risk quotient (RQ): ratio of the environmental concentration / predicted no-effect concentration (PNEC)
Results

No immediate ecological risk is expected on effluents.

Potential risks are expected due to the land application of sludge.
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Summary
Study of CECs in turf-grass field

Southern California is home to more than 500 golf courses and many of them are being irrigated with reclaimed water.

9 PPCPs and EDCs were assessed in the soil profiles and leachates from irrigated turf grass field.
**Lysimeters**

**Sandy loam and loamy sand soils**

**Regular Irrigation** \(1.1 - 1.2 \ ET_o\)
**Heavy Irrigation** \(1.5 - 1.6 \ ET_o\)

Applied for 3 months with spiked wastewater by sprinkler system

**Leachate & Soil** samples were collected
No compounds were found below top 35-cm soil layers.

Heavy irrigation may cause deeper migration of CECs and higher risk.

Only 6 compounds were detected, and other 3 remaining compounds have degraded.
3 screening models were used to assess the leaching potential of selected CECs.

- **Cohen’s criteria**: Medium to low risk of leaching.
- **Gustafson’s score (GUS)**: All tested PPCPs and EDCs were judged as “non-leachers”.
- **Jury’s screening model**: Improbable contamination risk for all CECs except: *Ibuprofen* and *Clofibric acid*. 

PPCP & EDC Leaching Potential
Even under high amount of irrigation, the CECs in the recycled water were not likely to contaminate the groundwater.
Outline

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Occurrence of PPCPs and EDCs in crop fields and groundwater from Palmdale Plant

Palmdale Water Reclamation Plant was placed in operation on 1953.

The effluents of this plant are pumped to irrigate plots growing trees and feed crops on City of Los Angeles.
4 plots with different treatment were selected.

Effluents were applied with center-pivot irrigation systems every other day.

Soil sampling depths:
- 0–10 cm
- 10–20 cm
- 20–30 cm
- 30–40 cm
- 40–50 cm
- 50–70 cm
- 70–100 cm
- 140–150 cm
Groundwater sampling

Six monitoring wells

3 times sampling events:

11/19/2008
01/28/2009
04/21/2009
Some target chemicals (PPCPs and EDCs) were detected in top 40 cm soil layers, but not in the deep depth. (Ibuprofen, ketoprofen and bisphenol A)

No target chemicals (PPCPs and EDCs) were detected in groundwater samples taken from monitoring wells.
Results

Alteration of soil properties

TC and TN contents increased in the top 20 cm soil layers; (without alteration below the 20 cm depth.)
Recycled water application increased soil organic matter in the top depth of 20cm.
Results

EC has elevated for all three plots compared with control.
Summary

- Irrigation with recycled water satisfy both water shortage and nutrients deficiency.
- CECs were detected in influent to WWTPs
- But low concentrations in the effluents
- There are potential risks on land application of sewage sludge
- CECs have relatively low risk of leaching.
- No CECs were found in deep soil layers (>40cm),
- Neither in groundwater.
- The microbial degradation is an important process affecting the fate and transport of CECs.
Thanks for attention
Selected publications


