Safe Application of Reclaimed Wastewater in Agriculture and Landscape

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Summary

Water reuse has become an integral part of comprehensive water planning to meet the increasing demands on limited water resources in the arid and semi-arid Southwest. While current wastewater reclamation technology is capable of producing finished water of any desirable quality, the amount of impurities (pollutants) in reclaimed wastewater after conventional treatment may accentuate the potential impact of the direct use of reclaimed wastewater for agricultural and landscape irrigation, the largest users of reclaimed wastewater. Through the support of the Regional Water Program, we investigated the impacts of water reuse on agricultural production, the environment, and human health and outreach activities to promote reclaimed wastewater reuse. Our key activities include: (1) Assessing the leaching potential of pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) in fields receiving reclaimed wastewater for irrigation (2) using computer models to assess the potential impact of salinity on crop growth; and (3) impacting public perception to promote safe application of reclaimed wastewater for irrigation. Accordingly, our group has carried out many forms of outreach such as co-organizing water reuse conferences; making presentations on safe application of reclaimed wastewater reuse, publishing technical bulletins and other educational materials, as well as participated in various community activities. Our research and outreach activities have not only increased stakeholder acceptance of water reuse practices but have also resulted in fund leverage to further expand our efforts. The ultimate goal of this project is to advance water sustainability though increasing water reuse to protect water supplies and the natural environment.

This project was selected as a "2010 Project of Excellence for the National Institute of Food and Agriculture, National Water Program".

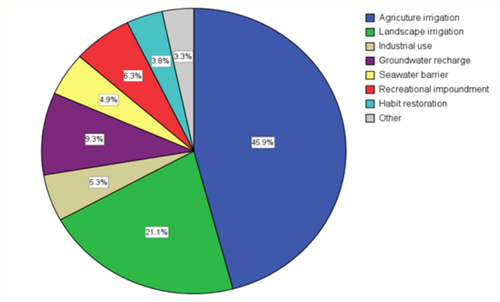
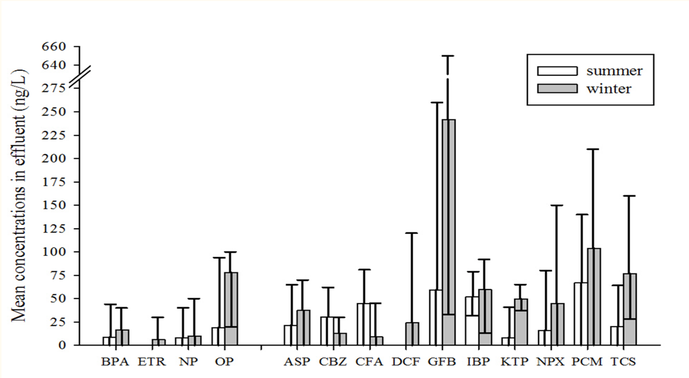


Figure 2. Wastewater Reuse in California (CSWRCB, 2003)

Fate and Transport of PPCPs and EDCs in Environment

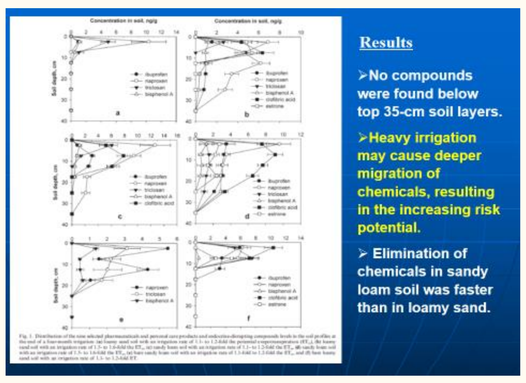
- **Seasonal Variation of PPCPs and EDCs wastewater**



- Seasonal variation of the compounds' concentrations in the wastewater was significant .
- Risk Quotients (RQs) were greater than unity for 2 EDCs (estrone and octylphenol) and carbamazepine in the sludge samples, indicating potential environmental risk.

• *Yong Yu, Laosheng Wu, Andrew C. Chang. 2013. Seasonal variation of endocrine disrupting compounds, pharmaceuticals and personal care products in Wastewater Treatment Plants. Science of the Total Environment. 442: 310-316.*

- **PPCPs and EDCs in soil**



• *Xu, J., W. Chen, L. Wu, and A. Chang. 2009. Adsorption and degradation of ketoprofen in soils, Journal of Environmental Quality 38: 1177-1182.*
• *Xu, J.; Wu, L.; Chang, A. C.; Zhang, Y., Impact of long-term reclaimed wastewater irrigation on agricultural soils: A preliminary assessment. Journal of Hazardous Materials* ***2010,*** *183, (1-3), 780-786.*

- **PPCPs and EDCs in runoff water**

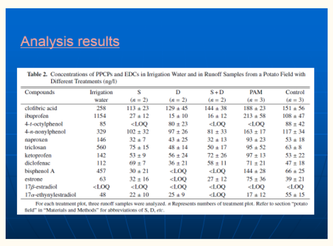


Table 2. Concentrations of PPCPs and EDCs in Irrigation Water and in Runoff Samples from a Potato Field with Different Treatments (ng/l)

Compounds	Irrigation water	S (n = 2)	D (n = 2)	S + D (n = 2)	PAM (n = 3)	Control (n = 3)
clofibric acid	258	113 ± 23	129 ± 45	144 ± 38	188 ± 23	151 ± 56
ibuprofen	1154	27 ± 12	15 ± 10	16 ± 12	213 ± 58	108 ± 47
4-t-octylphenol	85	<LOQ	80 ± 23	<LOQ	<LOQ	88 ± 42
4-n-nonylphenol	329	102 ± 32	97 ± 26	81 ± 33	163 ± 17	117 ± 34
naproxen	146	32 ± 7	43 ± 25	32 ± 13	93 ± 23	53 ± 18
triclosan	560	75 ± 15	48 ± 14	50 ± 17	95 ± 52	63 ± 8
ketoprofen	142	53 ± 9	56 ± 24	72 ± 26	97 ± 13	53 ± 22
diclofenac	112	69 ± 7	36 ± 21	58 ± 11	71 ± 21	47 ± 18
bisphenol A	457	30 ± 21	<LOQ	<LOQ	144 ± 28	66 ± 25
estrone	63	32 ± 16	<LOQ	27 ± 12	75 ± 36	39 ± 21
17β-estradiol	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
17α-ethynylestradiol	48	22 ± 10	25 ± 9	<LOQ	17 ± 12	55 ± 15

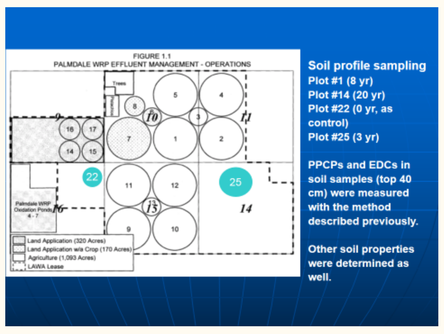
For each treatment plot, three runoff samples were analyzed. a Represents numbers of treatment plot. Refer to section "potato field" in "Materials and Methods" for abbreviations of S, D, etc.

- ➢ **Almost all of the PPCPs and EDCs in reclaimed irrigation wastewater were detected in runoff water;**
- ➢ **Concentrations of the PPCPs and EDCs in runoff water were lower than those of effluent irrigation water.**

• *Xu, J.; Wu, L.; Chen, W.; Jiang, P.; Chang, A. C.-S., Pharmaceuticals and Personal Care Products (PPCPs), and Endocrine Disrupting Compounds (EDCs) in Runoff from a Potato Field Irrigated with Treated Wastewater in Southern California. Journal of Health Science* ***2009,*** *55, (2), 306-310.*

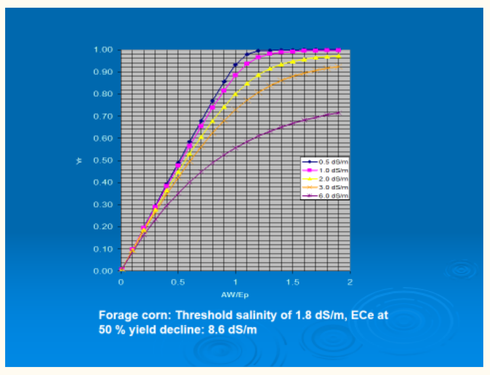
- **Evaluate the leaching potential of PPCPs and EDCs**

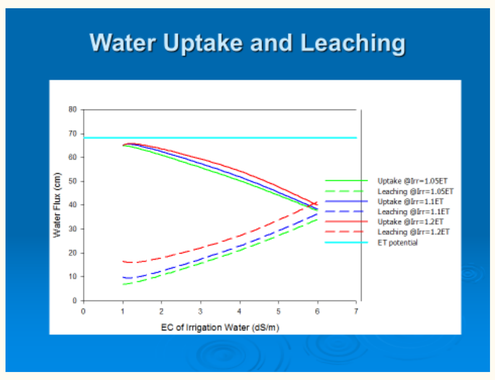
- **On top 40 cm soil layers:**
- ✓ **Ibuprofen, ketoprofen and bisphenol A were detectable in plot #1 and #25.**
- ✓ **Ibuprofen, triclosan, ketoprofen and bisphenol A were detectable in plot # 14.**
- ✓ **No target chemical was found in plot # 22 (control).**
- **Conclusion: No target chemicals (PPCPs and EDCs) were detected in groundwater samples taken from monitoring wells.**

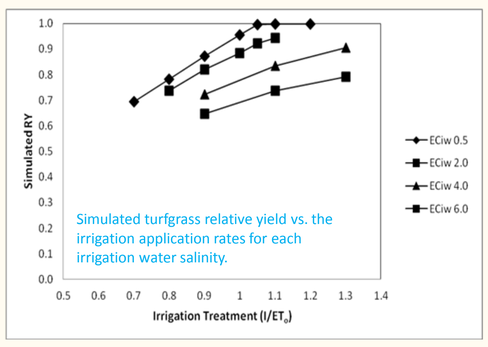


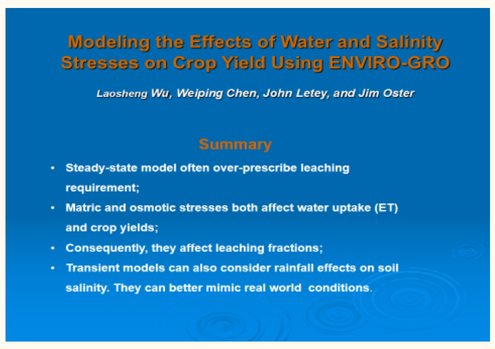
• *Xu, J.; Chen, W.; Wu, L.; Green, R.; Chang, A. C., Leachability of Some Emerging Contaminants in Reclaimed Municipal Wastewater-Irrigated Turf Grass Fields. Environmental Toxicology and Chemistry* ***2009,*** *28, (9), 1842-1850.*
• *Xu, J.; Wu, L.; Chen, W.; Chang, A. C., Leaching Potential of Nonsteroidal Anti-Inflammatory Drugs in Soils. Environmental Toxicology and Chemistry 2010, 29, (4), 800-807.*

Assessment of Salinity Effect on Crop Growth





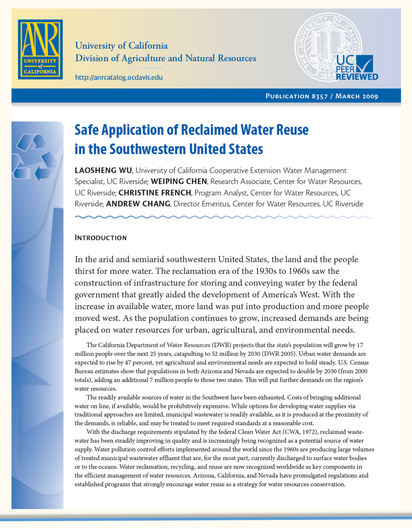




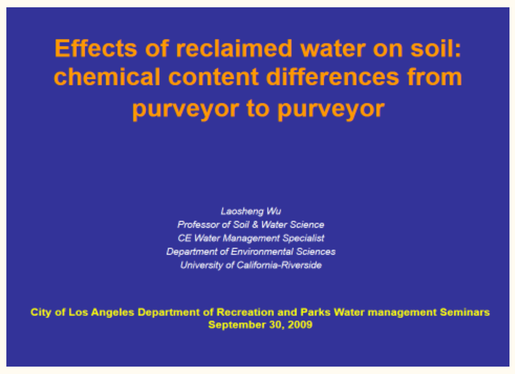
• *Letey, J., G. J. Hoffman, J. W. Hopmans, S. R. Grattan, D. Suarez, D. L. Corwin, J. D. Oster, L. Wu, and C. Amrhein. 2011. Evaluation of soil salinity leaching requirement guidelines. Ag. Water Management. 98: 502–506.*
• *Oster, J. D., J. Letey, P. Vaughan, L. Wu, and M. Qadir. 2012. Comparison of transient state models that include salinity and matric stress effects on plant yield. Ag. Water Management. 103:167-175.*

Outreach Activities

- **Water Reuse Technical Bulletin**



- **Presentations**



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