

Professor Dr.-Ing. JÖRG E. DREWES

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EDUCATION

Doctorate in Environmental Engineering (Ph.D.), Technical University of Berlin, Germany 1997

Dipl. Ing. Environmental Engineering (M.S.), Technical University of Berlin, Germany 1992

EXPERIENCE

7/2007-present: **Visiting Associate Professor**, UNSW Water Research Centre, The University of New South Wales, Sydney, Australia.

4/2006-present: **Associate Professor**, Environmental Science and Engineering Division, Colorado School of Mines, Golden CO. **Director**, Advanced Water Technology Center (AQWATEC). Research and teaching in water supply engineering with an emphasis on advanced water treatment and fate of organic compounds in engineered and natural systems.

8/2001-4/2006: **Assistant Professor**, Environmental Science and Engineering Division, Colorado School of Mines, Golden CO.

9/1999-7/2001: **Associate Director**, National Center for Sustainable Water Supply (NCSWS), Arizona State University, Tempe, AZ. Coordination of multi-agency and multi-university research and research on character and fate of organics in natural and engineered systems leading to indirect potable reuse.

8/1997-8/1999: **Visiting Professor**, Arizona State University, Tempe, AZ. Research on advanced characterization techniques for organic carbon in groundwater recharge systems.

7/1992-7/1997: **Research Associate**, Technical University of Berlin, Germany, Research on advanced wastewater treatment using powdered activated carbon and ozonation prior to groundwater recharge. Teaching design of water treatment processes, water chemistry, and environmental analytical chemistry.

RESEARCH INTEREST

Water and wastewater treatment engineering; desalination; treatment of co-produced water; potable and non-potable water reuse (soil-aquifer treatment, advanced oxidation and microfiltration/reverse osmosis); natural treatment systems (riverbank filtration, aquifer recharge and recovery); process performance assessments in indirect potable reuse; state-of-the-art characterization of natural and effluent organic matter; fate and transport of emerging contaminants (endocrine disrupting compounds, pharmaceutical residues, household chemicals) in natural and engineered systems.

AWARDS and HONORS

Panel Member, National Research Council (NRC) on Water Reuse 2008-2010; American Water Works Association Rocky Mountain Section Outstanding Research Award, 2007; Dr. Nevis Cook Graduate Teaching Award, Colorado School of Mines, 2003. Quentin Mees Research Award for outstanding water-related environmental research in the State of Arizona, 1999. Research Scholarship administered by the Deutsche Forschungsgemeinschaft (DFG), 1997 – 1999. Willy-Hager Award for outstanding research in the field of water and wastewater treatment, Germany, 1997.

PROFESSIONAL AFFILIATIONS AND SERVICE

Member, Editorial Board *Journal of Environmental Science and Health*. Member, American Water Works Association (AWWA); Water Environment Federation (WEF); International Water Association (IWA); American Membrane Technology Association (AMTA); North American Membrane Society (NAMS); Association of Environmental Engineering & Science Professors (AEESP), Member, Project Advisory Committee, Water Research Foundation, Environmental Protection Agency, Water Environment Research Foundation (WERF), and WaterReuse Foundation (WRF). Member, WEF Water Reuse Committee. Member, Rocky Mountain Section AWWA/WEA Water Reuse Committee. Member, Blue Ribbon Panel, City of Aurora, Colorado. Member, Reference Panel, Western Corridor Project, Queensland, Australia. Peer review for scientific journals (*Env. Sci. & Techn.*, *J. Env. Sci. and Health*, *Chemosphere*, *Water Research*, *J. Membrane Science*, *J. Env. Eng.*, et al.).

CURRENT AND COMPLETED RESEARCH PROJECTS (exceeding \$9.8M, selected projects listed)

Co-PI – “Trace Organic Compounds Removal during Wastewater Treatment – Categorizing Wastewater Treatment Processes by their Efficacy in Reduction of a Suite of Indicator TOxC”. 2009-2011. PI A. Salveson (Carollo), Co-PIs Drs. Snyder (SNWA), Dickenson (CSM), Rauch-Williams (Carollo). Water Environment Research Foundation (WERF) CEC4R08.

PI – “An Integrated Framework for Management and Treatment of Produced Water”. 2008-2010. Co-PIs Drs. Cath and Xu (CSM), J. Graydon (Kennedy/Jenks), and J. Veil and S. Synder (Argonne Ant. Lab.) U.S. Dept. of Energy.

Co-PI – “Maximizing Recovery of Recycled Water for Groundwater Recharge”. 2009-2010. PI. C. Yu (PSOMAS). Co-PI C. Bellona (CSM). WaterReuse Foundation WRF-08-010.

Co-PI – “Water Reuse 2030”. PI K. Linden (CU-Boulder), Co-PI S. Khan (UNSW, Australia). 2009-2010. WaterReuse Foundation WRF-06-017.

PI - “Predictive Models to Aid in the Design of Membrane Systems for Organic Micropollutants Removal”. 2008-2010. Co-PIs Dr. Chris Bellona and Mark Eberhart (CSM) and Dr. Shankar Chellam (University of Houston). WaterReuse Foundation WRF-06-009.

PI – “Field Evaluation of a Sequencing batch/Membrane Bioreactor Hybrid System for Decentralized Wastewater Treatment”. 2008-2011. Co-PI T. Cath (CSM). Aqua-Aerobics Systems, Inc.

Co-PI – “Comparison of Chemical Composition of Reclaimed and Conventional Waters”. 2007-2008. PI Dr. Shane Snyder (SNWA), Co-PIs Dr. Eric Dickenson (CSM) and Brett Vanderford (SNWA). WaterReuse Foundation WRF-06-006.

PI – “Development of Surrogates to Determine the Efficacy of Groundwater Recharge Systems for the Removal of Trace Organic Chemicals”. 2006-2009. Co-PIs Dr. Eric Dickenson (CSM) and Dr. Shane Snyder (SNWA). WaterReuse Foundation WRF-05-004.

Co-PI - “Critical Assessment of Implementing Desalination Technology”. 2007-2008. PI Dr. Pei Xu, Co-PIs Drs. Tzahi Cath and Andrea Schaefer (University of Edinburgh. Awwa Research Foundation.

PI – “Aquifer Recharge and Recovery City of Aurora”. CH2MHill/City of Aurora. 2/05-12/07.

Co-PI – “Evaluation of River Bank Filtration Systems to Optimize Removal of Bulk Organic Matter, Emerging Organic Micropollutants and Nutrients”. Awwa Research Foundation #3180. 1/06/12/07 (PI Ken Thompson, CH2MHill).

PI – “Multi-beneficial use of co-produced water through high-pressure membrane treatment and capacitive deionization technology.” 2004-2005. PI. U.S. Bureau of Reclamation/Mendell Energy, Inc.

Co-PI – “Comprehensive Utility Guide for Endocrine Disruptors and Pharmaceuticals in Drinking Water. Awwa Research Foundation #3033. 4-05-8/06 (PI Shane Snyder, SNWA).

Co-PI – “Desalination Product Water Recovery and Concentrate Volume Minimization”. Awwa Research Foundation #3030. 5/05-2/07. (PI Sandeep Sethi, Carollo Engineers).

PI – “Contributions of Household Chemicals to Municipal Wastewater Systems and the Environment”. Water Environment Research Foundation 03-CTS-21UR. 10/04-2/07.

PI - Development of Indicators and Surrogates for Chemical Contaminants in Water Reclamation Systems. WaterReuse Foundation 03-WRF-014. 1/05-12/06.

PI – “Comparison of NF and RO in terms of water quality and operational performance”. Awwa Research Foundation #3012. 1/04-4/06.

PI – “Rejection of organic micropollutants in high-pressure membranes applications leading to indirect potable reuse”. Water Reuse Foundation 02-WRF-001. 10/02-02/05.

Co-PI - “Removal of Endocrine Disruptors in Water Reclamation Processes”. Water Environment Research Foundation (WERF) and Water Reuse Task Force 01-HHE-20T. 6/02-11/05 (PI William Sonzogni, Wisconsin State Laboratory of Hygiene).

PI - “Comparison of Efficiencies of long-term Soil-Aquifer Treatment (SAT) and Best Available Technologies (reverse osmosis and nanofiltration membranes) for indirect potable reuse of domestic effluents”. National Water Research Institute (NWRI)/U.S. Bureau of Reclamation. 7/00-3/01.

Co-PI - „Investigation on soil-aquifer treatment for a sustainable water reuse“. Awwa Research Foundation/ U.S. Environmental Protection Agency. 9/97-10/03.

PUBLICATIONS (Selection)

Papers in peer-reviewed journals

Drewes, J. E. & Jekel, M. (1996), Simulation of Groundwater Recharge With Advanced Treated Wastewater, *Water Science & Technology* **33**, 10-11, 409-418.

Drewes, J. E. & Jekel, M. (1998), Behavior of DOC and AOX using advanced treated wastewater for groundwater recharge. *Water Research* **32**, 10, 3125-3133.

Drewes, J.E. & Fox, P. (1999), Fate of natural organic matter (NOM) during groundwater recharge using reclaimed water. *Water Science & Technology* **40**, 9, 241-248.

Drewes, J.E. & Fox, P. (2000), Effect of drinking water sources on reclaimed water quality in water reuse systems. *Water Environment Research* **72**, 3, 353-362.

- Drewes, J. E., Fox, P. & Nellor, M. (2000), Efficiency and Sustainability of Soil-Aquifer Treatment for Indirect Potable Reuse of Reclaimed Water. I. Chorus et al. (eds.), *Water, Sanitation & Health*. IWA Publishing, London, 227-232.
- Drewes, J. E. & Shore, L. S. (2001). Concerns about pharmaceuticals in water reuse, groundwater recharge, and animal waste. In: Ch. Daughton and T. L. Jones-Lepp (Eds.) American Chemical Society Symposium Series 791 "Pharmaceuticals and personal care products in the environment" No. 791, Washington, D.C., 206-228.
- Drewes, J.E., Fox, P. & Jekel, M. (2001), Occurrence of iodinated X-ray contrast media in domestic effluents and their fate during indirect potable reuse. *Journal of Environmental Science and Health, Part A* **36A**. 1633-1645.
- Drewes, J. E. & Shore, L. S. (2001), Concerns about pharmaceuticals in water reuse, groundwater recharge, and animal waste. In: Ch. Daughton and T. L. Jones-Lepp (Eds.) American Chemical Society Symposium Series 791 "Pharmaceuticals and personal care products in the environment" No. 791, Washington, D.C., 206-228.
- Drewes, J. E. & Fox, P. (2001), Source Water Impact Model (SWIM) – A new planning tool for indirect potable water reuse systems. *Water Science & Technology* **43** (10), 267-275.
- Drewes, J. E. & Croue, J.-P. (2002), New approaches for structural characterization of organic matter in drinking water and wastewater effluents. *Water Science & Technology – Water Supply* **2**, 2, 1-10.
- Drewes, J. E. & Summers, R. S. (2002). Removal of NOM during bank filtration: Current knowledge and research needs. In: C. Ray, Melin, G. and Linsky, R. (eds.), *Riverbank filtration: Improving source water quality*. Kluwer Academic Publishers, Dordrecht, The Netherlands. 303-310.
- Drewes, J. E., Heberer, T., Rauch, T. & Reddersen, K. (2003), Fate of pharmaceuticals during groundwater recharge. *J. Ground Water Monitoring and Remediation* **23**, 3, 64-72..
- Drewes, J. E., Reinhard, M., & Fox, P. (2003), Comparing microfiltration-reverse osmosis and soil-aquifer treatment for indirect potable reuse of water. *Water Research* **37**, 3612-3621.
- Kimura, K., Amy, G., Drewes, J. E., & Watanabe, Y. (2003). Adsorption of hydrophobic compounds onto NF/RO membranes – an artifact leading to overestimation of rejection. *J. Membrane Science* **221**, 89-101.
- Mansell, J. and Drewes, J. E. (2004). Fate of steroidal hormones during soil-aquifer treatment (SAT). *J. Ground Water Monitoring and Remediation*. **24**, 2, 94-101.
- Bellona, C., Drewes, J. E., Xu, P. & Amy, G. (2004). Factors affecting the rejection of organic solutes during NF/RO treatment – A literature review. *Water Research* **38**, 2795-2809.
- Mansell, J., Drewes, J. E., & Rauch, T., (2004). Removal mechanisms of endocrine disrupting compounds (steroids) during soil-aquifer treatment. *Water Science & Technology* **50**, 2, 229-237.
- Rauch, T. & Drewes, J.E. (2004). Assessing the removal potential of soil-aquifer treatment systems for bulk organic matter. *Water Science & Technology* **50**, 2, 245-253.
- Drewes, J. E. (2004). Fate and transport of organic constituents during ground water recharge using water of impaired quality. Risk Assessment of Waste Water Re-use on Groundwater Quality. J. Steenvoorden and T. Endreny (eds.). *Wastewater Re-use and Groundwater Quality*. International Association of Hydrological Sciences (IAHS) Publ. 285. 85-91. Oxfordshire, UK.
- Bellona, C. & Drewes, J. E. (2005). The role of physico-chemical properties of membranes and solutes for rejection of organic acids by nanofiltration membranes. *Journal of Membrane Science* **249**, 227-234.
- Xu, P., Drewes, J. E., Bellona, C., Amy, G., Kim, T., Adam, M. & Heberer, T. (2005). Rejection of emerging organic micropollutants in nanofiltration/reverse osmosis membrane applications. *Water Environment Research* **77**, 1, 40-48.
- Drewes, J. E., Hemming, J., Ladenburger, S., Schauer, J. & Sonzogni, W. (2005). An assessment of endocrine disrupting activity changes in water reclamation systems through the use of bioassays and chemical measurements. *Water Environment Research* **77**, 1, 12-23.
- Rauch, T. & Drewes, J. E. (2005). Quantifying biological organic carbon removal in groundwater recharge systems. *J. Environmental Engineering*, June, 909-923.
- Kim, T.-U., Amy, G. & Drewes, J. E. (2005). Rejection of trace organic compounds by high-pressure membranes. *Water Science & Technology* **51**, 6-7, 335-344.
- Drewes, J. E., Bellona, C., Oedekoven, M., Xu, P., Kim, T.-U., & Amy, G. (2005). Rejection of wastewater-derived micropollutants in high-pressure membrane applications leading to indirect potable reuse. *Environmental Progress* **24**, 4, 400-409.
- Rauch-Williams, T. & Drewes, J. E. (2006). Using soil biomass as an indicator for the biological removal of effluent-derived organic carbon during soil infiltration. *Water Research* **40**, 961-968.
- Drewes, J. E., Quanrud, D., Amy, G. & Westerhoff, P. (2006). Character of Organic Matter in Soil-Aquifer Treatment Systems. *J. Environmental Engineering* **11**, 1447-1458.
- Xu, P., Drewes, J. E., Kim, T., Bellona, C. & Amy, G. (2006). Effect of membrane fouling on transport of emerging organic contaminants in NF/RO membrane applications. *J. Membrane Science* **279**, 165-175.
- Xu, P. and Drewes, J. E. (2006). Viability of nanofiltration and ultra-low pressure reverse osmosis membranes for multi-beneficial use of methane produced water. *Sep. Pur. Techn.* **52**, 67-76.
- Amy, G. and Drewes, J. E. (2006). Soil-aquifer treatment (SAT) as a natural and sustainable wastewater reclamation/reuse technology: Fate of wastewater effluent organic matter (EfOM) and trace organic compounds. *Environmental Monitoring and Assessment* (in press).
- Drewes, J. E., Hoppe, C., & Jennings, T. (2006). Fate and transport of N-nitrosamines under conditions simulating full-scale groundwater recharge operations. *Water Environment Research* **78**, 13, 2466-2473.
- Sethi, S., Walker, S, Drewes, J. E., & Xu, P. (2006). Existing and emerging concentrate minimization and disposal practices for membrane systems. *Florida Water Resources Journal*, June, 38-48.
- Bellona, C. and Drewes, J. E. (2007). Viability of a low pressure nanofilter in treating recycled water for water reuse applications – A pilot-scale study. *Water Research* **41**, 3948-3958.

- Kim, T-U., Drewes, J.E., Summers, R.S., and Amy, G. (2007). Solute transport model for trace organic neutral and charged compounds through nanofiltration and reverse osmosis. *Water Research*, 41, 3977-3988.
- Sethi, S., Xu, P. and Drewes, J.E. (2007). When less is more. *Civil Engineering* 77, 9, 72-75.
- Xu, P., Drewes, J.E. and Heil, D. (2007). Beneficial use of co-produced water through membrane treatment: Technical-economic assessment. *Desalination* Vol 225/1-3 pp 139-155.
- Benko, K. and Drewes, J.E. (2008). Co-produced water in the Western United States: Geographical distribution, occurrence, and composition. *Environmental Engineering Science* 25, 2, 239-246.
- Trenholm, B., Vanderford, B.J., Drewes, J.E., & Snyder, S.A. (2008). Determination of household chemicals using gas chromatography and liquid chromatography with tandem mass spectroscopy. *J. Chromatography A*. 1190: 253-262.
- Bellona C., Oelker, G., Luna, J., Filteau, G., Amy, G. & Drewes, J.E. (2008). Comparing nanofiltration and reverse osmosis for drinking water augmentation. *J. American Water Works Association* 100:9, 102-116.
- Lowe, K., Van Cuyk, S., Siegrist, R. & Drewes, J. E. (2008). Field Evaluation of the Performance of Engineered Onsite Wastewater Treatment Units. *J. Hydrologic Engineering*, 13:8, 735-743.
- Drewes, J.E., Dickenson, E. R. V., Sedlak, D. L., and Snyder, S.A. (in review). Applying Surrogates and Indicators to Assess Removal Efficiency of Trace Organic Chemicals in Indirect Potable Reuse Systems: Oxidation Processes. *Environmental Science and Technology*.

Peer-Reviewed Books and Book Contributions

- Drewes, J. E. & Jekel, M. (1996). Reuse of Advanced Treated Sewage Effluent for Groundwater Recharge. Nordic Hydrological Programme. Report No. 38. 161-167.
- Drewes, J. E., Bornhardt, C. & Jekel, M. (1996). Untersuchungen zur Nutzung von Klarwässern für eine Versickerung auf Rieselfeldböden. Schriftenreihe im Fachbereich Umwelt und Gesellschaft. Landschaftsentwicklung und Umweltforschung, Technische Universität Berlin, Berlin. Nr. 101. 93-100.
- Drewes, J. E. (1996). Wende zu einer nachhaltigen Wassernutzung. K.H. Hübler, U. Weiland (Eds.). Nachhaltige Entwicklung. Eine Herausforderung für die Forschung? Verlag für Wissenschaft und Forschung. Berlin. 153-166.
- Drewes, J. E. (1997). Behavior of organic compounds in domestic effluents used for groundwater recharge. Fortschritt-BerichteVDI-Verlag No 174, Umwelttechnik, Düsseldorf (in German).
- Drewes, J. E., Fox, P. & Ziegler, D. (1998). Impact of drinking water sources on refractory DOC in water reuse systems. Peters et al. (eds.), Artificial Recharge of Groundwater. Balkema, Rotterdam, 461-463.
- Drewes, J. E. (1998). Anforderungen an eine nachhaltige Wassernutzung in Berlin-Brandenburg. Forschungs- und Sitzungsberichte. Nachhaltige Raumentwicklung. Szenarien und Perspektiven für Berlin-Brandenburg. Band 205. Akademie fuer Raumforschung und Landesplanung. Hannover. 199-217.
- Drewes, J. E., Fox, P. & Nellor, M. (2000). Efficiency and Sustainability of Soil-Aquifer Treatment for Indirect Potable Reuse of Reclaimed Water. I. Chorus et al. (eds.), Water, Sanitation & Health. IWA Publishing, London, 227-232.
- Drewes, J. E. & Shore, L. S. (2001). Concerns about pharmaceuticals in water reuse, groundwater recharge, and animal waste. In: Ch. Daughton and T. L. Jones-Lepp (Eds.) American Chemical Society Symposium Series 791 "Pharmaceuticals and personal care products in the environment" No. 791, Washington, D.C., 206-228.
- Drewes, J. E. & Summers, R. S. (2002). Removal of NOM during bank filtration: Current knowledge and research needs. In: C. Ray, Melin, G. and Linsky, R. (eds.), Riverbank filtration: Improving source water quality. Kluwer Academic Publishers, Dordrecht, The Netherlands. 303-310.
- Drewes, J. E., Barrett, M., Appleyard, S., Chilton, J. & Fastner, J. (in press). Chemicals: Health Relevance, Transport and Attenuation. In: WHO Ground Water Monograph. World Health Organization (WHO), Geneva.
- Drewes, J. E. (2004). Fate and transport of organic constituents during ground water recharge using water of impaired quality. Risk Assessment of Waste Water Re-use on Groundwater Quality. J. Steenvoorden and T. Endreny (eds.). Wastewater Re-use and Groundwater Quality. International Association of Hydrological Sciences (IAHS) Publ. 285. 85-91. Oxfordshire, UK.
- Drewes, J. E. (2005). Wastewater Reclamation and Reuse Research. J.H. Lehr (ed) The Encyclopedia of Water. Wiley Water.
- Drewes, J. E., Gower, A., Mitchell, R. & Zabel, T. (2007). Chemicals: Health Relevance, Transport and Attenuation. In: WHO Surface Water Monograph. World Health Organization (WHO), Geneva.
- Xu, P., Drewes, J. E., Oedekoven, M., Bellona, C., Amy, G. (2007). Rejection of non-ionic organic micropollutants by nanofiltration membranes: Effect of membrane fouling. AWWA Best Membrane Papers Book. Kerry Howe (ed.). American Water Works Association (AWWA), Denver, Colorado.
- Drewes, J.E. (2007). Removal of Pharmaceutical Residues during Wastewater Treatment. Eds. M. Petrovic and D. Barcelo. Analysis, Fate and Removal of Pharmaceuticals in the Water Cycle. Vol. 50. Wilson & Wilson's. Elsevier, Amsterdam. 427-447.
- Ray, C., Grischek, T., Hubbs, S., Drewes, J.E., Haas, D. and Darnault, C. (2008). Riverbank Filtration for Drinking Water Supply. ASCE Riverbank Filtration. American Society of Civil Engineers. Riverbank Filtration Task Force. Wiley (in press).
- Drewes, J.E. and Khan, S. (in review). Water Reuse for Drinking Water Augmentation. J. Edzwald (ed.) Water Quality and Treatment, 6th Edition. American Water Works Association. Denver, Colorado.

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Professor and Chair

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EDUCATION

- Ph.D.** *Civil Engineering*, University of California, Davis, 1982 (Environmental Engineering)
MS *Civil Engineering*, University of California, Davis, 1980 (Environmental Engineering)
BS *Civil Engineering*, University of California, Davis, 1977, (Summa Cum Laude)
BA *Psychology*, Stanford University, 1967 (Honors)

EXPERIENCE

- **1999 - present: Professor**, research and primary teaching undergraduate and graduate courses in Environmental Engineering, *Department of Civil, Environmental & Architectural Engineering, University of Colorado, Boulder, CO.*
- **1989 - 1999: Associate Professor**, research and primary teaching undergraduate and graduate courses in Environmental Engineering, *Department of Civil, Environmental & Architectural Engineering, University of Colorado, Boulder, CO.*
- **1982 - 1989: Assistant Professor**, research and primary teaching undergraduate and graduate courses in Environmental Engineering, *Department of Civil, Environmental & Architectural Engineering, University of Colorado, Boulder, CO*
- **1979 - 1982: Graduate Student Research Assistant**, Ph.D. dissertation project: control of activated sludge flocculation in Sequencing Batch Reactors. Environmental Engineering, *Department of Civil Engineering, University of California, Davis, CA.*
- **1978 - 1979: Graduate Teaching Assistant** in environmental engineering courses: solid waste management, water quality, wastewater design, and pilot plant laboratory. *Department of Civil Engineering, University of California, Davis, CA.*
- **1976 - 1978: Engineering Assistant**, Water Quality Section, Division of Operations & Maintenance, State Water Project, *State of California Department of Water Resources, Sacramento, CA.* Projects on aquatic weed and algae control in reservoirs and canals, modeling of thermocline-induced oxygen depletion in reservoirs, and design of wind generator for automated water quality data monitoring in remote field sites.

AWARDS & PROFESSIONAL REGISTRATION

- Eminence Member, American Academy of Environmental Engineers, 2006
- CU-Lead Alliance, Faculty Appreciation Award, 2006
- Distinguished Achievement Award, CEAE Department, 2006
- Clarence Eckel Faculty Achievement Award, CU, Dept. CEAE, 2001
- Faculty Appreciation Award, CU Multicultural Engineering Program, 2000-2001

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- Distinguished Engineering Educator, (national) Society of Women Engineers, 2000
- Faculty Award for Women Scientists and Engineers, National Science Foundation, 1992-1997
- National Water Research Institute, Service Award, 1996
- Association of Environmental Engineering Professors, Service Award, 1997
- Water Environment Federation, 1st Prize for Ph.D. Dissertation to my student, Rita Klees, 1990
- Dept. Civil, Env., & Arch. Eng. Awards: Research, 1985, 1992; Service, 1998
- Dept. Civil & Arch. Engineering Student-Selected Teaching Awards: 1986, 1998
- **Registered Professional Engineer, Colorado #26151**

RESEARCH INTERESTS

- Water/wastewater treatment processes based on anaerobic respiration by bacteria, including: denitrification, perchlorate and iron (Fe(III)) respiration by suspended microorganisms and in biofilm.
- Processes for biodegradation of toxic organic compounds using mixed populations of bacteria.
- Application of bacterial population dynamics to in-situ remediation of acid mine drainage and other biological treatment processes using mixed microorganism communities.
- Water recycling and wastewater treatment in extreme environments.
- Activity of autotrophic bacteria in biofilm: nitrification, manganese oxidation and iron oxidation.
- Spatial scale effects on behavior of biological processes for treatment of water and wastes.

REFEREED JOURNAL PUBLICATIONS

- Gutierrez-Padilla, G.D., A. Bielefeldt, S. Ovtchinnikov, J. Pellegrino, and J. Silverstein. "Simple scanner-based image analysis for corrosion testing: Concrete application. *J. Mat. Proc. Technol.* 209:51-57, 2009.
- Choi, H. and JoAnn Silverstein. "Inhibition of perchlorate reduction by nitrate in a fixed biofilm reactor, *J. Hazardous Mat.*, 159:440-445, 2008.
- Choi, H. and JoAnn Silverstein, "Effluent Recirculation to Improve Perchlorate Reduction in a Fixed Biofilm Reactor," *Biotech. Bioeng.*, 98:132-140, 2007.
- Bilgin A.A., Harrington J.M. and Silverstein J "Enhancement of bacterial iron and sulfate respiration for in situ bioremediation of acid mine drainage sites: a case study. *Minerals and Metallurgical Processing (SME)*, 24 (3): 139-144 2007.
- Baeseman, J.L., R.L. Smith, and J. Silverstein, "Denitrification Potential in Stream Sediments Impacted by Acid Mine Drainage: Effects of pH, Various Electron Donors, and Iron, *Microbial Ecol.*, 51(2):232-241, 2006.
- Bilgin, A., J. Silverstein, and M. Hernandez. "Microbial neutralization of acid mine drainage in the presence of soluble ferri-Hydroxide complexes," *Environ. Sci. Technol.*, 39:7826-7832, 2005.
- Bilgin, A., J. Silverstein, and J.D. Jenkins, "Iron Respiration by *Acidiphilium cryptum* at pH 5." *FEMS Microbiology*, 49:137-143, 2004.
- Jo, K-H. and J. Silverstein, "Acclimation of activated sludge to degrade toxic levels of 2,4-dinitrophenol, *Wat. Sci. Technol.*, 50(6):45-50, 2004.
- E.A. Marchand and J. Silverstein, "The Role of Enhanced Heterotrophic Bacteria Growth on Iron Oxidation by *A. ferrooxidans*," *Geomicrobiol. J.*, 20(3):231-244, 2003
- E.A. Marchand and J. Silverstein, "The Influence of Heterotrophic Microbial Growth on Biological Oxidation of Pyrite," *Environ. Sci. Technol.*, 36:5483-5490, 2002.
- Kuchenrither, R.D., S. Sharvelle, and J. Silverstein, "Risk Exposure. Are treated wastewater and biosolids hazardous to your health?" *Wat. Environ. Tech.*, 38-40, May 2002.

Silverstein, C.V.

- Pasmore, M., P. Todd, S. Smith, D. Baker, J. Silverstein, D. Coons, and C.N. Bowman, "Effects of ultrafiltration membrane surface properties on *Pseudomonas aeruginosa* biofilm initiation for the purpose of reducing fouling," *J. Membrane Sci.*, 194:15-32, 2001.
- Pasmore, M., P. Todd, S. Smith, D. Baker, J. Silverstein, D. Coons, and C.N. Bowman, "Effects of ultrafiltration membrane surface properties on *Pseudomonas aeruginosa* biofilm initiation for the purpose of reducing fouling," *J. Membrane Sci.*, 194:15-32, 2001.
- Brion, G. and Silverstein, J., "Selection a Sensitive Bacteriophage Assay for Evaluation of a Prototype Water Recycling system," *J. Life Support and Biosphere Sci.*, 8:9-14, 2001.
- Peccia, J., E.A. Marchand, J. Silverstein, and M. Hernandez, "Development and Application of Small-Subunit rRNA Probes for Assessment of Selected Thiobacillus Species and Members of the Genus Acidophilium," *Appl. Environ. Microbiol.*, 66(7):3065-3072, 2000.
- Oh, J. and J. Silverstein, "Oxygen inhibition of activated sludge denitrification," *Wat. Res.* 33(8):1925-1937, 1999.
- Glass, C. and J. Silverstein, "Denitrification of High-Nitrate, High-Salinity Wastewater," *Wat. Res.*, 33(1):223-229, 1999.
- Brion, G. and J. Silverstein, "Iodine Disinfection of a Model Bacteriophage, MS2, Demonstrating Apparent Rebound," *Wat. Res.*, 33(1):169-179, 1999.
- Jo, K-H. and J. Silverstein, "Substrate inhibition of degradation of 2,4-dinitrophenol in activated sludge," *Wat. Environ. Res.*, 70:94-100, 1998.
- Glass, C. and J. Silverstein, "Denitrification Kinetics of High Nitrate Concentration Water: pH Effect on Inhibition and Nitrite Accumulation," *Wat. Res.*, 32:831-839, 1998.
- Glass, C., J. Silverstein, and J. Oh, "Inhibition of denitrification by activated sludge by nitrite," *Wat. Environ. Res.*, 69:1086-1093, 1997.
- Silverstein, J. and C. Glass, "Equal Opportunity and Equality in Environmental Engineering," Forum, *J. Environ. Eng. (ASCE)*, 124(7):581-583, 1998.
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- Harris, J., J. Silverstein and D. Andrews, "Educating Women in Science," in *Educating the Majority*, Macmillan Co., New York, NY, 1989.

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- Silverstein, J. and E.D. Schroeder, "Nitrification and Denitrification in SBR's," *Wat. Treatment Tech.*, 24:64-66, 1983. (Japan)

PUBLISHED CONFERENCE PROCEEDINGS

- Silverstein, J., H. Rajaram, and J. Jenkins, "Preventing Pyrite Oxidation: A Geomicrobial Strategy for Source Control of Acid Mine Drainage. SME Annual Meeting and Exhibit, Denver, 2009.
- Andre, B., H. Rajaram, J. Silverstein, and T. Yacob. "Pore-scale Rate Model of Acid Rock Drainage Geochemistry and Geomicrobiology." SME Annual Meeting and Exhibit, Denver, 2009.
- Gutierrez-Padilla, Ma-G., A. Bielefeldt, M. Hernandez, J. Silverstein. Biokinetics of Sulfur Oxidizing Microorganisms and Monitoring of Microbially Induced Concrete Corrosion in Pipelines, Corrosion NACEexpo/2006 61st Annual Conference and Exposition, San Diego, 2006.
- Choi, H. and J. Silverstein, "Use of Internal Recirculation to Improve Perchlorate Reduction in a Fixed Biofilm Process, 2006 AWWA Annual Conference, San Antonio, TX, 2006
- A. Azra Bilgin, James M. Harrington, and JoAnn Silverstein, "Enhancement of Bacterial Iron and Sulfate Respiration for in-situ Bioremediation of Acid Mine Drainage Sites: A Case Study," 2005 Soc. Mining, Metallurgy and Exploration (SME) Annual Meeting, Salt Lake City, Feb. 2005.
- Nam, S-N., S. Kim, H. Choi, J. Yoon, J. Silverstein, and G. Amy, "Perchlorate Rejection by High-Pressure Membranes and Brine Stream Treatment by Chemical and Biological Processes," Membrane Tech. Conf., AWWA, 2005.

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PRESENTATIONS

Silverstein, C.V.

- A. Azra Bilgin and JoAnn Silverstein, "Determination of Community Composition and Physiological Structure in AMD Environments by PLFA Analysis," ISSM-ISEB Joint International Symposium, Jackson Hole, 2005
- J. Baeseman, R.L. Smith, J. Silverstein, "Seasonal Variability of Denitrification in Heavy Metal-Stressed Mountain Streams," ISSM-ISEB Joint International Symposium, poster, Jackson Hole, August 2005
- J. Jenkins, J. Silverstein, "Bacterial Population Changes Resulting from Drainage through Mine Waste Rock," poster, ISSM-ISEB Joint International Symposium, Jackson Hole, August 2005.
- Joy Jenkins and JoAnn Silverstein, "The Effect of Drainage Flow and Saturation Conditions on Microbial Pyrite Oxidation in Mine Waste Rock," Invited presentation, Society of Environmental Toxicology and Chemistry (SETAC) North America, 26th Annual Meeting, Baltimore, Nov. 2005.
- April Tumey, JoAnn Silverstein, Harihar Rajaram, "Geomicrobial model of acid mine drainage production at the rock surface scale," poster, ISSM-ISEB Joint International Symposium, Jackson Hole, August 2005.
- Hyeoksun Choi and JoAnn Silverstein, "Biological Reduction of Perchlorate in a Fixed Biofilm Process: Effects of ClO₄- Concentration, Flow Recirculation, and Nitrate." poster, Strategic Environ. Research & Devel. Program (SERDP), 2005 Symposium, Washington, DC, Nov. 2005.
- Baeseman, J.L., R.L. Smith, and J. Silverstein, "Denitrification in Acid Impacted Streams," American Soc. Microbiol. Annual Conf., Salt Lake City, Utah, 2002.
- Silverstein, J. "Activated Sludge Denitrification in Sub-optimal Conditions: Effects of Oxygen, Substrate Availability and pH." (invited paper) Symposium: Fundamentals, Modeling and Applications of Nitrification and Denitrification, VPI & SU, Roanoke, VA, 1999.
- Silverstein, J. and J. Oh, "Nitrite Accumulation in Denitrification Systems: Effects of Dissolved Oxygen, Substrate Limitation and pH," (invited paper), *Intl. Recirc. Aquaculture Conf.*, Roanoke, VA, 1998.
- Pasmore, M., E. Bjercknes, J. Bonomo, P. Todd, J. Silverstein and C.N. Bowman, "Biofilm Fouling of Water Processing Membranes: The Role of Surface Properties," *11th Ann. Colorado Biotech. Symposium, Fort Collins, CO*, 1998.
- Silverstein, J. "Putting the Bugs to Work: Using Microorganisms to Improve Water Quality on Boulder Creek," *Boulder Creek Watershed Forum*, 1998.
- Silverstein, J. and G. Carlson, "Demonstration of a Novel Process for Biological Denitrification of Ground Water for Drinking Water Treatment in a Rural Community," (invited paper), *49th Ann. Nat. Ground Wat. Assoc. Conf.*, Las Vegas, NV, 1997.
- Silverstein, J. "Demonstration of Drinking Water Denitrification in a Rural Colorado Community," (invited presentation), Annual conference, Assoc. State Drinking Water Agencies, Los Angeles, CA, 1996.
- Silverstein, J. "Teaching a Capstone Design Course in Environmental Engineering," (invited presentation), National Conference on Educational Needs in Environmental Engineering, Assoc. of Environ. Eng. Professors and American Academy of Environmental Engineering, Orono, ME, 1996.
- Panel: "Career and Family Paths for Women Engineering Professors," (invited presentation) *Annual Conference, Women in Engineering Programs Advocates Network*, Denver, CO, 1996.
- *Silverstein, J., "Demonstration of Drinking Water Denitrification at Wiggins, Colorado," *Annual Conference of Electric Power Research Institute*, Community Environmental Center, San Diego, CA, 1996
- Silverstein, J., "Environmental Engineering Ethics," (invited presentation), *GTE Seminar Series on Professional Ethics*, Purdue Univ., Calumet, Indiana, Sept. 1994.

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- *Veydovec, W., Silverstein, J., Cook, N.E., Jr., Figueroa, L.A., Hund, R., Lehmkuhl, G., "Inhibition of SBR Denitrification by High Nitrate Wastewater," *ASCE Nat. EE Conf.*, Boulder, CO, July 1994.
- *Carlson, G. and Silverstein, J., "Biofilm Adsorption of Natural Organic Material from Drinking Water," *ASCE Nat. EE Conf.*, Boulder, CO, July 1994.
- *Brion, G.M., Gerba, C.P. and Silverstein, J., "Selection of a Model Indicator Virus for Space Water Recycle," 24th International Conf. Environ. Systems (ICES), Germany, July 1994
- Silverstein, J., et al., "Health Risks of Recycled Water Systems," *Ann. Conf. Soc. Aerospace Medicine*, San Antonio, TX, May 1994.
- Silverstein, J., "Denitrification by Mixed Microbial Consortia in Activated Sludge and Biofilm Reactors," (invited paper), *Florida Environmental Chemistry Conference*, Palm Coast, FL, 1993.
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- *Brion, G.M. and Silverstein, J., "Inactivation of a Model Coliphage Virus in Water by Iodine," *Proc. 22nd Intl. Conf. Environ. Systems (ICES)*, # 921361, Soc. Automotive Engineers (SAE), Warrendale, PA, 1992.
- *Barkley, R., Hurst, C., Dunham, A., Silverstein, J., and Brion, G.M., "Generation of Iodine Disinfection By-Products (IDP's) in a Water Recycle System," *Proc. 22nd Intl. Conf. Environ. Systems (ICES)*, # 921362, Soc. Automotive Engineers (SAE), Warrendale, PA, 1992.
- *Schulz, J. and J. Silverstein, "A Systems Approach to Water Recycling Research, Third Int'l Conf. Eng. Const. in Space, Am. Soc. Civil Eng., Denver, CO, May 1992.
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- Hess, T.F.; Silverstein, J.; and Schmidt, S.K.; "Supplemental Substrate Enhancement of 2,4-Dinitrophenol Degradation in Sequencing Batch Reactors," *Water Pollution Control Fed. National Conf.*, Washington, D.C., 1990.
- *Klees, R. and Silverstein, J.; "The Use of Recirculation to Improve Nitrification in Rotating Biological Contactors," *Water Pollution Control Fed. National Conf.*, Washington, D.C., 1990.
- *Cook, N.E., Jr. and Silverstein, J.; "Biological Denitrification of a Potable Water Supply," *NATO Intl. Conf. Nitrate Pollution*, Lincoln, NE, 1990.
- *Silverstein, J. and Cook, N., "Nitrate Pollution of Shallow Groundwaters in the West," *Groundwater Eng. Mgmt. Conf.*, Denver, CO, 1990.
- *Silverstein, J. and Klees, R., "Cold Weather Operation of Sludge Compost Piles," *Water Pollution Control Fed. National Conf.*, San Francisco, CA; 1989.

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- *Silverstein, J. and Hubenthal, R., "SCDAS--A PC Model for Secondary Clarifier Design and Operation;" *Water Pollution Control Fed. National Conf.*, San Francisco, CA; 1989.
 - *Klees, R. and Silverstein, J., "Effects of Hydraulic Loading and Recirculation on Nitrification in a Rotating Biological Contactor (RBC) System," *Rocky Mountain Water Pollution Control Assoc. Conf.*, Santa Fe, NM; 1989. (Student Paper Prize)
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 - *Barrett, J. and Silverstein, J., "Optimization of a Low-Technology Potable Water Treatment Method for Use in Tropical Climates," *Am. Public Health Assoc. National Conf.*, Chicago, IL, 1989.
 - Silverstein, J., Schmidt, S. and Hess, T., "Degradation of 2,4 dinitrophenol in a Sequencing Batch Reactor," Colo. Inst. Research Biotechnol. Annual Conference, Boulder, CO; 1989.
 - Cook, N.E.; Silverstein, J. and Hogrewe, W. "Denitrification of Potable Water - Effect of the Biofilm Process on Disinfection," *Am. Water Works Assoc. National Conf.*, Los Angeles, CA; 1989.
 - Hess, T., Silverstein, J. and Schmidt, S., "Biodegradation of DNP in Axenic Cultures and Activated Sludge," *Hazardous Waste Research Conf.*, Kansas State Univ., Manhattan, KA, 1989.
 - Figueroa, L. and Silverstein, J. "Inhibition of Nitrification in Rotating Biological Contactors," *Rocky Mountain Water Pollution Control Fed. Annual Conf.*, Snowmass, CO, 1988.
 - Hess, T.; Schmidt, S. and Silverstein, J. "Biodegradation of Dinitrophenol," *Colo. Biotech. Symp.*, Ft Collins, CO, 1988.
 - Figueroa, L. and Silverstein, J. "Inhibition of Nitrification by Particulate BOD," (invited paper) *Rocky Mountain Pollution Control Fed. Mid-Year Conf.*, Denver, CO, 1988.
- paper

REPORTS

- Silverstein, J. and G. Carlson, "Biological Denitrification of Drinking Water for rural Communities." Final Report, Vol 2, EPRI Project # WO-2662-84, 1999.
- Silverstein, J. and E. Wheeler, "Biological Oxidation of Ammonia and Manganese in a Nitrifying Trickling Filter at the Boulder Wastewater Treatment Plant," *Final Report to City of Boulder, CO*, 1998.
- Silverstein, J. and G. Carlson, "Development of Safe and Rapid Biofilm Inoculation Protocol to Enhance Commercialization of Biological Processes for Drinking Water Treatment," *Final Report, Colorado Advanced Materials Institute for Entrepreneurs' Technical Assistance Program (CAMI/ETAP)*, ETAP98.3.6, 1998.
- Silverstein, J., "Demonstration of Biological Denitrification of Drinking Water for Rural Communities," Final Report, Vol 1, EPRI Project # WO-2662-84, 1997.
- Silverstein, J. and A. Baron, "Fiberoptic Oxygen Sensor for Mixed Waste Biological Treatment Oxygen Control," *Final Report, Colorado Advanced Materials Institute for Entrepreneurs' Technical Assistance Program (CAMI/ETAP)*, ETAP96.3.8, 1997.
- Silverstein, J., N.E. Cook, and L.A. Figueroa, "Denitrification of High-Nitrate and High Salinity Waste Brine by Activated Sludge," report to Dept. of Energy, Los Alamos, National Lab, 1995.
- Silverstein, J., N.E. Cook, and L.A. Figueroa, "Denitrification of Saltcrete Brine at Rocky Flats," (three volumes) *Final Report to EG&G/Rocky Flats, Inc.*, 1993.
- Center for Space Environmental Health, NASA Center for Research and Training: "Recycled Water Quality," (chapters in five annual reports), *NASA-NSCORT Program*, 1992-1996.
- Cook, N.E., J. Silverstein, B. Veydovec, M. deMendonça, and R. Sydney, "Field Demonstration of Biological Denitrification of Polluted Groundwater and Pilot Scale Field Testing of Biological

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Denitrification with Widely Varied Hydraulic Loading Rates," *Completion Report No. 162, Colorado Water Resources Research Institute, Fort Collins, CO*, 1991.

Silverstein, J., "Nitrification in Trickling Filter and a Rotating Biological Contactor at the Longmont [Colorado] Wastewater Treatment Plant," *Final Report to City of Longmont, CO*, 1990.

Cook, N.E. and J. Silverstein, "Biological Denitrification of Polluted Groundwater," *Completion Report No. 153, Colorado Water Resources Research Institute, Fort Collins, CO*, 1989.

Silverstein, J., "Aerated Static Pile Composting of Wastewater Sludge at the Longmont [Colorado] Wastewater Treatment Plant," *Final Report to City of Longmont, CO*, 1987.

Silverstein, J., "Addition of Waste Rice Hulls to Bricks," *Final Report to Adolph Coors Brewing Company*, 1987.

PATENT

Silverstein, J. (inventor), Univ. Colorado (owner), "Biological Denitrification of Water," U.S. (#5,681,471, Oct. 28, 1997) and international (European Patent Office, no. 97903788.4-2104, 10/8/98), currently licensed by Univ. Colorado to Meridian Water Corporation.

FIELD PILOT PLANT AND DEMONSTRATION STUDIES

Biofilm Denitrification Pilot Study, included slow sand filter post-treatment. Location: City of Brighton, Colorado, 1992-1994, Sponsor: Colorado Water Resources Research Institute. Capacity, 0.2 – 1 gpm.

Biofilm Denitrification Demonstration, included slow-sand filter post-treatment. Location: Wiggins, Colorado, 1996-1998, Sponsors: Electric Power Research Institute, National Rural Electric Coop Association, Colorado Department of Local Affairs, Nitrate Removal Technologies, LLC. Capacity: 10 – 20 gpm.

Assisted Nitrate Removal Technologies, LLC with subsequent pilot study by in Suffolk County, NY, including microfiltration post-treatment, and development of full-scale operating denitrification plant for drinking water treatment in Coyle, OK. Capacity: 27.5 gpm treated (55 gpm blended), including slow sand filter post-treatment. Developed pathogen-free inoculation method and evaluated the effect of carbon sources (1998-1999).

Biofilm Nitrification in Trickling Filters and Rotating Biological Contactors, Longmont Wastewater Treatment Plant, Sponsors: City of Longmont, Colorado Utilities Department. Capacity: 0.3 – 1 gpm. (1988-1990)

Wastewater Biosolids Aerated Static Pile Composting, Location: Longmont Wastewater Treatment Plant, Sponsor: City of Longmont, Colorado Utilities Department. Capacity: 50 DT/month. (1985-1987)

RESEARCH GRANTS

"Geomicrobial Strategy for Prevention of Acid Mine Drainage," PI (co-PI Hari Rajaram), NSF, \$196,000, 2005-2008.

"Perchlorate reduction in sewer conditions," PI, Geomatrix Engineering, \$30,800. 2005.

"Perchlorate Removal from Contaminated Groundwater." Co-PI with Gary Amy, Castaic Lake Water Agency, \$47,000, 2003-2004.

"Interactions between Microbial Nitrogen Cycling and Acid Mine Drainage Contaminants in Impacted Streams," PI. \$77,600, NSF, 2002-2004. (100%)

"Research Experience for Undergraduates in Environmental Engineering," PI. \$300,000. NSF. 2000-2004. (100%)

Silverstein, C.V.

- "Wastewater Bioprocessor Experiment Definition," \$275,000. NASA - Johnson Space Center NRA grant (1998-2000), co-PI.
- "Development of Safe and Rapid Biofilm Inoculation Protocol to Enhance Commercialization of Biological Processes for Drinking Water Treatment," PI, Colorado Advanced Materials Inst., Entrepreneurs' Tech. Assistance Program (CAMI/ETAP), \$74,000, 1997-98. (100%)
- "Bioremediation of Acid Mine Drainage," PI, Kennecott Copper, \$10,500, 1997-98. (100%)
- "Ammonia and Manganese Removal from Wastewater in a Nitrifying Trickling Filter," co-PI, City of Boulder, CO, \$25,000, (1997-98). (80%)
- "Fiberoptic Oxygen Sensor for Mixed Waste Biological Treatment Oxygen Control," PI, Colorado Advanced Materials Institute, Entrepreneurs' Technical Assistance Program (CAMI/ETAP), \$93,500, (1996-97). (100%)
- "Water Contaminant Distribution in Space Recycle Systems," co-PI, NASA Center of Research and Training (NSCORT) Center for Space Environmental Health, with CU Boulder, CU Health Sciences Center, Univ. Rochester Dept. Environmental Medicine, Martin-Marietta Aerospace Corp., \$5,500,000. (1991-96). (10%)
- "Biodegradation of Xenobiotic Organic Contaminants," PI, Faculty Award for Women Scientists and Engineers, NSF, \$250,000. (1992-97). (100%)
- "Denitrification of High Nitrate Strength Saltcrete Brine," Department of Energy, Los Alamos National Lab, PI, \$90,000 (5/94-10/95). (100%)
- "Drinking Water Denitrification Demonstration in a Rural Community," PI, Electric Power Research Institute (\$100,000), National Water Research Institute, \$51,000, Global Environmental Technologies, Inc. (\$22,500), State of Colorado Department of Local Affairs (\$35,000), Town of Wiggins, Colorado (\$2,500), Nitrate Removal Technologies, LLC (\$54,000) Morgan County Rural Electric Assoc. (in-kind, \$30,000), Tri-State Generating and Transmission Assoc., Inc. (in-kind, \$20,000) awarded May 1995, cash total: \$265,000, in-kind total: \$50,000 (5/94 - 10/97) (100%)
- "Biofouling of Membranes Used in Drinking Water Treatment," co-PI, Center for Separations Using Thin Films, (Univ. Colorado), \$105,000 (6/94 -6/97). (100%)
- "Denitrification of Solar Pond Water," PI, EG&G/Rocky Flats, \$175,000 (1992-93). (60%)
- "An Integrated Ozone Bioreactor System Versus Membrane Separation of DBP Precursors," PI, EPA Cooperative Research Agreement, \$536,000. (10/91-4/94). (33%)
- "Biodegradation of Organic Compounds in Water," PI, NSF, \$130,155 (1988-91). (60%)
- "Nitrification of Wastewater in Trickling Filter and Rotating Biological Contactor Processes," PI, City of Longmont, CO, \$225,000, (1988-90). (100%)
- "Denitrification of Contaminated Groundwater: Laboratory and Field Pilot Plant Studies," co-PI, Colorado Water Resources Research Institute, \$54,000, (1988-90). (100%)
- "Study of Sequencing Batch Reactor Wastewater Treatment Process in Bailey, CO," PI, KKBNA Engineering Consultants, \$5,000, (1987). (100%)
- "Aerated Static Pile Composting of Wastewater Sludge," PI, City of Longmont, CO, \$100,000, (1984-86). (75%)
- "Use of Waste Rice Hulls in Bricks," PI, Adolph Coors Brewing Co., \$25,000, (1985). (100%)
- "Measurement of Extracellular Polysaccharides in Activated Sludge Flocs," PI, Research Initiation Grant, NSF, \$54,000 (1983-85). (100%)

UNIVERSITY SERVICE

CEAE Department

- Chair, 2002 – 2010 (two terms)
- Executive Committee: 1998-2000 (representative from Environmental Engineering group), 1985-87.
- Personnel Committee, 1998-present

Silverstein, C.V.

- ABET 1999-2000 Directed Accreditation General Review Preparation Committee, 1998-99. Wrote Self-Study Report, Directed Outcomes Assessment for Environmental and Water Resources Engineering Track Curriculum, and coordinated Fall 1999 ABET visit under EC 2000 Rules.
- ABET: Wrote Interim Review Self-Study Report (summer 2001) and was liaison to ABET re-visit, fall 2001.
- Operations Committee, 1992-1998
- Curriculum Committee, 1987-91
- Graduate Committee, 1982-87.
- PRP Self-Study Committee, 1988-89.
- GAANN (Ph.D. Fellowship) Executive Committee, Chair, 1995-97.
- Search Committees: Environmental Engineering, chair, (1997, 1988, 1987); member, (1995, 1993, 1985). Member: Illumination Engineering (1998), Water Resources Engineering (1985, 1993), Geotechnical Engineering (1985), Structural Engineering (1984), Architectural Engineering/Building Systems (1986), Construction Engineering (1985)

College of Engineering

- Administrative Council (Dept. Chairs), 2002-present
- Faculty Advisory Board, Women in Engineering Program, 1993 - 1998
- Faculty Liaison, BioEngineering Program, 2001-2003
- Member, Vice Chancellor's Ad Hoc Committee for Dean Corotis' Performance Review, 1999.
- Search Committee for Dean of College of Engineering, 1995.
- Search Committee for Director, Women in Engineering Program, 1997.
- Search Committee for Assistant Director for Student Affairs, SEED (Minority Engineering), 1998 and 1999.
- Ad-hoc Committee on Women in Engineering Program, 1994.
- Faculty Advisory Board, Minority Engineering Program, 1990-92.
- Dean's Ad-hoc Committee on Minorities and Women in Engineering, 1986.
- Proposal Review, Joint Program for Biomedical Engineering, College of Engineering and Health Sciences Center, 1997.
- Assist on Proposal for Environmental Engineering BS Degree Program, 1996.
- High School Honors Institute, environmental engineering activity, Engineering Open House

Boulder Campus

- Boulder Campus Salary Equity Committee, 2007-present
- Vice Chancellor's Advisory Committee, 2004 - 2006
- Search Committee for Vice Chancellor for Research and Dean of the Graduate School 2006-2007
- Faculty Advisory Council, Center of the American West, 2001-present
- PRP-Internal Review Committee, Environmental Studies Program, 2001
- Vice-Chancellor's Program Review Panel, (Liaison and PRP Report preparation for Electrical and Computer Engineering, Chemical Engineering and Computer Science Departments) 1995-98.
- Committee on Graduate Research and Creative Work Awards, 1990-2001
- Hazardous Material Advisory Board, 1994-96, Chair, 1995-96.
- Vice-Chancellor's Salary Equity Committee, 1990-91.
- Boulder Faculty Assembly Comm. on Faculty Women, Chair, (member BFA Exec. Comm.) 1989-93.
- Search Committee for Director, Office of Intellectual Property Technology Transfer, 1995.
- Search Committee for Director, Residence Hall Academic Program in Environmental Science, 1997.

CU System

Silverstein, C.V.

- Emerging Leaders Program, 2005
- President's Council on Global Change and Environmental Sciences, 1993-95.
- System-wide Graduate School Committee, 1996-98

DIVERSITY

- Author of one book chapter and several papers on women and minorities in engineering
- Advisor/mentor to nine women doctorates in Civil Engineering from CU Boulder (two are Hispanic-American women) and one African-American man. Of these ten, five have gone on to teaching/research careers in universities where they in turn are mentoring women and minority students.
- Member of the first Faculty Advisory Board of Women in Engineering Program in the College of Engineering at the University of Colorado
- Faculty Advisory Board, Minority Engineering Program.
- Co-PI and Chair of Awards Committee, Graduate Assistantships in Areas of National Need (GAANN) grant from US Dept. Education, with focus to award fellowships to outstanding scholars in Civil Engineering who are also women and/or minority students. 9/18 GAANN Scholars were women; 1/18 was a minority (Hispanic-American) student.
- Member and Chair for six years, Boulder Faculty Assembly Committee on Faculty Women. Major activities: salary equity survey resulting in >\$100,000 in annual salary increases for women and minority faculty; report on women non-regular faculty at CU; parental leave policy for faculty.
- Vice Chancellor's Salary Equity Committee: evaluation of over 200 minority and women faculty vitae using method of comparison with 600 white male counterparts as well as statistical analysis to determine past discrimination and to recommend salary adjustments to alleviate.
- Member of Committee to prepare "Minority Graduate Education" program proposal to the National Science Foundation for CU Boulder.

PROFESSIONAL SERVICE

- Project Advisory Committee, Water Research Foundation (formerly AwwaRF) "Biological Denitrification Demonstration," Thornton, CO, 2008-2009.
- Project Advisory Committee, Water Research Foundation (formerly AwwaRF) "Biological Denitrification Demonstration," Glendale, AZ, 2008-2009.
- Member, Ad hoc Panel to review amicus brief on land application of biosolids in San Bernadino County, CA, Water Environment Federation, 2008.
- Member, standing Committee on Biological Treatment of Drinking Water, American Water Works Association, 2008-present.
- Liaison, Rocky Mountain Water and Wastewater Operators Short School.
- Chair, External Review Committee, Dept. Civil Engineering, Univ. Arizona, 2007.
- Membership Nominating Committee, American Academy of Environmental Engineers, 2006 – present.
- Research Advisory Board, *National Water Research Institute*, 1995 - present
- Board of Directors, *Assoc. Environ. Engineering Professors*, 1994-1997 (Secretary, 1994-1996)
- *National Research Council*, Committee to Evaluate the Use of Treated Municipal Wastewater Effluents and Sludge in the Production of Crops for Human Consumption, 1994-1996
- Technical Advisory Board, *Teledyne Water Pik Company*, Fort Collins, CO, 1994-1996
- External Peer Review Committee, *Rockwell Corp. and EG&G/Rocky Flats*, reports on feasibility of methods for mixed waste disposal for Federal Facilities Compliance Agreement, 1988-89.
- Technical Advisor, *City of Boulder, Colorado Biosolids Study Review Group*, 1996-1997

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- Technical Advisor, *City of Broomfield, Colorado*, Wastewater Facilities Plan, 1998.
- Expert testimony, Land Application of Biosolids, *Colo. Water Quality Control Commission*, 1997.
- Expert testimony, Land Application of Biosolids, *Joint Legislative Committee on Agriculture, Natural Resources and Energy, Colorado General Assembly*, 1998.
- Chair, *Current Research* session, WEF Biosolids Management Conf., Denver, CO, 1995.
- Organizing Committee, ASCE Environ. Eng. Div. National Conf., Boulder, CO, 1994.
- Peer Review (1983-present).
PROPOSALS: National Science Foundation (mail and panels: CAREER, IGERT, PIRE, SBIR, GRFP, CBET, S&T Center), USAID, Colorado, Wyoming and National Water Research Centers (USGS and Dept. Interior), National Water Research Institute, Water Environment Research Foundation, NY Solid Waste and Combustion Research Center
JOURNALS: *J. Environ. Eng. (ASCE)*, *Wat. Res.*, *Wat. Environ. Res.*, *Environ. Sci. Tech.*, *Wat. Sci. Tech.*, *J. Separ. Sci.*, *Environ. Prog.*, *Aquaculture Eng.*, *Biotechnology & Bioengineering*.

PROFESSIONAL SOCIETIES

- American Academy of Environmental Engineers
- Tau Beta Pi
- Chi Epsilon
- Phi Kappa Phi
- Sigma Xi
- Society of Women Engineers
- Association of Environmental Engineering and Science Professors
- American Society of Civil Engineers
- Water Environment Federation
- International Water Association
- American Society for Microbiology
- American Water Works Association

ENGINEERING CONSULTING

- National Water Research Institute* Blue Ribbon Panel to Review Nitrogen and Selenium Management Program, Count of Orange, California, 2006.
- National Water Research Institute* Panel to Review Santa Clarita Valley Joint Sewerage System Chloride Source Report, Sanitation Districts of Los Angeles County, October 2002.
- Aquatic Environmental Services*. Evaluation of Pinery Wastewater Treatment Plant, Douglas County, CO.
- Eldorado Springs Water Initiative*. Evaluation of Wastewater Collections and Treatment Alternatives for the Eldorado Springs community.
- US Air Force*. Develop Operations to Improve Nitrification and Denitrification at USAF Academy Wastewater Treatment Plant.
- Cornish Consultants*. Evaluation of Temperature Phased Anaerobic Digestion for a 100-MGD Treatment Plant.
- David Evans & Assoc.* Evaluation of US Air Force Academy wastewater treatment process performance and recommendations for improvements.*
- NSF, International (Washington, DC)*, development of test protocol for package biological processes for drinking water treatment to remove nitrate.*
- Nitrate Removal Technologies, LLC (Golden, Colorado)* Commercialization of patented drinking water denitrification process.*

Silverstein, C.V.

San Gabriel Basin Water Quality Authority (West Covina, California), Feasibility of biofilm denitrification process for destruction of perchlorate contaminant in drinking water wells.
Aquatic Environmental Services, (Boulder, Colorado), wastewater treatment facility audit of Bardenpho-type activated sludge system at the Pinery, Colorado.*

GRADUATE STUDENT RESEARCHER SUPERVISION

Principal Advisor or co-advisor to 22 Ph.D. students and 50 MS thesis students who completed degrees (1989-2007), Currently advising 3 Ph.D. students. Director and PI, NSF-sponsored Research Experience for Undergraduates Program (1999-2004), sponsored 40 undergraduate summer research interns.

COURSES TAUGHT

Undergraduate: Introduction to Environmental Engineering, Water and Wastewater Treatment, Thermodynamics, Environmental Engineering Design Capstone Course, Introduction to Civil Engineering, Water Quality Lab.

Graduate: Biological Wastewater Treatment, Pilot Plant Laboratory, Aquatic Chemistry, Hazardous/Industrial Waste Management, Drinking Water Treatment.

CURRICULUM VITAE

ROBERT G. ARNOLD

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University of Arizona
Tucson, Arizona 85721
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EDUCATION:

1986 Ph.D. California Institute of Technology
Pasadena, California

Thesis: "Dissimilative Fe(III) Reduction by Pseudomonas sp. 200",
345 pp. Advisor: Michael R. Hoffmann

1976 MSEE University of North Carolina
Chapel Hill, North Carolina

Thesis: "Optimization of Unit Processes for Sulfide Removal from the
Municipal Groundwater Supply at Roper, North Carolina", 139 pp.
Advisor: Philip C. Singer.

1969 BSME United States Naval Academy, Annapolis, Maryland

EMPLOYMENT:

1997-Present Professor
Department of Chemical and Environmental Engineering
The University of Arizona, Tucson, Arizona

1992-1997 Associate Professor
Department of Chemical and Environmental Engineering
The University of Arizona, Tucson, Arizona

1986-1992 Assistant Professor
Department of Civil Engineering and Engineering Mechanics
The University of Arizona, Tucson, Arizona

1977-1981 Environmental Engineer
County Sanitation Districts of Los Angeles County

1969-1974 Military Service, U.S. Naval Officer

REGISTRATION: State of California Civil Engineer
License No. C031415

PROFESSIONAL HONORS:

- 1987 National Science Foundation
Presidential Young Investigator
- 1989 "Outstanding Faculty Member--Civil Engineering," 1989--awarded
annually by University of Arizona Civil Engineering undergraduates.
- 1992 Quentin Mees award recipient for research. Annual award for research in
environmental engineering from the Arizona Water and Pollution Control
Association.
- 2002 Quentin Mees award recipient for research.

PROFESSIONAL SERVICE:

- 1996-2002 Associate editor and/or editor-in-chief for ASCE *Journal of
Environmental Engineering*.
- 2000-present Member, Water Environment Research Foundation Research Council
- 2002-present Member, Water Reuse Foundation's Research Advisory Council

PEER-REVIEWED PUBLICATIONS

- Willinger, M., E. Rupp, B. Barbaris, S. Gao, R. Arnold, E. Betterton, and A. Saez. 2009.
Thermocatalytic destruction of gas-phase perchloroethylene using propane as a hydrogen
source. Journal of Hazardous Materials. 167:770-776.
- Gao, S., E. Rupp., S. Bell, M. Willinger, *et al.* 2008. Mixed redox catalytic destruction of
chlorinated solvents in soils and groundwater: from the laboratory to the field. Annals of the
New York Academy of Sciences. 1140:435-445.
- Arnold, R. and K. Arnold. Accepted for publication, 2008. Integrated Urban Water
Management in the Tucson, Arizona Metropolitan Area. UNESCO.
- Teske, S. and R. Arnold. 2008. Removal of natural and xeno-estrogens during conventional
wastewater treatment. Rev Environ Sci Biotechnol. 7:107-124.

Arnold, R., S. Teske, M. Tomanek, J. Engstrom, C. Leung, *et al.* Accepted for publication, 2008. Fate of polybrominated diphenyl ethers during wastewater treatment/polishing and sludge stabilization/disposal. *Annals of the New York Academy of Sciences*.

Zhang, J., M. Tomanek, H. Dong, R. Arnold, *et al.* 2008. Fate of polybrominated diphenyl ethers, nonylphenol, and estrogenic activity during managed infiltration of wastewater effluent. *J Environ Engr.* 134(6): 433-442.

Orbay, O., S. Gao, B. Barbaris, E. Rupp, E. Saez, R. Arnold and E. Betterton. 2007. Catalytic dechlorination of gas-phase perchloroethylene under mixed redox conditions. *Appl. Catalysis (B Environmental)*. Science Direct at www.sciencedirect.com.

Arnold, Carpenter, Kirk, Koh, Armour, Cebrian, *et al.* 2007. Meeting Report: Threats to human health and environmental sustainability in the Pacific Basin. *Environ. Health Perspect.* 115: 1770-1775.

Conroy, O., A.E. Saez, D. Quanrud, W.P. Ela and R.G. Arnold. 2007. Changes in estrogen/anti-estrogen activities in ponded secondary effluent. *Sci. Total Environ.* 382: 311-323.

Miller, J.H., W.P. Ela, K.E. Lansey, P.L. Chipello and R.G. Arnold. 2006. Nitrogen transformations during soil-aquifer treatment of wastewater effluent – oxygen effects in field studies. *J. Environ. Engr.* 132(10): 1298-1306.

Quast, K., K. Lansey and R. Arnold. 2006. Boron isotopes as artificial tracers. *Ground Water* 44: 453-466.

De Las Casas, C.L., K.G. Bishop, L.M. Bercik, M. Johnson, M. Potzler, W.P. Ela, A.E. Saez, S.G. Huling and R.G. Arnold. 2006. In-place regeneration of granular activated carbon using Fenton's reagents. In: *Innovative Approaches for the Remediation of Subsurface Contaminated Hazardous Waste Sites: Bridging Flask and Field Scales*, ACS Symposium Series 940: 43-65.

Ju, X., M. Hecht, R.A. Galhotra, W.P. Ela, E.A. Betterton, R.G. Arnold and A.E. Saez. 2006. Destruction of gas-phase trichloroethylene in a modified fuel cell. *Environ. Sci. Technol.* 40: 612-617.

Conroy, O., D.M. Quanrud, W.P. Ela, D. Wicke, K.E. Lansey and R.G. Arnold. 2005. Fate of wastewater effluent hER-agonists and –antagonists during soil aquifer treatment. *Environ. Sci. Technol.* 39: 2287-2293.

Huling, S.G., P.K. Jones, W.P. Ela and R.G. Arnold. 2005. Repeated reductive and oxidative treatments of granular activated carbon. *J. Environ. Engr.* 131: 287-297.

- Li, H., E.A. Betterton, R.G. Arnold, W.P. Ela, B. Barbaris and C. Grachane. 2005. Convenient new chemical actinometer based on aqueous acetone, 2-propanol, and carbon tetrachloride. Environ. Sci. Technol. 39: 2262-2266.
- He, J., R.G. Arnold, A.E. Saez, E.A. Betterton and W.P. Ela. 2004. Removal of aqueous phase TCE using membrane air stripping contactors. ASCE, Journal of Environmental Engineering. 130: 1232-1241.
-
- He, J., W.P. Ela, E.A. Betterton, R.G. Arnold and A.E. Saez. 2004. Reductive dehalogenation of aqueous-phase chlorinated hydrocarbons in an electrochemical reactor. Ind. Eng. Chem Res. 43: 7965-7974.
- Li, H., R.G. Arnold, E.A. Betterton, W.P. Ela and B. Barbaris. 2004. Comment on "The mechanisms of rate enhancing and quenching trichloroethene photodecay in the presence of sensitizer and hydrogen sources" Water Research. 38: 2791-2792.
- Quanrud, D.M., K. Quast, O. Conroy, M.M. Karpiscak, C.P. Gerba, K.E. Lansey, W.P. Ela and R.G. Arnold. In press 2004. Estrogenic activity and volume fraction of wastewater origin in monitoring wells along the Santa Cruz River, Arizona. Ground Water Monitoring and Remediation, 24(2): 86-93.
- Quanrud, D.M., O. Conroy, D. Wilke, G. Seidel, W. Ela, P. Littlehat, G. Gerba, K. Lansey and R.G. Arnold. Accepted for publication, 2004. Comparison of *in vitro* methods for measurement of estrogenic effects in treated wastewater. Journal of Water and Health.
- He, J., A.E. Sáez, W.P. Ela, E.A. Betterton and R.G. Arnold, 2004. Destruction of aqueous phase carbon tetrachloride in an electrochemical reactor with a porous cathode. Industrial Engineering Chemistry Research. 43:913-923.
- Quanrud, D.M., M.M. Karpiscak, K.E. Lansey and R.G. Arnold, 2004. Transformation of effluent organic matter during subsurface wetland treatment in the Sonoran Desert. Chemosphere. 54(6):777-788.
- Kommineni, S., W.P. Ela, R.G. Arnold, S.G. Huling, B.J. Hester, and E.A. Betterton, 2003. NDMA treatment by sequential GAC adsorption and Fenton-driven destruction. Environmental Engineering Science. 20(4):361-373.
- Quanrud, D.M., J. Hafer, M. Karpiscak, J. Zhang, K. Lansey and R. Arnold, 2003. Fate of organics during SAT: sustainability of removals in the field. Water Research. 37(14):3401-3411.
- Quanrud, D.M., S. Carroll, C.P. Gerba and R.G. Arnold, 2003. Virus removal during simulated SAT. Water Research. 37(4):753-762.

- Quanrud, D., R. Arnold, K. Lansey, C. Begay, W. Ela and A.J. Gandolfi, 2003. Fate of organics during soil aquifer treatment: biodegradability, chlorine reactivity, and genotoxicity. Journal of Water and Health. 01(1):33-44.
- Chen, G., E. Betterton, R. Arnold and W. Ela, 2003. Electrolytic reduction of TCE and CHCl_3 at Pt-or Pt-coated ceramic electrode. Journal of Applied Electrochemistry. 33:161-169.
- Quanrud, D., K. Lansey and R. Arnold, 2002. Fate of organics during SAT: fractionation and chemical characterization studies. Water Research.
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- Liu, Z., R. Arnold, E. Betterton, E. Smotkin, 2001. Reductive dehalogenation of gas-phase chlorinated solvents using a modified fuel cell. Environ. Sci. Technol. 35:4320-4326.
- Huling, S.G., R. Arnold, R. Sierka and M.R. Miller, 2001. Influence of peat on Fenton oxidation. Water Res. 35(7):1687-1694.
- Quanrud, D.M., M.M Karpiscak, K.E. Lansey and R.G. Arnold, 2001. Behavior of organic carbon during subsurface wetland treatment in the Sonoran desert. Water Science & Technology. 44(11/12):267-272.
- Holland, N., R.G. Arnold, E.A. Betterton, S. Gogosha, K. McKim, and Z. Liu, 2000. Acetone-photosensitized reduction of carbon tetrachloride by 2-propanol in aqueous solution. Environ. Sci. Technol. 34:1229-1233.
- Huling, S.G., R.G. Arnold, P.K. Jones and R.A. Sierka, 2000. Predicting Fenton-driven degradation using a contaminant analog. J. Environ. Engr. 126:348-353.
- Liu, Z., E.A. Betterton and R.G. Arnold, 2000. Electrolytic reduction of low molecular weight chlorinated aliphatic compounds: structural and thermodynamic effects on process kinetics. Environ. Sci. Technol. 34:804-811.
- Chen, G., E.A. Betterton and R.G. Arnold, 1999. Electrolytic oxidation of trichloroethylene using a ceramic electrode. J. Appl. Electrochem. 29:961-970.
- Liu, Z., R.G. Arnold, E.A. Betterton and K.D. Festa, 1999. Electrolytic reduction of CCl_4 — effects of cathode material and potential on kinetics, selectivity and product stoichiometry. Environ. Engineering. Sci. 16:1-13.
- Baygents, J.C., J.R. Glynn, O. Albinger, B.K. Biesemeyer, K.L. Ogden and R.G. Arnold, 1998. Variation in surface charge density in monoclonal bacteria populations: implications for transport through porous media. Environ. Sci. Technol. 32:1596-1603.
- Betterton, E.A., R.G. Arnold, Z. Liu, I. Diaz and G. Chen, 1998. Electrolytic systems for the treatment of solvent-contaminated water. J. Haz. Subst. Res. Internet. <http://www.engg.ksu.edu/HSR/JHSR/mainarea.shtml>.

- Glynn, J.R., B.M. Belongia, R.G. Arnold, K.L. Ogden and J. C. Baygents, 1998. Capillary electrophoresis measurements of electrophoretic mobility for colloidal particles of biological interest. Appl. Environ. Microbiol. 64:2572-2577.
- Huling, S.G., R.G. Arnold, R.A. Sierka and M.R. Miller, 1998. Measurement of hydroxyl radical activity in a soil slurry. Environ. Sci. Technol. 32:3436-3441.
- Tellez, C.M., K.P. Gaus, D.W. Graham, R.G. Arnold and R.Z. Guzman, 1998. Isolation of copper biochelates from *Methylosinus trichosporium* 0B3b and soluble methane monooxygenase mutants. Appl. Environ. Microbiol. 64:1115-1122.
- Logan, B.E., D. Jewett, R. Arnold, E. Bouwer and C. O'Melia, 1997. Closure to: Clarification of clean-bed filtration models. ASCE Journal of Environmental Engineering.
- Betterton, E.A., R. Arnold, J. Liu, I. Diaz, and G. Chen, 1997. Electrolytic Systems for the Treatment of Solvent-contaminated groundwaters. Journal of Hazardous Substances Research.
- Amy, G., J. DeBroux, R. Arnold and L. Wilson, 1996. Preozonation for enhancing the biodegradability of wastewater effluent in a potable-recovery soil-aquifer treatment system. Revue des Sciences de L'eau.
- Martin, M.M., B.E. Logan, W.P. Johnson, D.G. Jewett and R.G. Arnold, 1996. Scaling bacterial filtration rates in different sized porous media. ASCE Journal of Environmental Engineering. 122:407-415.
- Quanrud, D.M., R.G. Arnold, L.G. Wilson, H.J. Gordon, D.W. Graham and G.L. Amy, 1996. Fate of organics during soil aquifer treatment of secondary effluent. ASCE Journal of Environmental Engineering. 122:314-321.
- Picardal, F., R.G. Arnold and B.B. Huey, 1995. Effects of electron donor and acceptor conditions on reductive dehalogenation of tetrachloromethane by *Shewanella putrefaciens* 200. Applied Environmental Microbiology. 61:8-12.
- Rusin, P., J. Cassells, L. Quintana, R. Arnold and N. Chrisman, 1995. Elimination of toxic factors in leachate to enhance biooxidation of sulfide ores. Mining Engineering. 173-178.
- McCaulou, D.R., R.C. Bales and R.G. Arnold, 1995. Effect of temperature-controlled motility on transport of bacteria and microspheres through saturated media. Water Resources Research. 31:271-280.
- Padival, N.A., J.S. Weiss and R.G. Arnold, 1995. Control of *Thiobacillus* by means of microbial competition: Implications for corrosion of concrete sewers. Journal of Water Environment Research. 67:201-205.

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- Warren, K.D., R.G. Arnold, T.L. Bishop, L.C. Lindholm and E.J. Betterton, 1995. Kinetics and mechanism of reductive dehalogenation of carbon tetrachloride using zero-valence metals. Journal of Hazardous Materials. 41:217-227.
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- Betterton, E.A., R.G. Arnold, R.J. Kuhler and G.A. Santo, 1995. Reductive dehalogenation of bromoform in aqueous solution. Environmental Health Perspectives. 103:supplement 5; 89-91.
- Gross, M.J., O. Albinger, D.G. Jewett, B.E. Logan, R.C. Bales and R.G. Arnold, 1995. Measurement of bacterial collision efficiencies in porous media. Water Research. 29:1151-1158.
- Enzien, M.V., F. Picardal, T.C. Hazen, R.G. Arnold and C.B. Fliermans, 1994. Reductive dechlorination of trichloroethylene and tetrachloroethylene under aerobic conditions in a sediment column. Applied Environmental Microbiology. 60:2200-2204.
- Albinger, O., B.K. Biesemeyer, R.G. Arnold and B.E. Logan, 1994. Effect of bacterial heterogeneity on adhesion to uniform collectors by monoclonal populations. FEMS Microbiol. Lett. 124:321-326.
- Neilson, J.W., K.L. Josephson, I.L. Pepper, R.G. Arnold, G.D. DiGiovanni and N.A. Sinclair, 1994. Frequency of horizontal gene transfer of a large catabolic plasmid (pJP4) in soil. Applied Environmental Microbiology. 60:4053-4058.
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- Jewett, D.G., R.C. Bales, B.E. Logan and R.G. Arnold, 1993. Comment on application of clean-bed filtration theory to bacterial deposition in porous media. Environmental Science and Technology. 27:984-985
- Logan, B.E., T.A. Hilbert and R.G. Arnold, 1993. Removal of bacteria in laboratory filters: models and experiments. Water Research. 27:955-962.
- Kuhler, R.J., G.A. Santo, T.R. Caudill, E.A. Betterton and R.G. Arnold, 1993. Photoreductive dehalogenation of bromoform with TiO₂-cobalt macrocycle hybrid catalysts. Environmental Science and Technology. 27:2104-2111.

- Picardal, F.W., R.G. Arnold, H. Couch, A.M. Little and M.E. Smith, 1993. Involvement of cytochromes in the anaerobic biotransformation of tetrachloromethane by *Shewanella putrefaciens* 200. Applied and Environmental Microbiology.
- Fitch, M.W., D.W. Graham, R.G. Arnold, S.K. Agarwal, P. Phelps, G.E. Speitel and G. Georgiou, 1993. Phenotypic characterization of copper-resistant mutants of *Methylosinus trichosporium* OB3b. Applied and Environmental Microbiology. 59:2771-2776.
- Graham, D.W., J.A. Chaudhary, R.S. Hanson and R.G. Arnold, 1993. Factors affecting competition between type I and type II methanotrophs in two-organism, continuous-flow reactors. Microbial Ecology. 25:1-17.
- Jewett, D.G., B.E. Logan, R.G. Arnold and R.C. Bales, 1992. Error analysis of collision efficiency and quantification of column study results. EOS, Transactions, American Geophysical Union Fall Meeting, 73(43):166.
- Rusin, P., J. Cassells, J. Sharp, R. Arnold and N.A. Sinclair, 1992. Bioprocessing of refractory ores by bioreduction: extraction of silver, molybdenum, and copper. Mineral Engineering. 5:1345-1354.
- Rusin, P.A., J. Sharp, R.G. Arnold, N.A. Sinclair and T. Young, 1992. Enhanced recovery of silver and other metals from refractory oxide ores through bioreduction. Mining Engineering. 1467-1472.
- Rusin, P., L. Quintana, N.A. Sinclair, R.G. Arnold and K.L. Ogden, 1992. Physiology and kinetics of manganese-reducing *Bacillus polymyxa* strain D1 isolated from manganeseiferous silver ore. Geomicrobiology Journal. 9:13-25.
- Graham, D.W., D.G. Korich, N.A. Sinclair and R.G. Arnold, 1992. Application of a colorimetric assay procedure for the isolation of sMMO-bearing methanotrophs. Applied and Environmental Microbiology. 58:2231-2236.
- *Arnold, R.G., M.R. Hoffmann, T.J. DiChristina and F.W. Picardal, 1991. Regulation of dissimilative Fe(III) reduction in *Shewanella putrefaciens*. Applied and Environmental Microbiology. 63:789-798.
- Morton, R.L., W.A. Yanko, D.W. Graham and R.G. Arnold, 1991. Relationships between sewage quality and crown corrosion in Los Angeles County sewers. Metal concentrations and sulfate reduction. Research Journal of the Water Pollution Control Federation. 63:789-790.
- Logan, B.E., A. Steele and R.G. Arnold, 1989. Computer simulation of DDT distribution in Palos Verdes shelf sediments. ASCE, Journal of Environmental Engineering. 115:221-238.

Logan, B.E., R.G. Arnold and A. Steele, Computer simulation of DDT distribution in Palos Verdes shelf sediments. In: Contaminated Marine Sediments--Assessment and Remediation, Marine Board, NRC, National Academy Press, Washington, D.C., 1989.

Pill, K.G., G.E. Kupillas, F. Picardal and R.G. Arnold, 1991. Estimating the toxicity of chlorinated organic compounds using a multiparameter bacterial assay. Environmental Toxicology and Water Quality. 6:271-291.

Kupillas, G.E., K.G. Pill, F. Picardal and R.G. Arnold, 1991. A multiparameter chemical toxicity test using *Salmonella typhimurium* and *Spirochaeta aurantia*. Environmental Toxicology and Water Quality. 6:293-308.

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DiChristina, T.J., R.G. Arnold, M.E. Lidstrom and M.R. Hoffmann, 1988. Genetic basis of dissimilative iron reduction. Proceedings for International Association for Water Pollution Research and Control, Winter 1988.

Kupillas, G.E. and R.G. Arnold. A multiparameter toxicity test using *Salmonella typhimurium*. Proceedings of the 15th Annual Aquatic Toxicity Workshop in Montreal, 1988.

DiChristina, T.J., R.G. Arnold, M.E. Lidstrom and M.R. Hoffmann, 1988. Dissimilative iron reduction by marine *Eubacterium Alteromonas putrefaciens* strain 200. Wat. Sci. Tech. 20:69-79.

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RESEARCH IN PROGRESS

I am involved in ongoing research in the following areas:

1. ***Abiotic and biochemical catalysis of reductive dehalogenation.*** Heavily halogenated aliphatic contaminants such as perchloroethene, carbon tetrachloride and (to an extent) trichloroethene generally resist aerobic transformation mechanisms. The same compounds, however, are generally amenable to reductive transformations that yield less halogenated homologues. The several mechanisms of reductive dehalogenation are incompletely known. Mechanistic studies and dehalogenating systems under development in this laboratory follow:
 - i. Treatment of contaminated gas streams containing semi-volatile chlorinated solvents using a membrane electrode assembly (modified fuel cell apparatus).
 - ii. Electrolytic transformation of aqueous-phase chlorinated solvents.
 - iii. Catalyzed thermochemical destruction of gas-phase solvents.
 - iv. Photocatalytic, two-solvent systems consisting of acetone, isopropanol and the halogenated targets for reductive transformation reactions.
2. ***Oxidation of hazardous organic compounds in soils using H₂O₂ and Fenton-derived hydroxyl radicals.*** Research includes methods for quantifying radical production in environmental samples; utilization of Fenton-driven systems for in-place recovery of spent activated carbon.
3. ***Engineered systems leading to water reuse following infiltration and aquifer storage – the effect of soil-aquifer treatment on organic residuals, available nitrogen forms and pathogens in treated municipal wastewaters.*** Current research emphasis is on the fate of estrogenic and other endocrine disrupting compounds during wastewater treatment processes, biosolids handling and disposal, and effluent polishing operations.
4. ***Trace organic chemicals in products derived from wastewater treatment – reclaimed water and biosolids.*** Current research emphasis is on endocrine disrupting compounds and measurement of EDC activity in chemically complex environmental samples.
5. ***Engineering methods for minimum-cost salt removal from public water sources.*** Ongoing work is designed to establish the feasibility of salt management methods that are affordable in southwestern communities. Emphasis is an optimization of reverse osmosis (for maximum water recovery) and brine disposal.