

## General Biographical Information

### MARK M. BENJAMIN

Professor of Civil Engineering  
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## Academic Background

Ph.D.	Stanford University	Civil Engineering	1978
M.S.	Stanford University	Chemical Engineering	1973
B.S.	Carnegie-Mellon University	Chemical Engineering	1972

## Professional History

Professor, Department of Civil Engineering, Environmental Engineering & Science Program, University of Washington, Seattle, WA; 1989-2016 (Professor Emeritus, 2016-present).

Associate Professor, Department of Civil Engineering, Environmental Engineering & Science Program, University of Washington. Seattle, WA, 1983-1989.

Assistant Professor, Department of Civil Engineering, Environmental Engineering & Science Program, University of Washington, Seattle, WA, 1978-1983.

Visiting Professor, Department of Chemistry, University of Costa Rica, San Jose, Costa Rica, 1985-1986.

Visiting Professor, Department of Environmental Sciences, Hebrew University, Jerusalem, Israel, 1992-1993.

Visiting Professor, Department of Civil and Environmental Engineering, University of New South Wales, Sydney, Australia, 2000, 2009-10.

## Refereed Journal Publications

Benjamin, M.M. and Leckie, J.O. "Multiple-site adsorption of Cd, Cu, Zn, and Pb on amorphous iron oxyhydroxide," *J. Colloid Interface Sci.* 79:209-221 (1981).

Benjamin, M.M. and Leckie, J.O. "Competitive adsorption of Cd,Cu, Zn, and Pb, on amorphous iron oxyhydroxide," *J. Colloid Interface Sci.* 83:410-419 (1981).

- Benjamin, M.M. and Leckie, J.O. "A conceptual model for metal-ligand-surface interactions during adsorption," *Environ. Sci. Technol.* 15:1050-1057 (1981).
- Benjamin, M.M. and Felmy A. "Trace metal exchange between ferromanganese nodules and artificial seawater," *Marine Mining*, 3:151-183 (1981).
- Benjamin, M.M. and Leckie, J.O. "Effects of complexation by Cl, SO<sub>4</sub> and S<sub>2</sub>O<sub>3</sub> on adsorption behavior of Cd on oxide surfaces," *Environ. Sci. Technol.* 16, 3:162-170 (1982).
- Benjamin, M.M., Ferguson, J.F. and Buggins, M.E. "Treatment of sulfite evaporator condensate with an anaerobic filter," *TAPPI J.* 65:96-102 (1982).
- Herrera, C., Ferguson, J.F. and Benjamin, M.M. "Evaluation of the potential for contamination of drinking water from the corrosion of tin/antimony solder," *JAWWA* 74:368-375 (1982).
- Benjamin, M.M., Hayes, K.F. and Leckie, J.O. "Removal of toxic metals from power generation waste streams by adsorption and co-precipitation," *Water Poll. Control Fed. J.* 54:1472-1481 (1982).
- Benjamin, M.M. "Adsorption and surface precipitation of metals on amorphous iron oxyhydroxide," *Environ. Sci. Technol.* 17:686-692 (1983).
- Eis, B.J., Ferguson, J.F. and Benjamin, M.M. "The fate and effect of bisulfite in anaerobic treatment," *Water Poll. Control Fed. J.* 55:1355-1365 (1983).
- Ferguson, J.F., Eis, B.J., and Benjamin, M.M. "Neutralization in anaerobic treatment of an acidic waste," *Water Research* 18:573-580 (1983).
- Benjamin, M.M., Woods, S.L., and Ferguson, J.F. "Anaerobic toxicity and degradability of pulp mill waste constituents," *Water Research* 18:601-608 (1983).
- Hendrickson, K.J., Benjamin, M.M., Ferguson, J.F., and Goebel, L. "Removal of silver and mercury from chemical oxygen demand waste," *Water Poll. Control Fed. J.* 56:468-473 (1984).
- Anderson, P.A., and Benjamin, M.M. "Effects of silicon on the crystallization and adsorption properties of ferric oxides," *Environ. Sci. Technol.* 19:1048-1053 (1985).
- Nitchals, D.R., Benjamin, M.M., and Ferguson, J.F. "Combined anaerobic treatment of two waste streams from the sulfite pulping process," *Water Poll. Control Fed. J.* 57:253-262 (1985).
- Stone, A.B., Spyridakis, D.E., Benjamin, M.M., Ferguson, J.F., Reiber, S. and Osterhus, S. "The effects of short-term changes in water quality on copper and zinc corrosion rates," *JAWWA* 79:75-82 (1987).
- Schultz, M.F., Benjamin, M.M. and Ferguson, J.F. "Desorption of metals from ferrihydrite: Desorption kinetics and properties of the regenerated solid," *Environ. Sci. Technol.* 21:863-869 (1987).

Reiber, S.H., Ferguson, J.F., and Benjamin, M.M. "Corrosion monitoring and control in the Pacific Northwest," *JAWWA* 79:71-74 (1987).

Nordqvist, K.R., M.M. Benjamin, and J.F. Ferguson (1988) Effects of cyanide and polyphosphates on the adsorption of metals from simulated and real mixed-metal plating wastes, *Water Research*, Vol. 22, 837-846.

Reiber, S.H., J.F. Ferguson, and M.M. Benjamin (1988) An improved method for corrosion rate measurement by weight loss, *J. Amer. Water Works Assn.*, Vol. 80, No. 11, 41-46.

Woods, S., J.F. Ferguson, and M.M. Benjamin (1989) Characterization of chlorophenol and chloromethoxybenzene biodegradation during anaerobic treatment, *Environ. Sci. Technol.*, Vol. 23, 62-68.

Edwards, M. and M.M. Benjamin (1989) Regeneration and reuse of iron hydroxide adsorbents in treatment of metal bearing wastes, *J. Water Poll. Control Fed.*, Vol. 61, 481-490.

Edwards, M. and M.M. Benjamin (1989) Adsorptive filtration using coated sand: A new approach for treatment of metal-bearing wastes, *J. Water Poll. Control Fed.* Vol. 61, 1523-1533.

Paulson, A.J., M.M. Benjamin, and J.F. Ferguson (1989) Zinc solubility in low carbonate solutions, *Water Research*, Vol. 23, 1563-1569.

Puhakka, J.A., J.F. Ferguson, M.M. Benjamin, and M. Salkinoja-Salonen (1989) Sulfur reduction and inhibition in anaerobic treatment of simulated pulp mill wastewater, *System. Appl. Microbiol.*, Vol. 11, 202-206.

Lin, C-F. and M.M. Benjamin (1990) Dissolution kinetics of minerals in the presence of sorbing and complexing ligands, *Environ. Sci. Technol.*, Vol. 24, 126-134.

Anderson, P.A. and M.M. Benjamin (1990) Surface and bulk characteristics of binary oxide suspensions, *Environ. Sci. Technol.*, Vol. 24, 692-698.

Edwards, J.D. and M.M. Benjamin (1990) Diffusion dialysis for the recovery of acid from concentrated process solutions: The importance of chemical speciation, *Environ. Sci. Technol.* Vol. 24, 880-885.

Puhakka, J.A. M.M. Benjamin, J.F. Ferguson, and M. Salkinoja-Salonen (1990) Effect of molybdate ions on methanation of simulated and natural wastewater, *Appl. Microbiol. Biotechnol.*, Vol. 32, 494-498.

Puhakka, J.A., M. Salkinoja-Salonen, J.F. Ferguson, and M.M. Benjamin (1990) Carbon flow in acetoclastic enrichment cultures from pulp mill effluent treatment, *Water Research*, Vol. 24, 515-519.

Anderson, P.A. and M.M. Benjamin (1990) Modeling adsorption in aluminum-iron binary oxide suspensions, *Environ. Sci. Technol.*, Vol. 24, 1586-1592.

Edwards, M. and M.M. Benjamin (1991) A mechanistic study of ozone-induced particle destabilization, *JAWWA*, Vol. 83, No. 6, 96-105.

Edwards, M. and M.M. Benjamin (1992) The transformation of natural organic matter by ozone and its effect on iron and aluminum solubility, *JAWWA*, Vol. 84, No. 6, 56-66.

Lin, C-F. and M.M. Benjamin (1992) The effects of polyphosphate on the adsorption of metal ions onto ferrihydrite, *Water Res.*, Vol. 26, 397-407.

Edwards, M. and M.M. Benjamin. (1992) The effect of pre-ozonation on coagulant-natural organic matter interactions, *JAWWA* , Vol. 84, No. 8, 63-72.

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Labib, F., J.F. Ferguson, M. Benjamin, M. Merigh, and N.L. Ricker (1993) Mathematical modeling of an anaerobic butyrate degrading consortia: predicting their response to organic overloads, *EST*, Vol. 27, 2673-2684.

Bailey R.P., Bennett T., and Benjamin M.M. (1992) Sorption onto and recovery of Cr(VI) using iron-oxide-coated sand. *Water Sci. Technol.* Vol. 26(5-6), 1239-1244.

Edwards, M., M. Boller, and M.M. Benjamin (1993) Effect of pre-ozonation on removal of organic matter during water treatment plant operations, *Water Sci. Technol.*, Vol. 27, No. 11, 37-45.

Stenkamp, V.S. and M.M. Benjamin (1994) Effect of iron oxide coating on the filtration properties of sand, *JAWWA*, Vol. 86, 8:37-50.

Edwards M, M.M. Benjamin, and J.E. Tobiason (1994) Effects of ozonation on coagulation of NOM using polymer alone and polymer-metal salt mixtures, *JAWWA*, Vol. 86, No. 1, 105-116.

Sletten, R.S., M.M. Benjamin, J.J. Horng, and J.F. Ferguson (1995) Physical-chemical treatment of landfill leachate for metals removal, *Water Research*, Vol. 29, 2376-2386.

Edwards, M., M.M. Benjamin, and J. Ryan (1996) Organic matter acidity and its role in sorption to oxide surfaces, *Colloids and Surface A: Physicochemical and Engineering Aspects*, Vol. 107, 297-307.

Benjamin, M.M., R.S. Sletten, R.P. Bailey, and T. Bennett (1996) Sorption and filtration of metals using iron-oxide-coated sand, *Water Research*, Vol. 30, 2609-2620.

Chang, Y-J., and M.M. Benjamin (1996) Iron oxide adsorption and UF to remove NOM and control fouling, *JAWWA*, Vol. 88, No. 12, 74-88.

Chang, Y-J., C-W. Li, and M.M. Benjamin (1997) Use of iron oxide-coated media for NOM sorption and particulate filtration, *JAWWA*, Vol. 89, No. 5, 100-113.

Korshin, G.V., M.M. Benjamin, and R.S. Sletten (1997) Adsorption of natural organic matter (NOM) on iron oxide: effects on NOM composition and formation of organo-halide compounds during chlorination, *Water Research*, Vol. 31, 1643-1650.

McMeen, C., and M.M. Benjamin (1997) NOM removal by slow sand filtration through coated olivine, *JAWWA*, Vol. 89, No. 2, 57-71.

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Korshin G.V., M.M. Benjamin, and C-W. Li (1999), Use of differential spectroscopy to evaluate the structure and reactivity of humics." *Water Sci. Technol.* Vol. 40, No. 9, 9-16.

Li, C-W., M.M. Benjamin, and G.V. Korshin (2000), "Use of UV spectroscopy to characterize the reaction between NOM and free chlorine." *Environ. Sci. Technol.* Vol. 34, No. 12, 2570-2575.

Sørensen M., C.B. Koch, M.M. Stackpoole, R.K. Bordia, M.M. Benjamin, and T.H. Christensen (2000), "Effects of thermal treatment on mineralogy and heavy metal behavior in iron oxide stabilized air pollution control residues." *Environ. Sci. Technol.* Vol. 34, No. 12, 4620-4627.

Korshin, G.V., M.M. Benjamin, and H-B. Xiao (2001), "Interactions of chlorine with natural organic matter and formation of intermediates: Evidence by differential spectroscopy." *Acta Hydrochimica et Hydrobiologica* Vol. 28, No. 7, 1-7.

Voges, L.E., and M.M. Benjamin (2001), "The use of iron oxides to enhance metal removal in crossflow microfiltration." *ASCE J. Environ. Eng.* Vol. 127, No. 5, 411-419.

Vagliasindi, F.G.A., and M.M. Benjamin (2001), "Redox reactions of arsenic in As-spiked lake water and their effects on As adsorption." *Aqua* Vol. 50, No. 4, 173-186.

Wu, W., M.M. Benjamin, and G.V. Korshin (2001), "Effects of Thermal Treatment on Halogenated Disinfection By-Products in Drinking Water." *Water Research* Vol. 35, No. 15, 3545-3550.

Hansen, B.O., P. Kwan, M.M. Benjamin, C-W. Li, and G.V. Korshin (2001), "Use Of Iron Oxide Coated Sand To Remove Strontium From Simulated Hanford Tank Wastes." *Environ. Sci. Technol.* Vol. 35, No. 24, 4905-4909.

Benjamin, M.M. (2002), "Modeling the Mass-Action Expression for Bidentate Adsorption." *Environ. Sci. Technol.* Vol. 36, No. 3, 307-313.

Li, C-W., M.M. Benjamin, and G.V. Korshin (2002). "The Relationship Between TOX Formation and Spectral Changes Accompanying Chlorination of Pre-Concentrated or Fractionated NOM." *Water Research* Vol. 36, No. 13, 3265-3272.

Korshin, G.V., W. Wu, M.M. Benjamin, and O. Hemingway (2002), "Correlations between Differential Absorbance and the Formation of Individual DBPs." *Water Research* Vol. 36, No. 13, 3273-3282.

Chang, Y. and M.M. Benjamin (2003), "Formation of Natural Organic Matter Fouling Layer on Ultrafiltration Membranes." *ASCE J. Environ. Eng.* Vol. 129, No. 1, 25-32.

Kim, J., M.M. Benjamin, P. Kwan, and Y. Chang (2003), "A Novel Ion Exchange Process for Arsenic Removal." *JAWWA* Vol. 95, No. 3, 77-85.

Zhang, M., C. Li, M.M. Benjamin, and Y. Chang (2003), "Fouling and NOM Removal in Adsorbent/ Membrane Systems For Drinking Water Treatment." *Environ. Sci. Technol.* Vol. 37, 1663-1669.

Kim, J., and M.M. Benjamin (2004), "Modeling a Novel Ion Exchange Process for Arsenic and Nitrate Removal." *Water Research.* Vol. 38, No. 8, 2053-2062.

Lu, J., M.M. Benjamin, G.V. Korshin, H. Gallard (2004), "Reactions of the Flavonoid Hesperetin with Chlorine: Mass-Spectroscopic Studies of the Reaction Pathways." *Environ. Sci. Technol.* Vol. 38, No. 17, 4603-4611.

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Kim, J., W. Shi, Y. Yuan, and M.M. Benjamin (2007). "A serial filtration investigation of membrane fouling by natural organic matter." *J. Membrane Sci.* Vol. 294, No. 1-2, 115-126. doi:10.1016/j.memsci.2007.02.020.

Korshin, G.V., M.M. Benjamin, H-S. Chang, and H. Gallard (2007). "Examination of NOM Chlorination Reactions by Conventional and Stop-Flow Differential Absorbance Spectroscopy" *Environ. Sci. Technol.* Vol. 41, No. 8, 2776-2781.

Choo, K.H., S.C. Han, S.J. Choi, J. Jung, D. Chang, J-H. Ahn, and M.M. Benjamin (2007). "Use of Chelating Polymers to Enhance Manganese Removal in Ultrafiltration for Drinking Water Treatment." *J. Industrial and Engineering Chemistry*, Vol. 13, 163-169.

Han, S.C., K.H. Choo, S.J. Choi, and M.M. Benjamin (2007). "Modeling Manganese Removal in Chelating Polymer-Assisted Membrane Separation Systems for Water Treatment." *J. Membrane Sci.* Vol. 290, 55-61.

Brett, M.T., and M.M. Benjamin (2008). "A Reassessment of Lake Phosphorus Retention and the Nutrient Loading Concept in Limnology." *Freshwater Biology* Vol.53, 194-211.

Cai, Z.X., J.S. Kim, and M.M. Benjamin (2008). "NOM Removal by Adsorption and Membrane Filtration Using Heated Aluminum Oxide Particles." *Environ. Sci. Technol.* Vol. 42, 619-623.

Kim, J.S., Z.X. Cai, and M.M. Benjamin MM (2008). "Effects of adsorbents on membrane fouling by natural organic matter." *J. Membrane Sci.* Vol. 310, 356-364.

Shi, W., and M.M. Benjamin (2008). "Membrane Interactions with NOM and an Adsorbent in a Vibratory Shear Enhanced Filtration Process (VSEP) System." *J. Membrane Sci.* Vol. 312, 23-33.

Kim, J., Q. Deng, and M.M. Benjamin (2008). "Simultaneous Removal of Phosphorus and Foulants in a Hybrid Coagulation/Membrane Filtration System." *Water Research* Vol. 42, 2017-2024.

Benjamin, M.M. (2009). "New Conceptualization and Solution Approach for the Ideal Adsorbed Solution Theory (IAST)." *Environ. Sci. Technol.* Vol. 43, 2530-2536. doi:10.1021/es803652r.

Shi, W., and M.M. Benjamin (2009). "Fouling of RO membranes in a vibratory shear enhanced filtration process (VSEP) system." *J. Membrane Sci.* Vol. 331, 11-20. doi:10.1016/j.memsci.2008.12.027.

Kim, J., Z. Cai, and M.M. Benjamin (2010). "NOM fouling mechanisms in a hybrid adsorption/membrane system." *J. Membrane Sci.* Vol. 349, 35-43.

Shi, W., and M.M. Benjamin (2010). "Effect of shear rate on fouling in a Vibratory Shear Enhanced Processing (VSEP) RO system." *J. Membrane Sci.* Vol. 366, 148-157. doi:10.1016/j.memsci.2010.09.051.

Benjamin, M.M. (2011). "Clarification of a common misunderstanding of collision frequencies in the Smoluchowski equation." *JEED (ASCE)*. Vol.137, 297-300. doi: 10.1061/(ASCE)EE.1943-7870.0000328.

Cai, Z., and Benjamin, M.M. (2011). "NOM fractionation and fouling of low-pressure membranes in microgranular adsorptive filtration." *Environ. Sci. Technol.* Vol. 45, 8935-8940. doi:10.1021/es202219e.

Cai, Z., Wee, C., and Benjamin, M.M. (2013) “Fouling mechanisms in low-pressure membrane filtration in the presence of an adsorbent cake layer.” *J. Membrane Sci.* Vol 433, 32-38. doi: 10.1016/j.memsci.2013.01.007.

Malczewska, B., Liu, J., and Benjamin, M.M. (2015) “Virtual elimination of MF and UF fouling by adsorptive pre-coat filtration.” *J. Membrane Sci.* Vol 479, 159-164. doi:10.1016/j.memsci.2015.01.032.

Wang, L-F., and Benjamin, M.M. (2016) “HAOPs pretreatment to reduce membrane fouling: Foulant identification, removal, and interactions.” *J. Membrane Sci.* Vol 515, 219-229. doi:10.1016/j.memsci.2016.05.063.

Wang, L-F., and Benjamin, M.M. (2016) “A multi-spectral approach to differentiate the effects of adsorbent pretreatments on the characteristics of NOM and membrane fouling.” *Water Research* Vol 98, 56-63. doi:10.1016/j.watres.2016.03.066.

Malczewska, B., and Benjamin, M.M. (2016) “Efficacy of hybrid adsorption/membrane pretreatment for low-pressure membranes.” *Water Research* Vol 99, 263-271. doi:10.1016/j.watres.2016.04.065.

#### **Books:**

*Water Chemistry*, by Mark M. Benjamin, 2<sup>nd</sup> ed., Waveland Press (2015), <https://www.waveland.com/browse.php?t=224>.

*Water Quality Engineering*, by Mark M. Benjamin and Desmond Lawler, Wiley (2013), <http://www.wiley.com/WileyCDA/WileyTitle/productCd-1118169654.html>.

#### **Patents:**

“Granular Media for Removing Contaminants from Water and Methods for Make the Same. U.S. Patent 5,369,072, Issued Nov. 29, 1994.

“Method for Removing Contaminants from Water Using Iron Oxide Coated Mineral Having Olivine Structure.” U.S. Patent 5,911,882, Issued June 15, 1999.

“Method for Removing Contaminants from Water Using Membrane Filtration in Combination with Particle Adsorption to Reduce Fouling.” U.S. Patent 6,113,792, Issued September 5, 2000.

“Method for Removing Contaminants from Liquids Using Membrane Filtration in Combination with Particle Adsorption to Reduce Fouling.” U.S. Patent 8,070,951, Issued December 6, 2011.

#### **Awards and Honors**

H.P. Eddy Award for best research publication in Journal Water Pollution Control Federation, 1984, 1990.

Fulbright Senior Researcher Scholarship for study and research in Costa Rica, 1985-86.

American Water Works Assoc. Publication Award for best paper published in Journal of AWWA, 1988, 1994, 1995.

Advisor to winner of Engineering Science award for outstanding Ph.D. dissertation of 1988 in environmental engineering (C.F. Lin).

Advisor to winner of 1988 Water Pollution Control Federation 1st Place award for Master's thesis (Marc Edwards).

American Water Works Assoc. 1989 Distribution Systems Best Publication Award.

Appointed to endowed chair: Jungers Professor of Engineering, 1989-1995.

Advisor to winner of 1992 American Water Works Assn. Academic Achievement Award and CH2M-Hill Outstanding Dissertation Award for doctoral dissertation (Marc Edwards).

Advisor to winner of Engineering Science award for outstanding Ph.D. dissertation of 1998 in environmental engineering (C.W. Li).

Distinguished Research Award by Alcoa Foundation, 1998.

Distinguished Lecturer for AEESP at American Water Works Assn. Annual Conference, 2002.

AEESP Distinguished Lecturer (lecture tour of 15 universities). 2009-10.

USEPA Scientific Advisory Board for Drinking Water (2010-13).

Advisor to winner of 2013 American Water Works Assn. Academic Achievement Award, 1<sup>st</sup> place for doctoral dissertation (Zhenxiao Cai).

2015 AEESP Award for Outstanding Contribution to Environmental Engineering and Science Education (for textbook on Physical-Chemical Water Treatment Processes, co-authored with Desmond Lawler).