Paul G. Tratnyek (Principal Investigator)

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Professional Experience:

06/17-Present	Professor, OHSU-PSU School of Public Health, Environmental Systems and Human Health, Oregon Health & Science University Portland, OR.
01/03-05/17	Professor/Associate Professor (Associate Head 09/07-9/13) Institute of Environmental Health (IEH), Division of Environmental and Biomolecular Systems (EBS), Oregon Health & Science University (OHSU), Portland, OR.
12/91-12/02	Assistant/Associate Professor, Department of Environmental Science and Engineering, Oregon Graduate Institute of Science & Technology (OGI), Beaverton, OR.
09/00-10/01	Guest Scientist, Environmental Molecular Sciences Laboratory (EMSL), Pacific Northwest National Laboratory (PNNL), Richland, WA.
01/89-11/91	Research Fellow, Swiss Federal Institute for Water Resources and Water Pollution Control (EAWAG), Dübendorf, Switzerland.
09/87-11/88	National Research Council Research Associate, U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA

Education:

- Williams College, Williamstown, MA, B.A. (Biochemistry) June 1980.
- Colorado School of Mines, Golden, CO, Ph.D. (Applied Chemistry), December 1987.

Expertise and Research Interests:

Prof. Tratnyek's research concerns the physico-chemical processes that control the fate and effects of environmental substances, including minerals, metals (for remediation), organics (as contaminants), and nanoparticles (for remediation, as contaminants, and in biomedical applications). Dr. Tratnyek is best known for his work on the degradation of groundwater contaminants with zero-valent metals, but his interests extend to all aspects of contaminant reduction and oxidation (redox) in all aquatic media. Some of his recent work emphasizes the fate/remediation of emerging contaminants (e.g., nanoparticles and 1,2,3-trichloropropane) and next generation energetic compounds (e.g., DNAN).

Synergistic Activities (including Awards and Honors):

Numerous invited presentations on contaminant degradation by iron metal, including plenary or keynote talks at the 11th International Symposium on Environmental Geochemistry (7-10 August 2019, Peking Univ.), 9th Chinese National Conference on Environmental Chemistry (19-22 October 2017, Hangzhou, China), 2nd IWA Water Research Conference (11-14 January 2015; Shenzhen, China), Conference on Interfaces in Water and Environmental Science (25-28 May 2014, Leeuwarden, The Netherlands); IWA Specialty Conference on Metals in Water (6-9 November 2013, Shanghai, China); 2nd PRB/RZ Symposium, (14-15 November 2005, Antwerp, Belgium); Theis Conference on Iron in Groundwater, Jackson Hole, WY, 15-18 September 2000; Gordon Research Conference on Environmental Sciences: Water (25-30 June 2000, Plymouth, NH); and Gordon Research Conference on Inorganic Reaction Mechanisms (16-21 February 2003, Ventura, CA).

(Co)Principal organizer of relevant symposia, including: "Sulfidation of Metal-based Engineered and Natural Nanomaterials: Implications for their Fate and Effects in the Environment" (ACS National

Meeting, San Francisco, CA, 2-6 April 2017); "Attenuation Pathways of Lesser Chlorinated Compounds (1,2,3-TCP, 1,2-DCA, etc.)" (9th Battelle Conf. on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, 19-22 May 2014); "Predicting Molecular Properties of Environmental Contaminants: Empirical and Theoretical Models" (ACS National Meeting, Indianapolis, IN, 8-12 September 2013); "Aquatic Redox Chemistry" (ACS National Meeting, San Francisco, CA, 21-25 March 2010); and "Geochemistry and Biogeochemistry of Zero-Valent Metals" (Goldschmidt Conf. 20-25 May 2005, Moscow, Idaho).; "Biogeochemical Interactions in Permeable Iron (Fe^0) Reactive Barriers and Implications for Environmental Remediation" (AGU National Meeting, San Francisco, CA, 10-14 December 2001). "Chemical-Biological Interactions in Contaminant Fate" (ACS National Meeting, Washington, DC, 20-25 August 2000); "Environmental Fate and Effects of Gasoline Oxygenates" (ACS National Meeting, San Francisco, CA, 13-17 April 1997); "Contaminant Remediation with Zero-Valent Iron" (ACS National Meeting, Anaheim, CA, 2-7 April 1995).

Gordon Research Conference (GRC) on Environmental Sciences: Water. Chair 2014, Co-chair 2012; Speaker 2000 and 1992. GRC on Inorganic Reaction Mechanisms. Speaker 2003.

Associate Editor, Environmental Sciences: Processes and Impacts (3/2016-Present). Editorial Advisory Board, Environmental Science & Technology (3/2016-Present).

Lead organizer and editor of (*i*) themed issue on (semi)volatile halogenated hydrocarbons in the environment for the journal Environmental Science: Processes and Impacts (http://rsc.li/halocarbons), (*ii*) themed issue of on In Silico Environmental Chemistry for Environmental Science: Processes and Impacts (http://rsc.li/qsars), and (iii) ACS Symposium Series Book on Aquatic Redox Chemistry (10.1021/bk-2011-1071).

Recommended background online resources: https://zenodo.org/communities/tratnyekgroup/, https://www.youtube.com/results?search_query=paultratnyek, https://www.linkedin.com/in/pgtratnyek/, https://scholar.google.com/citations?=Paul_Tratnyek, http://www.researchgate.net/profile/Paul_Tratnyek, https://www.semanticscholar.org/author/Paul-G-Tratnyek/7145883.

Publications (Most Highly Cited per Google Scholar):

1. Matheson, L. J., and P. G. Tratnyek. 1994. Reductive dehalogenation of chlorinated methanes by iron metal. *Environ. Sci. Technol.* 28(12): 2045-2053. [DOI: 10.1021/es00061a012]. (**1730** Citations)(This paper received the AEESP's "Outstanding Paper" award in 2011, http://www.aeespfoundation.org/awards/outstanding-publication).
2. Nurmi, J. T., P. G. Tratnyek, V. Sarathy, D. R. Baer, J. E. Amonette, K. Pecher, C. Wang, J. C. Linehan, D. W. Matson, R. L. Penn, and M. D. Driessen. 2005. Characterization and properties of metallic iron nanoparticles: Spectroscopy, electrochemistry, and kinetics. *Environ. Sci. Technol.* 39(5): 1221-1230. [DOI: 10.1021/es049190u]. (**978** citations)
3. Johnson, T. L., M. M. Scherer, and P. G. Tratnyek. 1996. Kinetics of halogenated organic compound degradation by iron metal. *Environ. Sci. Technol.* 30(8): 2634-2640. [DOI: 10.1021/es9600901]. (**936** Citations)
4. Agrawal, A., and P. G. Tratnyek. 1996. Reduction of nitro aromatic compounds by zero-valent iron metal. *Environ. Sci. Technol.* 30(1): 153-160. [DOI: 10.1021/es950211h]. (**913** Citations)
5. Tratnyek, P. G., and R. L. Johnson. 2006. Nanotechnologies for environmental cleanup. *NanoToday* 1(2): 44-48. [DOI: 10.1016/S1748-0132(06)70048-2]. (**721** Citations)
6. Waldemer, R. H., P. G. Tratnyek, R. L. Johnson, and J. T. Nurmi. 2007. Oxidation of chlorinated ethenes by heat activated persulfate: Kinetics and products. *Environ. Sci. Technol.* 31(3): 1010-1015. [DOI: 10.1021/es062237m]. (**577** Citations)

7. Nam, S., and P. G. Tratnyek. 2000. Reduction of azo dyes with zero-valent iron. *Water Res.* 34(6): 1837-1845. [DOI: 10.1016/S0043-1354(99)00331-0]. (**492** Citations)

*Per Google Scholar on 2020/05/10: Total Citations = **14,808**, h-index = **53**.*

Publications (Most Recent)):

8. Tratnyek, P. G., E. Edwards, L. Carpenter, and S. Blossom. 2020. Environmental occurrence, fate, effects, and remediation of halogenated (semi)volatile organic compounds. *Environ. Sci. Proc. Impacts* 22(3): 465-471. [DOI: 10.1039/D0EM90008G].

9. Torralba-Sanchez, T. L., and P. G. Tratnyek. 2020. R script for the automated generation of reaction coordinate diagrams (RCDs) of chemical reaction energies and transformation networks. *In*: *Zenodo*. 17 January 2020 ed. [DOI: 10.5281/zenodo.3611472].

10. Torralba-Sanchez, T. L., E. J. Bylaska, A. Salter-Blanc, J., D. E. Meisenheimer, M. A. Lyon, and P. G. Tratnyek. 2020. Reduction of 1,2,3-trichloropropane (TCP): Pathways and mechanisms from computational chemistry calculations. *Environ. Sci. Proc. Impacts* 22(3): 606-616. [DOI: 10.1039/C9EM00557A].

11. He, F., L. Gong, D. Fan, P. G. Tratnyek, and G. V. Lowry. 2020. Quantifying the efficiency and selectivity of organohalide dechlorination by zerovalent iron. *Environ. Sci. Proc. Impacts* 22(3): 528-542. [DOI: 10.1039/C9EM00592G].

12. Qin, H., X. Guan, and P. G. Tratnyek. 2019. Effects of sulfidation and nitrate on the reduction of N-nitrosodimethylamine (NDMA) by zerovalent iron. *Environ. Sci. Technol.* 53(16): 9744-9754. [DOI: 10.1021/acs.est.9b02419].

13. Pavitt, A. S., and P. G. Tratnyek. 2019. Electrochemical characterization of natural organic matter by direct voltammetry in an aprotic solvent. *Environ. Sci. Proc. Impacts* 21(10): 1664-1683. [DOI: 10.1039/C9EM00313D].

14. Meduri, K., C. Stauffer, G. O'Brien Johnson, P. Longo, P. G. Tratnyek, and J. Jiao. 2019. Unique Structural Characteristics of Catalytic Palladium/Gold Nanoparticles on Graphene. *Microscopy Microanal.* 25(1): 80-91. [DOI: 10.1017/S1431927618016185].

15. Meduri, K., A. Rahimian, R. Humbert, G. O'Brien Johnson, P. Tratnyek, and J. Jiao. 2019. A Comparative Study of Carbon Supports for Pd/Au Nanoparticle-Based Catalysts. *Materials Performance and Characterization* 8(3): 479-489. [DOI: 10.1520/MPC20180147].

16. Kocur, C. M. D., D. Fan, P. G. Tratnyek, and R. L. Johnson. 2019. Predicting abiotic reduction rates using cryogenically collected soil cores and mediated reduction potential measurements. *Environ. Sci. Technol. Lett.* 7(1): 20-26. [DOI: 10.1021/acs.estlett.9b00665].

17. Jin, J., S. Zhang, B. Wu, Z. Chen, G. Zhang, and P. G. Tratnyek. 2019. Enhanced photooxidation of hydroquinone by acetylacetone, a novel photosensitizer and electron shuttle. *Environ. Sci. Technol.*: [DOI: 10.1021/acs.est.9b02751].

18. Chen, Z., X. Li, S. Zhang, J. Jin, X. Song, X. Wang, and P. G. Tratnyek. 2019. Overlooked role of peroxides as free radical precursors in advanced oxidation processes. *Environ. Sci. Technol.* 53(4): 2054-2062. [DOI: 10.1021/acs.est.8b05901].

19. Bradley, M. J., and P. G. Tratnyek. 2019. Electrochemical characterization of magnetite: Assessing extent of passivation with composite electrodes. *ACS Earth & Space Chemistry* 3(3): 688-699. [DOI: 10.1021/acsearthspacechem.8b00200].

20. Stauffer, C., K. Meduri, G. O'Brien Johnson, P. G. Tratnyek, and J. Jiao. 2018. Effect of synthesis time of carbon supported Pd/Au NPs on TCE degradation. *Microscopy Microanal.* 24(S1): 1802–1803. [DOI: 10.1017/S1431927618009492].

21. Shao, Q., C. Xu, Y. Wang, S. Huang, B. Zhang, L. Huang, D. Fan, and P. G. Tratnyek. 2018. Dynamic interactions between sulfidated zerovalent iron and dissolved oxygen: Mechanistic insights for enhanced chromate removal. *Water Res.* 135: 322-330. [DOI: 10.1016/j.watres.2018.02.030].

22. Qin, H., X. Guan, J. Z. Bandstra, R. L. Johnson, and P. G. Tratnyek. 2018. Modeling the kinetics of hydrogen formation by zerovalent iron: Effects of sulfidation on micro- and nano-scale particles. *Environ. Sci. Technol.* 52(23): 13887-13896. [DOI: 10.1021/acs.est.8b04436].

23. Pearce, C. I., J. P. Icenhower, R. M. Asmussen, P. G. Tratnyek, K. M. Rosso, W. W. Lukens, and N. P. Qafoku. 2018. Technetium stabilization in low-solubility sulfide phases: A review. *ACS Earth and Space Chemistry* 2(6): 532-547. [DOI: 10.1021/acsearthspacechem.8b00015].

24. Needoba, J. A., and P. G. Tratnyek. 2018. Planetary Health thematic web collection. *Environ. Sci. Proc. Impacts* 20(5): 744-745. [DOI: 10.1039/C8EM90021C].

25. Meduri, K., C. Stauffer, W. Qian, O. Zietz, A. Barnum, G. O. B. Johnson, P. G. Tratnyek, and J. Jiao. 2018. Palladium and gold nanoparticles on carbon supports as highly efficient catalysts for effective removal of trichloroethylene. *J. Mater. Res.* 33(16): 2404-2413. [DOI: 10.1557/jmr.2018.212].

26. Meduri, K., C. Stauffer, G. O. B. Johnson, P. G. Tratnyek, and J. Jiao. 2018. Electron microscopy characterization of the synergistic effects between Pd, Au NPs, and their graphene support. *Microscopy Microanal.* 24(S1): 1888–1889. [DOI: 10.1017/S1431927618009923].

27. Kašlík, J., J. Kolařík, J. Filip, I. Medřík, O. Tomanec, M. Petr, O. Malina, R. Zbořil, and P. G. Tratnyek. 2018. Nanoarchitecture of advanced core-shell zero-valent iron particles with controlled reactivity for contaminant removal. *Chem. Eng. J.* 354: 335-345. [DOI: 10.1016/j.cej.2018.08.015].

28. Huang, S., C. Xu, Q. Shao, Y. Wang, B. Zhang, B. Gao, W. Zhou, and P. G. Tratnyek. 2018. Sulfide-modified zerovalent iron for enhanced antimonite sequestration: Characterization, performance, and reaction mechanisms. *Chem. Eng. J.* 338: 539-547. [DOI: 10.1016/j.cej.2018.01.033].

29. Tratnyek, P. G., E. Bylaska, and E. J. Weber. 2017. In silico environmental chemical science: Properties and processes from statistical and computational modelling. *Environ. Sci. Proc. Impacts* 19(3): 188-202. [DOI: 10.1039/C7EM00053G].

30. Salter-Blanc, A. J., E. J. Bylaska, M. A. Lyon, S. C. Ness, and P. G. Tratnyek. 2017. Correction to structure–activity relationships for rates of aromatic amine oxidation by manganese dioxide. *Environ. Sci. Technol.* 51(21): 13058-13059. [DOI: 10.1021/acs.est.7b05101].

31. Pavitt, A. S., E. J. Bylaska, and P. G. Tratnyek. 2017. Oxidation potentials of phenols and anilines: Correlation analysis of electrochemical and theoretical values. *Environ. Sci. Proc. Impacts* 19(3): 339-349. [DOI: 10.1039/C6EM00694A].

32. Meduri, K., C. Stauffer, T. Lindner, G. O'Brien Johnson, P. G. Tratnyek, and J. Jiao. 2017. Effect of Synthesis temperature on the formation of GAC supported Pd and Au NPs. *Microscopy Microanal.* 23(S1): 1916-1917. [DOI: 10.1017/S1431927617010248].

33. Gu, Y., B. Wang, F. He, M. J. Bradley, and P. G. Tratnyek. 2017. Mechanochemically sulfidated microscale zero valent iron: Pathways, kinetics, mechanism, and efficiency of trichloroethylene dechlorination. *Environ. Sci. Technol.* 51(21): 12653–12662. [DOI: 10.1021/acs.est.7b03604].

34. Fenner, K., and P. G. Tratnyek. 2017. QSARs and computational chemistry methods in environmental chemical sciences [Introduction to the themed issue on "QSARs and computational chemistry methods in environmental chemical sciences" Paul G. Tratnyek and Kathrin Fenner (Eds.)]. *Environ. Sci. Proc. Impacts* 19(3): 185-187. [DOI: 10.1039/C7EM90008B].

35. Fan, D., Y. Lan, P. G. Tratnyek, R. L. Johnson, J. Filip, D. M. O'Carroll, A. N. Garcia, and A. Agrawal. 2017. Sulfidation of iron-based materials: A review of processes and implications for water treatment and remediation. *Environ. Sci. Technol.* 51(22): 13070–13085. [DOI: 10.1021/acs.est.7b04177].

36. Xu, C., B. Zhang, L. Zhu, S. Lin, X.-P. Sun, Z. Jiang, and P. G. Tratnyek. 2016. Sequestration of antimonite by zerovalent iron: Using weak magnetic field effects to enhance performance and characterize reaction mechanisms. *Environ. Sci. Technol.* 50(3): 1483-1491. [DOI: 10.1021/acs.est.5b05360].

37. Salter-Blanc, A. J., E. J. Bylaska, M. A. Lyon, S. Ness, and P. G. Tratnyek. 2016. Structure-activity relationships for rates of aromatic amine oxidation by manganese dioxide. *Environ. Sci. Technol.* 50(10): 5094-5102. [DOI: 10.1021/acs.est.6b00924].

38. Meduri, K., A. Barnum, G. O. B. Johnson, P. G. Tratnyek, and J. Jiao. 2016. Characterization of palladium and gold nanoparticles on granular activated carbon as an efficient catalyst for hydrodechlorination of trichloroethylene. *Microscopy Microanal.* 22(S3): 332-333. [DOI: 10.1017/S1431927616002518].

39. Fan, D., G. S. O'Brien Johnson, P. G. Tratnyek, and R. L. Johnson. 2016. Sulfidation of nano zerovalent iron (nZVI) for improved selectivity during in-situ chemical reduction (ISCR). *Environ. Sci. Technol.* 50(17): 9558–9565. [DOI: 10.1021/acs.est.6b02170].

40. Fan, D., D. M. O'Carroll, D. W. Elliott, Z. Xiong, P. G. Tratnyek, R. L. Johnson, and A. Nunez Garcia. 2016. Selectivity of nano zerovalent iron in in situ chemical reduction: Challenges and improvements. *Remediation J.* 26(4): 27-40. [DOI: 10.1002/rem.21481].

41. Fan, D., M. Bradley, A. W. Hinkle, R. L. Johnson, and P. G. Tratnyek. 2016. Chemical reactivity probes for assessing abiotic natural attenuation by reducing iron minerals. *Environ. Sci. Technol.* 50(4): 1868-1876. [DOI: 10.1021/acs.est.5b05800].

42. Tratnyek, P. G. 2015. Comment on "Evaluation of the kinetic oxidation of aqueous volatile organic compounds by permanganate" by M. G. Mahmoodlu, S. M. Hassanizadeh, and N. Hartog, in Science of the Total Environment (2014) 485–486: 755–763. *Sci. Total Environ.* 502: 722-723. [DOI: 10.1016/j.scitotenv.2014.08.065].

43. Sun, B., X. Guan, J. Fang, and P. G. Tratnyek. 2015. Activation of manganese oxidants with bisulfite for enhanced oxidation of organic contaminants: The involvement of Mn(III). *Environ. Sci. Technol.* 49(20): 12414-12421. [DOI: 10.1021/acs.est.5b03111].

44. Salter-Blanc, A. J., E. J. Bylaska, H. Johnston, and P. G. Tratnyek. 2015. Predicting reduction rates of energetic nitroaromatic compounds using calculated one-electron reduction potentials. *Environ. Sci. Technol.* 49(6): 3778–3786. [DOI: 10.1021/es505092s].

45. Fan, D., S. Chen, R. L. Johnson, and P. G. Tratnyek. 2015. Field deployable chemical redox probe for quantitative characterization of carboxymethylcellulose modified nano zerovalent iron. *Environ. Sci. Technol.* 49(17): 10589-10597. [DOI: 10.1021/acs.est.5b02804].

46. Tratnyek, P. G., R. L. Johnson, V. Lowry Gregory, and R. A. Brown. 2014. In situ chemical reduction for source zone remediation. *In*: B. H. Kueper, H. F. Stroo, C. M. Vogel , and C. H. Ward (ed.), *Chlorinated Solvent Source Zone Remediation*. SERDP and ESTCP Remediation Technology Monograph Series, Springer, New York, Vol. 7, pp 307-351. [DOI: 10.1007/978-1-4614-6922-3_10].

47. Liang, L., X. Guan, Z. Shi, J. Li, Y. Wu, and P. G. Tratnyek. 2014. Coupled effects of aging and weak magnetic fields on sequestration of selenite by zero-valent iron. *Environ. Sci. Technol.* 48(11): 6326-6334. [DOI: 10.1021/es500958b].

48. Kim, E.-J., J.-H. Kim, Y.-S. Chang, D. Turcio-Ortega, and P. G. Tratnyek. 2014. Effects of metal ions on the reactivity and corrosion electrochemistry of Fe/FeS nanoparticles. *Environ. Sci. Technol.* 48(7): 4002-4011. [DOI: 10.1021/es405622d].

49. Glaesemann Kurt, R., J. Bylaska Eric, P. G. Tratnyek, and J. Salter-Blanc Alexandra. 2014. Forecasting the environmental impacts of new energetic formulations. *In*: *JANNAF Workshop Proceedings - Fate, Transport and Effects of Insentitive Munitions: Issues and Recent Data, Environmental Restoration Report, May 2014*. pp 82-90.

50. Fan, D., R. P. Anitori, B. M. Tebo, P. G. Tratnyek, J. S. Lezama Pacheco, R. K. Kukkadapu, L. Kovarik, M. H. Engelhard, and M. E. Bowden. 2014. Oxidative remobilization of technetium sequestered by sulfide-transformed nano zerovalent iron. *Environ. Sci. Technol.* 48(13): 7409–7417. [DOI: 10.1021/es501607s].

51. Chen, S., D. Fan, and P. G. Tratnyek. 2014. Novel contaminant transformation pathways by abiotic reductants. *Environ. Sci. Technol. Lett.* 1(10): 432-436. [DOI: 10.1021/ez500268e].

52. Salter-Blanc, A. J., E. J. Bylaska, J. J. Ritchie, and P. G. Tratnyek. 2013. Mechanisms and kinetics of alkaline hydrolysis of the energetic nitroaromatic compounds 2,4,6-trinitrotoluene (TNT) and 2,4-Dinitroanisole (DNAN). *Environ. Sci. Technol.* 47(13): 6790-6798. [DOI: 10.1021/es304461t].

53. Kim, E.-J., K. Murugesan, J.-H. Kim, P. G. Tratnyek, and Y.-S. Chang. 2013. Remediation of trichloroethylene by FeS-coated iron nanoparticles in simulated and real groundwater: Effects of water chemistry. *Indus. Eng. Chem. Res.* 52(27): 9343-9350 [DOI: 10.1021/ie400165a].

54. Johnson, R. L., J. T. Nurmi, G. O'Brien Johnson, D. Fan, R. O'Brien Johnson, Z. Shi, J. Salter-Blanc Alexandra, P. G. Tratnyek, and G. V. Lowry. 2013. Field-scale transport and transformation of carboxymethylcellulose-stabilized nano zero-valent iron. *Environ. Sci. Technol.* 47(3): 1573-1580. [DOI: 10.1021/es304564q].

55. Fan, D., R. P. Anitori, B. M. Tebo, P. G. Tratnyek, J. S. Lezama Pacheco, R. K. Kukkadapu, M. H. Engelhard, M. E. Bowden, L. Kovarik, and B. W. Arey. 2013. Reductive sequestration of pertechnetate ($^{99}TcO_4^-$) by nano zero-valent iron (nZVI) transformed by abiotic sulfide. *Environ. Sci. Technol.* 47(10): 5302-5310. [DOI: 10.1021/es304829z].

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57. Salter-Blanc, A. J., E. J. Suchomel, J. H. Fortuna, J. T. Nurmi , C. Walker, T. Krug, S. O'Hara, N. Ruiz, T. Morley, and P. G. Tratnyek. 2012. Evaluation of zerovalent zinc for treatment of 1,2,3-trichloropropane contaminated groundwater: Laboratory and field assessment. *Ground Wat. Monitor. Remed.* 32(4): 42-52. [DOI: 10.1111/j.1745-6592.2012.01402.x].

58. Baer, D. R., P. G. Tratnyek, Y. Qiang, J. E. Amonette, J. Linehan, V. Sarathy, J. T. Nurmi, C. Wang, and J. Antony. 2012. Synthesis, characterization, and properties of zero-valent iron nanoparticles. *In*: *Environmental Applications of Nanomaterials (2nd Edition)*. Imperial College Press, pp 49-86. [DOI: 10.1142/9781848168053_0003].

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