Selected Resources in Nanotechnology and the Environment

Compiled and written by Rita C. Stephens, WMRC Library Intern and Laura L. Barnes, GLRPPR Help Desk Librarian (Last updated: July 19, 2006)

Introduction

There are two avenues to explore when researching nanotechnology and the environment. The first is the effect of nanomaterials on the environment and human health. The second is how nanomaterials can be used to benefit the environment. The resources listed here cover both aspects of the topic.

Background

Nanoscience
http://www.nsf.gov/news/overviews/nano/index.jsp
Overview from the National Science Foundation.

Nanotechnology
http://en.wikipedia.org/wiki/Nanotechnology
Wikipedia's entry on nanotechnologies includes a brief discussion of their environmental risks.

Royal Society of Chemistry: Nanoscience and Nanotechnology
http://www.royalsoc.ac.uk/landing.asp?id=1210
Excellent overview, including a section on risks.

U.S. Government Information

Consumer Product Safety Commission Nanomaterial Statement
http://www.cpsc.gov/LIBRARY/CPSCNanoStatement.pdf

National Nanotechnology Initiative
http://www.nano.gov/
The National Nanotechnology Initiative (NNI) is a federal R&D program established to coordinate the multiagency efforts in nanoscale science, engineering, and technology.

National Toxicology Program's Nanotechnology Safety Initiative
http://ntp.niehs.nih.gov/ntpweb/index.cfm?objectid=7E6B19D0-BDB5-82F8-FAE73011304F542A#
The goal of this research program is to evaluate the toxicological properties of major nanoscale materials classes which represent a cross-section of composition, size, surface coatings, and physicochemical properties, and use these as model systems to investigate fundamental questions concerning if and how nanoscale materials can interact with biological systems.

NIOSH: Nanotechnology
http://www.cdc.gov/niosh/topics/nanotech/
Provides an overview of NIOSH research on the occupational safety and health impacts of nanotechnology, as well as background information on the topic. See the topic index on the right side of the page for in-depth information about nanotechnology at NIOSH.

U.S. Department of Energy: Nanotechnology
http://www.science.doe.gov/News_Information/News_Room/2006/nano/index.htm
Main page is the press release announcing the development and construction of five Nanoscale Science Research Centers. Along the right side of the page, there are links to other DOE nanotechnology publications and resources.

U.S. EPA: Nanotechnology
http://es.epa.gov/ncer/nano/
Nanotechnology has both applications and implications for the environment. This site highlights EPA's research in nanotechnology and provides useful information on related research at EPA and in other organizations. Includes a list of publications and proceedings.

International Initiatives

European Commission: Nanotechnology
http://cordis.europa.eu/nanotechnology/home.html
Includes a section on biological and health risks at
http://ec.europa.eu/health/ph_risk/committees/04_scenihr/scenihr_opinions_en.htm.

International Association of Nanotechnology
http://www.nanotechcongress.com/index.htm
The International Association of Nanotechnology (IANT), is a non-profit organization with the goals to foster scientific research and business development in the areas of Nanoscience and Nanotechnology for the benefit of society.

International Council on Nanotechnology
http://icon.rice.edu/
ICON is an international, multi-stakeholder organization whose mission is to assess, communicate, and reduce the environmental and health risks of nanotechnology while maximizing its societal benefit. It envisions a future where nanotechnology emerges as a responsible and valued industry with an effective and proactive approach to risk management.

Nanoforum
http://www.nanoforum.org/
Nanoforum is a pan-European nanotechnology network funded by the European Union under the Fifth Framework Programme (FP5) to provide information on European nanotechnology efforts and support to the European nanotechnology community.

Research Centers & Institutes

Center for Biological and Environmental Nanotechnology
http://cben.rice.edu/
The Center for Biological and Environmental Nanotechnology (CBEN) is a National Science Foundation (NSF) funded Nanoscale Science and Engineering Center (NSEC) at Rice University. CBEN focuses on research at the interface between "dry" nanomaterials and aqueous media such as biology and the environment, developing the nanoscience workforce of the future, and transferring discoveries to industry. One research focus is using nanomaterials to solve environmental engineering problems.

Center on Nanotechnology and Society
http://www.nano-and-society.org/
The Illinois Institute of Technology's (IIT's) Center on Nanotechnology and Society, an affiliate of the Institute on Biotechnology and the Human Future (IBHF), at Chicago-Kent College of Law, catalyzes informed interdisciplinary research, education and dialogue on the ethical, legal, policy, business, and broader societal implications of nanoscale science and technology. One focus of their research is the environmental, health, and safety impacts of nanotechnologies (http://www.nano-and-society.org/health/).

Foresight Nanotech Institute
http://www.foresight.org/
Foresight Nanotech Institute's mission is to ensure the beneficial implementation of nanotechnology. The institute has identified six nanotechnology challenges (http://www.foresight.org/challenges/index.html) and focuses their efforts in these areas.

Nanotechnology and Society at University of Wisconsin-Madison
http://www.lafollette.wisc.edu/research/Nano/
An umbrella program, jointly sponsored by the nanoscience and engineering and social science faculties at UW-Madison, the initiative supports a range of programs and interdisciplinary research projects that explore societal, ethical, legal, policy, economic, and security issues surrounding nanotechnology.

Nanotoxicology at the University of Florida
http://www.nanotoxicology.ufl.edu/
Part of UFL's Particle Engineering Research Center and the Center for Environmental and Human Toxicology. Includes links to nanotoxicology research projects.

National Science Foundation Information on R&D Centers
http://www.nsf.gov/crssprgm/nano/info/centers.jsp
Links to U.S. nanoscience and technology research centers.

Northwestern University's Institute for Nanotechnology
http://www.nanotechnology.northwestern.edu/
The Nanoscale Science & Engineering Center includes a program on the societal and ethical implications of nanotechnologies (http://www.nsec.northwestern.edu/SocialEthical.htm).

Project on Emerging Nanotechnologies
http://www.nanotechproject.org/
This project of the Woodrow Wilson International Center for Scholars and the Pew Charitable Trusts seeks to inform and educate about the pros and cons of this tiny new technology. You'll find searchable databases of health and environmental implications, commercially available nano-products (>200, including some cosmetics), and agrifood R&D. Also provided are related reports and events.

News Sources

There are no journals specifically devoted to the environmental implications of nanotechnologies. Articles on the topic regularly appear in environmental journals like *Envrionmental Science & Technology* and *Environmental Health Perspectives*. General nanoscale science and technology journals like *Nano Letter, Journal of Nanoscience and Nanotechnology*, and *Journal of Nanoparticles Research* may also include articles and news about the environmental aspects of nanomaterials.

Environmental Health Perspectives Environmental News by Topic: Nanotechnology
http://www.ehponline.org/topic/nanotech.html
Click the Further Resources link for links to research articles that have appeared in the journal.

Environmental News Bits : Nanotechnology
http://lib.wmrc.uiuc.edu/enb/?cat=66

Foresight Nanotech Institute: Websites and Blogs
http://www.foresight.org/cms/resources/54

Bibliographies & Databases

Foresite Nanotech Institute: Resources
http://www.foresight.org/resources/
Includes comprehensive links to resources for researchers, investors, government agencies, news sources, directories, and publications.

ICON Environmental, Health and Safety (EHS) Database
http://icon.rice.edu/research.cfm
Originally developed by scientists at Oak Ridge National Laboratory, this database contains summaries (abstracts) and citations for research papers related to the EHS implications of nanoscale materials.

Links to Nanotoxicology Information on the Web
http://www.nanotoxicology.ufl.edu/Links.html
From the University of Florida's nanotoxicology program.

Nanotechnology Risk Resources
http://www.lafollette.wisc.edu/research/Nano/nanorisk/index.html
This site contains references to papers, articles, and books on (or related to) potential health and environmental risks of nanomaterials sorted by material or compound, body organ or biological effect studied, or other miscellaneous issues.

NELSI Global
http://www.nano-and-society.org/NELSI/
An international public policy document archive dedicated to nanotechnology's ethical, legal and societal implications (NELSI). Developed by the Center on Nanotechnology and Society at the Illinois Institute of Technology.

Meetings & Conferences

2006 Energy Technology International Conference (Cambridge, MA : June 26-28, 2006)
http://www.asmeconferences.org/energynano06/
The aim of this forum is to bring together different disciplines of energy technology by exploring their commonalities as well as their differences through exploiting nanoscience and nanotechnology.

Nanotechnology Events and Conferences
http://www.nanotech-now.com/events-2006.htm

NSTI Nanotechnology Conference and Trade Show
http://www.nsti.org/events.html
NSTI has sponsored the Nanotech conference since 1998. The website includes links to conference programs and paper abstracts. Most conferences include sessions on the environmental and energy implications of nanotechnology.

Books & Reports

Bartis. James; Landree, Eric. *Nanomaterials in the Workplace : Policy and Planning Workshop on Occupational Safety and Health.* Santa Monica, CA : RAND, 2006. (Available online at http://www.rand.org/pubs/conf_proceedings/2006/RAND_CF227.pdf)

Characterising the Potential Risks Posed by Engineered Nanoparticles: A First UK Government Research Report. London : Department for Environment, Food and Rural Affairs, Nanotechnology Research Co-ordination Group Secretariat, 2005. (Available online at http://www.defra.gov.uk/environment/nanotech/nrcg/pdf/nanoparticles-riskreport.pdf)

Developing Experimental Approaches for the Evaluation of Toxicological Interactions of Nanoscale Materials : Final Report. Gainesville, FL : University of Florida, 2004. (Available online at http://www.nanotoxicology.ufl.edu/workshop/images/NanoToxWorkshop.pdf)

Implications of Nanotechnology for Environmental Health Research. Institute of the Medicine, Washington, DC: National Academies Press, c2005.(Available online at http://www.iom.edu/CMS/3793/4897/26111.aspx)

Nano & the Environment. s.l. : Nanoforum.org; Institute for Environment and Sustainability (European Commission. Joint Research Centre), 2006. (Available online at http://www.nanoforum.org/dateien/temp/Nano and Environment workshop report.pdf?22052006234639)

Nanoscale Science, Engineering, and Technology in the Department of Energy: Research Directions and Nanoscale Science Research Centers. Washington, DC : U.S. Department of Energy, Office of Science, 2004. (Available online at http://www.sc.doe.gov/bes/brochures/files/NSRC_brochure.pdf)

Nanoscience and Nanotechnologies : Opportunities and Uncertainties. London : The Royal Society ; Royal Academy of Engineering, 2004. (Available online at http://www.raeng.org.uk/policy/reports/nanoscience.htm)

Nanotechnology and the Environment : Applications and Implications. Washington, DC: American Chemical Society, c2005.

Nanotechnology: Small Size - Large Impact? Zurich, Switzerland: Swiss Re; Schweizerische Rückversicherungs-Gesellschaft, 2004. (Available online at http://www.swissre.com/Internet/pwsfilpr.nsf/vwFilebyIDKEYLu/MBUI-6E7H3N/$FILE/nanotechnology_report.pdf)

Report of the OECD Workshop on the Safety of Manufactured Nanomaterials : Building Co-operation, Co-ordination and Communication, Washington D.C., United States, 7th-9th December 2005. Paris, France : Organisation for Economic Co-operation and Development,

2006. (Available online at http://appli1.oecd.org/olis/2006doc.nsf/43bb6130e5e86e5fc12569fa005d004c/b69b32217944d8a1c125715e0038d403/$FILE/JT03208175.PDF).

Size Does Matter : Nanotechnology : Small Science - Big Questions! Fitzroy, Australia : Friends of the Earth Australia, 2006. (Available online at http://www.foe.org.au/download/CR97.pdf)

Roco, Mihail.C. and Robert Sims Bainbridge, eds. *Societal Implications of Nanoscience and Nanotechnology: NSET Workshop Report*. Arlington, VA : National Science Foundation, 2001. (Available online at http://wtec.org/loyola/nano/NSET.Societal.Implications/nanosi.pdf)

Theodore, Louis & Robert G. Kunz. *Nanotechnology: Environmental Implications and Solutions*. Hoboken, NJ : John Wiley & Sons, 2005. ($99.95; ISBN 0471699764). (Review from *Environmental Health Perspectives* is available online at http://www.ehponline.org/docs/2005/113-7/EHP113pa488PDF.PDF)

Articles

Albrecht, M.A.; Evans, C.W.; Raston, C.L. "Green Chemistry and the Health Implications of Nanoparticles." *Green Chemistry* 8, 417-432 (2006).

Auffan, M.; Decome, L.; Rose, J.; Orsiere, T.; De Meo, M.; Briois, V.; Chaneac, C.; Olivi, L.; Berge-Lefranc, J.-L.; Botta, A.; Wiesner, M. R.; Bottero, J.-Y. "In Vitro Interactions between DMSA-Coated Maghemite Nanoparticles and Human Fibroblasts: A Physicochemical and Cyto-Genotoxical Study." *Environmental Science & Technology* 40(14), 4367-4373 (2006).

Barnard, Amanda. "Nanohazards: Knowledge is Our First Defence." *Nature Materials* 5, 245-248. (Available online at http://www.nature.com/nmat/journal/v5/n4/full/nmat1615.html)

Brunner, T. J.; Wick, P.; Manser, P.; Spohn, P.; Grass, R. N.; Limbach, L. K.; Bruinink, A.; Stark, W. J. "In Vitro Cytotoxicity of Oxide Nanoparticles: Comparison to Asbestos, Silica, and the Effect of Particle Solubility." *Environmental Science & Technology* 40(14), 4374-4381 (2006).

Castelli, L.M. "Nanotechnology Scores in Coatings : New Formulation Moves from Lab and Demonstration Phase into the Manufacturing Arena." *Metal Finishing* 103(10), 46-47 (2005).

Dror, I.; Baram, D.; Berkowitz, B. "Use of Nanosized Catalysts for Transformation of Chloro-Organic Pollutants." *Environmental Science & Technology* 39(5), 1283-1290 (2005).

Dunphy Guzman, K. A.; Taylor, M. R.; Banfield, J. F. "Environmental Risks of Nanotechnology: National Nanotechnology Initiative Funding, 2000-2004." *Environmental Science & Technology* 40(5), 1401-1407 (2006).

Henn, K.W.; "Utilization of Nanoscale Zero-valent Iron for Source Remediation - A Case Study." *Remediation Journal*, 16(2), 57-77 (2006).

Kalpin, Mark C.; Hoffer, Melissa. "Nanotechnology and the Environment : Will Emerging Environmental Regulations Stifle the Promise?" Paper presented at Nanotech 2005 (Anaheim, CA : May 8-12, 2005) (Available online at http://www.wilmerhale.com/files/Publication/5faad09c-3d37-46ba-ae2e-

0fd0acd4a1fd/Presentation/PublicationAttachment/10d017e2-53a6-4192-a0b8-1f7c1da97d16/nano_enviro_paper.pdf)

Lin, Y.; Cui, X.; Bontha, J. "Electrically Controlled Anion Exchange Based on Polypyrrole and Carbon Nanotubes Nanocomposite for Perchlorate Removal." *Environmental Science & Technology* 40(12), 4004-4009 (2006).

Lloyd, S. M. "Life Cycle Benefits of Using Nanotechnology To Stabilize Platinum Group Metal Particles in Automotive Catalysts." *Environmental Science & Technology* 39(5), 1384-1392 (2005).

Long, T. C.; Saleh, N.; Tilton, R. D.; Lowry, G. V.; Veronesi, B. "Titanium Dioxide (P25) Produces Reactive Oxygen Species in Immortalized Brain Microglia (BV2): Implications for Nanoparticle Neurotoxicity." *Environmental Science & Technology* 40(14); 4346-4352 (2006).

Mace, C.; "Nanotechnology and Groundwater Remediation: A Step Forward in Technology Understanding." *Remediation Journal*, 16(2), 23-33 (2006).

Masciangioli, T. "Environmental Technologies at the Nanoscale." *Environmental Science & Technology* . 37(5), 102A-108A (2003).

Oberdörster, E. "Nanotoxicology : An Emerging Discipline Evolving from Studies of Ultrafine Particles." *Environmental Health Perspectives*, 113(7), 823-839 (2005)

Reijnders, L. "Cleaner Nanotechnology and Hazard Reduction of Manufactured Nanoparticles." *Journal of Cleaner Production*, 14(2), 124-133 (2005).

Robichaud, C. O.; Tanzil, D.; Weilenmann, U.; Wiesner, M. R. "Relative Risk Analysis of Several Manufactured Nanomaterials: An Insurance Industry Context." *Environmental Science & Technology* 39(22), 8985-8994 (2005).

Roco, M. "Environmentally Responsible Development of Nanotechnology." *Environmental Science & Technology* 39(5), 106A-112A (2005).

Rothen-Rutishauser, B. M.; Schurch, S.; Haenni, B.; Kapp, N.; Gehr, P. "Interaction of Fine Particles and Nanoparticles with Red Blood Cells Visualized with Advanced Microscopic Techniques." *Environmental Science & Technology* 40(14), 4353-4359 (2006).

Song, W.; Li, G.; Grassian, V. H.; Larsen, S. C. "Development of Improved Materials for Environmental Applications: Nanocrystalline NaY Zeolites." *Environmental Science & Technology* 39(5), 1214-1220 (2005).

Stallone, K. B "A Low Cost Environmentally Benign CO2 Based Hydrometallurgicall Process." *Environmental Impact Assessment Review*, 6(6), 267-270 (2004).

Stoddart, Alison. "Nanotechnology: Friend or Foe?" *Chemical Science*. 21(5), C35. (Available online at http://www.rsc.org/Publishing/ChemScience/Volume/2006/05/nanotechnology.asp)

Toensmeier, Patrick A. "Nanotechnology Faces Scrutiny Over Environment and Toxicity." *Plastics Engineering* November, 14-16 (2004). (Available online at http://www.4spe.org/pub/pe/articles/2004/november/pg14_nanotech.pdf)

Trombly, J. "Nano-PV Set to Accelerate Solar-energy Use" *Environmental Science & Technology* 38(19), 376A (2004).

Wiesner, Mark R. "Assessing the Risks of Manufactured Nanomaterials." *Environmental Sience and Technology* 40(14), 4336-4345 (2006).