

Fate and Transport of Wastewater Constituents in Soil Treatment Systems: Endocrine Disrupters, Pharmaceuticals and Personal Care Products, and Household Chemicals

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ABSTRACT

Nonpoint source pollutants (NPS) have been estimated to contribute approximately 70% of pollution in our surface and groundwater. NPS pollutants of concern have traditionally included only nutrients and pathogens. Emerging NPS issues now include Endocrine Disrupting Chemicals (EDCs) and Pharmaceuticals and Personal Care Products (PPCPs). Many widely used compounds present in pharmaceutical, personal care, and household cleaning products are not removed by conventional wastewater treatment processes. Researchers have identified some of these pollutants in human and animal wastewater as well as surface and groundwater across the country & globally. Although the environmental effects of low concentrations of most of these chemicals are unknown, adverse effects of antibiotic and endocrine-disrupting compounds have been established. As well as these emerging contaminants – other chemical constituents of residential wastewater may include laundry aids, cleaners, electric dishwashing powders and liquids, water softeners etc... An overview of the breadth of these contaminants, their potential effect on the performance of onsite systems, the microbial treatment populations, the fate and transport, and the effects on soil dispersal systems will be presented. Further information can be found at

<http://www.deh.enr.state.nc.us/oww/nonpointsource/NPS.htm>.

"Faith" is a fine invention
For gentlemen who *see!*
But Microscopes are prudent
In an Emergency!

Emily Dickinson, 1861

OSWW NONPOINT SOURCE UPDATE: ONGOING AND EMERGING ISSUES

(Centralized Intern Training Fact Sheet)

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*It is estimated that as much as 70% of the water pollution in the US comes from nonpoint sources (NPS). Nonpoint sources of pollution can contaminate local and regional surface and ground waters. Pollutants that potentially come from OnSite Systems include nutrients, pathogens, and endocrine disrupting chemicals. The goals in pollution reduction and some of the important environmental and human health issues are described. Pollutants, such as nitrates, are important in designated nutrient sensitive river basins (in NC Neuse and Tar-Pamlico). The NPS program in the Onsite Wastewater Section- DEH, stems from the Clean Water Act and the 319 NPS Program (DWQ) in NC. Web links and other resources** for further study are linked below to the NPS links section.*

NUTRIENTS:

Goals: reduce amount of ammonium, nitrates, and phosphates leaching to surface and groundwater.

Lowered amounts = reduced toxic or environmental effects.

Effects: (human and environmental effects)

nitrates

- harmful algal blooms (HAB's)
- Cultural eutrophication
- Methemoglobinemia (blue baby)
- Some evidence of spontaneous miscarriages
- Low levels of nitrates prove toxic to amphibian tadpoles

phosphates

- Harmful algal blooms
- cultural eutrophication.

PATHOGENS:

Goals: reduce pathogens introduced into groundwater and surface waters. Reductions not effective unless below infectious doses of viruses, bacteria, protozoa, fungi, nematodes, tapeworms (see list of selected wastewater pathogens below.)

Effects:

- Diseases
- The list lengthens
- potential increasing incidence, human travel, population increases, etc...

Pathogen types: one fate, transport & persistence model does not fit all

Viruses – very tiny nm range– do not reproduce outside body

Bacteria –micrometer range -some may keep on reproducing ; some are spore forming .

Protozoa –5 micrometer + range - many have resistant stages.

One of top 4 emerging pathogens – Cryptosporidium (cryptosporidiosis)

–

One tough bug –physiology more like ours –

Persistent (23 months in surface waters) –

Extremely resistant to disinfection –

Many (fecal – oral) routes of infection: day care/ recreational waters/
drinking water/

handling infected animals/ contaminated food / etc. –

Host list lengthens: humans/ cattle/ swine/ geese etc. –

High mortality rates in individuals with weakened immune systems
(immunocompromised & immunosuppressed).

Worms: May live years / children at risk

(Good news – given proper conditions, free-living microbes may treat and/or eat many pathogens!)

EMERGING ISSUES - EMERGING ISSUES - EMERGING ISSUES - EMERGING ISSUES –
NEXT PAGE....continued

ENDOCRINE DISRUPTING CHEMICALS (EDCs)

Emerging Issues: Potential and identified EDC pollutants from wastewater & other NonPoint Sources.

Endocrine Disrupting Chemicals are environmental agents that alter the endocrine system (involves hormones and their receptors. The scientific field is called endocrine disruption or environmental endocrine research. Few if any of these chemicals have similar structures. The action of these chemicals are to mimic or block vertebrate & invertebrate hormones.

About EDCs - These chemicals have hormonal effects in humans and animals –

- A wide variety of chemicals –

- Data being gathered in surface and groundwater (USGS, DEH, etc..)

- Significant human and environmental effects are being documented related to prenatal and

postnatal exposure to these chemicals

Goals: To identify contributions, if any, to surface and groundwater from onsite systems in comparison to those being identified in wastewater in general. To identify and evaluate wastewater treatment technologies and reduce pollution from these chemicals.

Effects:

“An endocrine disrupter is an exogenous substance or mixture that alters functions(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or to its progeny, or (sub)populations”. World Health Organization “State-of-the-Science” 2002

PPCPs - PHARMACEUTICALS & PERSONAL CARE PRODUCTS

Emerging Issues: Potential and identified Pharmaceuticals & Personal Care Products pollutants from wastewater and other NonPoint Sources. Pollution from Personal Actions, Activities, and Behaviors

“PPCPs comprise a very broad, diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, fragrances, cosmetics, sun-screen agents, diagnostic agents, nutraceuticals, biopharmaceuticals, and many others. This broad collection of

substances refers, in general, to any product consumed by individuals for personal health or cosmetic reasons” EPA 2003.

Goals:To identify contributions, if any, to surface and groundwater from onsite systems in comparison to those being identified in wastewater and other NPS sources in general. To identify and evaluate onsite wastewater treatment technologies, subsurface fate and transport, and reduce pollution from these chemicals. To identify PPCP’s effects on septic tanks and their performance.

Effects:

Personal Care Products:

- These chemicals, such as shampoos, cosmetics, fragrances, sunscreen agents, have been found in surface waters across the nation.
- Some of these chemicals are also EDC’s

Pharmaceuticals:

- These compounds are implicated in increasing rates environmental microbial antibiotic resistance.
- Are Implicated in reduction of microbial activity in septic tanks

WASTEWATER TECHNOLOGIES:

Emerging Issues: Identify and implement use of alternative (innovative) OSWW technologies, reducing NPS pollution and decreasing the risk of surface and groundwater contamination from onsite systems.

Goals: Identify contributions to surface and groundwater from onsite systems in comparison to those being identified in wastewater in general. ;

- Identify wastewater treatment technologies that effectively reduce pollutants (nutrients, pathogens, etc) from onsite systems;
- Identify areas, target watersheds, and implement programs in NC, where more stringent onsite requirements would be most effective in pollutant reduction. ;These requirements might include: new onsite technology requirements; Advanced pretreatment systems- Disinfection requirements-increased setback distances; Life cycle management strategies-Inspection requirements

<i>*LIST OF SELECTED POTENTIAL WASTEWATER PATHOGENS/DISEASES</i>		
<u>Category</u>	<u>Pathogen</u>	<u>Disease</u>
VIRUSES		
	Enteroviruses > many types	gastroenteritis, meningitis, respiratory infections
	Coxsackie A, B	meningitis. other diseases
	Hepatitis A	infectious hepatitis
	Adenovirus (>40 types)	respiratory disease/ eye infections
	Rotavirus	gastroenteritis
	Parvovirus	gastroenteritis
	Norwalk virus (Norwalk-like virus)	diarrhea, fever, vomiting
	Reovirus	respiratory disease
	Astrovirus	gastroenteritis
	Calicivirus	gastroenteritis
	Coronavirus	gastroenteritis
FUNGI		
	<u>Aspergillus fumigatus</u>	respiratory infection
	<u>Candida albicans</u>	skin/membrane infections
BACTERIA		
	<u>Shigella</u>	shigellosis (dysentery)
	<u>Salmonella typhi</u> & <u>S. paratyphi</u>	typhoid fever
	<u>Salmonella (>1,000 serotypes)</u>	salmonellosis
	<u>Vibrio cholerae</u>	cholera
	<u>Escherichia coli (enter)</u>	gastroenteritis
	<u>Yersinia enterocolitica</u>	yersiniosis/ gastroenteritis
	<u>Leptospira spp.</u>	leptospirosis
	<u>Campylobacter jejuni</u>	gastroenteritis
	<u>Clostridium perfringens</u>	gastroenteritis
PROTOZOA		
	<u>Balantidium coli</u>	dysentery/ gastrointestinal ulcers

	<u>Cryptosporidium parvum</u>	diarrhea / nausea / fever
	<u>Entamoeba histolytica</u>	amoebic dysentery
	<u>Giardia lamblia</u>	giardiasis (diarrhea)
ROUNDWORMS		
	<u>Ascaris lubricoides</u>	ascariasis
	<u>Ancylostoma duodenale</u>	hookworm
	<u>Necator americanus</u>	necatoriasis / hookworm
	<u>Trichuris trichiura</u>	whipworm / trichuriasis
	<u>Toxacara</u>	roundworms
TAPEWORMS		
	<u>Taenia saginata</u>	taeniasis
	<u>Taenia soleum</u>	taeniasis
	<u>Vampyrolepis(Hymenolepis) nana</u> & <u>H. diminuta</u>	worm infection -(brain)

NPS and ONSITE WEB LINKS/ RESOURCES
Alphabetical by Category

BACK TO-----ONSITE WASTEWATER SECTION: DEH Web Page

<http://www.deh.enr.state.nc.us/oww/>

EMERGING ISSUES IN WASTEWATER POLLUTION **see below

ENVIRONMENTAL PROTECTION AGENCY (EPA) LINKS:

Environmental Definitions

<http://www.epa.gov/OCEPAterms/>

EPA's Office of Wastewater Management

Click on small communities option for information on grants and technical assistance

<http://www.epa.gov/OWM/>

EPA's Hardship Grants Program for Rural Communities

Provides information on monies destined to help small communities solve their wastewater disposal problems

<http://www.epa.gov/OWM/wm042002.htm#cwsrfft>

HAZARDS: Working with Wastewater

Health and Safety Executive

<http://www.hse.gov.uk/pubns/indg198.htm>

Health Issues for Wastewater Operators

<http://www.dep.state.pa.us/dep/deputate/waterops/redesign/subpages/tipsforwwworkers.htm>

<http://www.dutchessny.gov/dchd/envhealth/info/operator/safety.htm>

Leptospirosis

http://www.cdc.gov/ncidod/dbmd/diseaseinfo/leptospirosis_g.htm#How%20do%20people%20get%20leptospirosis

HUMAN HEALTH and GIS

Remote Sensing GIS and Human Health

<http://geo.arc.nasa.gov/sge.health.rsgisbib.html>

<http://www.idrc.ca/library/document/gis.html>

<http://www.atsdr.cdc.gov/gis/conference98/gisindex.html>

<http://www.crosslink.net/~ehp/updates.htm>

NONPOINT SOURCE POLLUTION PROGRAM

NC Nonpoint Source Management Program

<http://h2o.enr.state.nc.us/nps/bigpic.htm>

EPA NonPoint Source News-Notes (onsite issues often highlighted)

<http://www.epa.gov/owow/info/NewsNotes>

OTHER AGENCIES (including additional NC rules)

CAMA - Coastal Management Rules

<http://dcm2.enr.state.nc.us/>

Neuse and Tar- Pamlico River Basin Rules

<http://h2o.enr.state.nc.us/nps/tarp.htm>

Coast*A*Syst and Home*A*Syst North Carolina

<http://www.soil.ncsu.edu/assist>

Farm*A*Syst North Carolina-Improving your Septic System:

A program developed for farmers and household owners

<http://www.soil.ncsu.edu/publications/farmassist/>

National Small Flow Clearinghouse

Technical assistance to help those who work with small community and wastewater systems

http://www.nesc.wvu.edu/nsfc/nsfc_index.htm

North Carolina State University - Septic Systems Index

Information on extension services and academic work on septic systems

<http://plymouth.ces.state.nc.us/septic/index.html>

<http://www.soil.ncsu.edu/>

North Carolina Water Quality Group

General information on NPS pollution, NPS projects, and more links

<http://www.bae.ncsu.edu/bae/programs/extension/wqg/index.html>

Virginia Links:

Virginia Department of Health- Division of Onsite Sewage and Waste Services
Groundwater Contamination <http://www.vdh.state.va.us./onsite/text/grnd->

[wtr.htm](#)

Lagtime of Groundwater Dampens Hope for Fast Bay Clean Up

<http://www.vdh.state.va.us./onsite/text/bay-jour.htm>

Septic Tank Maintenance Facts and Folklore

<http://www.vdh.state.va.us./onsite/text/folklore.htm>

PATHOGENS IN WASTEWATER

<http://www.cdc.gov/ncidod/>

<http://ksu.edu/parasitology/links>

<http://www.awwarf.com/newprojects/factshts.html>

<http://www.life.sci.qut.edu.au/LIFESCI/darben/paramast.htm>

<http://www.rescuenet.com/rn/vault/wastewtr.html>

Viruses

<http://rotavirus.com/>

Bacterial diseases

http://www.cdc.gov/ncidod/dbmd/diseaseinfo/leptospirosis_g.htm#How%20do%20people%20get

%20leptospirosis

Cryptosporidium:

<http://www.outbreak.org>

<http://www.who.ch>

[http:// http://www.ksu.edu/parasitology/](http://http://www.ksu.edu/parasitology/)

<http://www.epa.gov/OWOW/watershed/Proceed/hoagland.html>

Literature compilations/resources/issues

J. of AWWA – September and October, 2000 issues / Cryptosporidium

TRACKING THE SOURCE OF PATHOGENS FROM WASTEWATER

Bacterial Source Tracking (BST)

<http://filebox.vt.edu/cals/cses/chagedor/CH.html>

Cryptosporidium Source Tracking (CST)

<http://www.vetmed.ucdavis.edu/vetext/Projects/22-DNAFINGERPRINT.HTML>

<http://faculty.vetmed.ucdavis.edu/faculty/docliver/Research/parasitology.htm>

*****EMERGING ISSUES WASTEWATER & NPS CONTAMINANTS*****

ENDOCRINE DISRUPTING CHEMICALS

General Background References:

EPA – What are EDC's (includes policy, assessments, etc...)

<http://www.epa.gov/scipoly/oscpendo/whatis.htm>

Endocrine Disrupters Fact Sheets (Filed/Sorted by levels of understanding....)

<http://www.greenfacts.org/endocrine-disruptors/level-1.htm>

Our Stolen Future.by Dr. Theo Colborn , Dianne Dumanoski, Dr. John Peterson
Myers.

Dutton, Penguin Books (NY), 1996 (ISBN 0-525-93982-2) Paperback version,
Plume/Penguin,1997.

MAJOR WEB BASED INVENTORIES AND INFORMATION AND RESEARCH

GLOBAL ASSESSMENT of the state-of-the-science of ENDOCRINE DISRUPTERS

WHO: 2002 In depth review and overview of EDC' s

http://www.who.int/pes/emerg_site/edc/global_edc_TOC.htm

GLOBAL EDC INVENTORY: EDRI –

Endocrine Disruptors Research Initiative:

information and references by the Endocrine Disrupter Working Group of the National
Science and Technology Council's (NSTC) Committee on the Environment and
Natural Resources (CENR)

<http://www.epa.gov/endocrine/>

TULANE UNIVERSITY:

Environmental Estrogens and Other Hormones: Center for Bioenvironmental
Research, Tulane <http://www.som.tulane.edu/ecme/eehome/>

EPA SITES on EDC's:

EPA : Endocrine Disrupter Home Page, including screening methods updates.

<http://www.epa.gov/scipoly/oscpendo/index.htm>

EPA:What are EDC's

<http://www.epa.gov/scipoly/oscpendo/whatis.htm>

Endocrine Disruptors Keystone Convening Report Regarding the Formation of the

ENDOCRINE DISRUPTOR SCREENING AND TESTING ADVISORY COMMITTEE
<http://www.epa.gov/scipoly/oscpendo/history/keystone.htm>

USGS INFORMATION - ASSESSMENT & RESEARCH

USGS FACT Sheets: Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in US Streams. <http://toxics.usgs.gov/pubs/FS-027-02/>

USGS FACTS Sheets: Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in US Wells 2000.

http://toxics.usgs.gov/regional/emc_groundwater.html

USGS National Water Quality Assessment Program (NAWQA)

http://water.usgs.gov/nawqa/nawqa_home.html

USGS CERC – Columbia Environmental Research Center

<http://www.cerc.cr.usgs.gov/endocrine/summary.html>

CANADIAN WEB REFERENCES

Canada – Wildlife and Endocrine Disruption: Water Quality Research Journal of Canada

Vol. 36(2): 169-346 (2001). Theme issue: Endocrine Disruption

<http://www.wfcanada.org/satellite/hormone-disruptors/science/frameset.html>

WORLD WILDLIFE FEDERATION

WWF Canada: Toxics : EDCs Canada Web Hormones

<http://www.wfcanada.org/satellite/hormone-disruptors/science/frameset.html>

WWF World Wildlife Federation : Toxics : Endocrine Chemicals

<http://www.worldwildlife.org/toxics/progareas/ed/>

PHARMACEUTICALS & PERSONAL CARE PRODUCTS– PPCP's

EPA: These web pages provide overviews, educational materials, updated evaluation, current science, fate and transport in the environment, and detailed web links on this group of emerging contaminants.

<http://www.epa.gov/esd/chemistry/pharma/index.htm>

<http://www.epa.gov/esd/chemistry/pharma/speaking.htm>

<http://www.epa.gov/esd/chemistry/pharma/>

<http://www.epa.gov/esd/chemistry/ppcp/relevant.htm>

SELECTED LITERATURE AND RESOURCES (EDC's & PPCP's)

1. Barnes, K.K., D.W. Kolpin, E.M. Furlong, M. T. Meyer, E. T. Thurman, S. D. Zaugg, L.B. Barber, and H.T. Buxton. 2002. Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance, Environmental Science & Technology, Volume 36 (6): 1202-1211.

2. Fox, G.A. 2001. Effects of Endocrine Disrupting Chemicals on Wildlife in Canada: Past,

Present and Future. *Water Quality Research Journal of Canada*, 36(2): 233-251.

3. Frick, E.A, A. K. Henderson, D. M. Moll, E. T. Furlong, and M. T. Meyers. 1999. Presence of Pharmaceuticals in Wastewater Effluent and Drinking Water, Metropolitan Atlanta, Georgia, July – September, 1999. www.ga.usgs.gov/nawqa/Pharm_final.pdf

4. Hayes, T.B., A. Collins, M. Lee, M. Mendoza, N. Noriega, A.A. Stuart, and A. Vonk. 2002. Hermaphroditic Demasculinized Frogs After Exposure to the Herbicide Atrazine at a Low Ecologically Relevant Dose. *PNAS*: Volume 99(8): 5476-5480. www.pnas.org/cgi/doi/10.1073/pnas.082121499.

5. (current review) McLachlan, J. A. 2001. Environmental Signaling: What Embryos and Evolution Teach Us about Endocrine Disrupting Chemicals. *Endocrine Reviews* Volume 22(3):319-341.

6. Roefer, P., S. Snyder, R. Zegers, D. J. Rexing, and J. L. Fronk. 2000. Endocrine Disrupting Chemicals in a Source Water. *J. AWWA 2000*: Volume 92 (8):52-58