

*Synopsis of Significant Works & Contributions
on the Environmental and Public Health Aspects of:*

**PPCPs, Illicit Drugs, Emerging Contaminants, and
Sewage Chemical Information Mining (SCIM)**

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(also see Curriculum Vitae: <http://www.epa.gov/nerlesd1/bios/daughton.htm>)

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**Pharmaceuticals and Personal Care Products (PPCPs)
as Environmental Contaminants**

"PPCPs" as environmental contaminants: this acronym was coined for "pharmaceuticals and personal care products" in this first synoptic review of PPCPs; subtle effects were first postulated as a major concern (one of the 20 most-cited papers in the fields of environment and ecology for 1998-2008:

<http://sciencewatch.com/inter/aut/2008/08-oct/08oct20PaprENV>) [1999]

Daughton CG; Ternes TA "Pharmaceuticals and Personal Care Products in the Environment: Agents of Subtle Change?" *Environmental Health Perspectives*, 1999, 107(suppl 6), 907-938; doi:10.2307/3434573

<http://www.epa.gov/nerlesd1/bios/daughton/errata.pdf> (*Open Access*)

Book on PPCPs: one of the first two books on PPCPs (as an outcome from the first all-day conference on PPCPs held in North America, 219th ACS National Meeting, 27 March 2000) [2001]

Daughton CG; Jones-Lepp TL (eds.) *Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues*, Symposium Series 791; American Chemical Society: Washington, D.C., 2001, 416 pp; doi:10.1021/bk-2001-0791

<http://www.epa.gov/nerlesd1/bios/daughton/book.htm>

PPCPs overview: an update to the original 1999 review article in *Environmental Health Perspectives* [2001]

Daughton CG "Pharmaceuticals in the environment: Overarching issues and overview," in *Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues*, Daughton, CG and Jones-Lepp, TL (eds.), Symposium Series 791; American Chemical Society: Washington, D.C., 2001, pp. 2-38; doi:10.1021/bk-2001-0791.ch001; pre-print:

<http://www.epa.gov/nerlesd1/bios/daughton/book-summary.htm>

Research needs and gaps for PPCPs: first comprehensive examination (arranged around the risk assessment paradigm) [2004]

Daughton CG "PPCPs in the Environment: Future Research — Beginning with the End Always in Mind," In *Pharmaceuticals in the Environment*, Kümmerer K (Ed.), 2nd edition, Springer, 2004, Chapter 33, pp. 463-495; pre-print:

<http://www.epa.gov/nerlesd1/bios/daughton/researchneeds-chapter.pdf>

Challenges Facing PPCPs Research: a perspective on the future direction of PPCPs research [2009]

Daughton CG "Chemicals from the Practice of Healthcare: Challenges and Unknowns Posed by Residues in the Environment," *Environmental Toxicology & Chemistry* (special issue: Pharmaceuticals and Personal Care Products in the Environment), **2009**, 28(12):2490-2494; doi:10.1897/09-138.1

<http://onlinelibrary.wiley.com/doi/10.1897/09-138.1/pdf> (Open Access)

PPCPs in drinking water: first comprehensive review; assessment of ramifications for human health [2008]

Daughton CG "Pharmaceuticals as Environmental Pollutants: the Ramifications for Human Exposure," In: *International Encyclopedia of Public Health*, Kris Heggenhougen and Stella Quah (Eds.), Vol. 5, Oxford: Academic Press; **2008**, pp. 66-102; doi:10.1016/B978-012373960-5.00403-2; pre-print:

<http://www.epa.gov/nerlesd1/bios/daughton/EoPH2008.pdf>

[request reprint: daughton.christian@epa.gov]

PPCPs in drinking water: synoptic review and comprehensive update to the prior 2008 review [2010]

Daughton CG "Pharmaceutical Ingredients in Drinking Water: Overview of Occurrence and Significance of Human Exposure," In: *Contaminants of Emerging Concern in the Environment: Ecological and Human Health Considerations*, Rolf Halden (Ed.), ACS Symposium Series 1048, American Chemical Society: Washington, D.C., Chapter 2, p 9-68, 2 November 2010; doi:10.1021/bk-2010-1048.ch002 (book doi:10.1021/bk-2010-1048); pre-print:

<http://www.epa.gov/esd/bios/daughton/ACS-SS1048-2010.pdf>

[request reprint: daughton.christian@epa.gov]

PPCPs in ground water: drug residues in reused/recycled water; ramifications for human health and perception of risk; importance of properly communicating the concept of the water cycle to facilitate public acceptance of water reuse [2004]

Daughton, CG "Groundwater Recharge and Chemical Contaminants: Challenges in Communicating the Connections and Collisions of Two Disparate Worlds," *Ground Water Monitoring & Remediation*, Spring **2004**, 24(2):127-138; doi:10.1111/j.1745-6592.2004.tb00721.x

<http://www.epa.gov/nerlesd1/bios/daughton/water-reuse.pdf> (Open Access)

PPCPs sources and origins: review of the pathways of entry to the environment [2007]

Daughton CG "Pharmaceuticals in the Environment: Sources and Their Management," Chapter 1, 1-58, In: *Analysis, Fate and Removal of Pharmaceuticals in the Water Cycle* (M Petrovic and D Barcelo, Eds.), Wilson & Wilson's Comprehensive Analytical Chemistry series (D Barcelo, Ed.), Volume 50, Elsevier Science; **2007**, 564pp; doi:10.1016/S0166-526X(07)50001-2

http://www.epa.gov/nerlesd1/bios/daughton/Chap1_Petrovic&Barcelo.pdf

Pseudopersistence: concept first introduced [2002, 2003]

Daughton, CG "Environmental stewardship and drugs as pollutants," *The Lancet* **2002**, 360, 1035-1036; doi:10.1016/S0140-6736(02)11176-7; reprint:

<http://www.epa.gov/nerlesd1/bios/daughton/lancet-page.pdf>

Daughton, CG "Cradle-to-Cradle Stewardship of Drugs for Minimizing Their Environmental Disposition while Promoting Human Health. I. Rationale for and Avenues toward a Green Pharmacy," *Environmental Health Perspectives*, **2003**, 111(5):757-774; doi:10.1289/ehp.5947

<http://www.epa.gov/nerlesd1/bios/daughton/green1.pdf> (Open Access)

Aquatic bioconcentration of PPCPs: First synoptic review of the literature on the occurrence of active pharmaceutical ingredients in aquatic tissues [2011]

Daughton CG and Brooks BW "Active Pharmaceutical Ingredients and Aquatic Organisms," In: *Environmental Contaminants in Biota: Interpreting Tissue Concentrations*, W. Nelson Beyer and James P. Meador (Eds.), 2nd ed., CRC Press, Taylor and Francis, Boca Raton, FL; Chapter 8, p 281-340, 2011; pre-print:

<http://www.epa.gov/esd/bios/daughton/APIs-aquaticbiota.pdf>

Previously unrecognized pathways to the environment and routes to human exposure for certain pharmaceuticals: sweat and dermal transfer first identified as routes of release and exposure [2009]

Daughton CG and Ruhoy IS "Environmental Footprint of Pharmaceuticals - The Significance of Factors Beyond Direct Excretion to Sewers," *Environmental Toxicology & Chemistry*, 2009, 28(12):2495-2521; doi:10.1897/08-382.1

<http://onlinelibrary.wiley.com/doi/10.1897/08-382.1/pdf> (Open Access)

pharmEcokinetics: concept introduced as an umbrella interconnecting all of the transformation processes that pharmaceutical ingredients undergo during therapy and in the environment [2009]

Daughton CG and Ruhoy IS "Environmental Footprint of Pharmaceuticals - The Significance of Factors Beyond Direct Excretion to Sewers," *Environmental Toxicology & Chemistry*, 2009, 28(12):2495-2521; doi:10.1897/08-382.1

<http://onlinelibrary.wiley.com/doi/10.1897/08-382.1/pdf> (Open Access)

PPCPs in a scholastic reference work: first presentation of topic targeted to high-school and college students [2003]

Daughton, CG "Chemicals from Pharmaceuticals and Personal Care Products," in *Water: Science and Issues*, E Julius Dasch (Ed.), New York: Macmillan Reference USA, 2003, vol. 1, p 158-164; reprint:

<http://www.epa.gov/nerlesd1/bios/daughton/Macmillan-PPCPs.pdf>

PPCPs published-literature bibliographic database: largest publically available compilation of citations relevant to the many aspects and dimensions of PPCPs as environmental contaminants [19 February 2008-present]

Daughton CG and Scuderi MST. 2012. "Pharmaceuticals and Personal Care Products (PPCPs): Relevant Literature," U.S. Environmental Protection Agency, Las Vegas, Nevada (a comprehensive bibliographic database of literature references compiled and maintained by Daughton and Scuderi; first implemented 19 February 2008)

<http://www.epa.gov/ppcp/lit.html>

Web site devoted to PPCPs: first PPCPs web site created in April 2000 and subsumed by the US EPA's current PPCPs web site on 18 July 2007 [2000-present]; original URL

(<http://www.epa.gov/nerlesd1/chemistry/pharma/index.htm>) now defunct and subsumed by:

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

Literature forensics: critical importance to science of the thorough examination of the literature [2001]

Daughton, CG "Literature Forensics? Door to What Was Known but Now Forgotten," *Environmental Forensics*, 2001, 2: 277-282.

<http://www.epa.gov/nerlesd1/bios/daughton/forensics.pdf> (Open Access)

Illicit Drugs and Drugs of Abuse as Environmental Contaminants and Their Use in Forensic Epidemiology

Illicit drugs and "sewage forensics": first conceptualization of new analysis tool that uses sewage monitoring of illicit drugs to estimate community-wide usage rates (dose reconstruction) [2001]

Daughton CG "Illicit Drugs in Municipal Sewage: Proposed New Nonintrusive Tool to Heighten Public Awareness of Societal Use of Illicit/Abused Drugs and Their Potential for Ecological Consequences," in *Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues*, Daughton CG and Jones-Lepp TL (Eds.), Symposium Series 791; American Chemical Society: Washington, D.C., 2001, pp. 348-364; doi:10.1021/bk-2001-0791.ch020; pre-print:

<http://www.epa.gov/nerlesd1/bios/daughton/book-conclude.htm>

Illicit drugs in the environment and "FEUDS": first synoptic review of illicit drugs as environmental contaminants and their use as a tool for gaging community-wide drug usage rates - FEUDS: "Forensic Epidemiology Using Drugs in Sewage" [2011]

Daughton CG "Illicit Drugs: Contaminants in the Environment and Utility in Forensic Epidemiology," *Reviews of Environmental Contamination and Toxicology*, 2011, 210:59-110; doi:10.1007/978-1-4419-7615-4_3; available:

http://www.epa.gov/esd/bios/daughton/Illicit_Drugs_Contaminants_in_the_Environment.pdf (Open Access)

Illicit drugs in the environment: introductory overview for the first book devoted solely to the topic of illicit drugs in the environment [2011]

Daughton CG "Illicit Drugs and the Environment," In: *Illicit Drugs in the Environment: Occurrence, Analysis, and Fate Using Mass Spectrometry*, Sara Castiglioni, Ettore Zuccato, and Roberto Fanelli (Eds.), Chapter 1, pp 3-27, 2011, Wiley Series on Mass Spectrometry, John Wiley & Sons, Hoboken, NJ; doi 10.1002/9781118000816.ch1; ISBN 978-0-470-52954-6;

<http://onlinelibrary.wiley.com/book/10.1002/9781118000816>

[request reprint: daughton.christian@epa.gov]

Pharmaceutical Waste Management/Disposal and Environmental Stewardship

PPCPs and environmental stewardship: topic first introduced to the medical literature [2001]

Daughton CG "Environmental stewardship and drugs as pollutants," *The Lancet* **2002**, 360, 1035-1036;
reprint:

<http://www.epa.gov/nerlesd1/bios/daughton/lancet-page.pdf>

Green Pharmacy: concept first introduced; comprehensive approach for environmental stewardship,
pollution prevention, and waste reduction for pharmaceuticals [2003]

Daughton CG "Cradle-to-Cradle Stewardship of Drugs for Minimizing Their Environmental Disposition
while Promoting Human Health," *Environmental Health Perspectives*, **2003**, 111(5):757-785 [two-part
monograph];

<http://www.epa.gov/nerlesd1/bios/daughton/green1.pdf> (Open Access)

<http://www.epa.gov/nerlesd1/bios/daughton/green2.pdf> (Open Access)

pharmEcovigilance: concept first introduced - linking protection of the environment with the quality of
medical care and the environment [2008]

Daughton CG and Ruhoy IS "The Afterlife of Drugs and the Role of PharmEcovigilance," *Drug Safety*,
2008, 31(12):1069-1082; doi:10.2165/0002018-200831120-00004
[request reprint: daughton.christian@epa.gov]

Daughton CG and Ruhoy IS "PharmEcovigilance: Aligning Pharmacovigilance with Environmental
Protection," In: *An Introduction to Environmental Pharmacology*, SZ Rahman, M Shahid, and V Gupta
(Eds.), Ibn Sina Academy, Aligarh, India; **2008**, Chapter 1 (Introductory Overview), pp 21-34; ISBN #
978-81-906070-5-6;

<http://www.epa.gov/nerlesd1/bios/daughton/IntroEnvironPharmacol-Chapter1-2008.pdf> (Open Access)

Daughton CG and Ruhoy IS "Accumulation and disposal of leftover medications: A key aspect of
pharmEcovigilance," In: *An Introduction to Environmental Pharmacology*, SZ Rahman, M Shahid, and
V Gupta (Eds.), Ibn Sina Academy, Aligarh, India; **2008**, Chapter 5, pp 101-107; ISBN #
978-81-906070-5-6;

<http://www.epa.gov/nerlesd1/bios/daughton/IntroEnvironPharmacol-Chapter5-2008.pdf> (Open Access)

Medication site-accumulation and disposal: first comprehensive examination of where and why
medications accumulate and require disposal [2008]

Ruhoy IS and Daughton CG "Beyond the Medicine Cabinet: An Analysis of Where and Why Medications
Accumulate," *Environment International*, **2008**, 34(8):1157-1169; doi:10.1016/j.envint.2008.05.002;
pre-print:

<http://www.epa.gov/nerlesd1/bios/daughton/EnvInt2008.pdf>

Medication waste: consumer sources and waste management [2007]

Daughton CG "Pharmaceuticals in the Environment: Sources and Their Management," Chapter 1, 1-58, In:
Analysis, Fate and Removal of Pharmaceuticals in the Water Cycle (M. Petrovic and D. Barcelo, Eds.),
Wilson & Wilson's Comprehensive Analytical Chemistry series (D. Barcelo, Ed.), Volume 50, Elsevier
Science; **2007**, 564pp; doi:10.1016/S0166-526X(07)50001-2

http://www.epa.gov/nerlesd1/bios/daughton/Chap1_Petrovic&Barcelo.pdf

Drug disposal data: first comprehensive summary of inventory of unused medications for a particular sub-population of a single metropolitan area over the span of a year [2008]

Ruhoy IS and Daughton CG "Beyond the Medicine Cabinet: An Analysis of Where and Why Medications Accumulate," *Environment International*, 2008, 34(8):1157-1169; doi:10.1016/j.envint.2008.05.002; pre-print:

<http://www.epa.gov/nerlesd1/bios/daughton/EnvInt2008.pdf>

Coroner office drug data: first methodology for measuring the disposal of drugs to sewage and the overall contribution of drug waste disposal to environmental contamination [2007]

Ruhoy IS and Daughton CG "Types and Quantities of Leftover Drugs Entering the Environment via Disposal to Sewage - Revealed by Coroner Records," *Science of the Total Environment*, 2007, 388(1-3):137-148; doi 10.1016/j.scitotenv.2007.08.013; pre-print:

<http://www.epa.gov/nerlesd1/bios/daughton/SOTE2007.pdf>

Drug disposal: options available to the consumer [2009]

Glassmeyer ST, Hinchey EK, Boehme SE, Daughton CG, Ruhoy IS, Conerly O, Daniels RL, Lauer L, McCarthy M, Nettesheim TG, Sykes K, and Thompson VG. "Disposal Practices for Unwanted Residential Medications in the United States," *Environment International*, 2009, 35(3): 566-572; doi:10.1016/j.envint.2008.10.007

Medication use and sustainability: introductory chapter in first book devoted to sustainability and pharmaceutical usage [2009]

Daughton CG and Ruhoy IS. "Pharmaceuticals and Sustainability: Concerns and Opportunities Regarding Human Health and the Environment," In: *A Healthy Future - Pharmaceuticals in a Sustainable Society*, collaborative publication of Apoteket AB, MistraPharma, and Stockholm County Council, Sweden; Chapter 1, pp 14-39, 2009; ISBN: 2184-01;

<http://www.epa.gov/nerlesd1/bios/daughton/Pharmaceuticals-Sustainability-2009.pdf> (*Open Access*)

Medication use and sustainability: overview of issues surrounding the sustainable use of pharmaceuticals, published in the first book devoted to the topic of sustainable pharmacy [2010]

Daughton CG and Ruhoy IS. "Reducing the Ecological Footprint of Pharmaceutical Usage: Linkages between Healthcare Practices and the Environment," In: *Green and Sustainable Pharmacy*, Klaus Kümmerer and Maximilian Hempel (Eds.), Springer, Chapter 6, 2010, pages 77-102; ISBN: 978-3-642-05198-2;

<http://www.springer.com/environment/environmental+management/book/978-3-642-05198-2>
[request reprint: daughton.christian@epa.gov]

Medication use and sustainability: EPA report providing the first in-depth overview of all issues surrounding the sustainable use of pharmaceuticals; synthesis of all materials previously published together with new insights on the topic of sustainable pharmacy [2010]

Daughton CG. "Drugs and the Environment: Stewardship & Sustainability." National Exposure Research Laboratory, Environmental Sciences Division, US EPA, Las Vegas, NV; NERL-LV-ESD 10/081, EPA/600/R-10/106; 12 September 2010, 196 pp

<http://www.epa.gov/nerlesd1/bios/daughton/APM200-2010.pdf>

Medication use and sustainability: overview of issues surrounding the sustainable use of pharmaceuticals; first comprehensive examination published in the medical literature [2011]

Daughton CG and Ruhoy IS. "Green Pharmacy & PharmEcovigilance: Prescribing and the Planet," *Expert Review of Clinical Pharmacology*, 2011, 4(2):211-232; doi:10.1586/ecp.11.6

<http://www.expert-reviews.com/doi/abs/10.1586/ecp.11.6>

<http://www.expert-reviews.com/doi/pdf/10.1586/ecp.11.6> (*Open Access*)

Co-organized the first national conference on drug disposal [2005]

U.S. EPA Workshop: Pharmaceuticals in the Environment, Office of Research and Development, National Exposure Research Laboratory, Las Vegas, NV, 23-25 August 2005

First presentation for Drug Enforcement Administration on science behind PPCPs [2006]

Daughton, CG "Pharmaceuticals as Environmental Contaminants: An Overview of the Science," invited presentation for: End User Drug Disposal Conference, organized by the Drug Enforcement Administration, Seattle Field Division, Portland District Office, Portland, OR, 25-26 April 2006.

Drug disposal and environmental stewardship published-literature bibliographic database: first, comprehensive publically available compilation of citations relevant to the many aspects and dimensions of this topic **[May 2010-present]**

Daughton CG and Scuderi MST. "Drug Disposal and Environmental Stewardship: Relevant Literature," U.S. Environmental Protection Agency, Las Vegas, Nevada (a comprehensive bibliographic database of literature references compiled and maintained by CG Daughton and MST Scuderi; first implemented May 2010)

<http://www.epa.gov/ppcp/lit.html>;

<http://www.epa.gov/ppcp/citations-disposal.pdf> [or .txt]

Emerging Contaminants

[Emerging Pollutants/Emerging Contaminants](#): one of the first papers published on this topic; first working definition presented for "emerging pollutants" [2001]

Daughton, CG "Emerging Pollutants, and Communicating the Science of Environmental Chemistry and Mass Spectrometry: Pharmaceuticals in the Environment," *Journal of the American Society of Mass Spectrometry*, **2001**, 12(10), 1067-1076; doi:10.1016/S1044-0305(01)00287-2; pre-print:

http://www.epa.gov/nerlesd1/bios/daughton/book_jasma.pdf

[A perspective on "emerging contaminants" \[2009\]](#)

Daughton CG. "Peering into the Shadows of Chemical Space. Emerging Contaminants and Environmental Science: Is either being served by the other?" Opening address for the *2nd International Conference on Occurrence, Fate, Effects, and Analysis of Emerging Contaminants in the Environment (EmCon09)*, 4-7 August 2009, Fort Collins, Colorado.

extended abstract:

<http://www.epa.gov/nerlesd1/bios/daughton/Daughton-abstract-EmCon09.pdf>

slide presentation:

<http://www.epa.gov/nerlesd1/bios/daughton/Daughton-slides-EmCon09.pdf>

[Additional perspectives on emerging and non-regulated contaminants \[2004, 2005, 2006, 2010\]](#)

Daughton CG "Non-Regulated Water Contaminants: Emerging Research," *Environmental Impact Assessment Review* 2004, 24(7-8):711-732; doi:10.1016/j.eiar.2004.06.003;

<http://www.epa.gov/nerlesd1/bios/daughton/EIAR.pdf> (*Open Access*)

Daughton CG "'Emerging' Chemicals as Pollutants in the Environment: a 21st Century Perspective," *Renewable Resources Journal*, 2005, 23(4):6-23; doi:10.1111/j.1745-6592.2004.tb00721.x;

http://www.epa.gov/nerlesd1/bios/daughton/emerging_contaminants.pdf (*Open Access*)

Daughton CG "'Emerging Pollutants' — Questions, Challenges, and the Future," guest editorial, *Norman Newsletter*, Network of Reference Laboratories for Monitoring of Emerging Environmental Pollutants, EU, inaugural issue, June 2006;

http://www.norman-network.net/newsletters/newsletter_norman_1.pdf

Daughton CG "Emerging Contaminants and the Ramifications for Environmental Science," invited plenary presentation, Northern California SETAC 20th annual meeting, *Contaminants of Emerging Concern: Responding to a 21st Century Challenge*, University of California, Berkeley, Clark Kerr Campus, 13 May 2010; slide presentation available:

<http://www.epa.gov/esd/bios/daughton/NorCal-SETAC-2010.pdf>

Sewage Chemical Information Mining (SCIM)

Monitoring sewage for illicit drugs to calculate community-wide usage rates: first conceptualization of monitoring sewage for illicit drugs to estimate community-wide usage rates (dose reconstruction). This idea would later be formalized under the term *FEUDS* and the more general term *SCIM* [2001]

Daughton CG "Illicit Drugs in Municipal Sewage: Proposed New Nonintrusive Tool to Heighten Public Awareness of Societal Use of Illicit/Abused Drugs and Their Potential for Ecological Consequences," in *Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues*, Daughton CG and Jones-Lepp TL (Eds.), Symposium Series 791; American Chemical Society: Washington, D.C., 2001, pp. 348-364; doi:10.1021/bk-2001-0791.ch020; pre-print: <http://www.epa.gov/nerlesd1/bios/daughton/book-conclude.htm>

Forensic epidemiology using drugs in sewage - FEUDS: the first synoptic review of the application of SCIM as a tool for gauging community-wide illicit drug usage rates - FEUDS: "Forensic Epidemiology Using Drugs in Sewage" [2011]

Daughton CG "Illicit Drugs: Contaminants in the Environment and Utility in Forensic Epidemiology," *Reviews of Environmental Contamination and Toxicology*, 2011, 210:59-110; doi:10.1007/978-1-4419-7615-4_3; http://www.epa.gov/esd/bios/daughton/Illicit_Drugs_Contaminants_in_the_Environment.pdf (Open Access)

Sewage information mining (SIM) for monitoring collective public health: the first mention (see page 100 of article) of the possible utility of monitoring chemicals (especially endogenous biomarkers) occurring in sewage as collective indicators of the specific or general status of public health or disease at the community-wide level. SIM (later called SCIM: "sewage chemical information mining") may create the opportunity to view communities from the new perspective of a "collective patient." This could potentially lead to the paradigm of combining human and ecological communities as a single patient – as an interconnected whole [2011]

Daughton CG "Illicit Drugs: Contaminants in the Environment and Utility in Forensic Epidemiology," *Reviews of Environmental Contamination and Toxicology*, 2011, 210:59-110; doi:10.1007/978-1-4419-7615-4_3; http://www.epa.gov/esd/bios/daughton/Illicit_Drugs_Contaminants_in_the_Environment.pdf (Open Access)

Analysis of small-area populations by sewage chemical-information mining - ASAP-SCIM: the first paper published to formalize the concept of SCIM (sewage chemical information mining) and the use of SCIM to estimate the size of small-area (local) populations: Analysis of Small-Area Populations by Sewage Chemical-Information Mining (ASAP-SCIM) [2012]

Daughton CG "Using Sewage to Gauge Human Health: Remote, Real-Time Health Assessment of Small-Area Populations via Human Biomarkers in Sewage," *Science of the Total Environment*, 2012, 414:6-12; doi:10.1016/j.scitotenv.2011.11.015; <http://dx.doi.org/10.1016/j.scitotenv.2011.11.015> (Open Access)

Using biomarkers in sewage to monitor community-wide human health - BioSCIM: the first proposed use of SCIM to gauge collective community-wide health (or disease). The concept relies on the monitoring of specific endogenous biomarkers excreted into sewage [2012]

Daughton CG "Using biomarkers in sewage to monitor community-wide human health: Isoprostanol as conceptual prototype," *Science of the Total Environment*, 2012, 424:16-38; doi:10.1016/j.scitotenv.2012.02.038; <http://dx.doi.org/10.1016/j.scitotenv.2012.02.038> (Open Access)