Microconstituents - “pollutants we should care about”

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What are Microconstituents?

Microconstituents – (WEF - Water Environment Federation) – natural and manmade substances in environment

CPC - Compounds of Potential Concern
PC - Pollutants of Concern
EC - Emerging Contaminants - USGS
CEC - Contaminants of Emerging Concern (name coined by Dr. Christian Daughton, EPA in 1999)

PPCP - Pharmaceuticals and Personal Care Products (name coined by Dr. Christian Daughton, EPA in 1999) 
http://www.epa.gov/ppcp/

- Human drugs – prescription and OTC (Over the Counter) drugs
- Veterinary drugs
- Pet products and supplements
- Food Supplements – nutraceuticals, caffeine, nicotine
- Fragrances
- Sun-screen agents
- Lotions, shampoos, soaps, deodorants, toothpaste
- Cosmetics

Fire retardants – PBDEs, or polybrominated diphenyl ethers (penta, octa, and deca)
Industrial chemicals – bisphenol A, phthalates
Pesticides – bactericides, herbicides, fungicides, insecticides

Terms and Definitions

“Emerging” contaminants are pollutants that we have become aware of for various reasons.

Some are “new” - just created/formulated.

Some are a new combination form of previously known pollutants.

Some just got noticed as effects are seen, analytical methods improve and detection limits are lowered.

PPCPs and other chemical compounds have existed in the environment for as long as they have been used commercially.
Endocrine Disruption? Adaptation?

“Gender-bending” in fish – the testes of male fish have female eggs (Mississippi R., Potomac R., Colorado R., St. Lawrence R., Shenandoah R.) – “Intersex”

Lobsters are having developmental issues, as well as problems with shell growth and reproduction (Maine)

Male birds with female organs (Great Lakes)

Feminized male alligators (Florida)

Antibiotic- resistant bacteria

Behavioral changes
  - in fish that cause them to not be attracted to or stay with their species
  - in polar bears that causes them to not mate
  - in birds that keeps them from tending their eggs and young

Problems for humans
  - Low sperm counts in young males living in US (phthalates looked at)
  - Testosterone levels in men in age specific groups declining over past 20 yrs (study in Boston)
  - Reproductive problems with males and females
  - 1200 male babies are born with genital abnormalities every year in the UK correlation to higher phthalate conc. in mothers’ blood and milk.
Terms and Definitions

**EDCs – Endocrine Disrupting Compounds**

An endocrine disruptor is a synthetic chemical that either mimics or blocks hormones and disrupts the body’s normal functions when absorbed into the body.

**Most common EDCs in wastewater treatment are:**

- reproductive steroid hormones (especially estrogens)
- biodegradation products of surfactants (shampoos & soaps)

**Other EDCs:** Natural products in environment, Household cleaners, Personal Care Products, Pharmaceuticals, Pesticides, Processed foods, Plants (contain natural compounds called phytoestrogens), Plastics, Industrial chemicals, Animal and veterinary sources, Air deposits of fire retardants, etc. [http://www.epa.gov/endo/](http://www.epa.gov/endo/) - Endocrine Disruptor Screening Program (EDSP) List of EDCs – approx 10,000 chemicals

- Some products will contain this statement (or something similar) on the label, “Do not use if you are pregnant or breast-feeding” or “Do not expose children under 5 years of age” which could indicate the product contains EDCs
Endocrine System

- Glands that produce and secrete hormones
- Hormones regulate growth, metabolism, sexual development and function
- Pituitary gland, hypothalamus, thyroid gland, parathyroid glands, adrenal glands, pineal body, reproductive glands, pancreas
Effluent changes gender of fish

By BOONSRI DICKINSON and TODD NEFF
Scripps Howard News Service        Tuesday, December 12, 2006

Boulder Creek, CO

50: 50 male:female ratio of white suckers upstream of POTW

10: 90 male:female ratio downstream

Fish are affected by conc. as low as 1.0 ppt of 17 beta estradiol (human estrogen)

POTWs average 1-10 ppt estrogen in eff

Experiment showed fish feminized in 7 days of exposure
Small things can have large impacts
Microconstituents are showing up everywhere

The most notable state-wide study was conducted by the U.S. Geological Survey (USGS) in 1999-2000, where 139 rivers in 30 states were tested and found that 80 percent (111 rivers) of them contained 31 different drugs. (Study #1)

Steroids, nonprescription drugs, and an insect repellent were the three chemical groups most commonly detected in susceptible streams. Detergent metabolites, steroids, and plasticizers generally were found at the highest concentrations – USGS, 2002

Spring 2007 – Shenandoah and James R basins in VA – found pesticides (chlorpyrifos, lindane, endosulfan, atrazine), fragrances (galaxolide, indole and tonalide), caffeine, nicotine, prescription drugs (carbamazepine, venlafaxine, trimethoprim), OTC drugs (acetaminophen), natural and synthetic hormones, phthalates, etc.

...”it is no longer a question of if these compounds are in our waters -- they are.”
Microconstituents are showing up everywhere

- USGS found drugs, plasticizers, phthalates in the discharge from Wastewater Treatment Plants (Study #2)
  - Wastewater Treatment Plants are designed to primarily treat domestic sewage. Removing other things requires more advanced treatment.

- Trace quantities of microconstituents found in drinking water after treatment by Water Treatment Plants (Study #3)
  - Water Treatment Plants remove things mostly by precipitation and filtration.
USGS River, Wastewater and Drinking Water Sampling

1. Wastewater Treatment Plant
2. USGS #2
3. Water Treatment Plant
4. USGS #3
5. USGS #1
6. River
7. Clean water back to you
Why don’t Treatment Plants remove microconstituents?

All Treatment Plants have steps 1, 2 and 5. Most Treatment Plants have steps 1, 2, 3 and 5. Many are adding step 4 to remove nutrients, which helps remove estrogenic compounds.
Where can you find microconstituents?

ALL municipal sewage, regardless of location, will contain microconstituents. Issue is not unique to any particular municipal area.

Each geographic area will differ only with respect to the types, quantities, and relative abundances of individual contaminants. Microconstituents can be incurred by air deposits as well as by water.

Microconstituents are being found in all tested waterways, and are usually ‘present’ tap water and bottled water.

‘Present’ does not mean they are harmful.
How do some pharmaceuticals get in the water?

- **Purposeful discharge**
  Disposal of expired or unwanted PPCPs to toilets and drains as well as trash.

- **Inadvertent discharge**
  "Just passin’ through..."
  10-90% of medications may be excreted in urine.

Excretion to sewage from humans ("pass-through"), pets, and agricultural sources (e.g., CAFOs – concentrated animal feeding operations), bathing, laundry, etc.
“Just passin’ through...”

adapted by Daughton from Ternes (April 2000)
Options for drug disposal

- Intentional drug disposal via sewer causing environmental problems – **Sewer disposal discouraged for all drugs in Virginia**.

- Trash disposal better option, but still not good. Leachate from landfills eventually goes to POTWs, and then to waterways.

- “One-time” drug collection event environmentally responsible
  - Police must be present if controlled substances are collected
  - Police or DEA registrant must transport to incinerator

- Drug Collection Boxes:
  - at participating police stations
  - at participating pharmacies

- Some companies that offer pre-paid Drug Mail-Back envelopes for disposal will take controlled meds, some can’t.
The drugs below were brought in by one person to a collection event on September 26th, 2015. Go to DEA.GOV after Sept 1st to access the event locator webpage.
Disposal of Home Pharmaceuticals
if no collection event or collection box is available

- Remove from pill bottle and put in a sealable baggie or container with lid.

- Mix in something to make meds “undesirable” and unrecognizable.

- Put in plastic container to keep intact and put in trash.

- Remove or cover identifying info on pill bottle before discarding.

http://www.deq.virginia.gov/Programs/Water/PermittingCompliance/PollutionDischargeElimination/Microconstituents.aspx
Do we need all the drugs we take? Have we evolved to dependency?

- Pill to sleep
- Pill to give energy
- Pill to lose weight
- Pill to gain weight
- Pill to calm down
- Pill to speed up
- Pill to stop reproduction
- Pill to encourage fertility
- Pill for pain
- Pill for ulcer from pain pill

- Would changes in diet, habits, physique help instead of another pill?
Are these pills really helping?

...the top prescription is for your arthritis, but it may cause a heart attack. The second prescription should prevent a heart attack, but it could damage your liver. The third should prevent liver trouble, but it may destroy your spleen. The fourth protects the spleen but has been known to eat away the prostate. The fifth.....
Inadvertant PPCP Sources

- POTWs, Septic tanks
- Leaching from landfills
- Runoff from CAFOs and excretions from medicated pets (up to 90% of ingested antibiotics pass through animals and humans)
- Aquaculture antibiotics
- Direct discharge of raw sewage (e.g. overflow, straight-piping)
- Runoff and products from genetically altered crops
- Outside washing of people/animals to dislodge externally applied meds and PCPs
- Naturally occurring sources of estrogen-like compounds in wines, soy products, decaying vegetation
- Discharge of sewage from boats
- Pesticides
- Flame retardants distributed by air as dust
Origins and Fate of PPCPs† in the Environment
Pharmaceuticals and Personal Care Products

Legend

1. Usage by individuals (1a) and pets (1b):
   - Metabolic excretion (unmetabolized parent drug, parent-drug conjugates, and bioactive metabolites); sweat and vomitus.
   - Excretion exacerbated by disease and slow-dissolving medications
   - Disposal of unused/outraged medication to sewage systems
   - Disposal of euthanized/medicated animal carcasses serving as food for scavengers (1c)

2. Release of treated/untreated hospital wastes to domestic sewage systems
   (weighting toward acutely toxic drugs and diagnostic agents, as opposed to long-term medications); also disposal by pharmacies, physicians, humanitarian drug surplus

3. Release to private septic/sewage
   - Treated effluent from domestic sewage treatment plants discharged to surface waters or re-injected into aquifers (recharge)
   - Overflow of untreated sewage from storm events and system failures directly to surface waters

4. Transfer of sewage solids ("biosolids") to land (e.g., soil amendment/fertilization)
   "Straight-piping" from horses (untreated sewage discharged directly to surface waters)
   - Release from agriculture: spray drift from tree crops (e.g., antibiotics)
   - Dung from medicated domestic animals (e.g., feed) - CAFOs (confined animal feeding operations)

5. Direct release to open waters via washing/bathing/swimming
   - Discharge of regulated/controlled industrial manufacturing waste streams
   - Disposal/release from clandestine drug labs and illicit drug usage

6. Disposal to landfills via domestic refuse, medical waste, and other hazardous wastes
   - Leaching from defective (poorly engineered) landfills and cemeteries

7. Disposal to open waters from aquaculture (medicated feed and resulting excreta)
   - Future potential for release from agricultural farming (production of therapeutics in crops)

8. Release of drugs that serve double duty as pest control agents:
   - Examples: 4-aminoquinine, experimental multiple sclerosis drug – used as acid; warfarin, anticoagulant – rodent poison; azacholesterol, antilifades – avian/rodent reproductive inhibitors; certain antibiotics – used for rodent pathogens; scataminophen, analgesic – brown tree snake control; caffeine, stimulant – mosquito control

9. Ultimate environmental transport/fate:
   - Most PPCPs eventually transported from terrestrial domain to aquatic domain
   - Phototransformation (both direct and indirect reactions via UV light)
   - Physicochemical alteration, degradation, and ultimate mineralization
   - Volatilization (mainly certain anesthetics, fragrances)
   - Some uptake by plants
   - Respirable particulates containing sorbed drugs (e.g., medicated feed dusts)

Christian G. Daughton, U.S. EPA-Las Vegas

January 2004
(Original February 2001)

From: http://www.epa.gov/nhes/chemistry/pharma/
Sources in the Home

- Air fresheners and other masking agents
- Aerosols
- Cleaners
- “New Car” Smell
- New furniture, fabrics and carpet
- Older foam rubber products
- New plastic and latex items
- New electronics
- Personal care products

PFC – perfluorinated compounds
PBDE – polybrominated diphenyl ethers
What is your contribution?

Think about the products that you used from the time you got up until now:

- **Personal care products**: lotions, powders, soaps (bars, soft soaps), deodorant, gels, colognes, sprays, shampoos, rinses, hair sprays, toothpaste, mouthwash, etc.

- **Make-up**: include nail polish and removers, each part of multi part make-up

- **Medication**: ingested or topical (include OTC things like chapstick, salves, lozenges)

- Vitamins, supplements
- Caffeine, tobacco, nicotine patches
- Cleaners, deodorizers, other chemicals

http://www.safecosmetics.org/get-the-facts/chemicals-of-concern/red-list/
What is your contribution?

In 2007, the average person used 9 PPCPs a day. Most recent number is 15 PPCPs per person per day.

Read the list of ingredients – remember:

EVERYTHING GOES SOMEWHERE!

• Do you need to use all of them?

• Can you substitute something less toxic to the environment?

• Can you reduce the antibacterial products (triclosan) you use and stay healthy?
<table>
<thead>
<tr>
<th>Personal Care Product</th>
<th>Number of Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubriderm lotion</td>
<td>18</td>
</tr>
<tr>
<td>Aveeno hand lotion</td>
<td>11</td>
</tr>
<tr>
<td>Ponds face cream</td>
<td>16</td>
</tr>
<tr>
<td>Vasoline</td>
<td>1</td>
</tr>
<tr>
<td>Dove soap</td>
<td>18</td>
</tr>
<tr>
<td>Pert shampoo</td>
<td>21</td>
</tr>
<tr>
<td>Secret deodorant</td>
<td>11</td>
</tr>
<tr>
<td>Chapstick</td>
<td>27</td>
</tr>
<tr>
<td>Mabelline mascara</td>
<td>9</td>
</tr>
<tr>
<td>Covergirl lipstick</td>
<td>5</td>
</tr>
<tr>
<td>Cologne</td>
<td>9</td>
</tr>
<tr>
<td>Claritin</td>
<td>5</td>
</tr>
<tr>
<td>Premarin</td>
<td>20</td>
</tr>
<tr>
<td>Pronamel toothpaste</td>
<td>13</td>
</tr>
</tbody>
</table>

14 products  183 Ingredients/Chemicals
Why use anti-bacterial soaps?

Contains Triclosan – synthetic anti-microbial agent and EPA registered pesticide

• It has been shown that washing hands with plain soap for 20 seconds is just as effective as anti-bacterial soaps.

• Most triclosan passes through wastewater treatment plants or ends up in the sludge - very persistent and toxic to marine life.

• May contribute to development of mutant bacteria that are antibiotic resistant.

Discourage use in residential and public areas where possible.
• The Silver Institute promotes silver in medical supplies as biocide, in water purification systems, pools and spas (https://www.silverinstitute.org/site/)

• Silver or triclosan treated clothing for “anti-odor” and “anti-bacterial” purposes will release coatings with bleach detergents (~25% after 2 washes, up to 50% with more washes), discharging to sewers → POTWs → state waters. Bacteria mutate to survive, becoming more antibiotic resistant.

• The Mayo Clinic – Colloidal silver isn't considered safe or effective for any of the health claims manufacturers make. Silver has no known purpose in the body, nor is it an essential mineral, as some sellers of silver products claim.

• 3/25/15  EPA requires registration under pesticide law of products containing nanoscale (smaller than 1 micrometer) silver designed to control microbes.
Argyria from silver ingestion

- Paul Karason started turning blue 15 years after he began ingesting silver-based prep and colloidal silver to self medicate a skin condition. Stan Jones, bottom left

- **Argyria** (ahr–JIRe–uh), a blue-gray discoloration of your skin, eyes, internal organs, nails and gums. While argyria doesn't pose a serious health problem, it can be a cosmetic concern because it doesn't go away when you stop taking silver products.

- Currently no FDA approved oral OTC or prescription drugs containing silver.

- [https://nccih.nih.gov/health/silver](https://nccih.nih.gov/health/silver)
How to reduce the effects of Microconstituents

**Consumers**
- Opt for purchasing and using safer products with less environmental impacts
- Urge manufacturers to consider more environmentally suitable alternatives in their products (reduce phthalates, triclosan, fire retardants, mercury, etc.) and show there is minimal to no risk to health by the additives
- Dispose of medications responsibly
- Improve product labeling to show ingredients

**Education**
- Education of the public to protect themselves and future generations

**Disposal habits**
- Disposal habits of the public, health care industry and manufacturers need to improve (P2, H2E, etc.)
- Buy green to ease disposal – avoid styrofoam, plastics
- Buy only what you need
- Compost when you can
- Recycle, reuse, repurpose!

**Community involvement**
- Community involvement to encourage better product use, unwanted pharmaceutical collections, recycling, etc.
Public Education

- Work on reducing amount of plastic bags going to landfill
  - Urge recycle
  - Advocate use of cloth bags/other reusable bags for shopping
  - Work with grocery stores/Walmarts to promote collection of the bags for recycle by TREX: [http://www.trex.com/recycling/](http://www.trex.com/recycling/)

- Look for grants to fund programs: [http://www.epa.gov/care/](http://www.epa.gov/care/)

  The Story of Electronics, The Story of Stuff, The Story of Cap & Trade, The Story of Bottled Water, etc.
Sources of Information on Microconstituents

- Site to check for news articles on the subject worldwide
  [http://www.environmentalhealthnews.org/](http://www.environmentalhealthnews.org/)

- The Association of State Drinking Water Administrators (ASDWA)
  [www.asdwa.org](http://www.asdwa.org)

- Pharmacy waste list server
  [http://lists.dep.state.fl.us/cgi-bin/mailman/listinfo/pharmwaste](http://lists.dep.state.fl.us/cgi-bin/mailman/listinfo/pharmwaste)

- USGS Emerging Contaminant Project site
  USGS Emerging Contaminants

- Health Care without Harm - [http://www.noharm.org](http://www.noharm.org)

- The Poseiden Report – Study on effectiveness of wastewater technologies on PPCPs in WW and DW – May 06
  [http://poseidon.bafg.de/servlet/is/2884/](http://poseidon.bafg.de/servlet/is/2884/)

- WHO Working Group on Pharmaceuticals in Drinking Water
  [http://water.epa.gov/scitech/swguidance/ppcp/who.cfm](http://water.epa.gov/scitech/swguidance/ppcp/who.cfm)
More Resources

- [http://www.epa.gov/ppcp/](http://www.epa.gov/ppcp/) This is EPAs site with references, explanations, etc. on the PPCP issue

- [http://www.epa.gov/ppcp/work.html](http://www.epa.gov/ppcp/work.html) EPA reference materials


- [http://toxics.usgs.gov/highlights/whatsin.html](http://toxics.usgs.gov/highlights/whatsin.html) USGS

- Practice Greenhealth: [https://practicegreenhealth.org/](https://practicegreenhealth.org/)
Wastewater Education Sites

- Educate the community on how wastewater plants work, what can and can’t be treated
  
  [http://www.deq.virginia.gov/Programs/Water/WastewaterAssistanceTraining/WastewaterTreatment.aspx](http://www.deq.virginia.gov/Programs/Water/WastewaterAssistanceTraining/WastewaterTreatment.aspx)

- Give handouts, do outreach to community by talks, presentations, tours – info available on EPA and DEQ sites

- Education of community on recycling/reuse
  
  [http://www.deq.virginia.gov/Programs/LandProtectionRevitalization/RecyclingandLitterPreventionPrograms.aspx](http://www.deq.virginia.gov/Programs/LandProtectionRevitalization/RecyclingandLitterPreventionPrograms.aspx)


  - newspapers
  - plastic
  - aluminum
  - other metals
  - CFLs and fluorescent tubes
  - mercury containing devices
  - Waste tires and littering programs

Microconstituents in the Environment

Overview

Studies have shown that our nation’s waters contain a broad range of chemicals and compounds that can cause ecological harm. As analytical test procedures continue to measure compounds in smaller and smaller concentrations, additional compounds are being identified in our waters. These products include both human and veterinary drugs, antibiotics, fragrances and cosmetics, soaps, fire retardants, pesticides and plasticizers (compounds which are used in a wide array of plastic products ranging from plastic bottles and eye glasses to sport safety equipment).

Fact Sheets

- DISPOSAL OF HOME PHARMACEUTICALS FLYERS
  - English
  - Español
  - Chinese
  - German

Information on collection events for Unwanted/Expired Home Pharmaceuticals and Collection Sites is in the hyperlink below:

Collection Events and Collection Sites

How do microconstituents get into the water?

PPCPs (Pharmaceuticals and Personal Care Products) can end up in the waters by these two methods:

- Purposeful disposal of expired or unwanted medications and personal care products to the toilet, drain or trash.
- Inadvertent disposal by excretion to sewage from humans ("pass-through"), pets, and agricultural sources (e.g., CAFOs – concentrated animal feeding operations)

Other microconstituents can end up in household dust and inhaled or ingested, or spread by air currents throughout the environment.

What can be done?

One of the most effective control strategies for preventing microconstituents from entering the environment is prevention. Prevention can take on many forms. One thing anyone can do is to use alternative cleaning products in their home. Cleaning solutions can easily be made with products that are commonly found in the home such as lemon juice, baking soda and vinegar.

For example, to make a less hazardous window cleaner add 2 tablespoons of vinegar to 1 quart of warm water and spray the mixture on windows and wipe dry. For a substitute to an all purpose cleaner mix ¼ cup baking soda and 1 quart warm water and wipe surfaces with a sponge and then dry. For more examples of alternative cleaning products, click the links below:

- Green Alternative Recipes for Household
- Non-Toxic Home Cleaning
- Vinegar as a Natural Weed Killer
- Home Cleaning Solutions Center
- New York DEC Safer Alternatives web site

Unused and Expired Pharmaceutical Collection Events

Send your information (dates, times, location, specifics about what can or can’t be accepted, point of contact and contact information, etc.) to Deborah DeBiasi with a link, and it will be posted.

Adapting to Pollution?

**THE BREW**

Pollution's not all bad -- these days you can get three, maybe four, eyes off of one newt.
Contact Information

Deborah.DeBiasi@deq.virginia.gov

WEB site address:  www.deq.virginia.gov
Virginia Department of Environmental Quality
Office of Water Permits
Industrial Pretreatment/Whole Effluent Toxicity (WET) Program
PPCPs, EDCs, and Microconstituents
http://www.deq.virginia.gov/Programs/Water/PermittingCompliance/PollutionDischargeElimination/Microconstituents.aspx

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