Characterization of Pharmaceuticals, and Personal Care Products in Municipal Wastewater and their Removal by Nutrient Treatment Technologies

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Workgroup for the Project

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Project Team

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Municipal WWTPs

LOTT Alliance Wastewater Treatment Plants

City of Puyallup Wastewater Treatment Plant

Pierce County Chambers Creek Wastewater Treatment Plant

Blue Pro Technologies, Inc

City of Hayden Wastewater Treatment Plant

Pharmaceuticals

Prescription
Over-the-counter
Diagnostic Agents
Nutraceuticals
Excipients

Personal Care Products

Shampoo and Soaps
Lotions and creams
Fragrances
Cosmetics
Sunscreens
Insect repellant

Some Chemicals of Concern in PPCPs

- Phthalates
- Bisphenol A
- Nonylphenol
- Parabens
- Fragrances
- Controlled Substances
- Mercury
- Lead
- Triclosan
- Formaldehyde
- Toluene
- Petroleum distillates
- Nanoparticles

Obviously we cannot stop taking medication, so to a large extent this is an "end-of-pipe" treatment issue.

There is <u>little</u> research on fate and transport of PPCPs, particularly in the Pacific Northwest.

Wastewater Treatment of PPCPs

Standard wastewater treatment:

- Primary treatment (grit removal)
- Secondary treatment (biological).
- Tertiary treatment not new but uncommon. Used to further reduce nutrients or temperature

Literature:

- Activated sludge is effective for removing some PPCPs but is not effective for all. Ternes (1998) found 80% of the 38 monitored PPCP compounds were found in at least one effluent sample.

- Enhanced biological nutrient removal can reduce a significant portion of the PPCPs contained in municipal effluent (Kimura et al., 2005).

Study Goals

PREMISE of study is based on the literature:

Biological nutrient removal technologies also co-remove PPCPs.

1) Screen five wastewater plants for PPCPs – 1 day
2) Analyzed influent, effluent and biosolids for
    - Nitrogen, phosphorus and total suspended solids
    - 72 Pharmaceuticals and personal care products
    - 27 Hormones or Steroids
    - 73 Semivolatile organic carbons
3) Is treatment related to nutrient removal
    - Three of the five WWTPs provide nutrient removal treatment

Study Sites and Treatment Process

Wastewater Treatment Plant	**Abbreviation for Treatment**	**Process of Treatment**
LOTT, Budd Inlet Olympia, WA	*EBNR*	Enhanced biological nitrogen removal (EBNR) incorporated into the secondary treatment process via a modified four stage Bardenfo process
LOTT, Budd Inlet Reclaimed Water	*EBNR + F*	A portion of the secondary effluent from the EBNR process is treated by chemical addition and sand filtration.
LOTT, Martin Way Lacey, WA	*EBNR (MRB)*	Enhanced biological nitrogen removal with filtration via a membrane bioreactor.
Hayden WWTP. Hayden, Idaho	*AD*	Secondary treatment by aeration ditch.
Hayden Wastewater Research Facility Operated by Blue Water Inc.	*CA + F*.	A portion of the Hayden WWTP secondary effluent receives tertiary treatment by chemical addition and tertiary two-stage sand filtration for phosphorus removal.
Puyallup WWTP. Puyallup, WA	*AS +N*	Activated sludge with nitrification.
Pierce County, Chambers Creek WWTP. Tacoma, WA	*AS*	Activated sludge.

Methods

First task was to decide which compounds to study

- 23 Compounds were chosen from literature
  - Chosen for toxicity, endocrine action, persistence, potential for bioaccumulation, or common use as tracer compounds
  - No consistency in literature; researchers have been developing their own lists

Second task was to find capable methods

- Up until last year – variable methods
- We used 3 EPA methods and ended up analyzing for 172 analytes
  - Analytical costs were very high ~ $3300 per sample, for 3 methods.

Results

- PPCPs are found in wastewater influent, effluent and biosolids
  - 56% of compounds were found in at least one sample.
  - 75 compounds were not detected in any of the samples
- All of the 23 analytes of concern were found in at least one sample, except for the estradiols.
  - Estradiols are readily bio-transformed (Servos et al., 2005.)
- Concentrations of the 23 analytes of concern
  - agreed with or were above other studies,
  - and were among the highest in the study

Of the 172 Compounds

Several large scale patterns were found:

1. Complete removal by secondary treatment technologies, **not** in biosolids (12 analytes, i.e acetaminophen)
2. Complete removal by secondary treatment, **are** present in biosolids (8 analytes, i.e. miconazole)
3. Complete removal by sequential tertiary treatment, **not** in biosolids (8 analytes, i.e. albuterol)
4. Complete removal by sequential tertiary treatment, **are** in biosolids (31 analytes, i.e. ciprofloxacin, triclosan).
5. 11 analytes increased in concentrations from influent to effluent
6. 3 Relatively unchanged: carbamazepine, fluoxetine and thiabendazol.

WWTPs with tertiary biological nutrient removal co-removed more PPCPs than secondary processes

- 21% of 172 compounds were removed by secondary treatment
- 32% more were removed by advanced tertiary treatments with EBNR.

- Biosolids were collected at only 3 of 5 WWTPs
  - Concentrations ranged over 6 orders of magnitude, some PPCPs are clearly concentrating (Hormones and SVOCs)
  - 19 compounds were found in biosolids samples only
  - Biosolids undergo further treatment off-site and was not part of this study

Categorical removal by treatment type

Category	PPCPs[1694]	Hormones/Steroids	Semivolatile Organics
Excellent = >80% of analytes had at least 80% reduction in concentration	*EBNR + F* *EBNR (MBR)*	*EBNR + F* *EBNR (MBR)* *CA + F* *AS + N* *EBNR* *AD* *AS*	*EBNR* *EBNR + F* *CA + F* *AD*
Moderate = >60% of analytes had at least 80% reduction in concentration	*CA + F*	--	*AS + N* *AS*
Poor = <60% of the analytes had at least 80% reduction in concentration	*EBNR* *AS + N* *AS* *AD*	--	*EBNR (MBR)*

EBNR + F = enhanced biological nutrient removal and tertiary filtration
EBNR (MBR) = enhanced biological nutrient removal in a membrane bioreactor
CA + F = chemical addition and filtration applied to secondary effluent
EBNR = secondary effluent with enhanced biological nutrient removal
AS + N = final effluent from activated sludge treatment operated to provide nitrification
AS = secondary effluent from activated sludge treatment
AD = secondary effluent from aeration ditch treatment

Take Home

- Short list of analytes and new methods for further studies
- This screening level study found tertiary treatments and nutrient reduction provided the most PPCP reduction
  - Could be SRT: The EBNR process recycles the water creating longer retention times, and presumable more biological contact time.
- There is very little research on fate and transport of PPCPs in the Northwest, particularly biosolids.
- Environmental effects were not explored by this study; but are needed to put this discussion in context.

“Simply because you can test for something does not make it relevant and if a compound was not detected it does not mean it is not present or significant.”

Leah Bowe, MA Dept of Env Protection.

McHUMOR by T. McCracken

"Hmphh. Happy as clams, indeed.
They're just all on Prozac."