PHARMACEUTICAL WATER PRE-TREATMENT FOR USE IN FISH HATCHERIES

LANCE KLEMENT, PE & MICHAEL WATTS, PHD, PE
ASSOCIATION OF CONSERVATION ENGINEERS
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INTRODUCTION

Fresh Water In High Demand – Municipalities Often Take Priority

Fish Hatcheries Are Large Users

Applications For WWTP Effluent Are Possible

WWTP Effluent Poses Risks - Nutrient Limits - PPCPs

What Are Safe Limits For Constituents?
REUSE WATER FOR FISH HATCHERIES

Final Discharge

WWTP Effluent

Hatchery

Will additional treatment be required to prevent deleterious effects to growth and reproduction?

- Macronutrients
- Pathogen vectors
- Bio-active Organics
PRESENTATION AGENDA

PPCPs

Fish Accumulation

Biological Effects

WWTP Removal Effectiveness

Conclusion
PPCPS
PHARMACEUTICALS AND PERSONAL CARE PRODUCTS
Over 3,000 different chemicals in wastewater
Can enter wastewater directly or indirectly
Each chemical has different characteristics
MANY CLASSES OF PPCPS

Pharmaceuticals
• Endocrine disrupters
• Neuro-receptors
• Steroids

Personal Care Products
• Sunscreens
• Perfumes
FISH ACCUMULATION
PPCP ACCUMULATION IN FISH NOT DOCUMENTED UNTIL RECENTLY

Main challenge is difference in uptake

Mammals through liver

Fish uptake through gills and directly into bloodstream, so much more sensitive
FISH ACCUMULATION STUDIES
SUMMARY

PPCPs can bioaccumulate in fish species downstream of WWTPs

SSRIs are of considerable concern

Higher treatment processes appear to reduce bioaccumulation
CONCENTRATIONS OF SELECT SSRI IN FISH EXPOSED TO WASTEWATER FOR 3 SPECIES

CC = Channel Catfish
BC = Black Crappie
BG = Bluegill

(Brooks et al., 2005)
BIOLOGICAL EFFECTS
BIOLOGICAL EFFECTS: QUESTIONS TO DETERMINE HATCHERY LIMITS:

- What constituents cause consumption concern?
- What constituents cause fish reproductive or biological effects?
- What constituents have available data?
BIOLOGICAL EFFECTS OF SSRIS (ZOLOFT, LUSTRAL)

- Documented biological fish effects
- Appears to follow treatment level versus removal, with highest disparity between advanced and basic treatment methods
- Commonly measured among studies
BIOLOGICAL EFFECTS

- Reduced nest guarding behavior to fish exposed to sertraline and other SSRIs (Jamieson, 1995)
- Other SSRIs such as fluoxetine reduce viability to some degree in concentrations as low as 1 ng/l (Black et al., 2005)
- Anti-depressants such as venlafaxine likely also cause adverse effects
Experimented on fathead minnows

Mean water concentrations of 5-25 ng/l of sertraline resulted in tissue concentrations of 500-2500 ng/l

Water concentrations as low as 3 ng/l resulted in reduced shelter-seeking behavior
**BIOLOGICAL EFFECTS**

**Estrogenics**
- Metabolized birth control compounds (ethynylestradiol)
- Documented fish effects
  - Reduced viability
  - Higher F:M ratios (may double)

**Purdom et al., 1994**
- Trout effects from ethynylestradiol concentrations as low as 10 ng/l

**Routledge et al., 1998**
- Trout effects at concentrations from 25-40 ng/l
Relative lack of studies of other PPCPs affecting fish

Fish effects documented by SSRIs and estrogenics
- Sertraline: 1 ng/l
- Ethynylestradiol: 10 ng/l
- Functional groups have similar effects at similar dosages
WWTP REMOVAL EFFECTIVENESS
### STAGES OF WASTEWATER TREATMENT

#### Primary Treatment
- **Removes 50% of solids, 25% of BOD**
- Primary clarification

#### Secondary Treatment
- Required for all public WWTPs, consists of biological treatment
  - Trickling filters, aeration basins, MBRs, etc.
  - Removes up to 85% of BOD

#### Tertiary Treatment
- Emphasis typically on more stringent discharge limits such as phosphorous or nitrogen
- Denitrification filters, sand filters, cloth media filters, membranes
THREE POTW EFFLUENTS FROM TX, AR & OK SAMPLED IN 2014 (PRIMARY)

Primary Effluent

4-Nonylphenol
4-tert-Octylphenol
BPA
Estradiol
Estrone
Ethinyl Estradiol
Fluoxetine
Norethisterone
Progesterone
Testosterone

ng/L
THREE POTW EFFLUENTS FROM TX, AR & OK SAMPLED IN 2014 (SECONDARY)

Secondary Effluent

Limited Removal

Excellent Removal

Primary

Secondary

4-Nonylphenol 4-tert-Octylphenol BPA Estradiol Estrone Ethinyl Estradiol Fluoxetine Norethisterone Progesterone Testosterone

0 500 1000 1500 ng/L
A POTW EFFLUENT FROM OK SAMPLED IN 2014 (GRANULAR MEDIA FILTER EFFLUENT)
SMALL-FOOTPRINT, ADVANCED TREATMENT PROCESSES FOR MANAGING RESIDUAL PHARMACEUTICALS

Activated Carbon
- Phys-Chem sorption and filtration
- Granular Media (filter beds, pressure filters)
- Powdered Media

Advanced Oxidation
- Ozone
- Peroxide + Ozone
ADVANCED TREATMENT: ACTIVATED CARBON FOR PPCP SORPTION

Excellent PPCP removal rates across all classes of PPCPs

Granular media can be regenerated

Powdered media is typically disposed with other residual solids (clarifier sludge)
ACTIVATED CARBON FILTERS

Effective in gravity-beds or pressure filters

Achieve additional filtration removal

- Turbidity

Removes most organics (not just PPCPs)
POWDERED ACTIVATED CARBON IN A HIGH-RATE CLARIFIER

- Multi-stage coagulation/flocculation mixing
- Powdered activated carbon injection (some systems offer PAC capture and reuse)

Small form factor
REMOVAL OF PPCPS BY COMBINED COAGULANT AND PAC DOSING
COMPACT, COMPLETE-SYSTEM OZONE SKIDS CAN BE TAILORED TO ANY APPLICATION

600 g O$_3$/hr Complete Generation/Injection Skid
COMPACT, COMPLETE-SYSTEM OZONE SKIDS CAN BE TAILORED TO ANY APPLICATION

All items shown inside dashed line will be assembled onto one skid
EFFECT OF OZONE ON RESIDUAL CECS IN WASTEWATER

After Ozone doses up to 8 ppm
OZONE CAN REDUCE OVERALL TOXICITY OF TREATED WATERS

Ozone added to dilute solutions of PPCPs

Microbial Toxicity

Inhibition

$\text{O}_3$/$\text{H}_2\text{O}_2$
OZONE IS ALSO A RAPID WASTEWATER DISINFECTANT

![Graph showing the reduction in Total Coliform (log(Nc/N)) with ozone concentration. The x-axis represents ozone concentration in ppm (1.3 ppm, 2.7 ppm, 5.1 ppm, 7.7 ppm) and the y-axis represents reduction in log(Nc/N). Two lines indicate the reduction at 30 sec and 120 sec.]
SUMMARY

WATER SUPPLY
• Wastewater is a viable option
• Characterization of constituents is important

PPCPs
• Estrogenics and SSRIs are of documented concern

WWTP Treatment
• Tertiary treatment presents best removal
• Small package options exist
QUESTIONS?

Lance Klement, PE
LPKlement@GarverUSA.com

Michael Watts, PhD, PE
MJWatts@GarverUSA.com