

Emerging Contaminants in Detroit River: Occurrence, Removal, and Environmental Impacts

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Introduction

Statement of Problem

- **Pharmaceuticals, personal care products, and endocrine disruptors have been detected in source and drinking water**
- **No hard evidence on acute human health yet**
- **Possible risks to biota, the environment, and long-term health**
- **Also, mixture and by-products effects unknown**
- **Sewage treatment plants one source of discharging contaminants into surface water**
- **Existing treatment processes not designed to remove PhACs/EDCs**

Introduction

Statement of Problem



Source: GAO.

Introduction

Project Description

- **Among the most comprehensive research projects in the field**
- **Covered occurrence, removal, toxicity, environmental impacts**
- **Four STPs and one WTP participated**
- **Completed in three phases: baseline, Phase One, and Phase Two**
- **Baseline: determine major parameters, 5 months, chemistry, removal, toxicity, environmental impacts**
- **Phase One: similar to Baseline, more focused, 13 months**
- **Phase Two: advanced treatment technologies, by-products**

Methodology

Project Descriptions

- **Baseline: occurrence and removal efficiency, environmental impacts**
- **220 substances. 46 pharmaceuticals and bisphenol A in this presentation**
- **Full path from the STP influent to the effluent and the drinking water**
- **Same batch of water**
- **24-hours composite samples**
- **Removal efficiencies of existing treatment processes**
- **Environmental impacts**

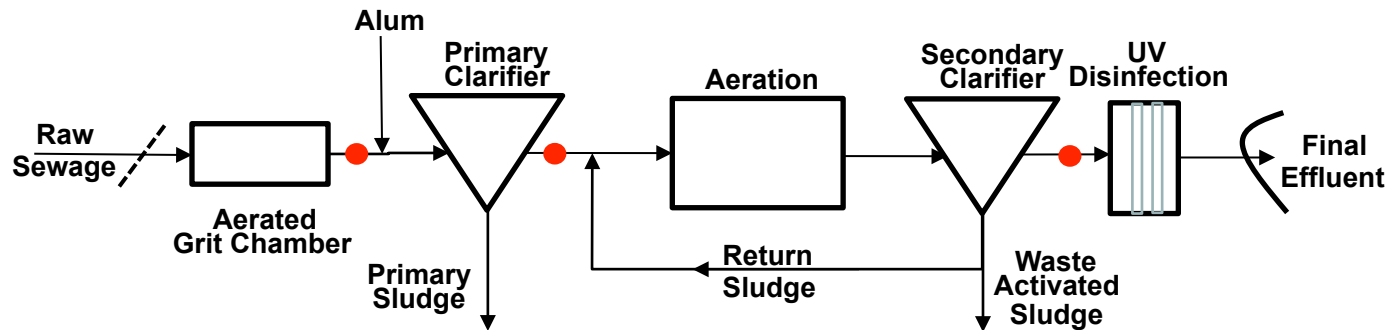
Methodology

Target Substances

PhACs & EDCs and associated MDLs (ng/L)					
Analgesic & Painkillers			27	Sulfathiazole	2
1	Acetaminophen *	2	28	Tetracycline	10
2	Ibuprofen *	0.5	29	Trimethoprim	1
3	Indomethacin *	5	Hormones, ovulation Inhibitors, estrogen replacement		
4	Ketoprofen	2	30	17- α -Estradiol	5
5	Naproxen *	2	31	17- α -Ethinyl Estradiol	5
Antibiotics			32	17- β -Estradiol	2
6	Carbadox	10	33	19-Norethsterone	5
7	Chloramphenicol	2	34	Diethylstilbestrol	10
8	Chlorotetracycline	10	35	Equilin*	2
9	Ciprofloxacin *	0.5	36	Estriol	5
10	Diclofenac *	1	37	Estrone*	2
11	Doxycycline	5	38	Progesterone *	20
12	Enrofloxacin	5	Lipid regulators, anti-coagulant		
13	Erythromycin	10	39	Bezafibrate	1
14	Lasalocid A	10	40	Clofibric acid *	0.5
15	Lincomycin	0.5	41	Gemfibrozil *	1
16	Meclocycline	10	42	Warfarin	5
17	Norfloxacin	10	Perfluoro surfactants		
18	Oxytetracycline	5	43	PFOA	1
19	Roxithromycin	2	44	PFOS	0.5
20	Sulfachloropyridazine	5	EDC		
21	Sulfadiazine	5	45	Bisphenol A *	2
22	Sulfadimethoxine	1	Others (antiepileptic, ionophore)		
23	Sulfamerazine	1	46	Carbamazepine *	1
24	Sulfamethazine *	1	47	Monensin sodium	10
25	Sulfamethizole	2			
26	Sulfamethoxazole *	2			

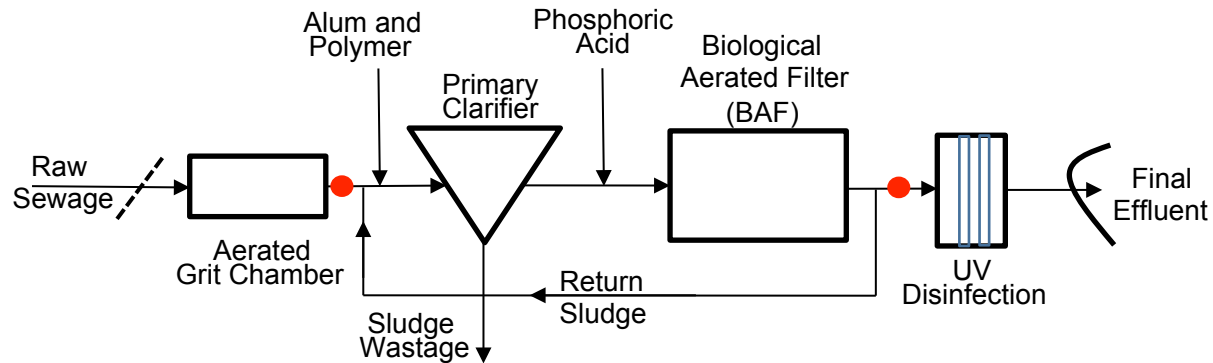
Methodology

Schematic of the Sewage Treatment Plant STP-1



Methodology

Schematic of the Sewage Treatment Plant STP-2



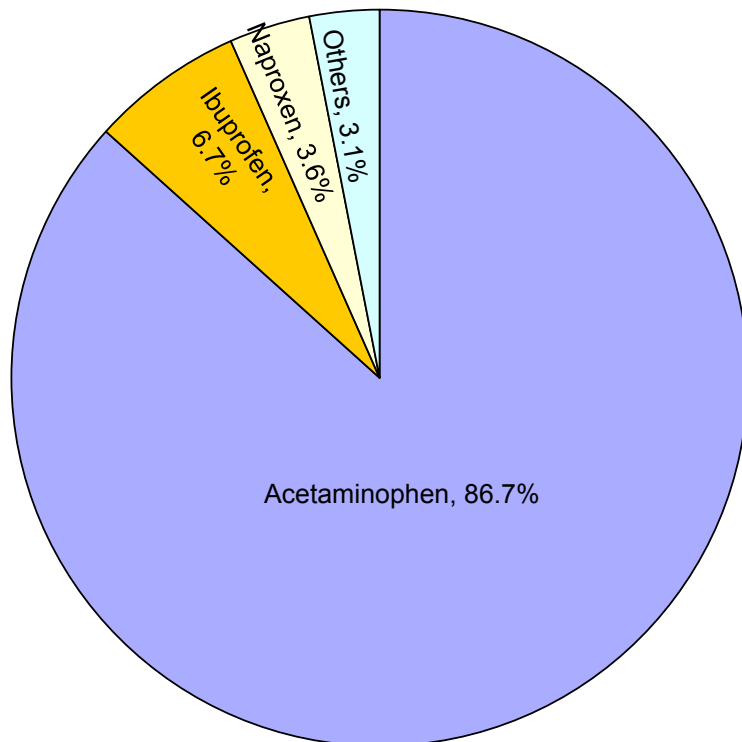
Results and Discussions

Overall Findings

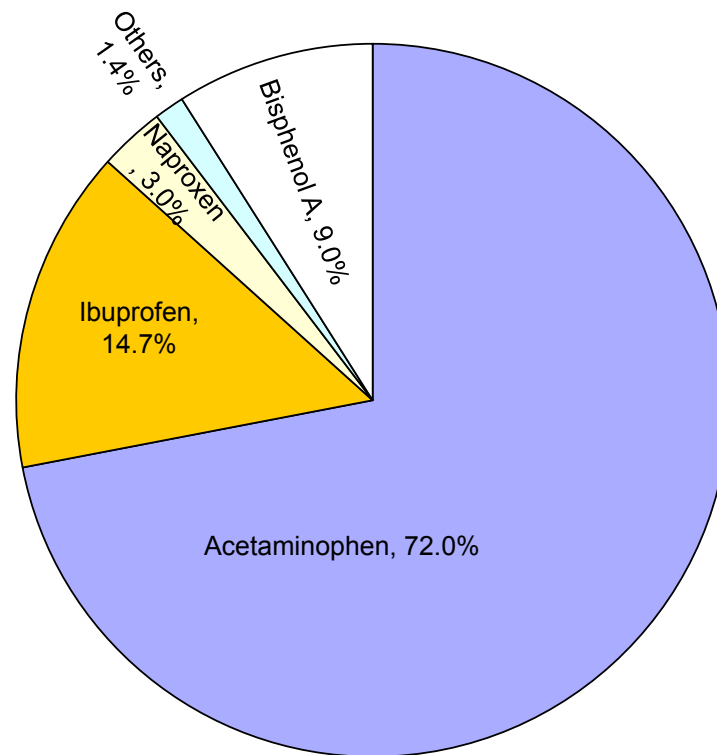
Location	Total Analyses	No. of detects	Median Monthly Conc, ng/L	Mean monthly Conc \pm SE, ng/L	Mean Removal \pm SE
WWTP-1					
Influent	188	133	212,049	183,000 \pm 46,000	
Primary	188	135	182,951	173,000 \pm 38,000	
Effluent	1,081	701	3,638	3,600 \pm 100	98% \pm 1%
WTP					
Intake	188	85	546	730 \pm 290	
Transient	141	58	615	640 \pm 100	
Finished	188	72	622	650 \pm 170	-8% \pm 24%
WWTP-2					
Influent	188	132	206,876	197,000 \pm 14,000	
Effluent	188	121	10,312	10,000 \pm 1,000	95.0% \pm 0.5%

Results and Discussions

Contribution to the STPs Influent



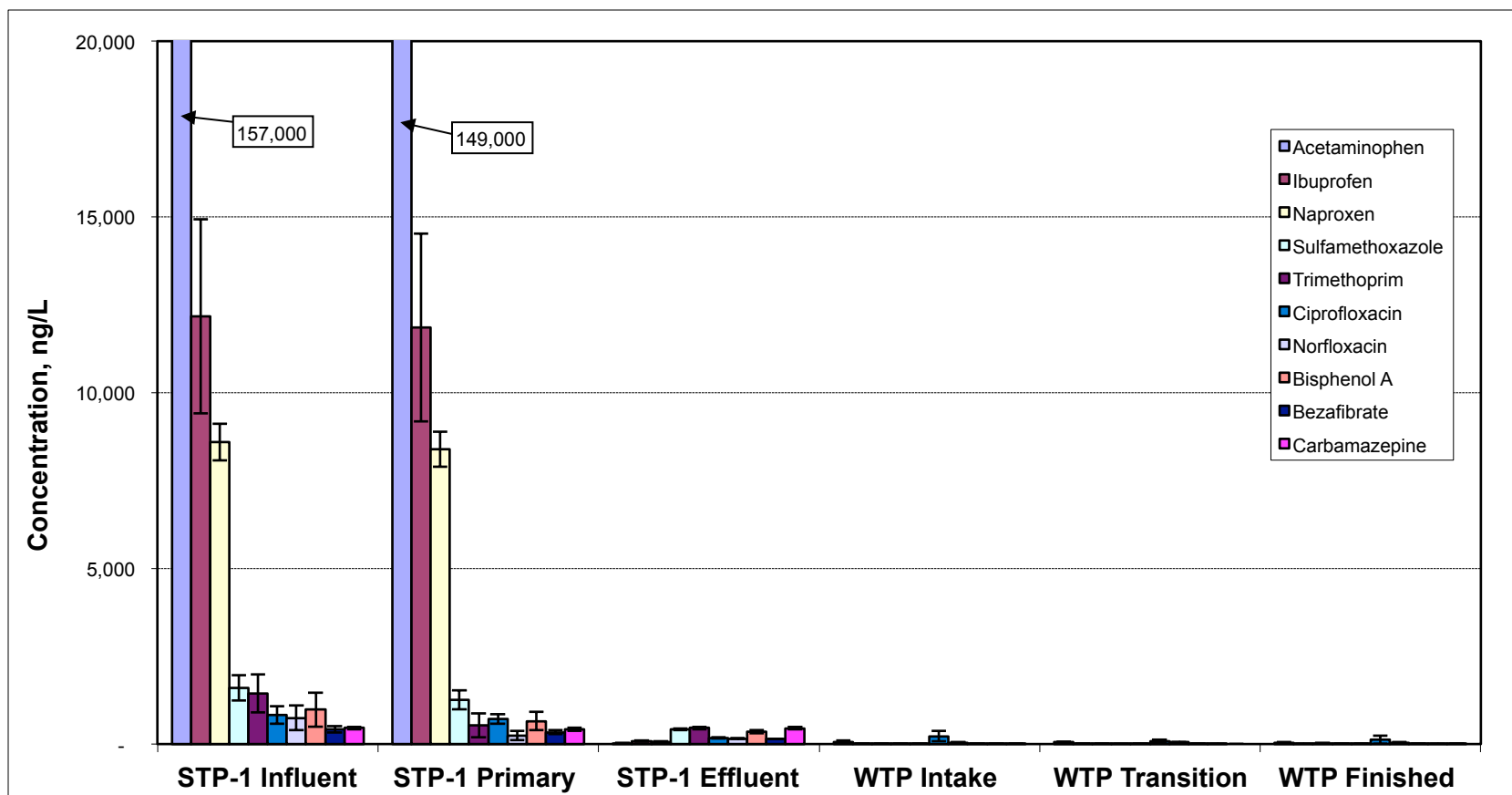
STP-1



STP-2

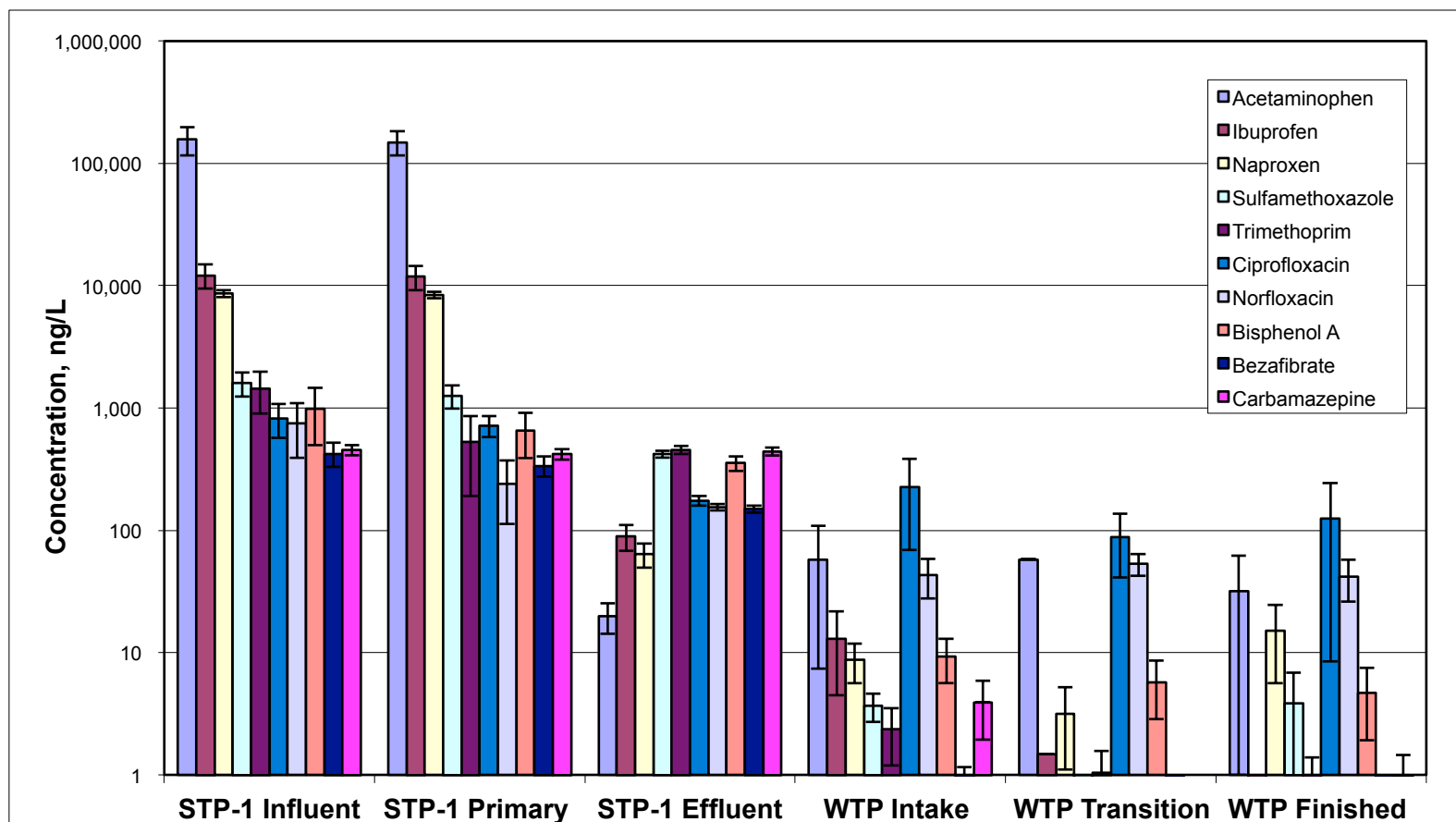
Results and Discussions

Top Ten Substances from STP-1 Influent to WTP Finished Water



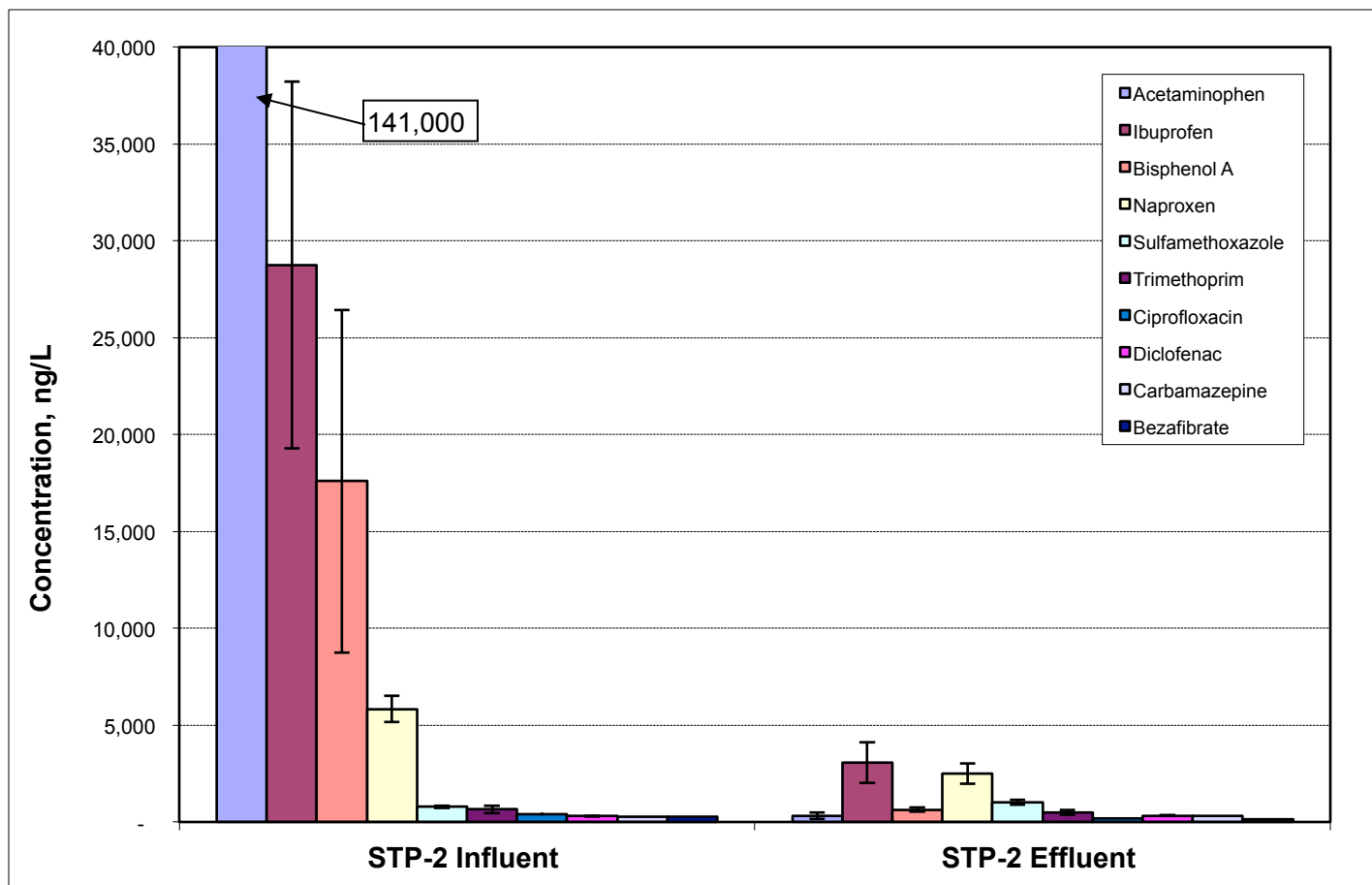
Results and Discussions

Top Ten Substances from STP-1 Influent to WTP Finished Water



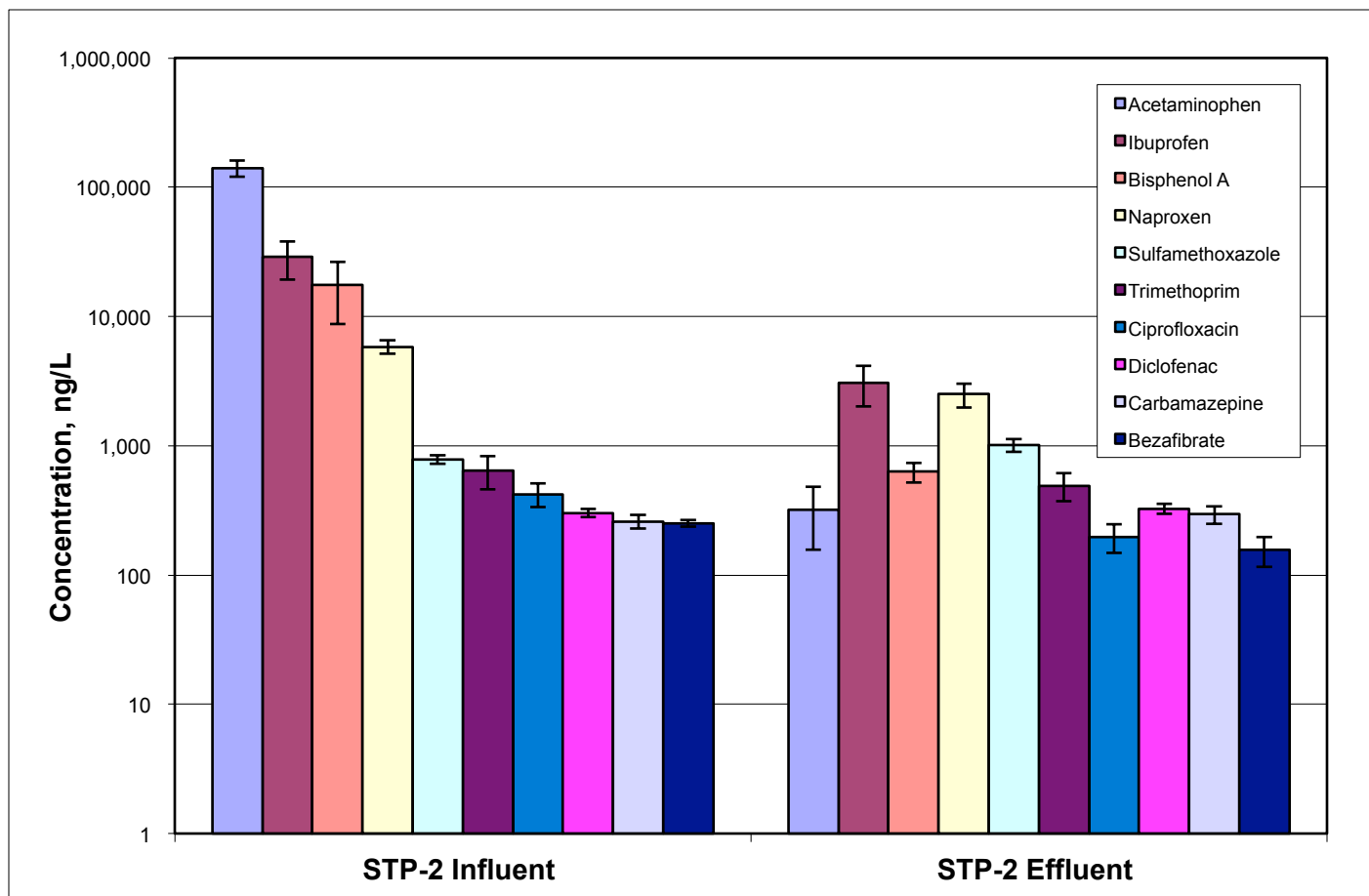
Results and Discussions

Top Ten Substances in the Influent and Effluent of STP-2



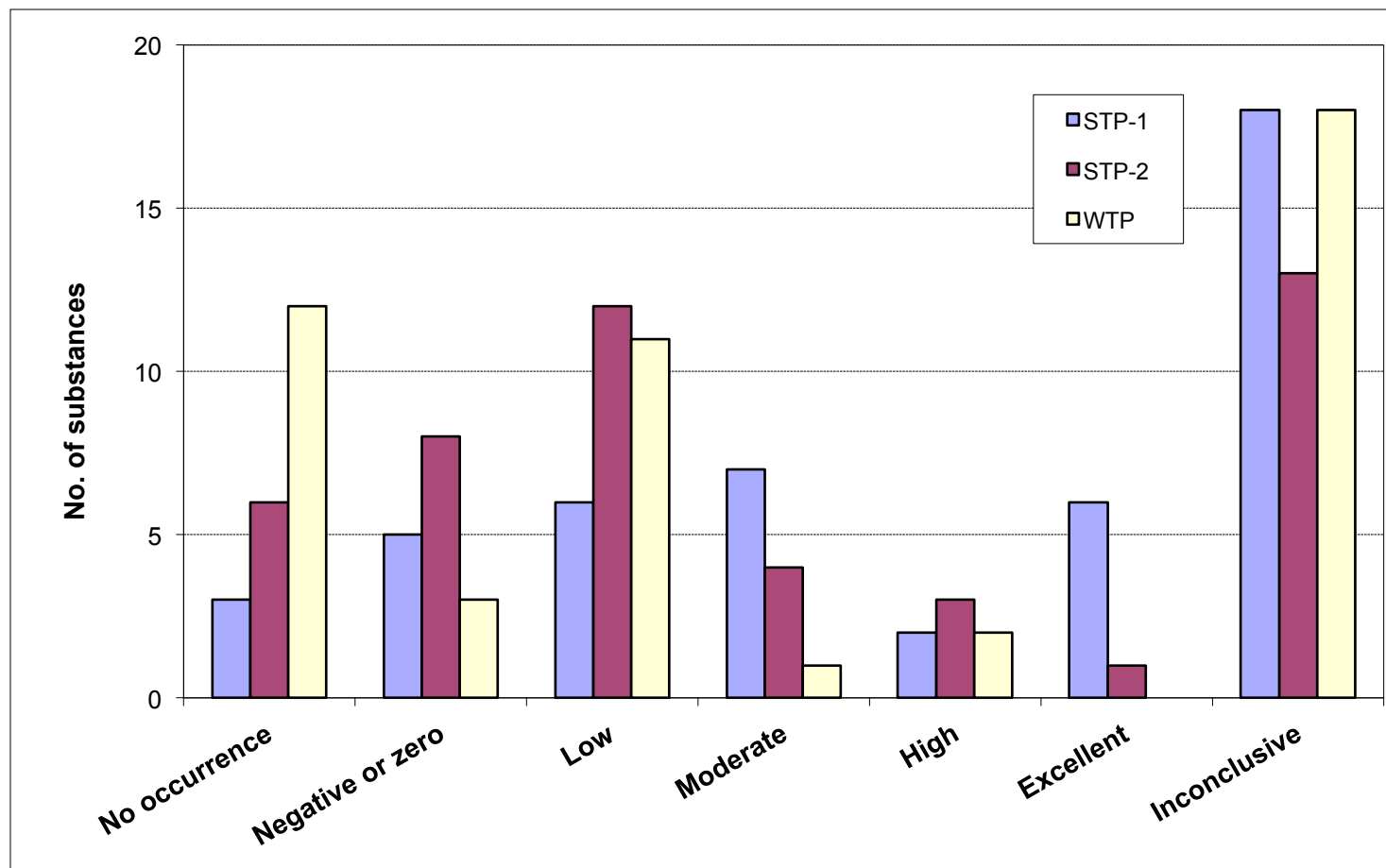
Results and Discussions

Top Ten Substances in the Influent and Effluent of STP-2



Results and Discussions

Comparison of Removal efficiency, STP-1, STP-2, WTP



Results and Discussions

Environmental Impacts

Toxicity tests conducted

Full life-cycle test:

- Fathead minnow (*Pimephales promelas*) life-cycle exposure test (5 months)

Acute and chronic toxicity tests (standard Environment Canada biological test methods):

- Rainbow trout (*Oncorhynchus mykiss*) acute lethality (96-h)
- Water flea (*Daphnia magna*) acute lethality (48-h)
- Fathead minnow survival, growth (7-d)
- Water flea (*Ceriodaphnia dubia*) survival, reproduction (3-brood)
- Duckweed (*Lemna minor*) growth inhibition (7-d)
- Algae (*Pseudokirchneriella subcapitata*) growth inhibition (72-h)

In vitro endocrine disruption screening assays:

- Yeast estrogenic screening (YES) assay
- Yeast androgenic screening (YAS) assay
- Thyroid transport receptor (T4/hTTR) binding assay

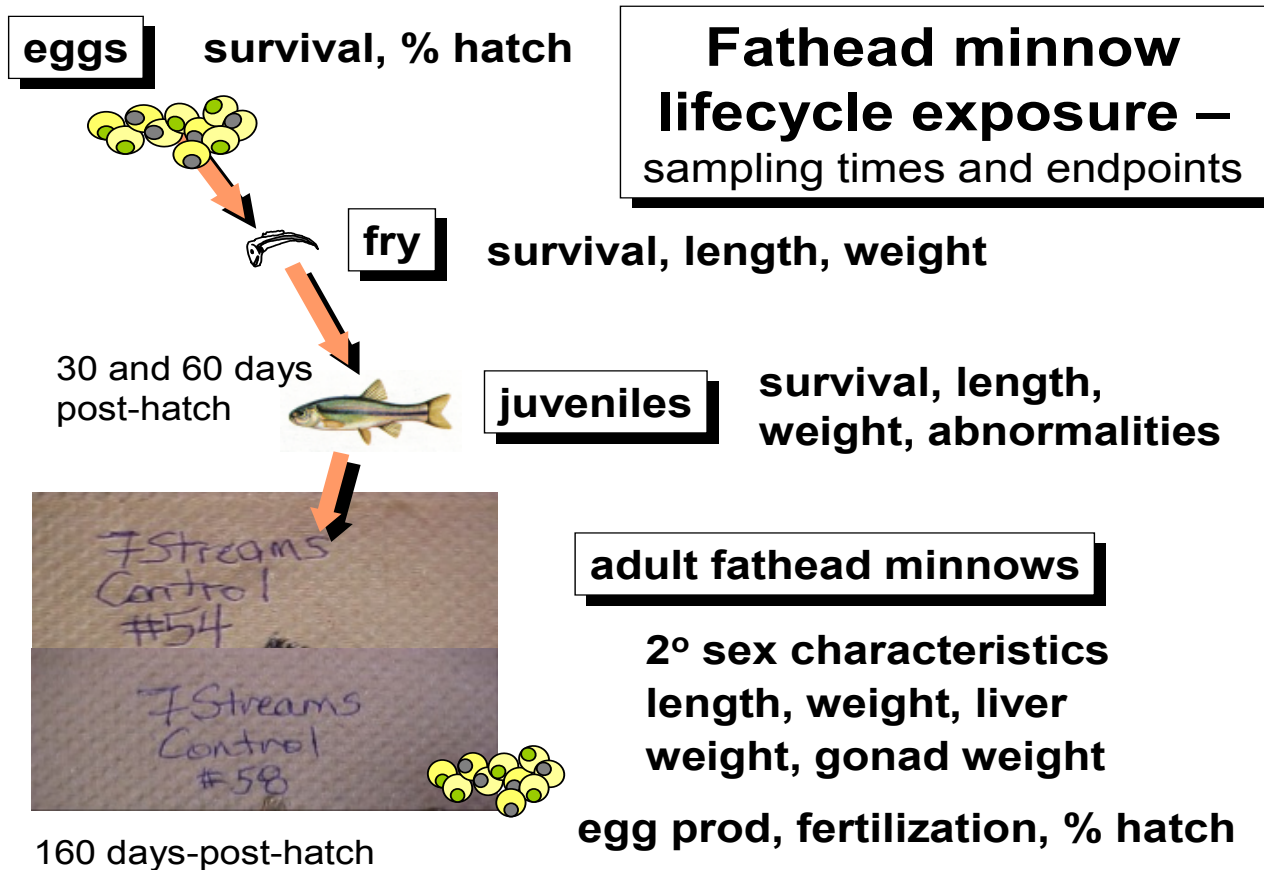
Methodology

Fathead Minnow Lifecycle Test

- Studied growth, development and reproduction of the fish exposed to the effluent of WWTP over full lifecycle
- Effluent sample circulated through the aquaria for one week, then, replaced with the next batch
- 100% effluent for the first 110 days, then reduced to 70% for 28 days
- Examined survival, sex ratio, secondary sex characteristics, egg production, fertilization, percentage hatch

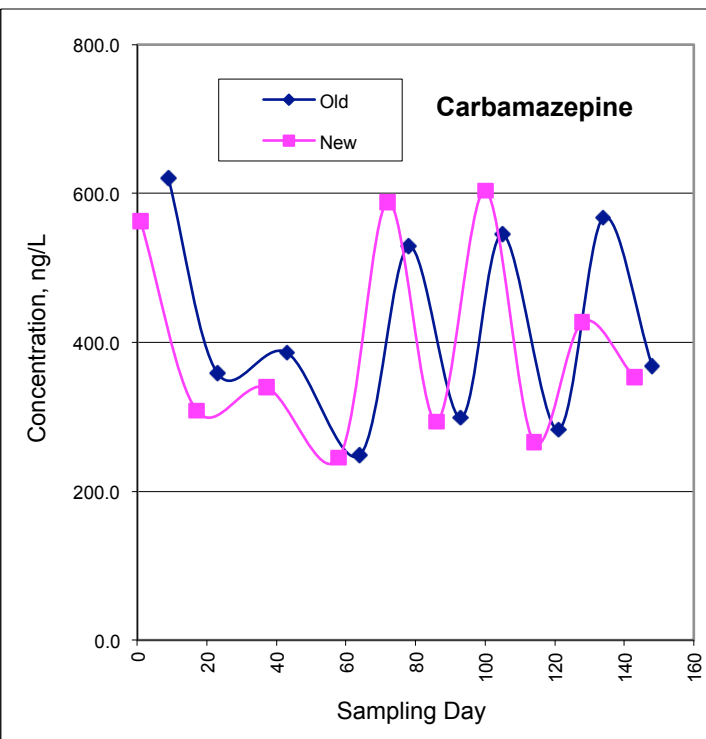
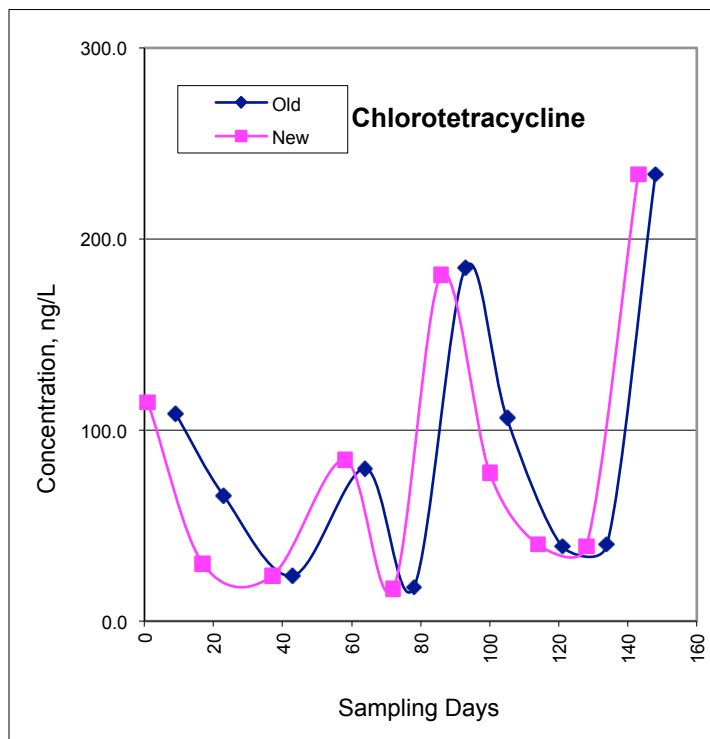
Methodology

Fathead Minnow Lifecycle Test



Results and Discussions

Composition Comparison of “Old” and “New” Water Samples



Results and Discussions

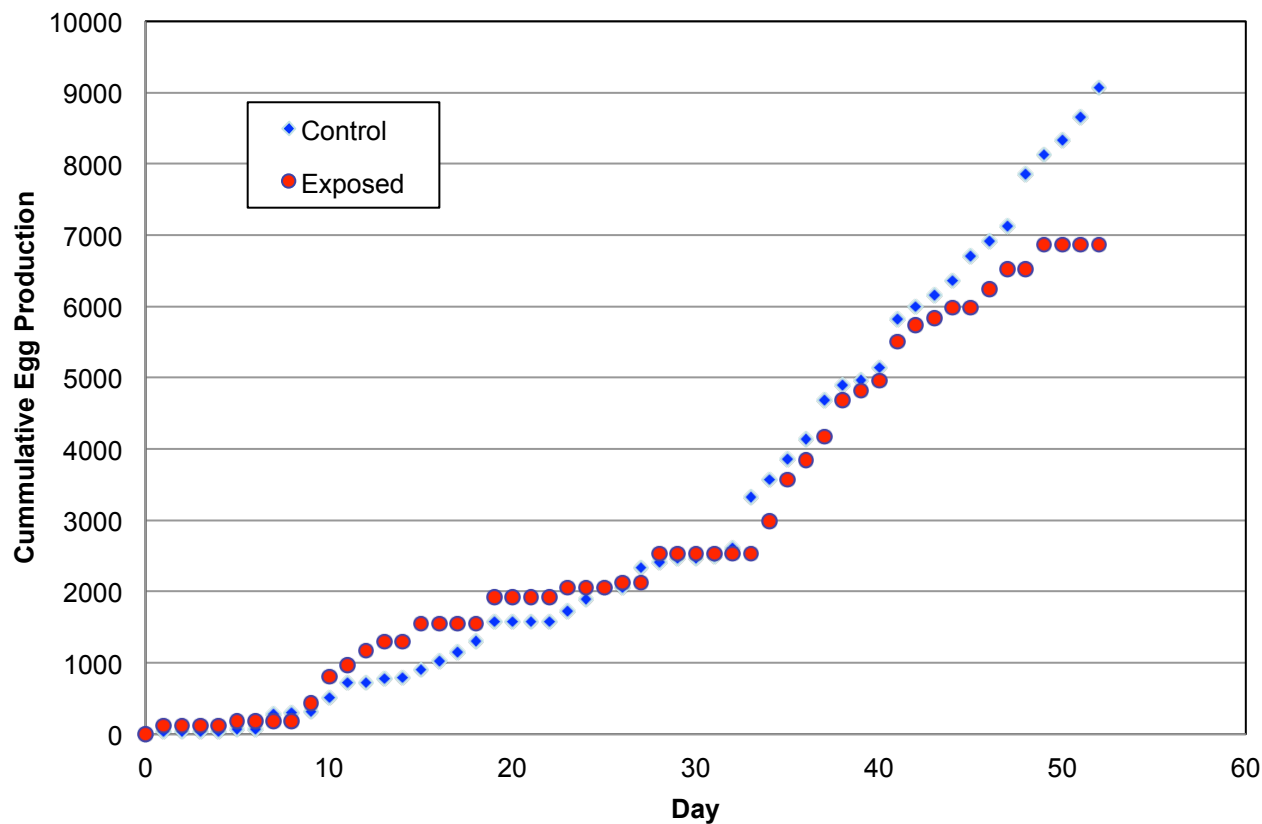
Growth and maturation of male and female fathead minnows

	Male		Female	
	Control	100% then 70% effluent	Control	100% then 70% effluent
No. of tanks	8	3	8	3
L \pm sd, mm	60 \pm 3	63 \pm 5	47 \pm 3	48 \pm 4
W \pm sd, g	3.0 \pm 0.4	3.3 \pm 0.7	1.2 \pm 0.2	1.3 \pm 0.3
CF \pm sd	1.4 \pm 0.1	1.3 \pm 0.1	1.1 \pm 0.1	1.2 \pm 0.1
LSI \pm sd	3.0 \pm 0.8	4.5 \pm 0.5	4.2 \pm 1.1	3.2 \pm 0.4
GSI \pm sd	1.5 \pm 0.3	2.3 \pm 0.5	13 \pm 5	16 \pm 5
O \pm sd mm ²	0.2 \pm 0.2	0.2 \pm 0.2	1.0 \pm 0.5	1.2 \pm 0.2
TI \pm sd	2.2 \pm 0.7	2.3 \pm 0.5	na	na
MI \pm sd	8 \pm 1	8 \pm 1	na	na

L: length; W: weight; CF: condition factor; LSI: liver-somatic index; GSI: gonadosomatic index; O: ovipositor area; TI: tubercle index; MI: male index

Results and Discussions

Cumulative Egg Production



Results and Discussions

Summary and Conclusions

Occurrence and Removal

- Acetaminophen, ibuprofen, naproxen, and bisphenol A were the most abundant at the influents of the STPs
- The above four substances were removed at high efficiency by the existing processes at the two STPs
- The overall removal efficiencies were between 95% and 98% due to the excellent removal of the four substances above
- The efficiencies of the STPs in removing other substances were generally low
- Concentrations of target substances at the intake of the WTP were very low and in the vicinity of their minimum detection limits

Results and Discussions

Summary and Conclusions

Toxicity (Fathead Minnow Lifecycle Test)

- The concentration of the water samples used for lifecycle test remained statistically the same during the test period
- Survival, growth, and sexual development of control and exposed fish were statistically the same
- Egg production and fertilization success were good, but egg hatching was reduced for exposed fish
- Liver somatic index and gonadosomatic index for male fish were statistically higher for exposed fish

Results and Discussions

Summary and Conclusions

- Generally, fathead minnow growth and reproduction were very good, considering that the fish were exposed to high effluent concentrations for an entire lifecycle
- Multi-generation test was not conducted

Thank You!

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Questions?



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