

# The Presence of Pharmaceuticals, Personal Care Products, and Other Contaminants in Source Water

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# Pharmaceuticals Use

Most drugs pass through a user's body unmetabolized. Large quantities of drugs are administered to both pets and livestock. These chemicals, which are often designed to be inherently toxic, enter waterways through direct runoff and through discharge of treated sewage. Frequently, sewage treatment does not affect the chemical structure, and therefore, the toxicity of drugs. Consequently, pharmaceuticals often enter the environment at levels similar to better studied agrochemicals.

# Land Applications of Biosolids

**Biosolids and products derived from biosolids are a potential source of pharmaceuticals and other emerging contaminants to the environment. Because this sludge, commonly called biosolids, is rich in plant nutrients, it is frequently applied to soils to fertilize plants and to improve the quality of soil.**

**These biosolids and biosolids composts are used widely in both residential and commercial landscaping and in row-crop agriculture. Because a variety of pharmaceuticals and other organics were found in SWTPs, the application of municipal biosolids on land may be a widespread source of emerging contaminants to surface and ground water.**

# Fate of Contaminants in Watershed!!

A study by USGS of the water-quality of streams found a diverse set of pharmaceuticals and organic wastewater chemicals in water samples indicated that the concentration of many of these chemicals, such as sulfamethoxazole (an antibiotic used to treat a wide range of bacterial infections), triclosan (an antimicrobial agent commonly used in soaps), and caffeine, increased dramatically downstream from the wastewater treatment plant.

# Fate of Contaminants in Watersheds...cont.

In that study also, other organic wastewater indicators (such as triclosan) were also found in much lower concentrations in the relatively pristine upper part of the watershed, and scientists attributed their occurrence to home septic systems and other sources on the landscape.

# Fate of Contaminants in Watersheds...cont.

Identifying what controls the fate and occurrence of chemicals in streams requires an understanding of the diverse factors present in a watershed, such as the geology, ground-water quality, types of ecosystems, multiple contaminant sources, climate, land use, and amount of urbanization.

**This approach could be used to understand the complex interaction of a watershed's characteristics (land use, population density, geology, hydrology, ...) and the fate and impact of contaminants, such as pharmaceuticals and organic wastewater chemicals, and to make more effective water management policies.**



# Agricultural Operations Impact

Agricultural practices can constitute a significant contribution to nonpoint sources of PPCPs and EDCs. Veterinary antibiotics were detected in surface water supplies in proximity to large-scale hog confinement operations.

The pollutants potentially leaving the CAFOs may affect watersheds directly or indirectly. The most often cited stressors affecting watersheds include nutrients, pathogens, sediments, EDCs, antibiotics, and metals.

**Direct effects occur when wastes flow directly into a receiving water as a result of poor storm water management or catastrophic failure of containment facilities. Indirect effects occur when wastes have been applied to a field and are subsequently moved into waterbodies by runoff after rainfall, percolation into groundwater with subsequent entry into streams or tile drain lines, or wind driven movement.**

**The nutrient content of the manure generated on the CAFO is one of the most significant problems. Nitrogen in the waste may be transferred in the environment in two ways. Ammonia may be volatilized from the waste directly into the air and generate odor and downwind deposition problems. Nitrate generated in the soil applied waste may enter surface or groundwater and may exceed the national drinking water limit to cause health problems in young children.**

# Effects of Pathogen Pollution

There is ample evidence that pathogens from agricultural operations have caused human disease outbreaks in the past. Ecological damage has also been indicated. More than 130 microbial pathogens have been identified from all animal species that may be transmitted to humans by various routes (USDA, 1992; USEPA, 1998). Of these, 24 pathogens are likely to originate from animal populations.

# Walkerton, Ontario

In May 2000, at Walkerton, Ontario, Canada, 2300 people were infected with *E. coli* O157:H7, and a smaller number were co-infected with *Campylobacter jejuni*. There were seven deaths, and more than 100 people were hospitalized.

After the tragedy, the Ontario government established a public Inquiry led by the Honourable Dennis O'Connor.

# Walkerton Case Study

It rained heavily in Walkerton from May 8 to May 12, 2000; 134 mm of rain fell during these five days. The heaviest rainfall occurred on Friday, May 12, when 70 mm fell.

A direct link was made to cow manure as the source of the pathogens since a pasture occupied by cattle was located near the ground water source for the city's water supply.

## PPCPs Study in Windsor, Ontario

- ❖ A study started in 2002 to investigate the presence of Pharmaceuticals, Personal Care Products, and Pesticides in source water (Detroit River)
- ❖ Compare the removal of these compounds by conventional water treatment processes vs. ozone treatment (Pilot Scale and Full Scale)

# PPCPs Study in Windsor, Ontario

The contribution of PPCPs from SWTPs and frequent CSOs are of concern to Windsor and other surrounding communities. In general, the sources, types, and concentrations of PPCPs in the river water are unknown, and they could be considered ecological and human health concern.



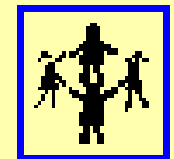
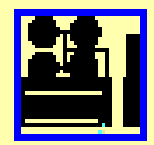
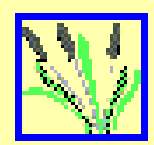
# Existing Knowledge

- ❖ In 2002, samples were collected from the pilot plant and analysis was conducted by Tulane University
- ❖ Trace levels of colibacillic acid, Bisphenol A, and naproxen were detected in raw water samples only
- ❖ The findings of that study confirm the presence of pharmaceuticals in Detroit River raw water

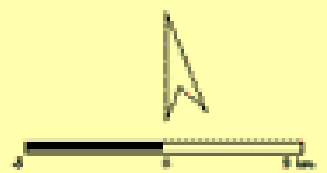
# Detroit



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## March 2002 samples

			Blank	RAW	F1	F2	A.H. Weeks
	RT	Q1	ng/L	ng/L	ng/L	ng/L	ng/L
Clofibric Acid	17.58	128	ND	103	ND	ND	ND
Ibuprofen	19.49	263	ND	ND	ND	ND	ND
Acet-d4*	19.68	284	ND	ND	ND	ND	0.17
Acetaminophen	19.74	280	ND	ND	ND	ND	ND
Caffeine	27.32	194	ND	ND	ND	ND	ND
Fluoxetine**	27.83	104	ND	ND	ND	ND	ND
Clorophene**	29.9	275	ND	ND	ND	ND	ND
Naproxen	30.74	243	ND	63	ND	ND	ND
Triclosan	31.29	200	ND	ND	ND	ND	ND
Bis-d14*	32.04	368	90.62	66.68	80.19	91.48	93.57
Bisphenol A	32.13	357	26	NQ	NQ	NQ	NQ
Est-d4*	36.18	346	84.33	77.21	82.14	74.62	90.7
Estrone	36.21	342	ND	ND	ND	ND	ND
17B-Est	36.39	285	ND	ND	ND	ND	ND
Cholesterol	40.33	329	6.3	6.3	6.3	11.3	1.8

\*% Recovery of Surrogate Standard

\*\*Not Quantitative

## July 2002 Samples

July 2002							
	RT	Q1	RAW ng/L	F1 ng/L	F2 ng/l	TREATED ng/L	MBL ng/l
Clofibric Acid	17.58	128	ND	ND	ND	ND	ND
Ibuprofen	19.49	263	ND	ND	ND	ND	ND
Acet-d4	19.68	284	ND	ND	ND	ND	ND
Acetaminophen	19.74	280	ND	ND	ND	ND	ND
Caffeine	27.32	194	ND	ND	ND	ND	ND
Fluoxetine	27.83	104	ND	ND	ND	ND	ND
Clorophene	29.9	275	ND	ND	ND	ND	ND
Naproxen	30.74	243	170	ND	ND	ND	ND
Triclosan	31.29	200	ND	ND	ND	ND	ND
Bis-d14 (%)	32.04	368	20	21.2	ND	19.2	87.4
Bisphenol A	32.13	357	ND	ND	ND	ND	ND
Est-d4(%)	36.18	346	17	15.7	ND	14.9	68.7
Estrone	36.21	342	ND	ND	ND	ND	ND
17B-Est	36.39	285	ND	ND	ND	ND	ND

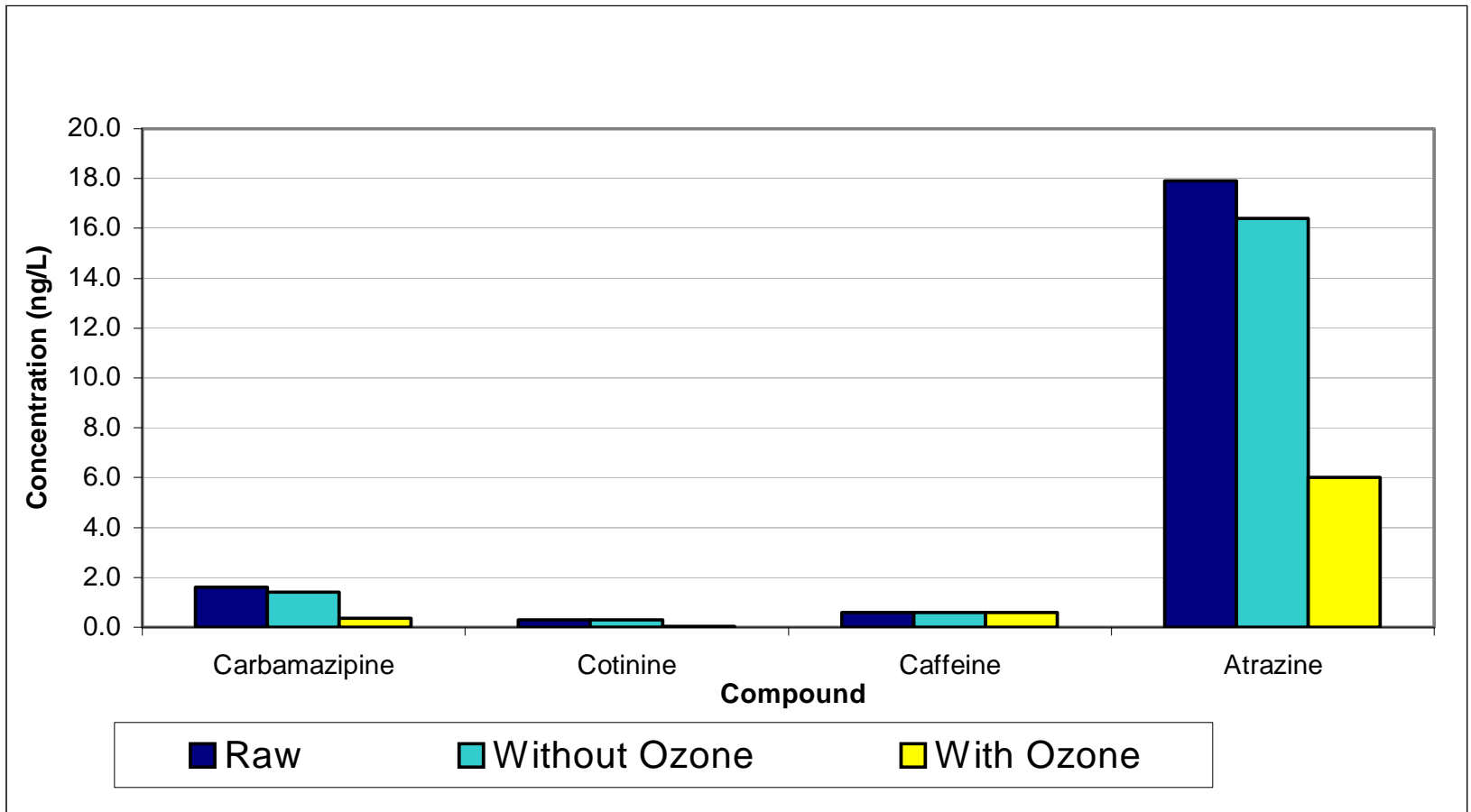
**Comments:**

F2 did not have surrogate standard added.

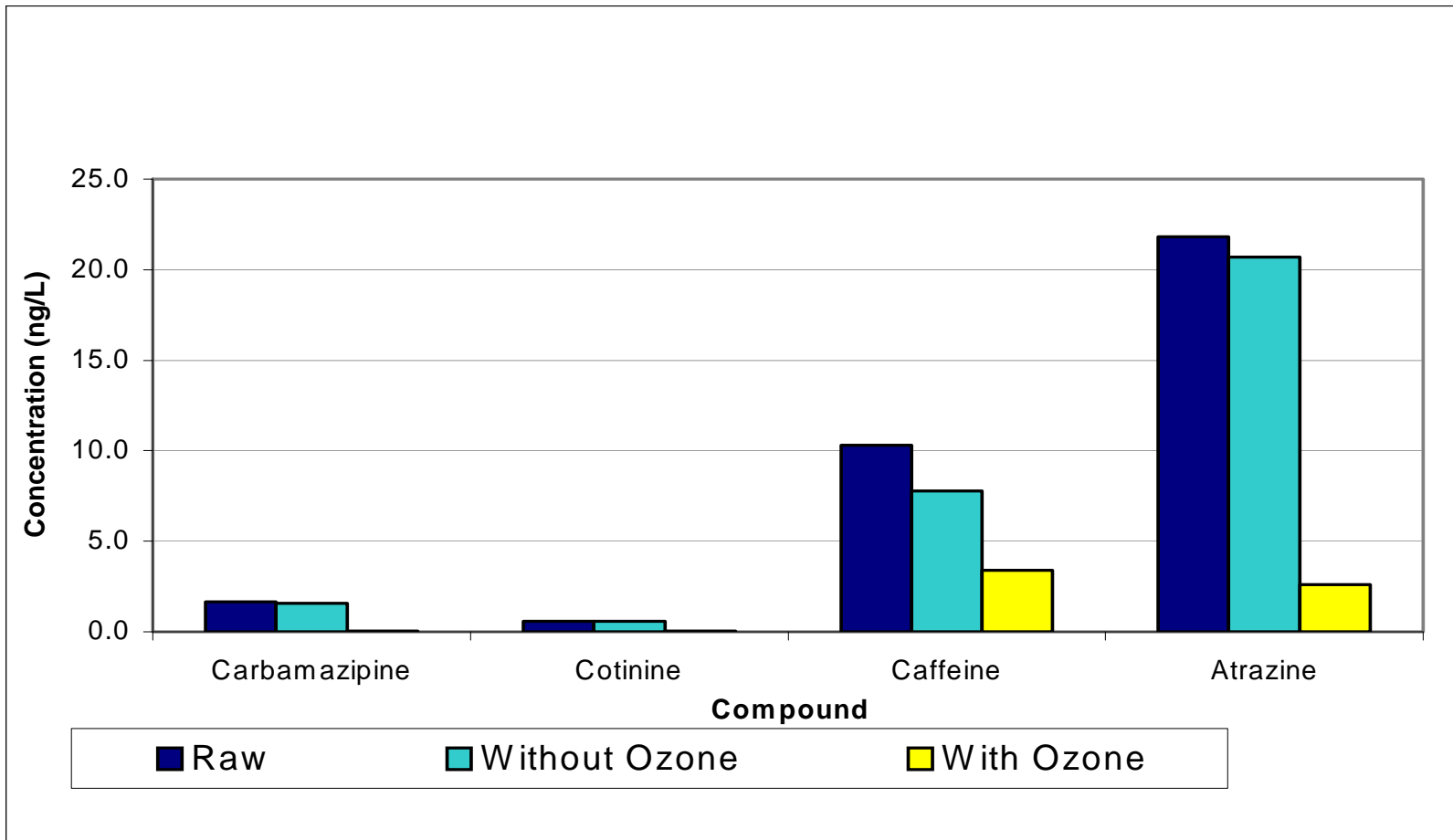
# PPCPs-Windsor..

The Second phase of the project started in the period from September 2002 to June 2003, the analysis were conducted by the University of Windsor. The analysis indicated the presence of certain compounds in Detroit River water, such as Carbamazepine, Cotinine, Atrazine and Caffeine

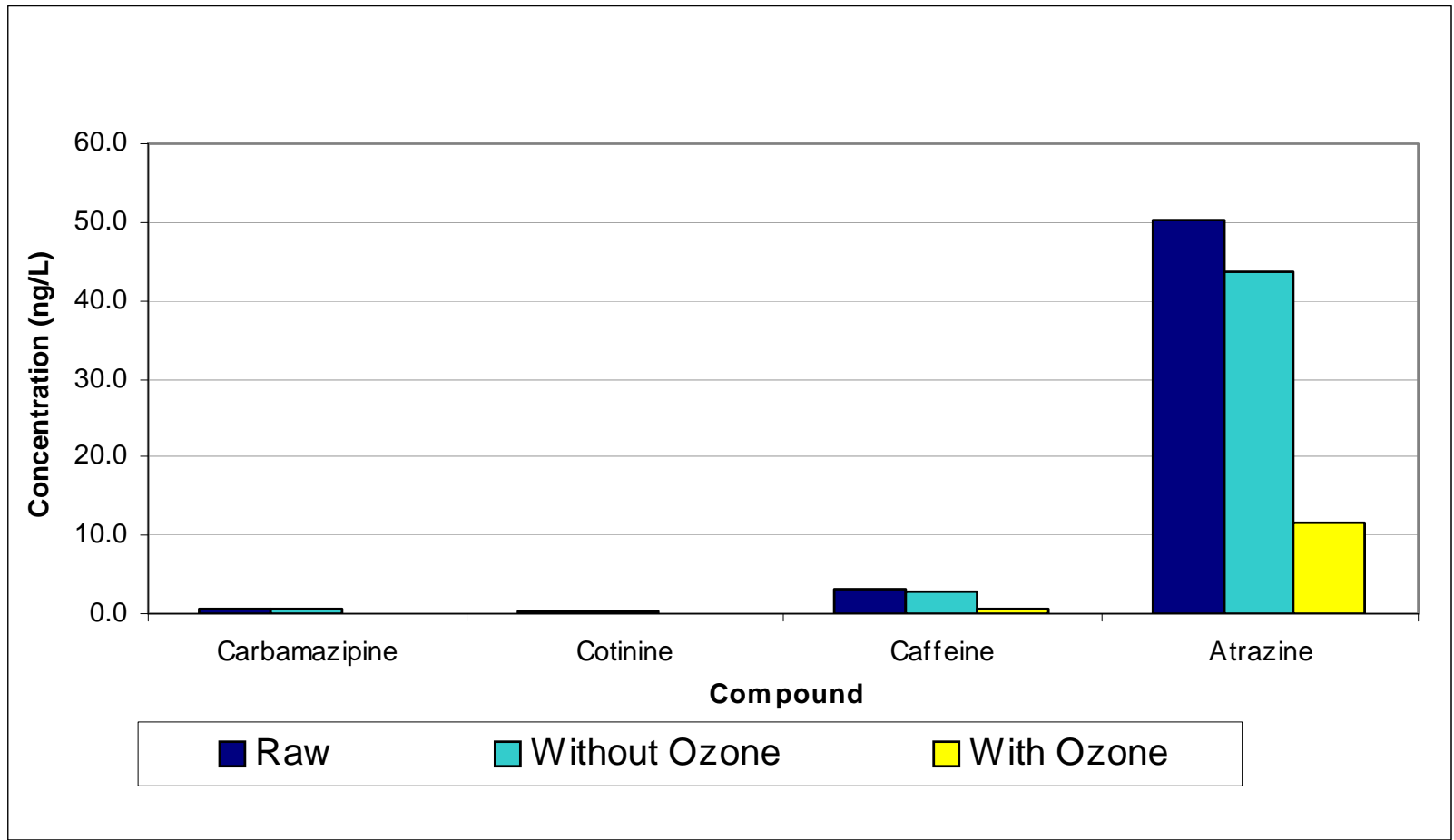
# Average for Compounds in Raw Water and Filters Effluent, September 2002 (Jasim et. al. 2006)



# Average for Compounds in Raw Water and Filters Effluent, April 2002 (Jasim et. al. 2006)

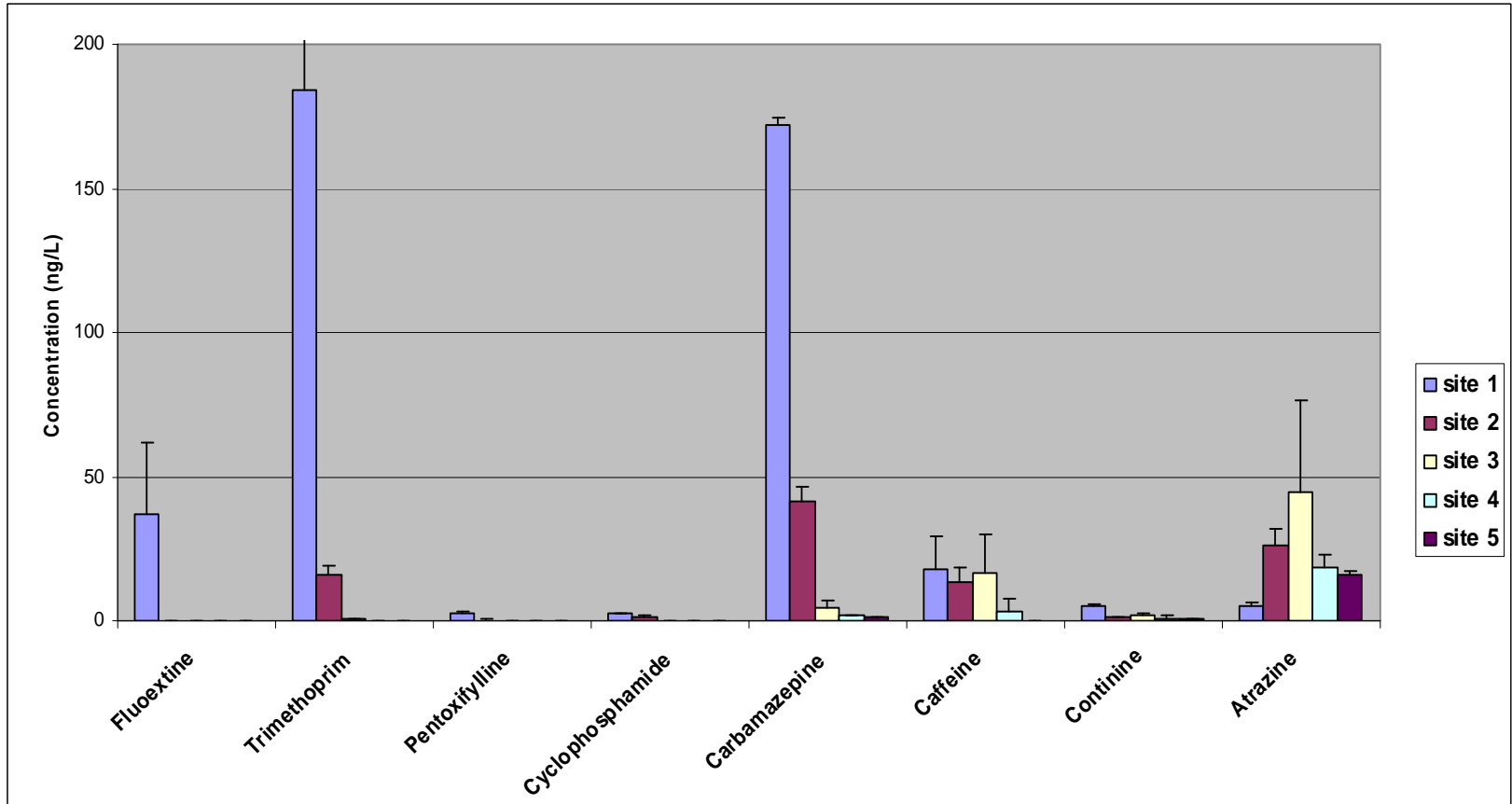


# Average for Compounds in Pilot Plant Raw Water and Filters Effluent, June 2003 (Jasim et. al. 2006)





# Neutral Drugs and Atrazine Identified in SWTP Effluent (Hua et al. 2003)



# New Study in Windsor-2004

- ❖ Windsor Utilities Commission
- ❖ AWWARF
- ❖ City of Detroit, Michigan
- ❖ Ontario Ministry of the Environment
- ❖ University of Windsor
- ❖ Oakland University, Rochester, MI
- ❖ Health Canada
- ❖ International Joint Commission
- ❖ Earth Tech Canada

# Existing Studies

- **Removal of Pharmaceuticals and Personal Care Products and Endocrine Disrupting Compounds from Drinking Water Using Novel Membrane Technologies (University of Ottawa, National University of Singapore, Hyflux Inc., Singapore., Walkerton Clean Water Centre & Ontario Ministry of Environment.)**
- **Evaluation of the Removal of Pharmaceuticals and Personal Care Products (PPCPs) and Endocrine Disrupting Compounds (EDCs) using Ozone and UV Application in Drinking Water Treatment -University of Windsor & Walkerton Clean Water Centre**
- **Removal of Endocrine Disrupting Compounds, Pharmaceuticals and Personal Care Products from Drinking Water using Advanced Oxidation Processes (Ozone & Hydrogen Peroxide)-University of Western Ontario & Walkerton Clean Water Centre**