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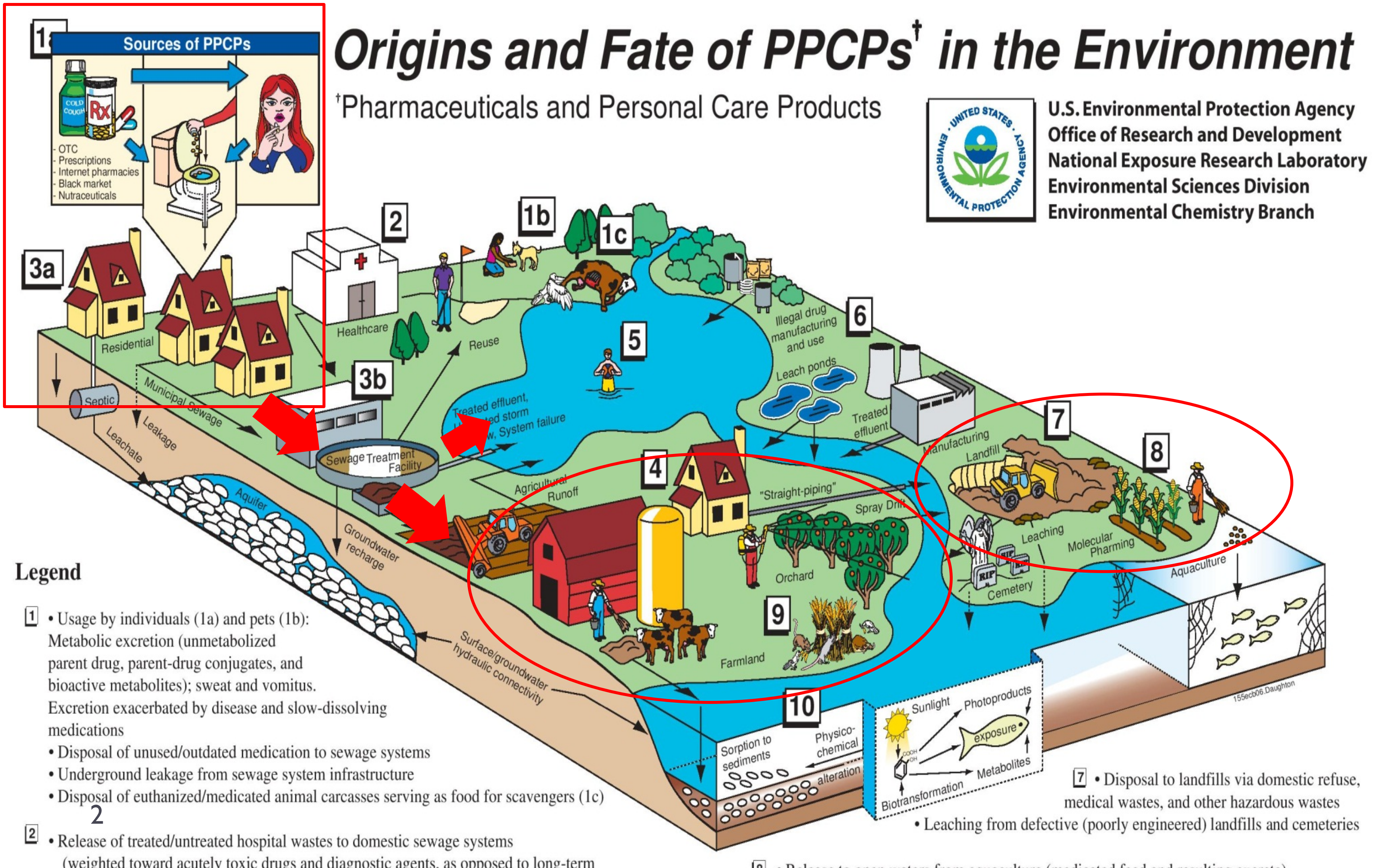
CEE 697z
Organic Compounds in Water and Wastewater

PPCPs: Source Loads and Observations in Natural Systems

Lecture #18

For Background see:
http://www.ecs.umass.edu/eve/background/chemicals/PPCPs/PPCP%20occurrence.html

EDC/PPCP Sources



Estimating Source Terms

- Use-based calculations (e.g., Sedlak)
  - Get national or regional use data
  - Estimate non-metabolized/adsorbed fraction
  - Estimate removal across conventional WWT
- Real WW effluent monitoring
  - Highly variable based on date, time, location, processes, climate, etc

Sui et al., 2011

Environmental Science & Technology

ARTICLE

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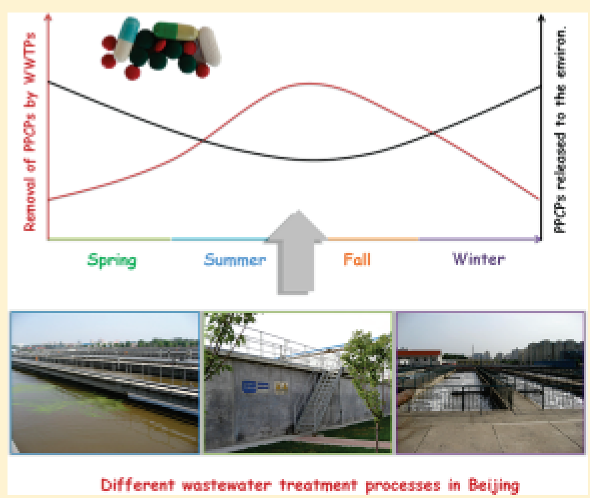
Seasonal Variation in the Occurrence and Removal of Pharmaceuticals and Personal Care Products in Different Biological Wastewater Treatment Processes

Qian Sui, Jun Huang, Shubo Deng, Weiwei Chen, and Gang Yu*

School of Environment, THU – VEOLIA Joint Research Center for Advanced Environmental Technology, Tsinghua University, Beijing 100084, China

Supporting Information

ABSTRACT: The occurrence of 12 pharmaceuticals and personal care products (PPCPs) in two wastewater treatment plants in Beijing was studied monthly over the course of one year. The removal of PPCPs by three biological treatment processes including conventional activated sludge (CAS), biological nutrient removal (BNR), and membrane bioreactor (MBR) was compared during different seasons. Seasonal variations of PPCPs in the wastewater influent were discrepant, while in the wastewater effluent, most PPCPs had lower concentrations in the summer than in the winter. For the easily biodegradable PPCPs, the performance of MBR was demonstrated to be more stable than CAS or BNR especially during winter months. Diclofenac, trimethoprim, metoprolol, and gemfibrozil could be moderately removed by MBR, while their removal by CAS and BNR was much lower or even negligible. Nevertheless, no removal was achieved regardless of the season or the treatment processes for the recalcitrant PPCPs. Studies on the contribution of each tank of the MBR process to the total removal of four biodegradable PPCPs indicated the oxic tank was the most important unit, whereas membrane filtration made a negligible contribution to their elimination.



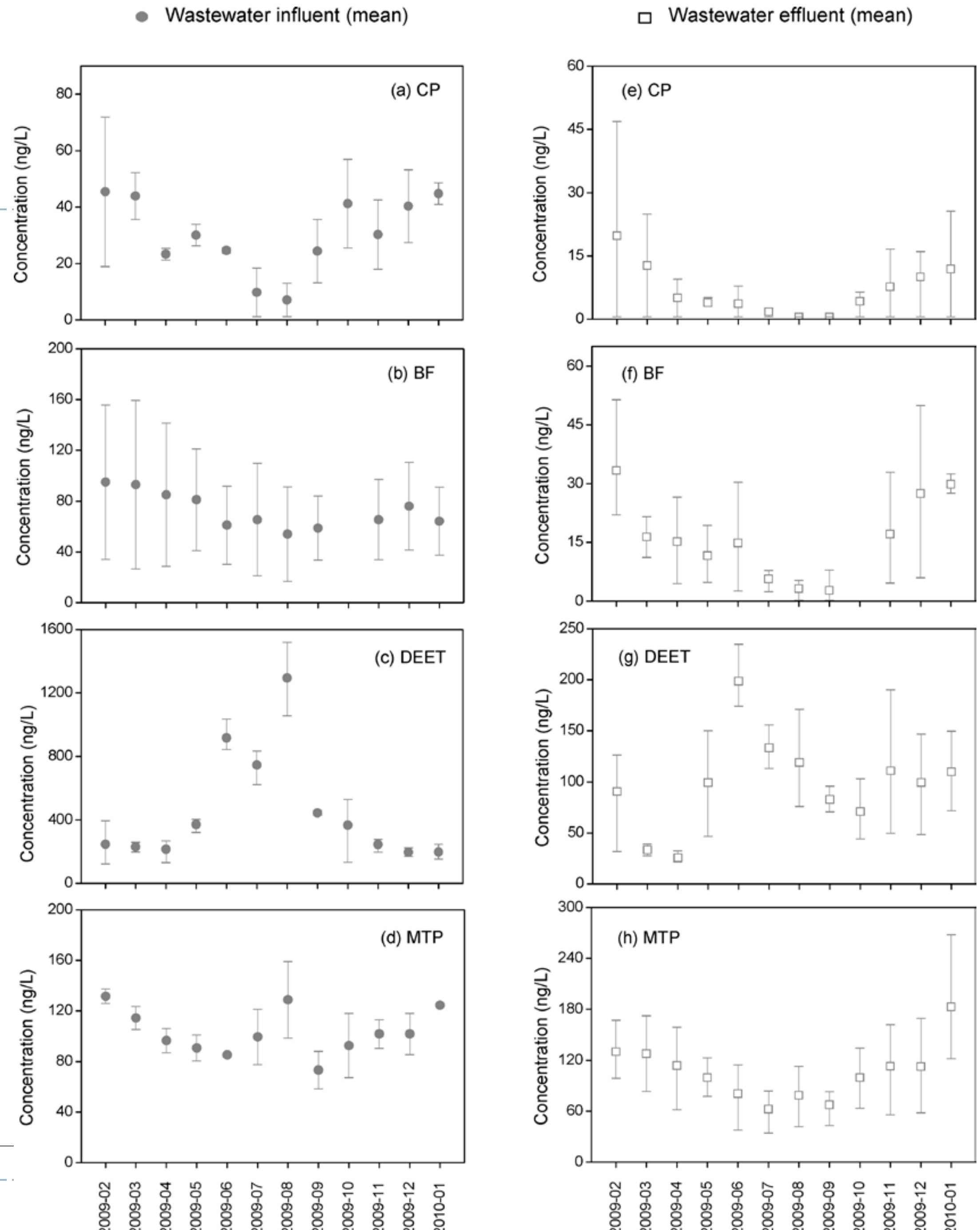
Sui, Q., Huang, J., Deng, S.B., Chen, W.W. and Yu, G. (2011) Seasonal Variation in the Occurrence and Removal of Pharmaceuticals and Personal Care Products in Different Biological Wastewater Treatment Processes. Environmental Science & Technology 45(8), 3341-3348.

Compounds Studied

- **BF** → Bezafibrate
- **CBZ** → Carbamazapine
- **CF** → Caffeine
- **CP** → Chloramphenicol
- **DEET** → N,N-diethyl-m-toluamide
- **DF** → Diclofenac
- **GF** → Gemfibrozil
- **MTP** → Metoprolol
- **SP** → Sulpiride
- **TP** → Trimethoprim

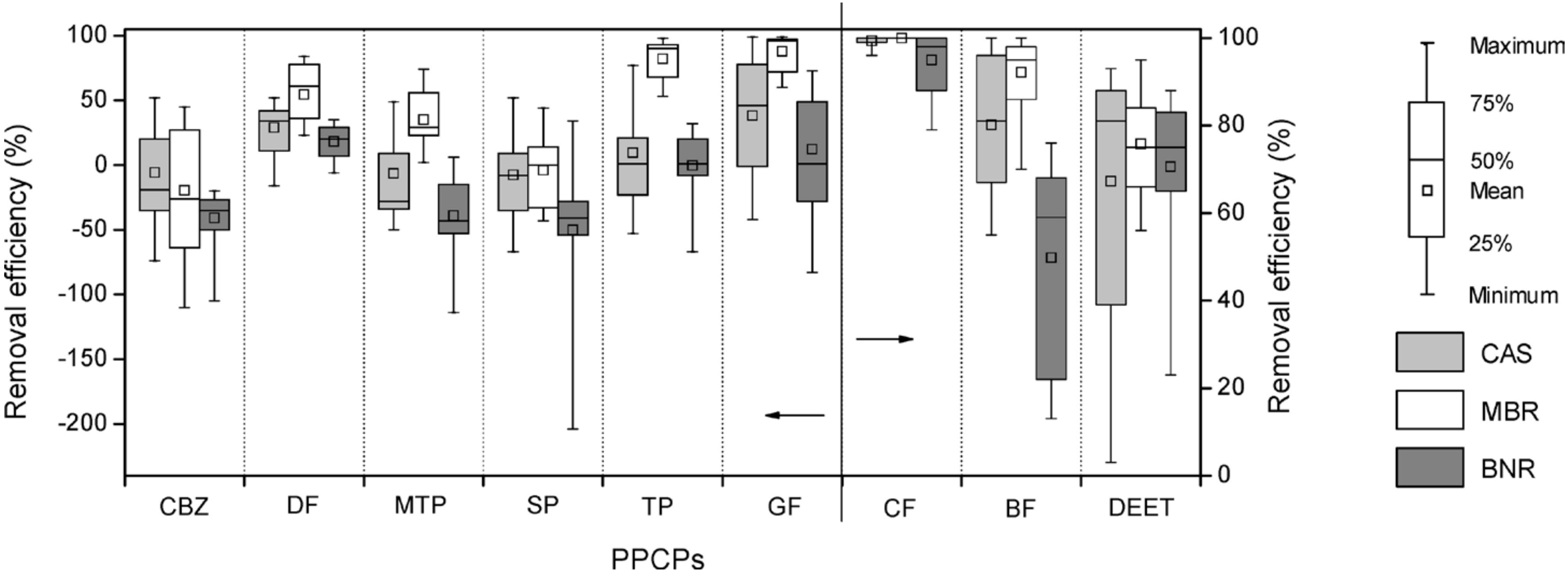
Seasonal Variability

Seasonal variation in the concentrations of some PPCPs in the wastewater influents (a−d) and effluents (e−h). The symbols represent the mean concentration, and error bars represent the maximum and minimum concentration in CAS, MBR, and BNR processes.



Published in: Qian Sui; Jun Huang; Shubo Deng; Weiwei Chen; Gang Yu; *Environ. Sci. Technol.* **2011,** 45, 3341-3348.

Process Removal Efficiencies



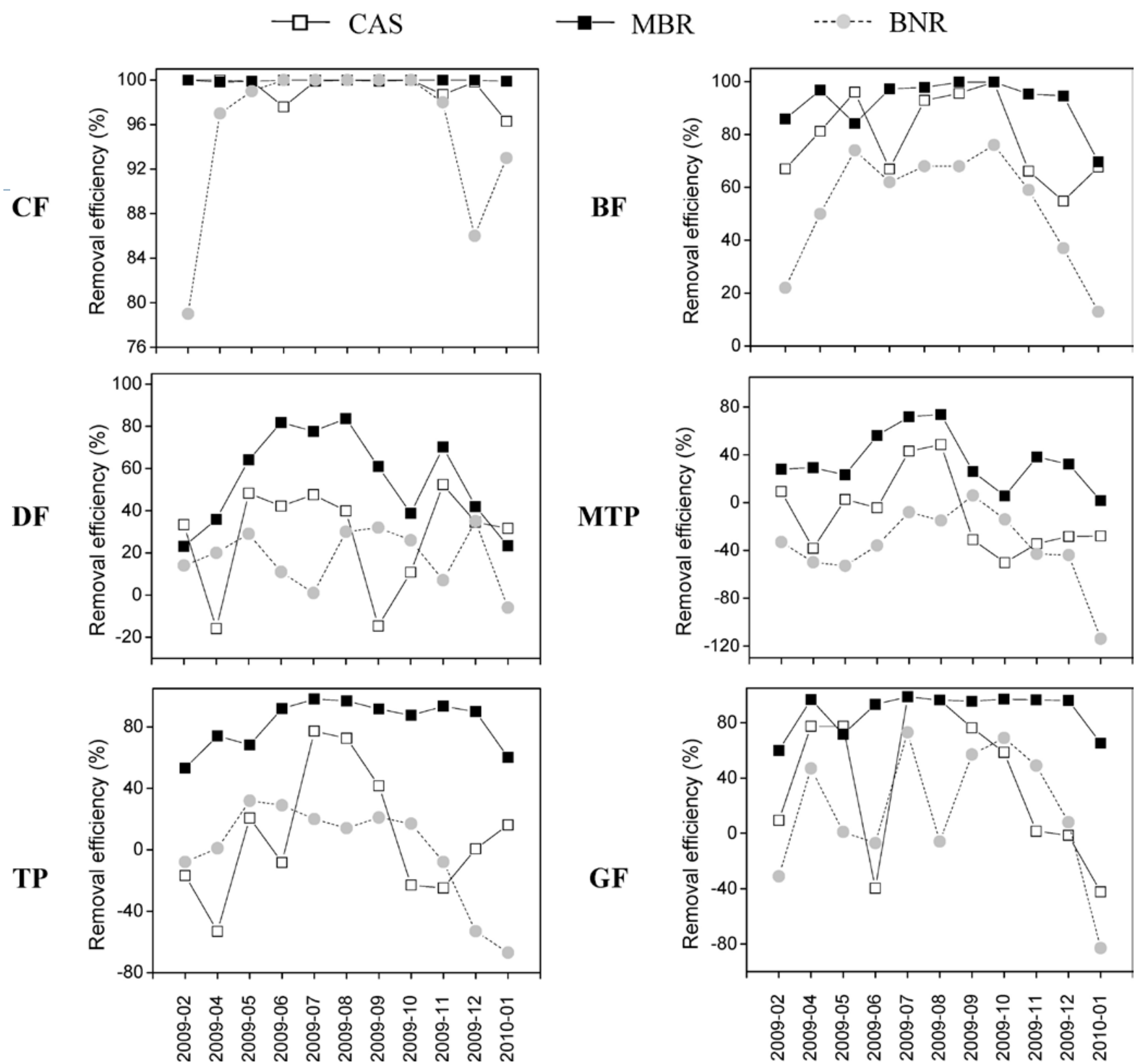
Comparison of the overall removal efficiencies by:

- Conventional Activated Sludge (CAS)
- Biological Nutrient Removal (BNR), and
- Membrane Bioreactor (MBR) processes.

ACS Publications
High quality. High impact.

Published in: Qian Sui; Jun Huang; Shubo Deng; Weiwei Chen; Gang Yu; *Environ. Sci. Technol.* **2011**, 45, 3341-3348.
DOI: 10.1021/es200248d

Seasonal variability for removal

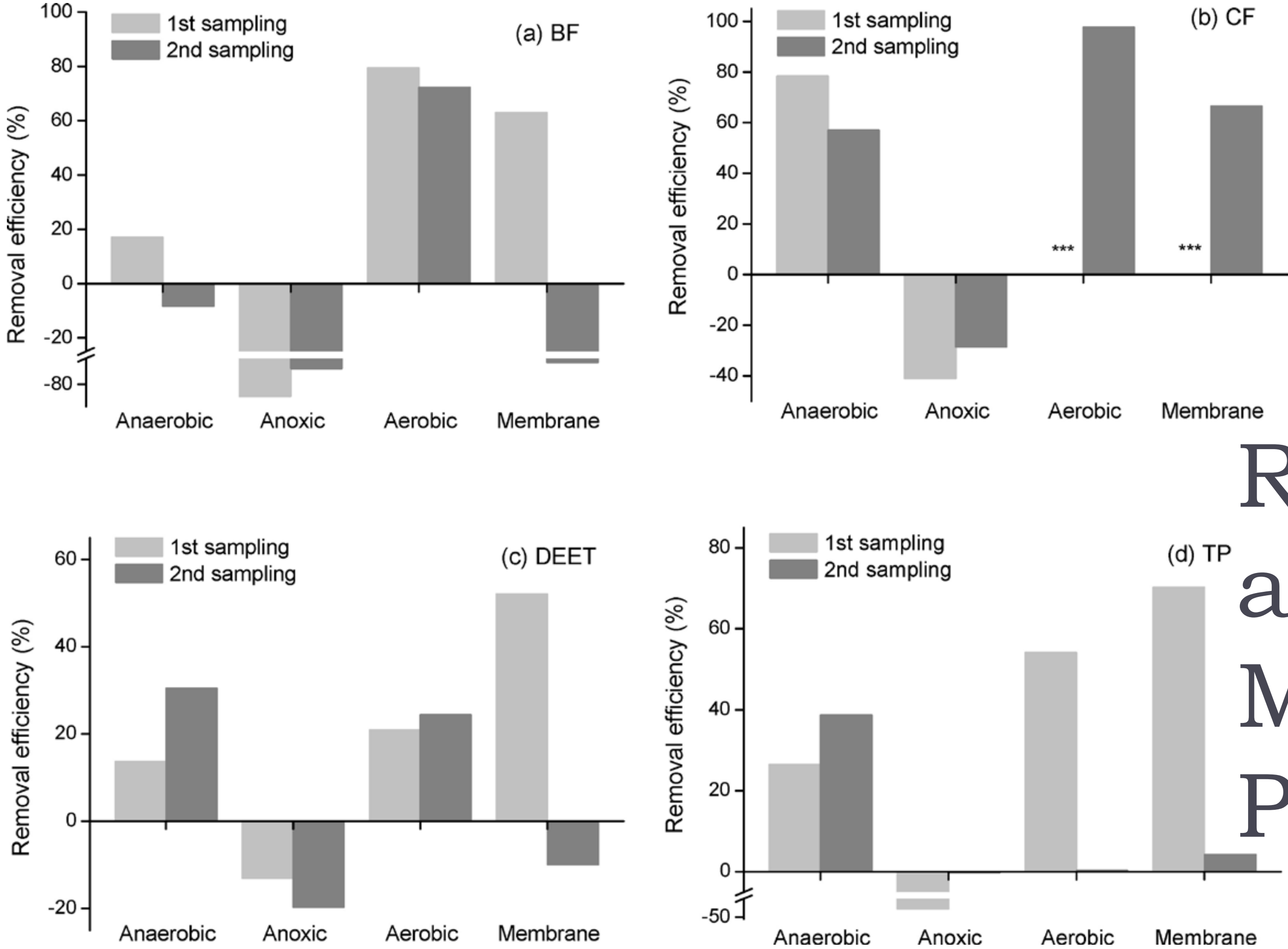


Seasonal variation in the removal efficiencies of PPCPs during the whole year: comparison among MBR and other two biological treatment processes.

ACS Publications High quality. High impact.

Published in: Qian Sui; Jun Huang; Shubo Deng; Weiwei Chen; Gang Yu; *Environ. Sci. Technol.* **2011**, 45, 3341-3348.
DOI: 10.1021/es200248d

Removal across MBR Process



Removal efficiencies of PPCPs in each tank of A/A/O-MBR process: (a) BF, (b) CF, (c) DEET, (d) TP. *** means that the removal efficiency of aerobic tank and membrane filtration could not be calculated because the CF concentrations were <LOQ after anoxic tank in the first sampling.

Published in: Qian Sui; Jun Huang; Shubo Deng; Weiwei Chen; Gang Yu; *Environ. Sci. Technol.* **2011,** 45, 3341-3348.
DOI: 10.1021/es200248d

Generic Mechanistic View

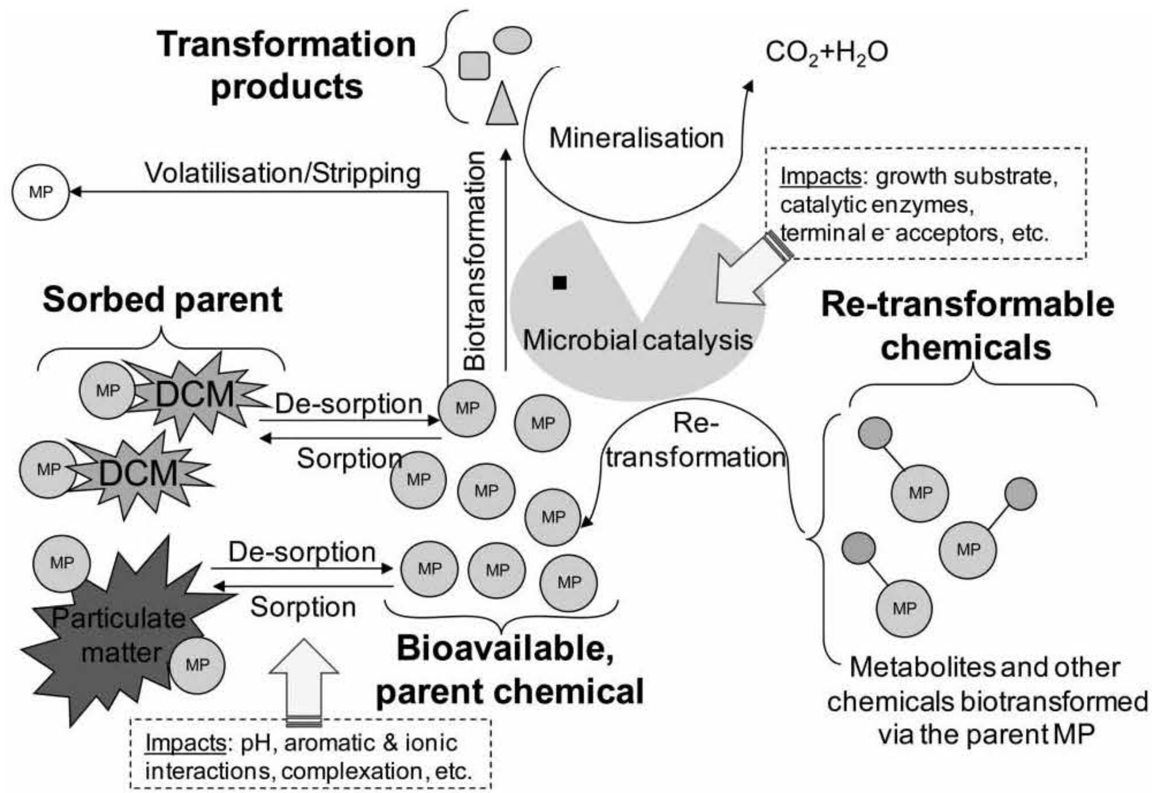


Figure 1 | Micro-pollutant (MP) fractions and processes, influencing MP removal in wastewater. Compiled based on studies by Criddle (1993); Alvarez-Cohen & Speitel (2001); Ternes & Joss (2006); Melcer *et al.* (2007); Monteith *et al.* (2008); Lindblom *et al.* (2009); Barret *et al.* (2010a); Plósz *et al.* (2010b,c). DCM: dissolved and colloidal matter.

Plosz, B.G., Benedetti, L., Daigger, G.T., Langford, K.H., Larsen, H.F., Monteith, H., Ort, C., Seth, R., Steyer, J.P. and Vanrolleghem, P.A. (2013) Modelling micro-pollutant fate in wastewater collection and treatment systems: status and challenges. Water Science and Technology 67(1), 1-15.

Nelson et al., 2010

Environmental Science & Technology

ARTICLE

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Diurnal Variability of Pharmaceutical, Personal Care Product, Estrogen and Alkylphenol Concentrations in Effluent from a Tertiary Wastewater Treatment Facility

Eric D. Nelson,* Huy Do, Roger S. Lewis, and Steve A. Carr

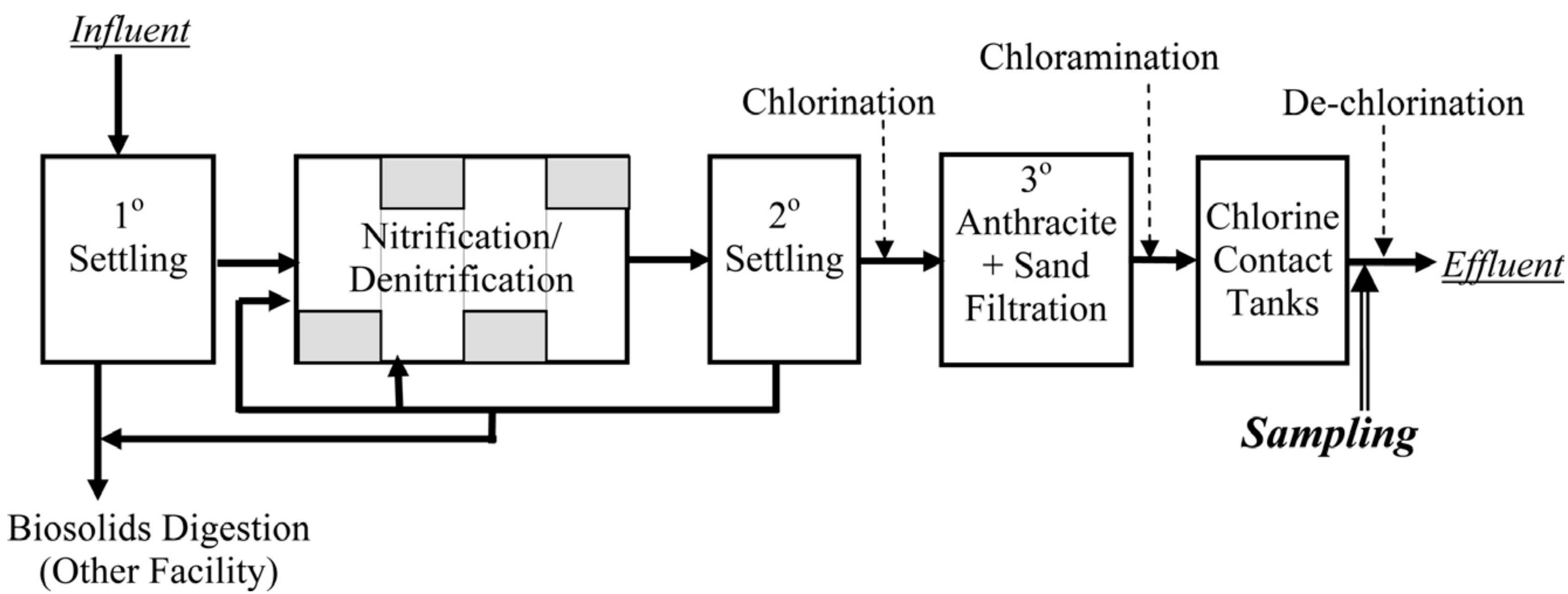
San Jose Creek Water Quality Laboratory, Sanitation Districts of Los Angeles County, 1965 Workman Mill Rd., Whittier California 90601, United States

S *Supporting Information*

ABSTRACT: Hourly samples of tertiary wastewater effluent were analyzed for 30 pharmaceuticals, personal care products, estrogenic steroids, and alkylphenols in order to better understand the rate at which these compounds enter the environment. Several distinct patterns of daily cycling were observed, and were characterized as three separate categories. The concentrations of compounds such as trimethoprim, sulfamethoxazole, naproxen, estrone, and triclosan varied greatly during a daily cycle, with relative standard deviations exceeding 100% of their daily mean. Less extreme daily cycles were seen for other compounds such as azithromycin, atenolol, *tert*-octylphenol, iopromide and gemfibrozil. Peak concentrations for most compounds occurred in the early evening (5−8 pm). However, some compounds including carbamazepine, primidone, fluoxetine, and triclocarban exhibited little or no variability.

Nelson, E.D., Do, H., Lewis, R.S. and Carr, S.A. (2010) Diurnal Variability of Pharmaceutical, Personal Care Product, Estrogen and Alkylphenol Concentrations in Effluent from a Tertiary Wastewater Treatment Facility. Environmental Science & Technology 45(4), 1228-1234.

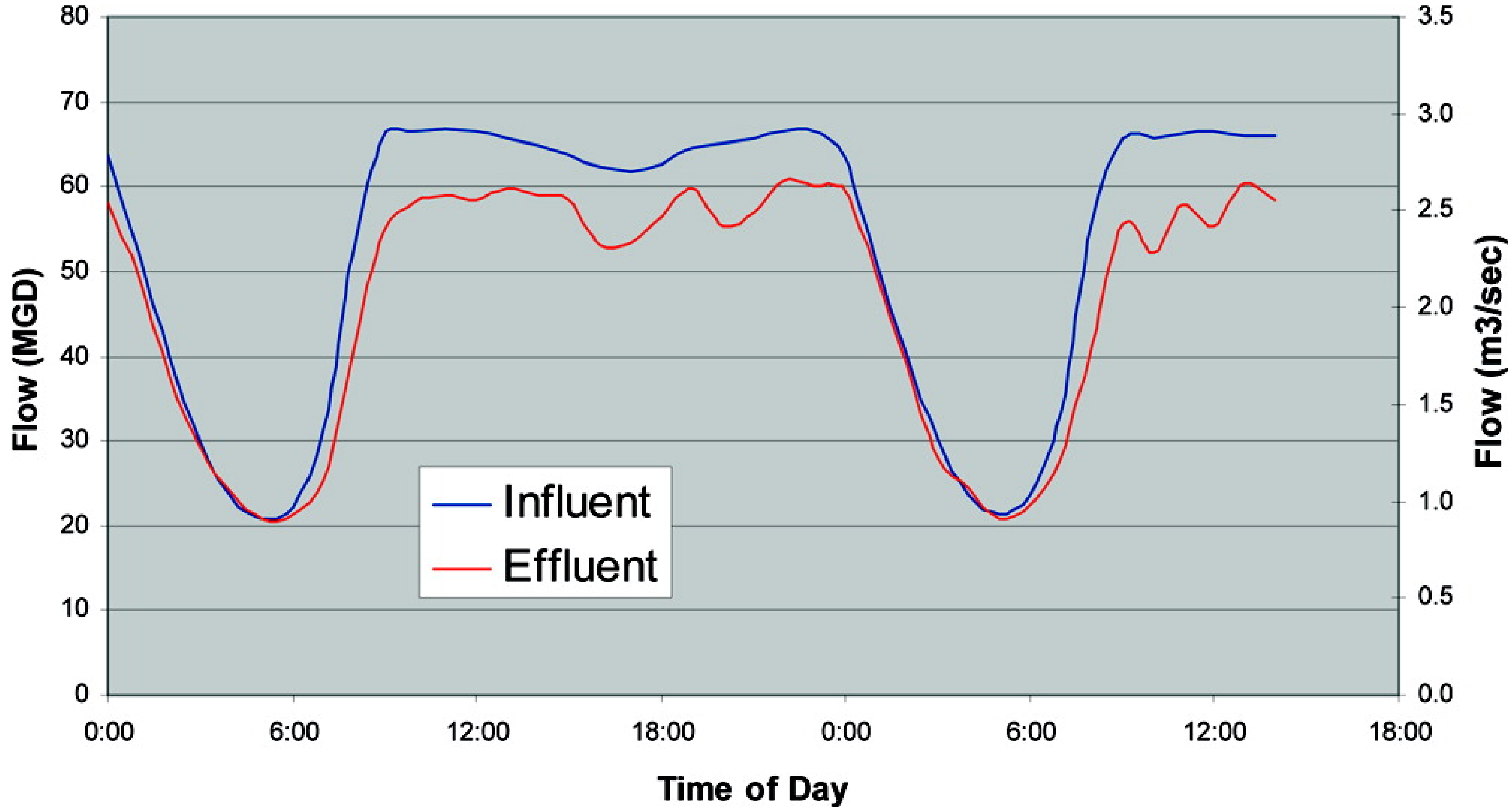
Tertiary WRF, Los Angeles



Simplified schematic of treatment plant train, and location of sample collection.

Published in: Eric D. Nelson; Huy Do; Roger S. Lewis; Steve A. Carr; *Environ. Sci. Technol.* **2011**, 45, 1228-1234.
DOI: 10.1021/es102452f

Flow Variability



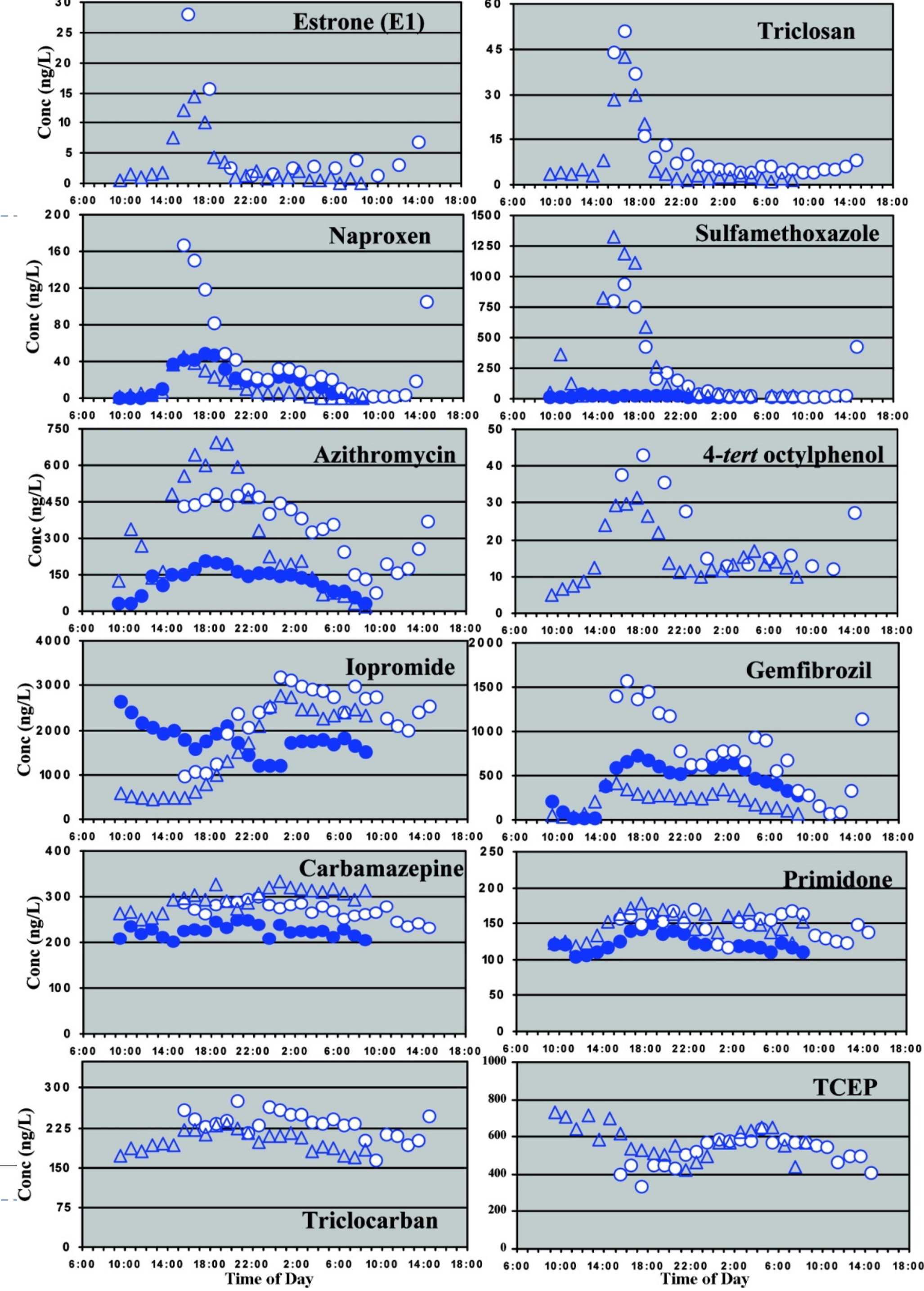
Composite daily plant flow (combined of three events). Less consistent effluent flow is due to periodic back flushing of 3° filter beds.

Published in: Eric D. Nelson; Huy Do; Roger S. Lewis; Steve A. Carr; *Environ. Sci. Technol.* **2011**, 45, 1228-1234
DOI: 10.1021/es102452f

Diurnal Variability in WW

Hourly concentrations of selected analytes in wastewater effluent.

Closed circles represent samples from July 2008, open circles represent May 2009, and open triangles represent October 2009.



Published in: Eric D. Nelson; Huy Do; Roger S. Lewis; Steve A. Carr; *Environ. Sci. Technol.* **2011,** 45, 1228-1234.

- [To next lecture]