The Effect of Increased Flows on the Treatability of Emerging Contaminants at a Wastewater Treatment Plant during Rain Events

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Objectives

- Introduction/Purpose of research
- Background of emerging contaminants
- Description of the treatment plant
- Procedures
- Results/Discussion
- Conclusions
- Acknowledgements

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Emerging Contaminants

- “Emerging contaminants" can be broadly defined as any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and (or) human health effects. ***USGS***

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History of Emerging Contaminants Research

- Pharmaceuticals were first reported in U.S. surface waters during investigations in the 1970s, although they were not regulated as legacy pollutants such as PCBs and DDTs (Snyder 2006).
- There have been many publications documenting the presence of antibiotics in groundwaters, surface waters, wastewaters and landfill leachates, including the National Reconnaissance study sponsored by the U.S. EPA and the U.S Geological Survey (Xu 2007; Kolpin 2003).

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The Purpose of This Research

- To evaluate the effects of stormwater on wastewater treatability for each unit process.
- To understand other factors that affect the treatability of emerging contaminants and compare them to the effects of wet weather flows.
- To determine the concentrations of emerging contaminants that enter and leave the treatment plant.
- To compare wet weather emerging contaminant loadings at the treatment plant with stormwater sheetflow emerging contaminant characteristics.

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Types of Emerging Contaminants

- Pharmaceuticals and Personal Care Products (PPCPs)
- Estrogens
- Pesticides
- Microorganisms
- Heavy metals
- Polycyclic aromatic hydrocarbons (PAHs)

Widely varying chemical characteristics of these compounds results in their varying fates and treatabilities (mostly relating to their associations with organic solids and their water solubilities).

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Reported Characteristics of Pharmaceuticals that Affect their Treatability and Fate

Chemical Name (Pharmaceutical)	MW (g/mol)	Log kow	Solubility (mg/L)	Half-life (hours)
Carbamazepine	236.1	2.45	17.7	10-20
Fluoxetine	309.3	4.05	38.4	24-72
Gemfibrozil	250.12	4.78	5.0	1.5
Ibuprofen	206	3.5-4.0	41.5	2
Sulfamethoxazole	253	0.9	600	10
Triclosan	289.5	4.8-5.4	2-4.6	125
Trimethoprim	290.32	0.79	400	8-10

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Reported Characteristics of PAHs that Affect their Treatability and Fate

Chemical Name	MW (g/mol)	log kow	Solubility (mg/L)	Half Life (days)
naphthalene	128.2	3.37	31.5	3
acenaphthylene	152.2	3.89	3.80	21-121
acenaphthene	154.2	4.02	16.1	10-60 (soils) 1-25 (surface waters)
fluorene	166.2	4.12	1.90	2-64
anthracene	178.2	4.53	0.045	108-139
phenanthrene	178.2	4.48	1.12	5.1
pyrene	202.2	5.12	0.132	16-200
fluoranthene	202.2	5.14	0.260	880

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Reported Characteristics of Pesticides that Affect their Treatability and Fate

Chemical Name (Pesticides)	MW (g/mol)	Solubility in water (mg/L)	log kow	Half-life
Methoxychlor	345.65	0.1	4.68-5.08	>100 days
Aldrin	364.91	0.027	6.5	20-100 days
Dieldrin	380.91	0.1	6.2	5 years
Chlordane	409.76	insoluble	~5.54	4 years
Arochlor Σ	257.9-453	insoluble	5.6-6.8	various
Lindane	290.83	17	3.8	15 months
Heptachlor	373.32	0.056	6.10	6 months-3.5 years
Heptachlor-epoxide	389.40	0.35	5.40	na

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- Hilliard Fletcher Wastewater Treatment Plant
  - A secondary treatment system with a pretreatment phase, a primary clarifier, an aeration tank, a secondary clarifier and UV disinfection system.
  - Current capacity is 30 MGD; being upgraded to 45 MGD by 2013.
  - Separate sanitary sewer system

City of Tuscaloosa photo

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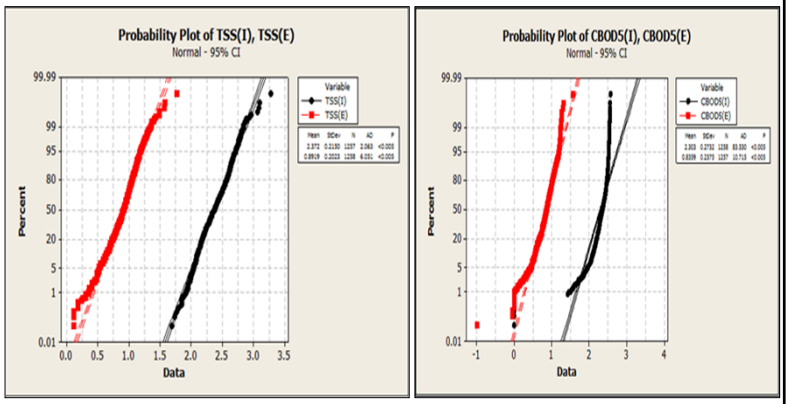
Treatability of Tuscaloosa WWTP



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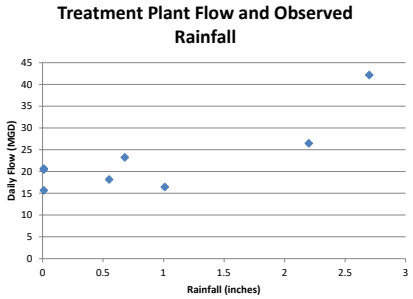
Wastewater Treatment Flows and Rains during Wet Weather Sampling

	Rainfall (in)	Flow rate (MGD)
01/16/10	0.55	18.2
03/02/10	0.68	23.3
04/24/10	1.01	16.5
06/25/10	trace	20.7
10/24/10	trace	15.7
11/02/10	trace	20.5
03/09/11	2.7	42.2
09/20/11	2.2	26.5



Increased daily flows at wastewater treatment plant associated with rains greater than about 1.5 or 2 inches

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Comparison of pH and pka

Wet weather date	Influent pH	Effluent pH
01/16/10	7.23	6.80
03/02/10	7.42	6.79
04/24/10	6.94	6.61
06/25/10	6.93	6.62
10/24/10	7.02	6.72
11/02/10	6.92	6.48
03/09/11	7.24	6.64
09/20/11	7.09	7.04

Pharmaceutical	pka
Carbamazepine	13.9
Fluoxetine	9.5
Gemfibrozil	4.5
Ibuprofen	4.91
Sulfamethoxazole	pka1=1.7, pka2=5.6
Triclosan	8.0
Trimethoprim	6.6

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Sample Collection

- Four composite one liter samples collected during each event:
  - At the inlet right before the screen and grit chamber
  - After wastewater leaves the primary clarifier
  - After biological treatment and wastewater leaves the secondary clarifier
  - After final effluent is treated by UV
- Seven wet weather samples and seven dry weather samples collected during a range of treatment flow conditions and analyzed for:
  - pharmaceuticals
  - PAHs
  - Pesticides
- Wet weather sheetflow samples also being collected in area
- This presentation presents a preliminary evaluation of the available data

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Analyses

- Acidic and basic pharmaceuticals
  - EPA standard method 1268 (modified)
  - Solid phase extraction
  - High performance liquid chromatography (HPLC) analysis with UV detector
- PAHs
  - EPA standard method 8270 SIM targeted ions
  - Separation flask with Kuderna-Danish (KD) concentration
  - Gas chromatography with mass spectrophotometer detector (GC-MSD) analysis
- Pesticides
  - EPA standard method 508
  - Separation flask with Kuderna-Danish (KD) concentration
  - Gas chromatography with electron capture detector (GC-ECD) analysis

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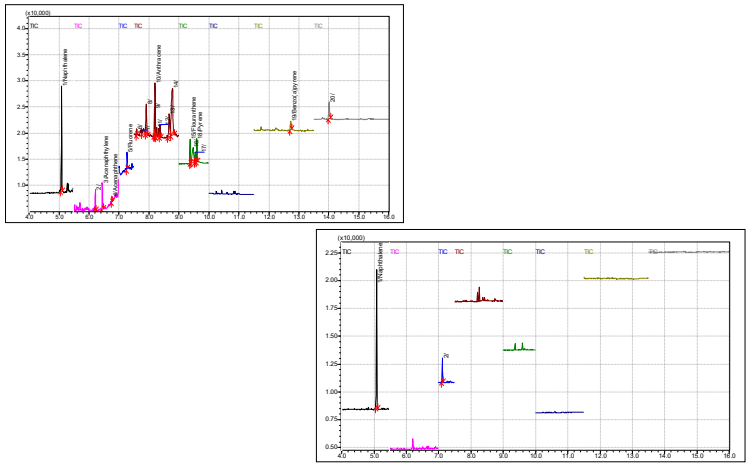
Preliminary PAH results



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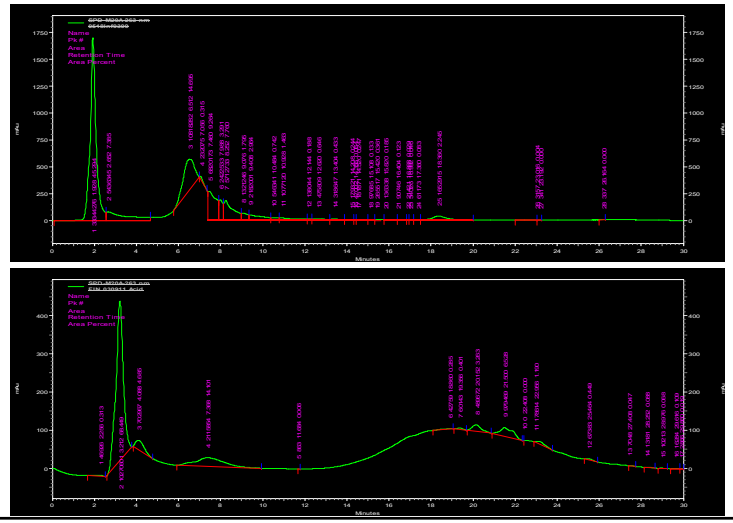
Preliminary Pharmaceutical Data



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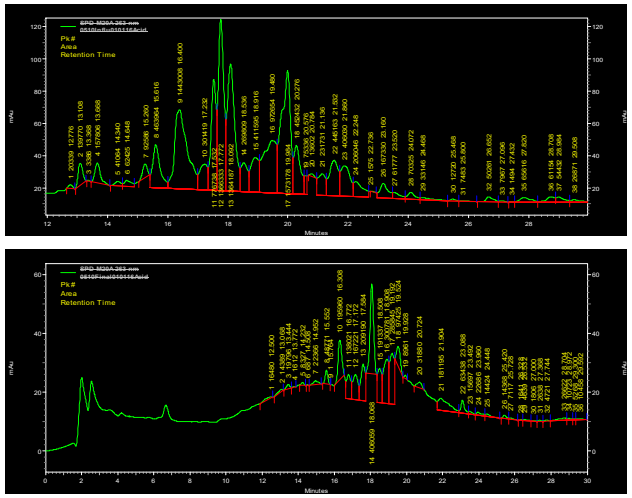
Preliminary Pharmaceutical Data



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Preliminary Conclusions

- Stormwater only affects the flow rate at the treatment facility during large rainfall events (>1.5 inches). However, the preliminary data shows stormwater infiltration into the separate sanitary system does contribute to the mass load of ECs to the wastewater treatment plant: there were increases in masses for both PAHs and pharmaceuticals during some of the rain events.
- Some inconsistencies in rain and flow. For example, the flow rate was low for April 2010, the rainfall was over one inch and most of the PAHs during this weather event had the highest concentrations and lowest treatability.
- Final conclusions will be based on the complete data set, but these preliminary data indicate performance as expected, with minimal wet weather effects, although wet weather is shown to be a significant source of some of the ECs.

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