Toxics, BMPs and the Chesapeake Bay: Headlines for Bay Managers

URBAN STORMWATER WORK GROUP

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Presentation Outline

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3. Urban BMPs are Very Effective at Removing Them
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Project Background

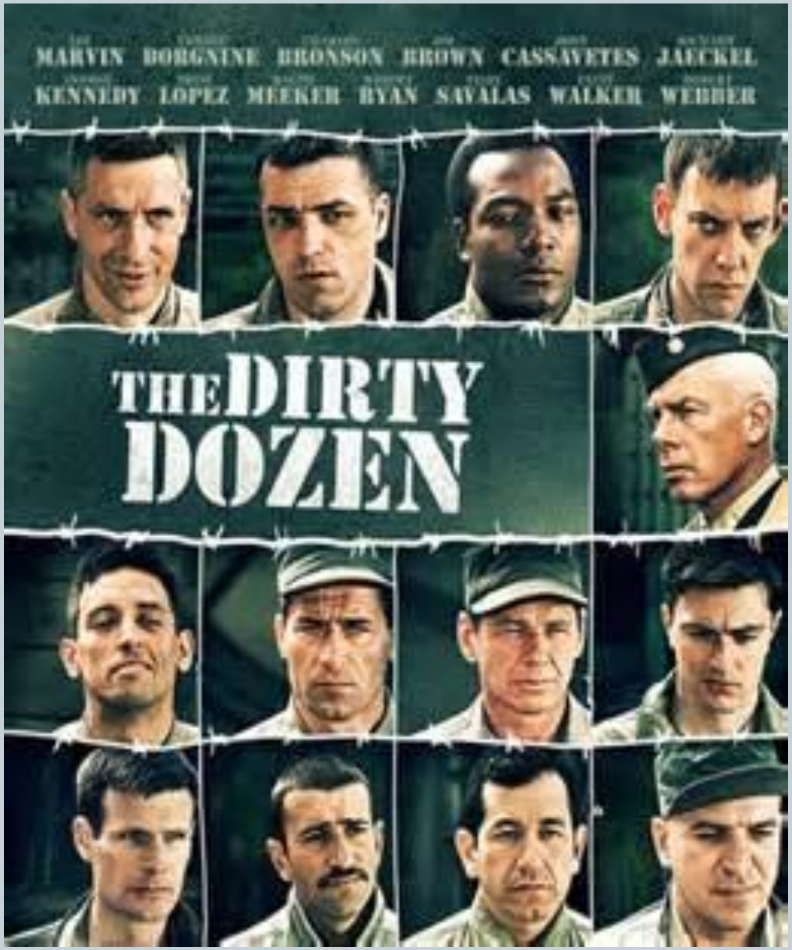
One year research synthesis project that evaluated 35 group of toxins generated by the ag, urban wastewater sectors

Goal: Investigate toxic reduction benefits associated with Bay BMP implementation for the TMDL, and give managers better data for local TMDLs to control toxic pollutants in the watershed

Scope: More than 400 papers reviewed

Funding: From CBT and WQGIT

2. Most Toxins are Generated from Urban Watersheds



THE DIRTY DOZEN UTCs

- PCBs
- PAH
- TPH
- Mercury
- UTM (Cd, Cu, Pb, Zn)
- OTM (As, Cr, Fe, Ni)
- Pyrethroid Pesticides
- Legacy OC Pesticides
- Legacy OP Pesticides
- Plasticizers (Phthalates)
- Flame Retardants (PBDE)
- Dioxins

Urban Toxic Contaminant (UTC) Criteria

- The toxin is primarily associated with urban land use, compared to other sectors in the watershed.
- The toxin is either generated within the urban sector or is deposited from the atmosphere onto impervious surfaces and subsequently washed off.
- Urban stormwater runoff is the predominant pathway for transporting it thru the watershed.
- The toxin has "sediment-like characteristics" and can be removed by settling or filtering practices.
- The toxin is generated or produced in an upland landscape position in the watershed where it can be effectively treated by an urban BMP that captures surface runoff.
- Physical evidence exists that the toxin is captured and/or retained within an urban stormwater BMP.

Urban Toxic Contaminants
(continued)

Toxin Category	1. urban land use?	2. urban sources ?	3. stormwater pathway ?	4. Sediment characteristics	5. Upland Position ?	6. Urban BMP Retention?
PP	Y	Y	Y	Y	y	y
OCP	Y	Y	Y	Y	y	y
OPP	Y	Y	Y	Y	y	ND
Plasticizer	Y	Y	y	Y	y	y
PBDE	y	Y	y	Y	y	y
Dioxins	Y	Y	y	Y	ND	ND
PP: Pyrethroid Pesticides, OCP: Organochlorine pesticides, OPP organophosphate pesticides. PBDE: Polybrominated diphenyl ethers				Y = Yes, based on strong evidence y = Yes, supported by limited monitoring data ND = no data available to assess		

3. Urban BMPs are Very Effective at Removing UTCs

- Since most UTCs have sediment-like properties, they are effectively trapped by most urban BMPs before they get to local waterways and the Bay.

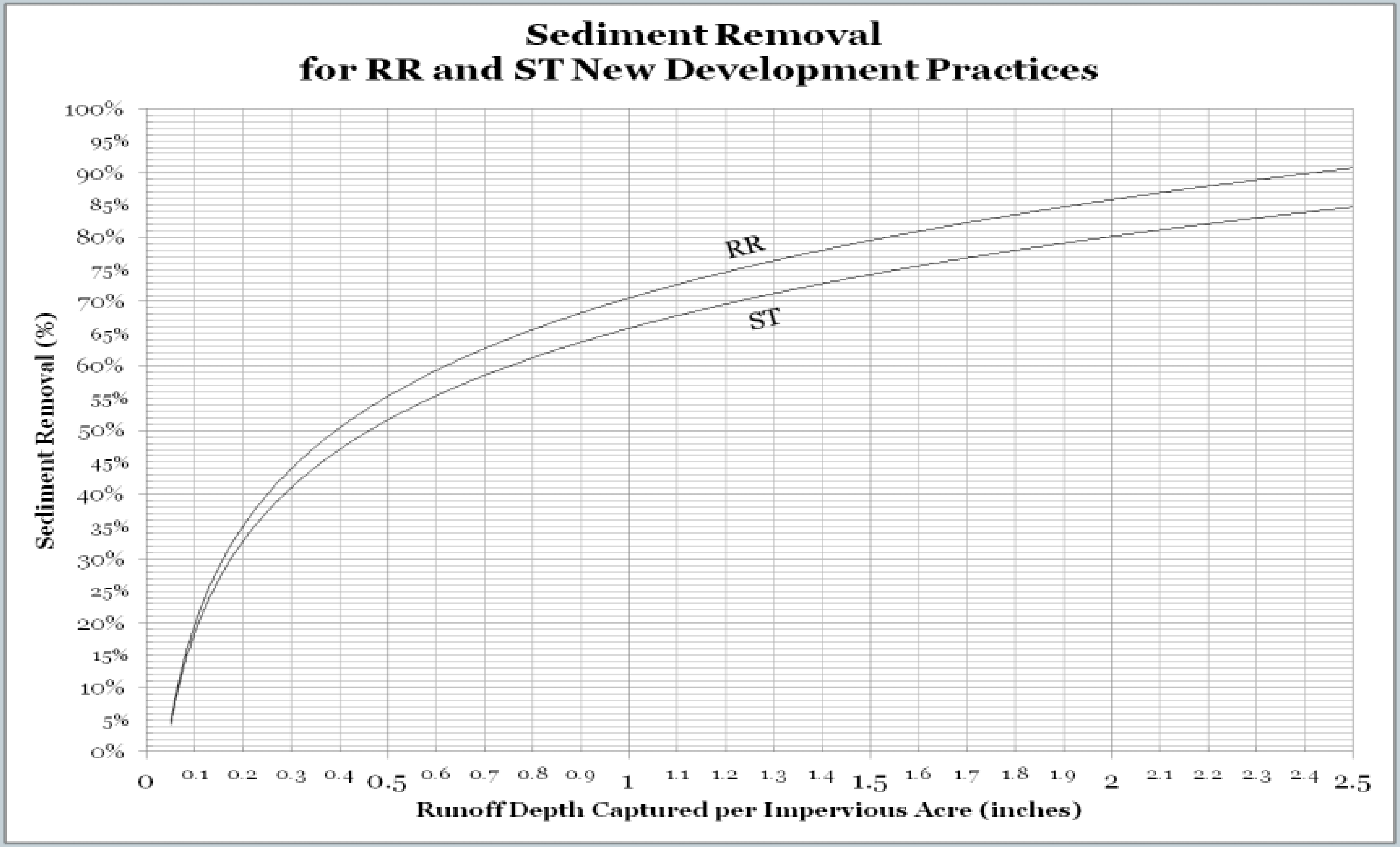
UTC and TSS Removal Benchmarks

- Linking UTCs to a benchmark TSS removal rate
- Allows users to project UTC removal rates based on known TSS removal rates
- Can calculate reductions based on much larger CBP database on sediment removal by urban BMPs

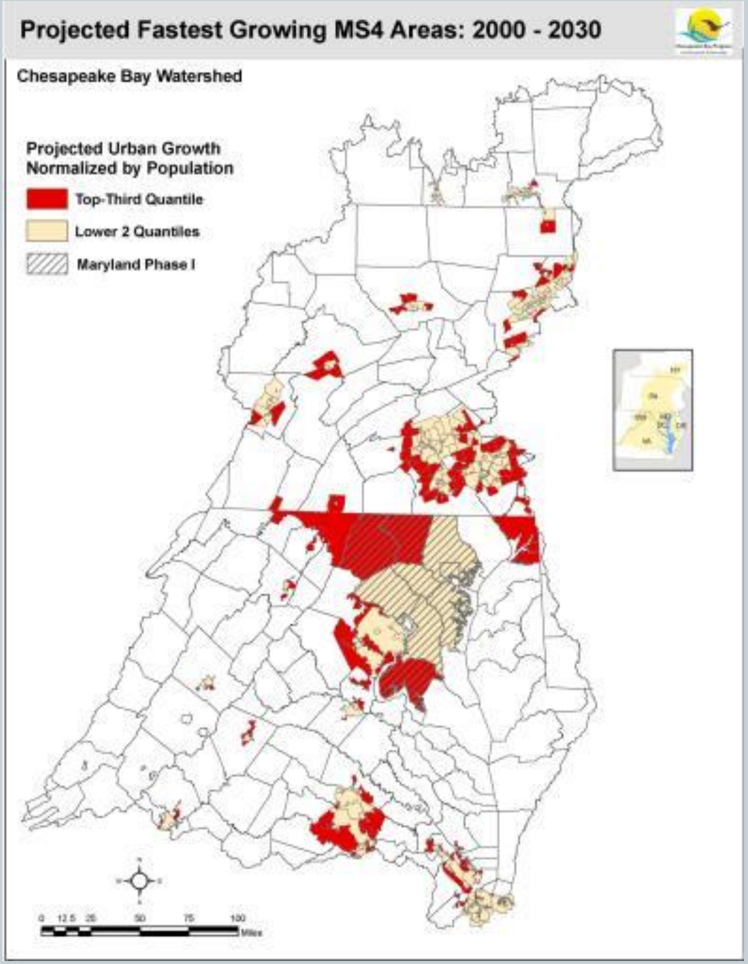
BMP Treatability for Urban Toxic Contaminants

Toxin Category	BMP Removal Rate?	Measured or Estimated?	Behaves like Sediment?	BMP Retention?	Sediment Toxicity Concern?
PCBs	TSS	E	Y	Y	Mod
PAH	> TSS	E	Y	Y	High
TPH	> TSS	M	Y	Y	Low
Mercury	> TSS	E	Y	Y	Mod
UTM	< TSS	M	Y	Y	Mod
OTM	< TSS	M	Y	Y	Mod

More precise removal estimates using expert panel adjustor curves



Urban BMP Coverage in Bay Watershed



- Urban BMPs now cover 30% of urban land in the watershed – most of any region in the nation
- BMP coverage could increase to 40 or 50% by 2025 due to TMDL compliance in the urban sector
- UTC removal by nearly all urban BMPs is moderate to very high

4. Risk of UTC Accumulation in BMP Sediments

- Cautionary tale that some persistent UTCs are accumulating in the sediments of older ponds, but the Bay-wide shift to LID practices, such as bioretention, are minimizing this future risk

UTC Accumulation In BMP Sediments

- Persistent UTCs accumulate in BMP sediments over many decades at levels that trigger sediment toxicity guidelines.
- As many as 8 UTCs pose a risk for sediment toxicity: PCB, PAH, Hg, Ni, Cr, Cu, Cd, and Zn
- Most research on older stormwater pond sediments

6. Troubling Trends in Insecticides

- The insecticides applied to crops and urban areas have changed over time, and are now less persistent in the environment and do not bioaccumulate in tissues.
- However, they are still mobile in the environment and are deadly to aquatic invertebrates at the part per trillion level

Evolution in Insecticides Over Time

Era	**Insecticide**	**Types**	**Notes**
1940 to 1970	Organochlorines (OC)	DDT	Banned in the 1970s
		DDD/DDE	DDT degradation products
		Dieldrin	Banned in 1985
1960 to 2000	Organophosphate (OP)	Chlordane	Banned in 1978
		Chlorpyrifos	Restricted in 2002
		Diazinon	Restricted
		Dichlorvos	Increased use after 2002
2000 to present	Pyrethroids	Bifenthrin	Replacements for OCP and OPP
		Permethrin	Less toxic than bifenthrin
2005 to present	Fipronil	Fipronil	Most aquatic life toxicity in recent surveys
	Neonictinoids	Imdiacloprid	Emerging concerns about aquatic toxicity

Pyrethroid Pesticides

- Pyrethroid pesticides include bifenthrin, permethrin and others
- New class of insecticides introduced in the last decade
- Non-persistent in the environment and unlikely to bio-accumulate in vertebrates
- Extremely lethal to aquatic invertebrates in urban streams, even at part per trillion level
- Routinely detected in urban creek sediments

Pyrethroid Pesticides

- Meet criteria to qualify as an UTC, although some data gaps remain
- Strong affinity for sediment and organic matter
- BMP removal rates should be comparable to suspended sediment
- More research needed on persistence and toxicity in BMP sediments.

8. UTCs and Watershed Lag Times

- Environmental benefits of reducing toxins may not be fully realized for several decades
- Long lag time between when they are first deposited on watershed surfaces or soils and cycle through the stream network to ultimately reach the Chesapeake Bay.

- Researchers suggest long lag times for the following UTCs:
  - PCBs
  - PAH
  - Mercury
  - UTMs
  - DDT and Chlordane

- What does this signify for nutrients?

8. Conservation Tillage and Herbicides

- How the profound shift to conservation tillage as a cornerstone BMP for corn and soybeans in the Bay watershed has changed herbicide use and impacts over the last 3 decades

Trends in Herbicides Applied to Corn and Soybeans

ERA	**1970's -1980's**	**1990-2000**	**2001 to present**
Most Common Herbicides Detected	• Atrazine	• Atrazine • Metoachlor • Acetochlor • Alachlor	• Glyphosate • AMPA • Some Atrazine
Tillage Practices	>25% of crops use conservation till	Climbs to about 50 to 60% of crop acres	Climbs to nearly 90% of row crops
Genetically Engineered Crops	None	GE corn and soybeans enter market in mid to late 1990's	GE seeds comprise 92 to 94% share of crop acres

Changes in Herbicide Impacts Over Time

ERA	**1970's -1980's**	**1990-2000**	**2001 to present**
Most Frequently Detected	• Atrazine	• Atrazine • Metoachlor • Acetochlor • Alachlor	• Glyphosate • AMPA • Some Atrazine
Water Quality Risks	Atrazine suspected in SAV loss, but later exonerated	Aquatic life criteria frequently exceeded for metoachlor and atrazine. Possible Endocrine disruptor	Routinely detected in surface waters, but aquatic life criteria not exceeded
Groundwater Concerns	Major concern for rural drinking water wells	Declining levels measured toward end of the era	Rarely detected in groundwater or soil water at this time

Glyphosate and AMPA

- Glyphosate and its degradate, AMPA, are mobile in the environment and are frequently detected in surface waters, but are not as persistent in soil or water as the herbicides they replaced.
- Glyphosate and AMPA are much less toxic to bird, fish and aquatic life, do not bioaccumulate in tissues, and have minimal impacts of human health.
- Limited monitoring data suggest that vegetated buffers, constructed wetlands, biofilters and ponds all have a moderate to high capability to remove and degrade glyphosate and AMPA.

9.Antibiotics and Biogenic Hormones are Removed But then Re-emerge

Better Treatment, More Residuals

- Improved manure management at AFOs and the shift to BNR at WWTPs has increased removal of antibiotics and biogenic hormones from effluent, but the residuals are concentrated in animal manure and municipal biosolids that are applied back to croplands.
- Poor data quality make it difficult to fully assess this risk
- The phase out of antibiotics and hormones from livestock production and better antibiotic stewardship are the long term solution

Biogenic Hormones

- Biogenic hormones include estrogen, testosterone, estrone, estradiol and progesterone
- Concern about their potential endocrine disrupting properties.
- Concentrations of biogenic hormones in the part per trillion range can negatively impact aquatic life and possibly cause intersex fish.
- Discharged from animal feeding operations and wastewater treatment plants.
- Higher concentration w/ high watershed density of either animal feeding operations or sewage effluent

More on Biogenic Hormones

- Vegetated buffers, constructed wetlands and lagoons are highly effective in removing biogenic hormones in runoff from AFOs
- BNR upgrades are very effective in removing biogenic hormones in wastewater effluent
- Hormones concentrate in animal manure and municipal biosolids.
- When treatment residuals are applied to crops, they can potentially migrate back into the watershed.

Antibiotics

- Antibiotics detected in streams and groundwater in the Chesapeake Bay include tetracycline, oxy-tetracycline and sulfamethoxazole.
- Concern about increased bacterial resistance that could reduces the therapeutic effect of these medicines
- Can degrade soil microbial community and reduce denitrification rate
- Half of human antibiotic use, and most livestock use "is unnecessary, inappropriate, and makes everyone less safe" (CDC, 2013).

More on Antibiotics

- Same 4 watershed sources as biogenic hormones
- Antibiotics are persistent, hydrophilic and very soluble -- may not be effectively removed by conventional WWTPS or BMPs
- Recent trend to phase out of antibiotics used in poultry, swine and cattle feeding operations.

Questions and Answers