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

TOXIC CONTAMINANT WORK GROUP

JANUARY 13TH MEETING

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Presentation Outline

1. Conservation Tillage and Herbicides
2. Troubling Trends in Ag and Urban Insecticides
3. Antibiotics and Biogenic Hormones are Removed and then Re-emerge
4. Pollution Prevention Still Trumps BMPs
5. Legacy Pesticides and Watershed Lag Times
6. Update on Urban Toxic Contaminants

1. 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	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

Comparative Data Quality for Agricultural Herbicides

Factor	Herbicide Group		
	Atrazine/ Simazine	Metoachlor/ Alachor	Glyphosate/ AMPA
Ag Runoff EMCs	M	L	L
Ag Groundwater	M	VL	M
Ag Streams	H	L	M
Degradation Rate	M	L	L
BMP Removal	L	VL	L
BMP Sediment	VL	VL	VL

VL = Very Low (<3 studies, none from CB)
L = Low (< 5 studies, some from CB)
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H = High (10 to 25 studies)
VH = Very High (>25 studies)

Herbicide	Groundwater Advisory ?	Exceeds Aquatic Life Benchmarks ?	MCL	Half-life in Soils	Half-life in Water
			(ug/l)	Days	
Atrazine	Yes	Yes	3	146	742
Simazine	Yes	Yes	4	91	32
Metoachlor	Yes	Yes	100	26	410
Alachlor	Yes	Yes	2	21	640
Glyphosate *	No	No	700	35	96
AMPA*	No	No	nd	7-14	76-240

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.

2. Troubling Trends in Ag and Urban 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.

Legacy Organochlorine Pesticides

- Organochlorine (OC) pesticides include DDT, DDE and dieldrin that were banned decades ago but still persist in the environment. Classified as a UTC, but were also used on crops and for mosquito control.
- Soils contaminated by OC pesticides more mobile in urban watersheds. Likely present in older pond sediments
- Sharply declining trends in OC pesticide levels in urban runoff and creek sediments and reduced bioaccumulation in fish, eagles and marine mammals.
- Continued tracking of OC pesticides may be warranted for another decade or two.

Legacy Organophosphate Pesticides

- Organophosphate (OP) pesticides include chlorpyrifos, diazinon and dichlorovos and were introduced 15 to 20 years ago to replace OC pesticides.
- Relatively non-persistent but still very highly toxic to aquatic life in urban streams, most were banned by the turn of the century
- Found in urban watersheds, are highly mobile, are carried by urban stormwater runoff and generally behave like a sediment particle.
- No data on BMP removal or persistence in BMP sediment
- Sharp declines in stormwater runoff and urban creek sediments since they were banned
- Less persistent pesticides can be eliminated from the environment due to short watershed lag times.

3.Antibiotics and Biogenic Hormones are Effectively Removed but then Re-emerge

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.

More on Biogenic Hormones

- Sustainable strategy to keep unnecessary hormones out of the food supply chain.
- Livestock producers, groceries and restaurant chains are p
- Reminder about the power of social and economic forces advocating for food quality and safety

Comparative Data Quality for Biogenic Hormones

Factor	Watershed Sources				
	WWTP Effluent	Combined Sewer Overflows	Municipal Biosolids	AFO Discharge	Manure Applied to Crops
Loading Data	L	VL	VL	VL	L
Runoff EMC	NA	VL	L	VL	L
Streams	M	L	L	L	VL
Groundwater	NA	NA	VL	VL	VL
Removal Rates	M	VL	VL	L	L
Sludge/Manure	L	VL	L	VL	L

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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.

Comparative Data Quality for Antibiotics

Factor	Watershed Sources				
	WWTP Effluent	Combined Sewer Overflows	Municipal Biosolids	AFO Discharges	Manure Applied to Crops
Loading Data	L	VL	VL	VL	VL
Runoff EMC	NA	VL	VL	VL	VL
Streams	M	L	VL	L	L
Groundwater	NA	NA	VL	VL	VL
Removal Rate	L	VL	VL	L	VL
Sludge/Manure	VL	NA	L	VL	VL

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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

Sustainable Solutions

- Continue the phase out of antibiotics and hormones from livestock production
- Better antibiotic “stewardship”

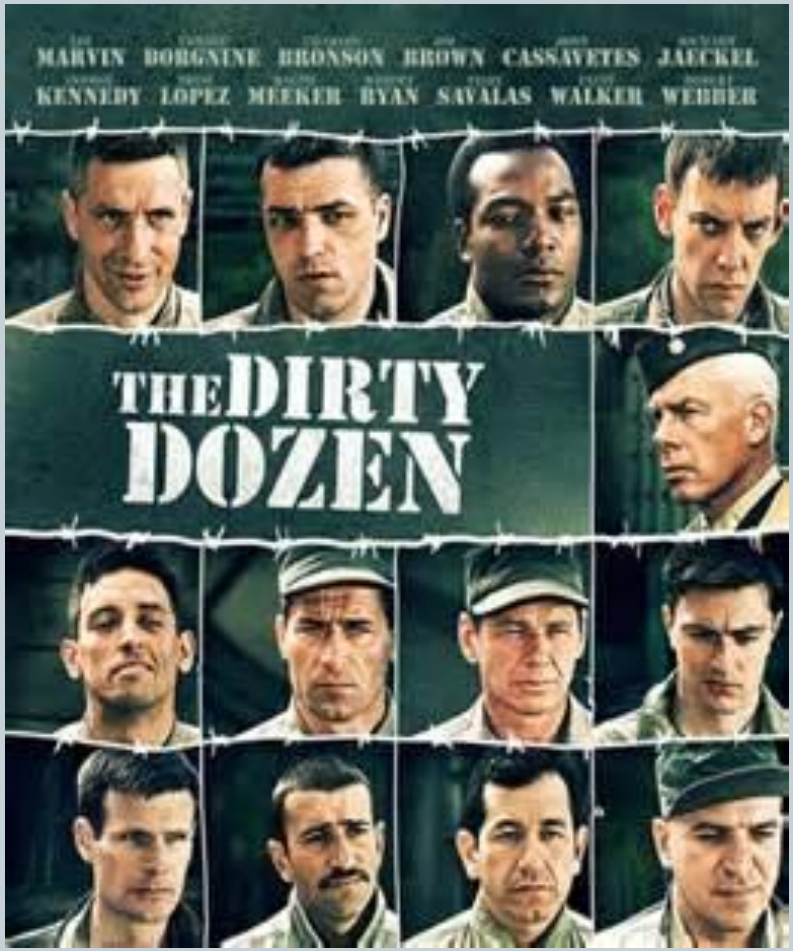
4. UTCs and Watershed Lag Times

- 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?

5. More UTCs Added to the Dirty Dozen



THE DIRTY DOZEN UTCs

- Pyrethroid Pesticides
- Legacy OC Pesticides
- Legacy OP Pesticides
- Plasticizers (Phthalates)
- Flame Retardants (PBDE)

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

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

BMP Treatability for Urban Toxic Contaminants
continued

Toxin Category	BMP Removal Rate?	Measured or Estimated?	Behaves like Sediment?	BMP Retention?	Sediment Toxicity Concern?
PP	TSS	E	Y	y	High
OCP	> TSS	E	Y	y	Low
OPP	< TSS	E	Y	?	Low
Plasticizers	< TSS	E	Y	Y	?
PBDE	< TSS	E	Y	Y	?
Dioxins	< TSS	E	Y	?	?

Review Process for Part 2 Memo

- Request technical review by Friday, January 29
- Will also be seeking input from
  - Urban Stormwater Workgroup
  - Agricultural Workgroup
  - Wastewater Work Group
  - Water Quality Goal Implementation Team
- Send to Tom @ CSN @ watershedguy@hotmail.com

Questions and Answers