Insecticide Market Trends and Potential Water Quality Implications

Kelly D. Moran, Ph.D.
TDC Environmental, LLC

Background

- Purpose: to evaluate water quality implications of urban diazinon & chlorpyrifos replacements
- Funding and project management
  - San Francisco Estuary Project
  - SF Bay Regional Water Quality Control Board
- Numerous contributors and peer reviewers
- Draft report comments due March 28th

  www.tdcenvironmental.com/Pesticides.html

Urban Runoff Carries Pesticides to Creeks

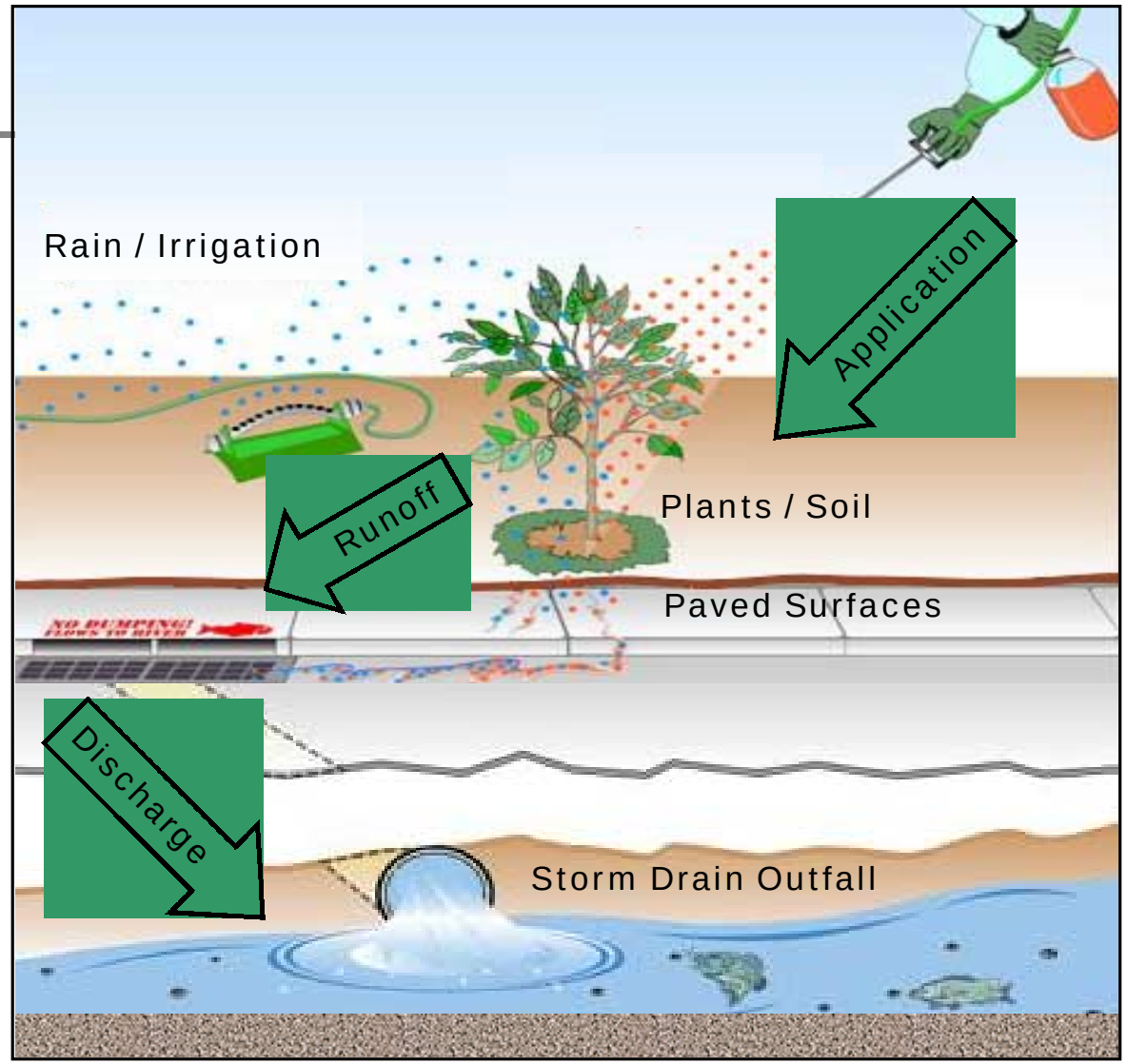


Figure courtesy SF Bay Regional Water Board, based on U.C. IPM Project drawing

Diazinon and Chlorpyrifos

- Most common urban insecticides
- Frequently found in urban creeks (nationwide) at levels of concern
- Ants were primary target pest
- Applications on outdoor impervious surfaces probably most important for urban creeks

U.S. EPA is phasing out most urban uses

Project Elements

- Identify urban diazinon/chlorpyrifos replacements
  - Products, formulations, & urban uses
  - Chemical properties & environmental fate
  - Chemical analysis methods
  - Aquatic toxicity
  - Regulatory status
- Establish environmentally relevant concentrations
- Evaluate potential water quality implications

Approach to Evaluation

- Literature review
  - Incidents of toxicity
  - Surface water concentration data
- Qualitative risk assessment
  - Pesticide use analysis
  - Transport and fate review
  - Comparison to diazinon and chlorpyrifos
- Weight of evidence analysis

Replacements in Urban Insect Control Marketplace

- Carbaryl
- Imidacloprid
- Malathion
- Pyrethroids
  - Bifenthrin, Cyfluthrin, Cypermethrin, Deltamethrin, Esfenvalerate, Permethrin, (λ-Cyhalothrin)
- Pyrethrins

These are most common, but other alternatives exist

New Products Look Just Like Old Products

Practical Definition of a Surface Water Quality Problem

- Exceeds water quality standards
- Toxic to aquatic species (includes sub-lethal effects)

Ceriodaphnia dubia (water flea)

Environmentally Relevant Concentrations

Pesticide	Fresh Water (ppb)	Salt Water (ppb)
Chlorpyrifos	*0.083*	*0.011*
Diazinon	*0.08*	*0.82*
Bifenthrin	0.07	0.00397
Carbaryl	2.53	0.81
Cyfluthrin	0.14	0.00242
Cypermethrin	0.002	0.005
Deltamethrin	0.01	0.017
Esfenvalerate	0.07	0.038
Imidacloprid	10,440	34
Malathion	0.43	0.34
Permethrin	0.03	0.001
Piperonyl Butoxide	2.4	1.25
Pyrethrins	5.2	1.4

Source: U.S. EPA or CDFG Water quality criteria (if available) or lowest aquatic toxicity value

Water Quality Standard Likely to be Lower than Environ. Relevant Conc.

- Sub-lethal effects not included (little data)
- Standard water quality species not tested

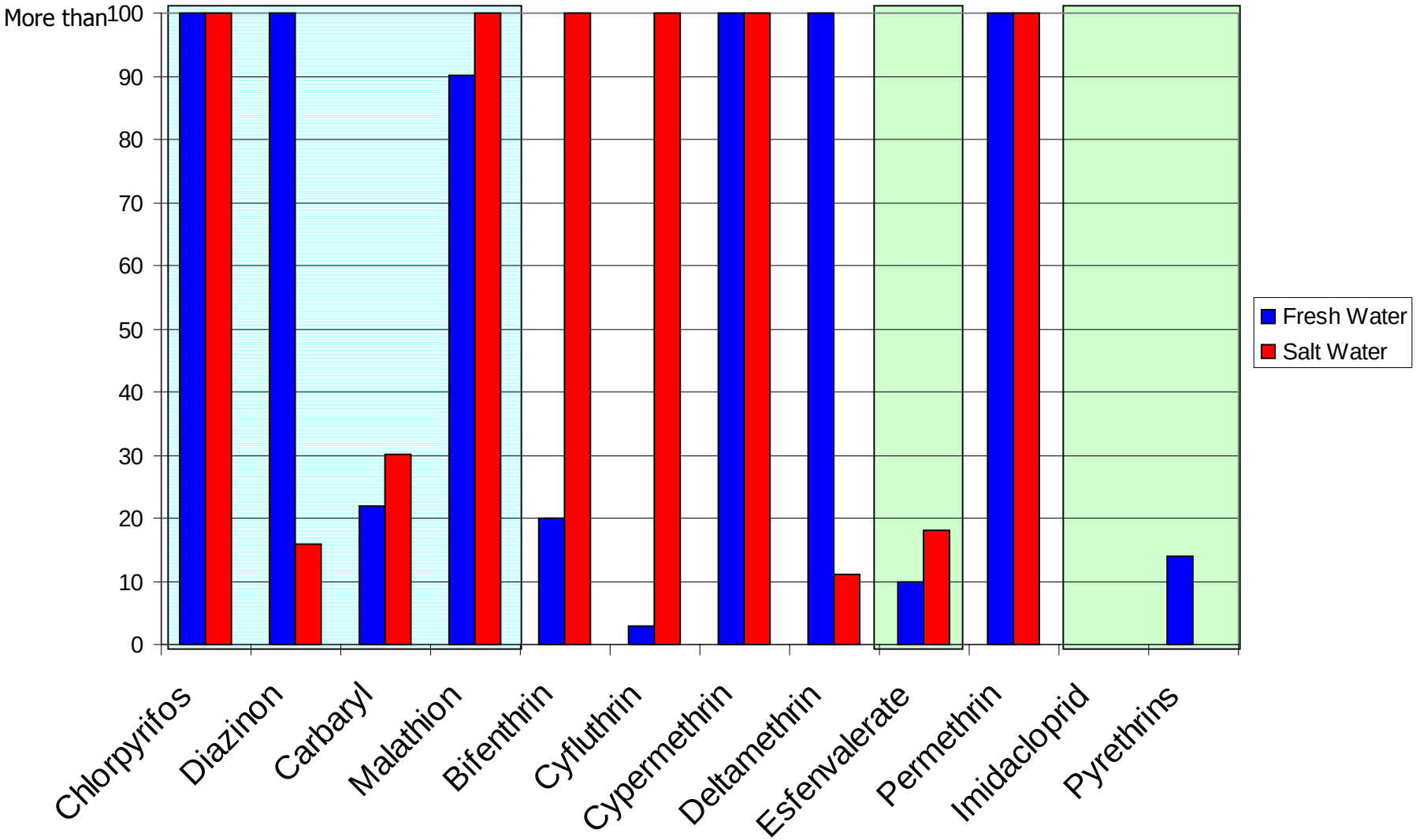
Data Gaps for Standard Freshwater Test Organisms	Bifenthrin	Carbaryl	Cyfluthrin	Cypermethrin	Deltamethrin	Esfenvalerate	Imidacloprid	Malathion	Permethrin	PBO	Pyrethrins
C. dubia (Water flea)				■	■	■	■				■
P. promelas (Fathead minnow)				■	■		■			■	■
S. capricornutum (Green algae)	■		■	■	■	■	■	■	■	■	■

Malathion and Carbaryl Evaluation

- Among the most frequently detected pesticides in urban surface waters
- Commonly detected at concentrations known to cause adverse effects to aquatic ecosystems

Use should be avoided

Application Rate Index: A typical 1,000 square foot urban application contains enough active ingredient to pollute how many million gallons of water?



Runoff Fractions

- Pyrethroids less mobile than OPs—but do wash off
  - Detected in runoff and surface water
  - Significant wash off from plant leaves
  - Lower surface water mobility indexes (SWMIs)

Pesticide	SWMI
Pyrethroids	0.07 to 0.12
Pyrethrins	0.07 to 0.11
Chlorpyrifos	0.09
Diazinon	0.18
Carbaryl	0.50
Imidacloprid	0.53

Pyrethroids Fate

- Unlikely to photodecompose
  - Long lasting on impervious surfaces
- Only a tiny fraction of amount applied («0.1%) needs to runoff to cause aquatic toxicity
- Will partition into sediments (how fast?)
  - Likely to accumulate in sediments
  - New data: sediment toxicity measured in CA
- Most are more toxic at lower temperatures

Pyrethroids Evaluation

- Extremely toxic to aquatic life at part per trillion concentration levels
- May cause adverse effects in the water column and/or in sediments
- Cumulative toxicity likely
- Many data gaps

Use should be avoided

Imidacloprid Evaluation

- Significantly less toxic to fresh water species than any other study list pesticide
- Much more toxic in salt water
- Very soluble in water—readily washed away from application location
- Potential to cause groundwater contamination
- Many data gaps

Use should be approached with caution at this time

Pyrethrins Evaluation

- Far less toxic to aquatic species than their pyrethroid cousins
- Rapid photodecomposition on outdoor surfaces
- Typically formulated with synergists (which may have impacts of their own)
- Many data gaps

Use should be approached with caution at this time

Synergists

Piperonyl Butoxide (PBO) evaluated

- May enhance the toxicity of other pesticides in surface water or sediments
- Not enough information to evaluate risk
- Other synergists not evaluated
  - N-octyl bicycloheptene dicarboximide (MGK-264)

Use should be approached with caution at this time

Recommendations: Data Gaps

- Toxicity testing data gaps
  - Species for "3-species test"
  - Data for imidacloprid & pyrethrins
- Sediment studies for pyrethroids
- Additional evaluation:
  - λ-Cyhalothrin
  - Synergists

Fathead minnow. Photo by Konrad Schmidt, courtesy Univ. of Minnesota

Recommendations: Data Gaps

- Make all information necessary to evaluate and prevent surface water quality impacts available for every registered pesticide
  - Chemical analytical methods
  - Wash-off rates
  - Fate in wastewater treatment & sludge
  - Toxicity data, including sub-lethal effects

Regulatory Recommendations

- Maximize ability of registration process to prevent water quality impacts
- Establish "surface water protection list"
- Develop ecological risk assessment methods for urban pesticide uses
  - Surface water
  - Sediments
  - Wastewater/sludge

Monitoring Recommendations

- Develop standard methods (for OPs and Pyrethroids)
  - Sample collection & storage
  - Toxicity testing
  - Toxicity Identification Evaluations (TIEs)
- Develop chemical analysis methods with environmentally relevant detection limits
  - Imidacloprid & deltamethrin
  - USGS/DFG working on bifenthrin, cyfluthrin, lambda cyhalothrin, cypermethrin, esfenvalerate, & permethrin

Monitoring Recommendations

- Urban surface water monitoring:
  - Measure toxicity
  - Both water column & sediments
  - Creeks, bay, & “bay margins”
- Monitor urban sales & use
- Statewide pesticide surveillance monitoring program needed

Outreach Recommendations

- Avoid
  - Diazinon
  - Chlorpyrifos
  - Carbaryl
  - Malathion
  - Pyrethroids
- Caution
  - Pyrethrins
  - PBO
  - Imidacloprid

Other "low-risk" alternatives may be preferable

Outreach Recommendations

- Manage Pests with IPM
  - Non-toxic and least-toxic controls
  - Use uncontained chemical pesticides only as a last resort

Preventing problems is much easier than cleaning them up