Changing Pesticide Use: Challenges for Water Quality Monitoring and Implications

Michelle L. Hladik, Ph.D.
U.S. Geological Survey
California Water Science Center
Sacramento, CA

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What is a Pesticide?

US EPA definition: “A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any PEST.”
Changing Pesticide Use

• Different Pesticides
  – New compounds
  – Changing pests/resistance
  – Restrictions/concerns on previously used compounds

• Crop types
  California: cotton → almonds

• Changes in application techniques
  Granular/Spray → seed coatings
Changing Insecticide Use

- Organophosphates (Chlorpyrifos, Diazinon)
- Pyrethroids (Bifenthrin, Permethrin)
- Neonicotinoids (Imidacloprid)

DDT 1940 - 1990
Organophosphates 1990 - 2000
Pyrethroids 2000 - 2010
Neonicotinoids
Neonicotinoids in the News

• Implicated in Colony Collapse Disorder (CCD) in honeybees (one of many factors)
• CCD (c. ~2006) worker bees abruptly disappear
• Risk to other pollinators (bumble bees, native bees, butterflies)

**ARE NEONICOTINOIDs KILLING BEES?**

*It's no longer a mystery. We know what's killing the bees.*

They're being poisoned by neonicotinoid insecticides

*Look at all the pretty flowers...*

Bee declines driven by combined stress from parasites, pesticides, and lack of flowers

Dave Goulson,* Elizabeth Nicholls, Cristina Botías, Ellen L. Rotheray

*Tell the EPA to Ban Neonicotinoids Before They Devastate the U.S.*

Facebook.com/organicconsumers

Stop the Mass Death of Bees

Support the Campaign for a total ban of Neonicotinoid Pesticides

www.CBCnetwork.org

USGS
Why are Neonics Popular?

• Most widely used insecticides in the world
  – Home use: Pets (topical), lawn and garden
  – Agricultural use: granular, foliar spray, seed treatment

• Similar to nicotine, neurotoxic to insects

• Active against a broad spectrum of insects

• Less toxic to vertebrates (mammals)
Neonicotinoids and Seed Treatment

- Systemic pesticides (taken up by plant)
- Can “target” application (precision agriculture)
- 2000 - clothianidin and thiamethoxam enter market; seed treatments become more common
- Nearly all corn and 1/3 of soybeans planted today use a neonicotinoid (plus one to five fungicides)
Environmental Fate

- Water soluble
- Ability to be mobile and persistent (~10% taken up by plants in seed coatings)
Changing Environmental Fate

1990 - Organophosphates
2000 - Pyrethroids
2010 - Neonicotinoids

USGS
Neonicotinoid Use in U.S.

Estimated Agricultural Use for Imidacloprid, 2014 (Preliminary)

https://water.usgs.gov/nawqa/pnsp/usage/maps/
Neonicotinoids Detected in Iowa Surface Waters - 2013

- Targeted location (Iowa) where use of neonics for seed treatment is high (corn, soybeans)
- Neonics detected frequently
- Highest frequency and concentrations during planting

Hladik et al., 2014, *Environ. Pollut.*, v. 193, 189-196
Neonicotinoid Transport
Planting and Hydrologic Events

Hladik et al., 2014, *Environ. Pollut.*, v. 193, 189-196

- Classic “spring flush” phenomena as herbicides (atrazine)
- associated with planting (seed treatments)
Nationwide Study

38 streams, one time sampling

Neonic Detection Frequency
1 or more 53%
2 or more 26%
3 or more 11%
5 or more 3%

Relation to Landcover
Clothianidin + row crops
Thiamethoxam + row
Imidacloprid + urban

Nationwide Study 2012-2014

- Site sampling varied in timing
- One Central California site had five neonics detected

Overall Detection Frequency

- Imidacloprid
- Clothianidin
- Thiamethoxam
- Dinotefuran
- Acetamiprid

Urban (n = 160)
Agriculture (n = 216)
Changing Toxicity

- Organophosphates
- Pyrethroids
- Neonicotinoids

Timeline:
- 1990
- 2000
- 2010
Neonicotinoid Toxicity

- EPA acute invertebrate aquatic life benchmarks 11000-35000 ng/L;
  2017 preliminary risk assessment of imidacloprid - 650 ng/L (acute) and 10 ng/L (chronic)
- Does not show “total neonic” toxicity
Neonics in U.S. Waterways

- Dissolve in water
- Can move away from application area
- Affect aquatic insects (mayflies, caddis flies)
- Indirect effects on birds
Direct vs Indirect Effects

- **Direct effects**
  - Acute toxicity to birds is lower than pesticides replaced; varies by species
  - One treated seed (corn, wheat, canola) can poison a bird
  - $1/10^{th}$ of a corn seed/day during egg-laying season can affect reproduction

- **Indirect effects**
  - Enter aquatic systems
  - Affect invertebrates/insects (esp. mayflies, caddisflies, midges)
  - No food for insectivorous birds
  - Hard to determine
Getting Attention
Charismatic Megafauna

Species People Care About

Less “Charismatic”
Indirect Effects

- **Birds (Netherlands)**
  - Correlated imidacloprid concentrations in surface water with reduced bird populations
  - 6 of 15 bird species in decline

- **Butterflies (California)**
  - Correlated neonicotinoid use with decreasing populations
  - More severe for smaller butterflies

- **Does not include causation**
Neonic Use Update

• Seed treatments use less active ingredient than broadcast applications, but near 100% usage on seeds means more total use.

• EPA study: soybean fields with treated seeds did not see increased yield, much use is prophylactic.
  – Seed treatments lead to less foliar applications in oilseed rape in England (Budget et al 2015)
  – Seed treatments no increase in sunflower yields in South Dakota (Bredeson and Lundgren, 2015)

• Neonics being phased out in US wildlife refuges

• EPA is currently reviewing neonics

• EU moratorium on agricultural use of 3 neonics since 2013

• Ontario, Canada cutting neonic use by 80% over 3 years

• Maryland banned consumer use of neonics (January 1, 2018)
Other Projects


- Neonics detected in drinking and tap water; low levels not required to be tested (University of Iowa) Klarich et al., 2017, Environ. Sci. Technol. Lett.

- Occurrence in Great Lakes tributaries

Summary

• Neonics frequently detected in streams across U.S.
  – Can exceed chronic and even acute levels
  – Most likely effects are on invertebrates

• Transport to streams driven by use and precipitation
  – Contributions from both urban and ag use
  – Many ag areas use seed treatment

• Seed treatments are increasing overall neonic use (and insecticide use) across the U.S., ~100% of corn is treated, new treatments for wheat, rice

• Occur in complex mixtures of pesticides (herbicides, fungicides) and other contaminants (pharmaceuticals, metals, microplastics)