Toxicology and Environmental Fate of 2,4-D

A Summary of Scientific Data and Typical Questions and Answers

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Why Worry About 2,4-D?

- 2,4-D (2,4-dicholorphenoxyacetic acid) is the most widely used pesticide in the world (3rd most widely used in the US)
- It is currently one of the most effective methods of controlling the growth of variable milfoil in NH lakes and rivers
- Thus, we are often exposed to 2,4-D and it is important to our mission of controlling the growth of milfoil in NH

What Is "Toxicology"?

- It's the science of how poisons affect living organisms
- The ultimate goal is to predict the effect of poisons (toxins) on humans
- We test the effects in different species of animals to predict the effects in humans
- We give as much toxin as the animals can tolerate to maximize the chance of observing toxic effects

Key Principles of Toxicology

- Concentration (dose) and Time of Exposure to a toxin are most important
- Route of Exposure is important:
  - Oral (eating or drinking)
  - Dermal (contact with skin, eyes, etc.)
  - Inhalation (breathing)
- Different species can have dramatically different reactions to toxins (e.g., Thalidomide)

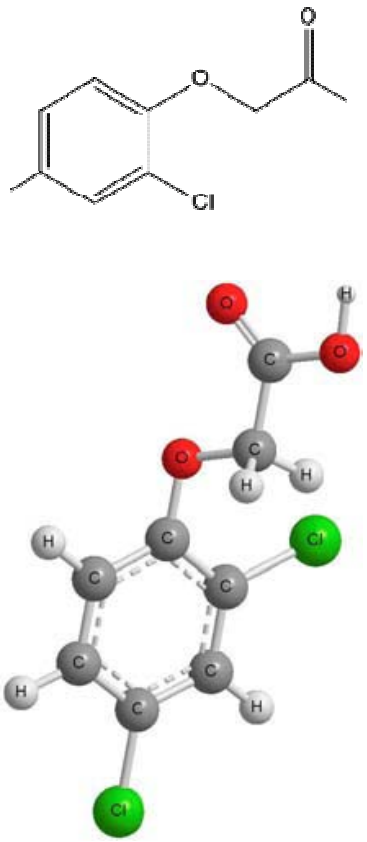
Key Principles of Toxicology

- We evaluate different toxic effects:
  - Toxicity (short-term (acute) and long-term (chronic) health effects, death [LD_{50} / LC_{50}], specific organ damage, behavioral effects)
  - Carcinogenicity (cancer)
  - Teratogenicity (birth defects)
  - Mutagenicity (causing mutations)
- Regulators evaluate all of the data and use mathematical models to estimate a "safe" dose for humans

What is 2,4-D?

- An herbicide (pesticide) used primarily as a broadleaf weed killer
- A synthetic plant hormone (auxin)
- Mostly used for weed control in residential (lawns), agricultural (wheat, corn, rice, soybeans, sugar cane, potatoes, grasslands, orchards), and forestry settings, and for control of aquatic weeds
- Developed in 1942; now over 1,500 herbicide products include 2,4-D such as Navigate, Aqua-Kleen, Weed B Gon, Weedaway, etc.

Chemical Structure



Environmental Fate of 2,4-D

- In water, 2,4-D's half-life is from 9 hours to < 15 days
  - Dependent on levels of oxygen, microbial activity, acidity, sunlight, and plants
- In sediments, 2,4-D's half-life is between 1-14 days
  - In one study in alkaline water with little oxygen, 2,4-D was detected in sediment for 186 days

The "half-life" is the time required for half of the chemical to break down in the environment:

1 half-life = 50% remaining

2 half-lives = 25% remaining

3 half-lives = 12% remaining

4 half-lives = 6% remaining

5 half-lives = 3% remaining

Toxic Effects of 2,4-D

- Acute (single exposure) toxicity:
  - Oral – “low” toxicity
  - Dermal – “low” toxicity, severe eye irritation
  - Inhalation – “low” to “very low” toxicity
  - Dogs are more sensitive – vomiting, weakness
  - Humans – “low” toxicity; mostly associated with suicide attempts; causes vomiting, diarrhea, headache, confusion
  - Most toxic effects result when the kidneys are overloaded and renal capacity is exceeded

Toxic Effects of 2,4-D

- Chronic (long-term exposure) toxicity:
  - 90-day "No Observed Effect Level" in rats is comparable to feeding an average man 2.86 pounds of 2,4-D per day for 90 days
  - 2-year NOEL in rats and mice was comparable to 9 ounces of 2,-4-D per day for 2 years in humans
  - Doses comparable to 5.7 pounds per day for 2 years (in humans) caused toxicity in the eye, kidney, thyroid, and liver in rats
  - Human chronic exposure to 2,4-D has not been linked to any effects seen with other pesticides

Carcinogenicity of 2,4-D

- US EPA evaluated 2,4-D for carcinogenic effects in 1988, 1992, and 2004
- Animals studies consistently show no carcinogenic effects; there are some positive results
- Epidemiological studies claiming a link between 2,4-D and cancer were evaluated and found to lack enough evidence for the linkage
- US agencies list 2,4-D as “not classifiable as to human carcinogenicity
- Some international agencies list 2,4-D as a “potential human carcinogen”

Teratogenicity of 2,4-D

- Studies in rats and mice fed doses comparable to 9½ lbs per human showed no observable reproductive effects
- Mice and rats fed doses comparable to 38 pounds per human showed signs of reproductive toxicity, but very limited teratogenic effects
- No direct evidence of reproductive or teratogenic effects in humans is available

Mutagenicity of 2,4-D

- 2,4-D has been extensively tested for mutagenicity
- It is non-mutagenic in most test systems
- One study reported chromosome damage in cultured human cells
- Most effects seen are cytotoxic – not mutagenic

Ecological Effects of 2,4-D

- "Low" to "Very Low" toxicity to wildfowl (mallards, pheasants, quail, pigeons), brown shrimp, dungeness crabs, and most aquatic invertebrates
- Honeybees had impaired reproductive effects at moderate doses, but actually survived longer than controls at low doses
- Some formulations are highly toxic to fish while others are only slightly toxic (including formulations used for milfoil)

In Summary

- 2,4-D has been used on our crops and in our lakes and rivers for 50+ years
- For a pesticide, it is remarkably non-toxic or only slightly toxic to most non-target species, especially humans
- At the carefully regulated concentrations used to treat variable milfoil, 2,4-D is essentially non-toxic to non-target species and disappears from the environment within days

Questions and Answers

- These are general responses to common questions that are asked about 2,4-D, and general “non-technical” responses that are intended to be clear and understandable to the general public
- Much information is available about 2,4-D, in particular, the U.S. Environmental Protection Agency’s website
- People with additional questions about this product are encouraged to consult that site for more detailed explanations of this information

Questions and Answers (1)

- Isn't 2,4-D in Agent Orange? That was TERRIBLE stuff!

2,4-D was a component of Agent Orange, but did NOT cause the infamous adverse health effects.

Agent Orange was a combination of two herbicides (2,4,5-T and 2,4-D).

The serious Agent Orange health effects were caused by a dioxin formed when 2,4,5-T is manufactured.

As a result, 2,4,5-T was banned in 1985, and has not been used in NH since 1983

Neither 2,4,5-T nor dioxins are present in any of the herbicides used for milfoil control in NH

Questions and Answers (2)

- We've read that the inert (or "other") ingredients in Navigate are toxic to humans, animals, and/or the environment. Is this true?

Many of the common concerns stem from the clay carrier used to form the Navigate pellets – the clay particles becoming airborne and could affect the lungs.

New technologies and application methods have lessened the amount of dust that results from application of the product in the granular form.

Questions and Answers (3)

- We've heard that the breakdown products (in water) are more toxic than 2,4-D itself. Is this true?

There have been documented toxic forms of degradates of 2,4-D, but they have only been measured under controlled laboratory conditions.

It is thought that in natural systems, the breakdown products that may be more toxic are quickly converted into other more non-toxic forms.

2,4-D breakdown products have a fairly short half-life, so by-products are generally short-lived.

Questions and Answers (4)

- If 2,4-D is so safe, why do they ban swimmers in the lake for 30 days after treatment?

There is no 30-day swim ban after treatment; the current pesticide label imposes no swim restriction.

The swim restriction in NH is 24 hours, primarily to keep swimmers away from 2,4-D pellets as they settle to the bottom, dissolve, and are absorbed by the milfoil plants.

Questions and Answers (5)

- We've heard that 2,4-D is an endocrine disrupter. What does that mean?

EPA has become concerned in recent years that disposal of consumer pharmaceuticals might be causing adverse "hormonal" effects in the environment – endocrine disruptors.

Since 2,4-D is a synthetic plant hormone (auxin), it is logical to think that it might have endocrine disrupting effects.

EPA is currently evaluating the endocrine disrupting potential of 2,4-D, but no direct evidence of this has been shown to date.

Questions and Answers (6)

- Maine has banned the use of 2,4-D – that means it's toxic, right?

Maine has not banned 2,4-D, they just do not use it often.

They just recently used it to control a new infestation of Eurasian water milfoil in one of their ponds.

- Canada has banned the use of 2,4-D – that means it's toxic, right?

Canada did ban the product for some time, but they reversed their decision in 2008 and now allow its use – but interestingly, not for aquatic use.

Questions and Answers (7)

- We've heard that 2,4-D causes cancer. Is that true?

There are no scientifically accepted data that support that 2,4-D is a carcinogen.

For the 4th time, EPA is currently re-evaluating the carcinogenicity of 2,4-D, but there is no direct linkage to cancer.

- We've heard that 2,4-D causes birth defects. Is that true?

There are no scientifically accepted data to support this claim.

Questions and Answers (8)

- We've heard that 2,4-D kills fish. Is that true?

We have not documented any fish kills as a result of a 2,4-D treatment in NH.

Generally a fish kill can be caused by decomposition of large amount of vegetation, so in a whole-lake treatment targeting all plants, decomposition may lead to loss of oxygen and fish kills.

Safeguards are put in place (on the pesticide label and in the permitting process) to make sure treatments are conducted in a way that will lessen the likelihood of this.

Used at appropriate concentrations to kill milfoil, 2,4-D is not directly toxic to fish to result in their death.

Questions and Answers (9)

- Is it true that 2,4-D kills other aquatic plants?

2,4-D is an herbicide and its purpose is to kill plants; so yes, this is true.

Pesticide effectiveness is a function of dose and exposure time. Milfoil is killed by a low application rate (100 lbs/acre in most scenarios), which is too low a concentration to affect most other aquatic plants.

Our goal is not to kill all plants, so we use low concentrations when possible. Higher rates are only used when dilution is a factor (flowing water), and then a slightly higher rate is applied to achieve a target concentration in the water to overcome dilution effects.

Questions and Answers (10)

- I know you say it's safe, but isn't all that data just provided by the manufacturers who want to protect their product and profits?

Much of the testing is done by Federal government agencies, which are not paid by manufacturers, so they are not influenced in their research

Questions and Answers (11)

- I worry about 2,4-D getting into my drinking water. Isn't that a danger?

Permitting agencies are very cautious about allowing chemical treatments near drinking water sources.

They "run the numbers" to make sure there is no risk of contamination that would exceed drinking water standards, and often err on the side of caution and call any amount of herbicide in the water too much.

For wells, it is unlikely that 2,4-D moves readily through the soil to groundwater. We have never detected it in near-shore wells adjacent to treatment area in NH that DES and Agriculture have sampled.

Questions and Answers (12)

- I know you say it's safe, but I still worry about chemicals building up in our lake and drinking water. How do you know that 2,4-D doesn't build up in the water?

2,4-D is not a product that bioaccumulates in nature. It is broken down by microbes and by oxygenation.

Routine water quality monitoring post-treatment in the last several years shows that 2,4-D does not linger in the water column, and sediment sampling shows it does not persist in sediments.