



Norflurazon

Roadside Vegetation Management Herbicide Fact Sheet



This fact sheet was developed by Oregon State University and Intertox, Inc. to assist interested parties in understanding the risks associated with pesticide use in Washington State Department of Transportation's (WSDOT) Integrated Vegetation Management program.

Introduction

Norflurazon is a pyridazinone herbicide used to control grass and broadleaf weeds. Norflurazon inhibits carotenoid synthesis, which causes chlorophyll depletion and inhibition of photosynthesis in plants. Norflurazon is the only active ingredient (78.6%) in the herbicide **Predict**. According to the product label, Predict also contains 21.4 % other ingredients (unspecified). The Washington State Department of Transportation (WSDOT) is considering the future use of Predict for total pre-emergent grass and broadleaf weed control. Predict also has agricultural uses.

WSDOT assessed the potential risks to human, wildlife, and aquatic animals exposed to bromoxynil in their Integrated Vegetation Management (IVM) program. Evaluating potential risks takes into account both the toxicity of a pesticide and the characteristics of possible exposure.

WSDOT Application Rates and Use Patterns on Highway Rights-of-Way

WSDOT is currently evaluating the use of Predict for maintenance of a bare ground strip at the edge of pavement. Predict is typically applied at up to 5 pounds of product—or about 3.9 pounds of norflurazon—per acre. Applicators use truck-mounted booms placed 18" above the ground to make a single application of norflurazon in the spring. In 2005 WSDOT applied 70 pounds of norflurazon for evaluation purposes.

Laboratory Testing: Before pesticides are registered by the U.S. Environmental Protection Agency (EPA), they must undergo laboratory testing for short-term (acute) and long-term (chronic) health effects. Laboratory animals are purposely fed doses high enough to cause toxic effects. These tests help scientists determine how chemicals might affect humans, domestic animals, or wildlife in cases of overexposure. Pesticide products used according to label directions are unlikely to cause toxic effects. The amount of pesticide that people and pets may be exposed to is low compared to the doses fed to laboratory animals.

Human Health Effects

The U.S. Environmental Protection Agency (EPA) classifies Predict as category IV (Very Low Toxicity) with a signal word of CAUTION because of harm if swallowed or absorbed through skin (see "Toxicity Category and Signal Word" table).

Acute toxicity: Norflurazon has low toxicity if individuals accidentally eat residues, and very low toxicity if it is inhaled or gets on skin. In rabbits, norflurazon was slightly irritating to the skin and mildly irritating to the eye. Norflurazon was not a skin sensitizer in guinea pigs.

Chronic toxicity: In a 6-month study in dogs fed norflurazon, moderate doses resulted in increased liver and thyroid weights and cholesterol. Rats fed norflurazon for 9 months experienced increased liver and gonad weights and kidney toxicity at moderate doses. Mice fed norflurazon for 2 years had spleen, liver, and kidney abnormalities at moderate to high doses.

Reproductive effects: Maternal and developmental toxicity has been observed in rats and rabbits administered moderate doses of norflurazon. In reproductive studies with mice and rats, no effects on reproduction and

Toxicity Category and Signal Word

	High Toxicity (<i>Danger</i>)	Moderate Toxicity (<i>Warning</i>)	Low Toxicity (<i>Caution</i>)	Very Low Toxicity (<i>Caution</i>)
Oral LD50	Less than 50 mg/kg	50-500 mg/kg	500-5000 mg/kg	Greater than 5000 mg/kg
Dermal LD50	Less than 200 mg/kg	200-2000 mg/kg	2000-5000 mg/kg	Greater than 5000 mg/kg
Inhalation LC50	Less than 0.05 mg/l	0.05-0.5 mg/l	0.5-2.0 mg/l	Greater than 2.0 mg/l
Eye Effects	Corrosive	Irritation persisting for 7 days	Irritation reversible in 7 days	Minimal effects, gone in 24 hrs
Skin Effects	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation

Note: Highlighted categories specify the range for norflurazon cited in this fact sheet.

development were seen at any dose.

Carcinogenic effects: Norflurazon has been determined to be nonquantifiable, but likely to be a human carcinogen based on liver tumors in mice fed norflurazon for 104 weeks.

Fate in humans and animals: Rats rapidly excrete norflurazon metabolites in urine and feces. Norflurazon does not bioaccumulate (build up) in mammals.

Wildlife and Aquatic Effects

Effects on mammals: Norflurazon is practically non-toxic to small mammals based on an acute oral LD50 of 9300 mg/kg reported for rats.

Effects on birds: Norflurazon is practically non-toxic to slightly toxic to birds. Formulated product with 80% active ingredient was slightly toxic to the mallard duck and bobwhite quail with reported LD50 values of >1,000 mg/kg. An LD50 of >2,510 mg/kg was reported for mallard ducks exposed orally to technical grade norflurazon. In subacute dietary studies, norflurazon was practically nontoxic to both bobwhite quails and mallard ducks with LC50 values of >10,000 mg/kg.

LD50/LC50: Acute toxicity is commonly measured by the lethal dose (LD) or lethal concentration (LC) that causes death in 50 percent of treated laboratory animals. LD50 indicates the dose of a chemical per unit body weight of an animal and is expressed as milligrams per kilogram (mg/kg). LC50 is the concentration of a chemical per volume of air or water and is expressed as milligrams per liter (mg/L). Chemicals are highly toxic when the LD50 or LC50 value is small and practically nontoxic when the value is large. However, the LD50 and LC50 do not reflect potential health effects such as cancer, birth defects, or reproductive toxicity that may occur at levels of exposure below those that cause death.

Effects on fish: Norflurazon was moderately to slightly toxic to freshwater fish based on 96-hour acute toxicity studies using 98.6% active ingredient. For rainbow trout and bluegill sunfish, LD50 values were 8.1 and 16.3 mg/L, respectively.

Effects on aquatic insects: U.S. EPA reported that norflurazon is slightly toxic to freshwater invertebrates based on a no-observed-effect-concentration (NOEC) of 15 mg/L in *Daphnia magna*. In estuarine and marine invertebrates, norflurazon was classified as slightly to moderately toxic based on acute toxicity studies. For mysid, an LC50 of

Wildlife Toxicity Category

Risk Category	Mammals	Birds	Fish or Aquatic Insects
	Acute Oral or Dermal LD ₅₀ (mg/kg)	Acute Oral LD ₅₀ (mg/kg)	Acute LC ₅₀ (mg/L)
Practically nontoxic	>2,000	>2,000	>100
Slightly toxic	501-2,000	501-2,000	>10-100
Moderately toxic	51-500	51-500	>1-10
Highly toxic	10-50	10-50	0.1-1
Very highly toxic	<10	<10	<0.1

Highlighted categories specify the range for norflurazon cited in this fact sheet. The toxicity of norflurazon to wildlife receptors varies by species.

5.53 mg/L was reported following exposure to 99.4% active ingredient. In toxicity tests with the Eastern oyster, a NOEC of 1.2 mg/L were reported following exposure to 98.6% active ingredient.

Environmental Fate

A typical half-life for norflurazon in soils is 90 days (see “Half-life” text box). Microbes and sunlight break down norflurazon in the environment. Norflurazon’s potential to leach to groundwater is intermediate; surface runoff potential is high, and potential for loss on eroded soil is intermediate. Norflurazon has low volatility and the potential for loss to the atmosphere is low. Norflurazon does not bioconcentrate (build up) through the food chain. Norflurazon is adsorbed through the roots and is translocated (moved throughout) to other plant parts.

Half-life is the time required for half of the compound to degrade.

- 1 half-life = 50% degraded**
- 2 half-lives = 75% degraded**
- 3 half-lives = 88% degraded**
- 4 half-lives = 94% degraded**
- 5 half-lives = 97% degraded**

Remember: the amount of a chemical remaining after a half-life will always depend on the amount of the chemical originally applied.

Human Health Risk Assessment

WSDOT evaluated several human exposure scenarios, including workers applying herbicides and the public (adults and children) picking and eating drift-contaminated berries, eating drift-contaminated garden vegetables, and walking through sprayed vegetation. For each exposure scenario, WSDOT evaluated conditions of average exposure and extremely conservative conditions of maximum exposure (see “Human Cancer/Non-cancer Risk Classification” text box and “Human Risk Classification for Average Exposure Scenarios” table).

Norflurazon is expected to pose negligible potential risks of adverse non-cancer effects to WSDOT workers and the public under conditions of average exposure. All hazard quotients are below 1. Under conditions of maximum exposure, Norflurazon is expected to pose a low potential risk of adverse non-cancer effects to workers engaged in broadcast hydraulic spray operations and children and adults ingesting drift-contaminated garden vegetables; the HQs in these scenarios range from 3.6 to 4.6. Norflurazon is expected to pose negligible potential risks in all other exposure scenarios. Norflurazon is not regulated as a carcinogen.

Human Cancer/Non-cancer Risk Classification:

Scientists estimate non-cancer health risks by generating a hazard quotient (HQ). This number is the exposure divided by the toxicity. When the HQ is less than 1, exposures are unlikely to cause any adverse health effects. When the HQ is greater than 1, the potential for non-cancer health effects should be considered. Risk assessments for chemicals that cause cancer (carcinogens) estimate the probability of an individual developing cancer over a lifetime. Cancer risks estimated in this way are very conservative, and actual cancer risks are likely to be much lower. Cancer risk estimates of less than 1 in 100,000 are within the range considered negligible by most regulatory

Human Risk Classifications for Average Exposure Scenarios

Hazard Quotient (Non-cancer Risk)	Cancer Risk	Potential Risks and Management Priority
Less than 1	Less than 1 in 100,000	Negligible
Between 1 and 10	Between 1 in 10,000 and 1 in 100,000	Low
Between 10 and 100	Between 4 in 1,000 and 1 in 10,000	Moderate
Greater than 100	Greater than 4 in 1,000	High

Note: Highlighted categories specify the range of potential risk for specific exposure scenarios involving bromoxynil.

Wildlife Risk Assessment

Wildlife risk assessment considers herbicide behavior in the environment and routes of exposure. Indirect exposure to mammals and birds can occur when they eat contaminated prey or vegetation. Direct exposure can occur when mammals and birds contact herbicide residues with their skin or eyes or when they inhale vapors or particulates. WSDOT’s current application rates and use patterns for norflurazon are expected to pose an insignificant risk to mammals. The estimated dietary exposures to rats, mice, and meadow vole based

on maximum label application rates would be 1,700, 200, and 260-fold lower, respectively, than the acute dietary LD50 for norflurazon. The estimated dietary exposures of norflurazon to quail, marsh wren, and American robin based on maximum label application practices would be 120, 13 and 10-fold lower, respectively, than the acute dietary LD50 for bobwhite quail. These estimated dietary exposures are considered low for quail, moderate for wren, and high for robin.

Aquatic Risk Assessment

WSDOT takes extra precautions applying herbicides near open water, wetlands, and wellhead protection zones. However, contamination may result from application drift, rainfall runoff, or residue leaching through the soil into groundwater. Fish and aquatic insect exposure to norflurazon occurs primarily through direct contact with contaminated surface waters or sediment. Norflurazon does not bioaccumulate (build up) in aquatic animals, but is persistent in water. The relative risks to fish and aquatic invertebrates from norflurazon applied at levels established by WSDOT were calculated to be slight in all physiographic provinces except in the Puget Trough, where the risk is moderate.

Additional Resources

- National Pesticide Information Center 1-800-858-PEST (7378) and <http://npic.orst.edu>
- Washington State Department of Transportation, Roadside Maintenance Branch 1-360-705-7865
- Washington Department of Agriculture, Pesticide Management Division 1-877-301-4555 (toll free)