Washington State Department of Transportation

Bromacil

Roadside Vegetation Management

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. WSDOT updated in 2017 to reflect current products and usage.

Herbicide Fact Sheet

Introduction

Bromacil is an herbicide used for weed and brush control on road shoulders. It is especially useful against perennial grasses. Bromacil stops photosynthesis, which in turn causes plants to stop growing. Bromacil (40%) is combined with the active ingredient diuron in the herbicide **Krovar**, which is used by the Washington State Department of Transportation (WSDOT) for control of pre-emergent (before plants begin to grow) weeds, brush, and grasses in the maintenance of vegetation-free gravel shoulders. Bromacil also has agricultural uses.

WSDOT assessed the potential risks to humans, wildlife, and aquatic animals exposed to bromacil 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.

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.

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

Typical rights-of-way application rates of Krovar range from 6 to 8 pounds of product per acre, or a maximum of about 3.2 pounds of bromacil per acre. It is applied by truck-mounted side boom mounted 18" from the ground in October and November or from March to May. Due to the potential for bromocil to damage or destroy trees when roots are present in the application area, Krovar is used primarily in open areas on the east side of the state. WSDOT workers applied 3,179 pounds of bromacil statewide during 2016.

Human Health Effects

The U.S. Environmental Protection Agency (EPA) classifies Krovar as toxicity class III (slight toxicity) with a signal word of CAUTION (see Toxicity Category and Signal Word table).

Acute toxicity: Bromacil is very slightly to slightly toxic if individuals accidentally eat or touch residues and practically nontoxic if inhaled (see Laboratory Testing text box). Bromacil is a mild eye irritant and a very slight skin irritant. It is not a skin sensitizer.

Chronic toxicity: Bromacil caused body weight decreases, cellular thyroid changes, increased numbers of thyroid cysts, cellular adrenal gland changes, and retinal (eye) damage when fed to rats in moderate to high doses for 2 years. Dogs fed bromacil for 2 years had decreased body weight.

Reproductive effects: Studies have shown that bromacil does not affect reproduction when fed to rats over three generations. Bromacil did cause skeletal changes in the offspring of pregnant rats fed high doses or exposed to very high air concentrations. It also caused an increase in the number of miscarriages when fed to rabbits in high doses. The EPA suggests that these reproductive effects are the result of toxicity to the mother

and are not the result of direct developmental toxicity; therefore, EPA does not consider bromacil to be a developmental toxicant.

Toxicity Category and Signal Word

	High Toxicity (*Danger*)	Moderate Toxicity (*Warning*)	Low Toxicity (*Caution*)	Very Low Toxicity (*Caution*)
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

Highlighted categories specify the range for bromacil use cited in this fact sheet.

Carcinogenic effects: Rats fed moderate to high doses of bromacil for 2 years showed an increase in the number of tumors in the thyroid gland. Mice fed high doses of bromacil for 18 months showed an increase in the number of liver tumors. The EPA classifies bromacil as a Group C, possible human carcinogen. Bromacil tested positive for mutagenicity (causes mutation) in some animal cells tests but negative in others. The EPA does not consider bromacil mutagenic.

Fate in humans and animals: Bromacil is in a group of chemicals that is absorbed through the gut and excreted primarily in the urine. Bromacil was detected in small amounts in the milk of cows fed 5 milligrams per kilogram (mg/kg) in their food. The urine and feces of these cows did not contain bromacil.

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.

Wildlife Effects

Effects on Mammals: Krovar—the product containing bromacil and diuron—is practically nontoxic or slightly toxic to mammals. The acute LD50 for rats fed bromacil is 2,300 mg/kg. The highest practical dose tested on the skin of rabbits caused no deaths, but 4 hours of direct skin contact with concentrated Krovar resulted in a slight but reversible skin irritation. The LD50 for rabbits exposed by skin contact is greater than 2,000 mg/kg.

Effects on birds: Bromacil is practically nontoxic to birds. The LD50 for bobwhite quail fed bromacil is greater than 2,250 mg/kg. The LC50 for bobwhite quail and mallard ducks fed lower doses of bromacil for 8 days is greater than 10,000 mg/kg.

Effects on fish: Bromacil is practically nontoxic to slightly toxic to fish and does not bioaccumulate (build up) in fish.

Effects on aquatic invertebrates: Data on the toxicity of Krovar to aquatic insects is not available.

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 bromacil use cited in this fact sheet.

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.

Environmental Fate

The half-life of bromacil in soils is about 60 days, but may be as long as 8 months in some conditions (see half-life text box). It has a high potential to leach through soils and contaminate groundwater. Bromacil moves rapidly into the roots of plants and absorbs slightly through the leaves. Misapplication of bromacil can destroy shade trees and other non-target vegetation.

Human Health Risk Assessment

WSDOT evaluated several human exposure scenarios, including adults and children eating drift-contaminated garden vegetables or children directly touching drift-contaminated berries or sprayed vegetation. For each exposure scenario, WSDOT evaluated conditions of average exposure and extremely conservative conditions of maximum exposure (see Human Cancer/Non-cancer text box and Human Risk Classification under Conditions of Average Exposure table). The risks presented below are associated with use of Krovar, which is a combination of the two active ingredients, bromacil and diuron.

Krovar poses a potential low risk of adverse non-cancer effects to the public under the average exposure scenarios. The hazard quotients for these scenarios range from 1.1 to 1.6. Hazard quotients for all other average public exposure scenarios are below 1. Under the conditions specified for the maximum exposure scenarios, Krovar poses a potential low to high adverse non-cancer risk to the public. Values range from 4.3 for adults who eat drift-contaminated berries to 305 for children who eat drift-contaminated garden vegetables. The conditions specified for the maximum exposure scenarios are worst-case scenarios and are unlikely to occur.

Workers making broadcast spray applications are at a low risk of adverse non-cancer effects from Krovar under average exposure scenarios. The hazard quotient for this scenario is 8.6. Workers who broadcast spray Krovar face potentially high risks under conditions of maximum exposure. The estimated hazard quotient for this exposure scenario is 292. The estimated cancer risks for WSDOT workers and the public for all average case scenarios are negligible. Under maximum exposure conditions, potential cancer risks for WSDOT workers and the public are negligible, low, or moderate.

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, potential non-cancer health effects may be possible. 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 agencies.

Human Risk Classifications under Conditions of Average Exposure

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 bromacil (and diuron).

Wildlife Risk Assessment

Wildlife risk assessment considers pesticide 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 Krovar residues with their skin or eyes or when they inhale vapors or particulates. WSDOT's current application rates and use patterns for Krovar pose a negligible to low risk to mammals. The estimated dietary doses for rats, deer mice, and meadow voles are approximately 30 to 250 times lower than the rat LD50 of 2,300 mg/kg. The risk to birds is low to moderate. The estimated dietary doses for American robins and bobwhite quail are approximately 15 to 160 times lower than the quail LD50 of 2,250 mg/kg.

Aquatic Risk Assessment

WSDOT takes extra precautions applying herbicides near open water, wetlands, or 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 bromacil occurs primarily through direct contact with contaminated surface waters. Bromacil does not bioaccumulate (build up) in aquatic animals. Bromacil ranges from practically nontoxic to slightly toxic in fish and aquatic insects (see Wildlife Toxicity Category table). WSDOT's current use of bromacil poses a low risk to fish and aquatic insects in all areas of the state.

Additional Resources

- National Pesticide Information Center 1-800-858-PEST (7378) and http://npic.orst.edu
- Extension Toxicology Network (EXTOXNET) http://extoxnet.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)