Washington State
Department of Transportation

Diuron

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

Diuron is a broad-spectrum herbicide used for weed, grass, and brush control on highway shoulders. It stops photosynthesis, which in turn causes plants to stop growing. It also inhibits seed germination. Diuron is the only active ingredient in the herbicide products **Karmex DF** (80%), **Direx 80DF** (80%), and **Direx 4L** (40%). The product **Krovar** is a combination of diuron and the herbicide bromacil. The Washington State Department of Transportation (WSDOT) applies all of these products as pre-emergents, that is, to control vegetation before it begins to grow, in the maintenance of gravel shoulders.

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

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

Typical rights-of-way application rates range from 4 to 6 pounds of **Karmex**, **Diuron**, and **Direx** per acre, or a maximum of about 4.8 pounds of diuron per acre. Workers apply **Krovar** at a rate of 6 to 8 pounds per acre, or a maximum of about 3.2 pounds of diuron per acre. Applicators use truck-mounted side booms mounted 18 inches from the ground to apply diuron-containing products in October and November or from March to May. WSDOT workers applied 47,500 pounds of diuron statewide during 2002.

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 Karmex DF, Direx 80DF, and Direx 4L as toxicity category III (low toxicity) with a signal word of CAUTION (see Toxicity Category and Signal Word table). The EPA classifies Krovar as toxicity category II (moderate toxicity) with a signal word of WARNING because it can cause eye irritation and may cause a reaction if it touches the skin.

Acute toxicity: Diuron has slight toxicity if individuals accidentally eat, touch, or inhale residues (see Laboratory Testing text box). Diuron is moderately irritating to the eyes and slightly irritating to the skin. It is not a sensitizer.

Chronic toxicity: Diuron causes slight anemia, enlarged spleen, bone marrow changes, and abnormal blood pigments when fed to rats for 2 years at moderate doses. Diuron causes abnormal blood pigments, blood parameter changes, and increased spleen weights when fed to dogs in moderate doses for 2 years. It causes decreases in body weight gain, increases in organ weights, increased pigments in the kidneys, changes in liver and urinary bladder cells, and changes in blood cell counts when fed to mice in high doses.

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 diuron use cited in this fact sheet.

Reproductive effects: Separate studies have shown that diuron does not affect reproduction when fed to rats over two or three generations. However, diuron did cause birth defects, including reduced fetal body weight and delayed bone formation, in the offspring of pregnant rats (but not rabbits) fed diuron at moderate doses. High doses of diuron fed to pregnant rats cause embryo death and circulatory system, liver, and skeletal problems in the offspring.

Carcinogenic effects: Diuron causes an increased number of bladder, kidney, and uterine cancers (carcinomas) when fed to mice at moderate doses. High doses cause an increase in the number of mammary gland tumors in female mice. The EPA classifies diuron as a "known/likely" human carcinogen. Numerous diuron studies show no gene mutation or DNA damage; however, diuron did cause an increase in the average number of chromosome changes in rat bone marrow.

Fate in humans and animals: Studies show that animals eliminate diuron in the feces and urine. However, cows fed very low doses had small amounts of diuron in the milk, and cattle accumulated low levels of diuron in fat, muscle, liver, and kidneys.

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: Diuron is slightly toxic to mammals. The acute LD50 for rats fed diuron ranges from 1,017 to 3,750 milligrams per kilogram (mg/kg) (see LD50/LC50 text box and Wildlife Toxicity Category table). Diuron toxicity is associated with depression of the nervous system.

Effects on birds: Diuron is slightly toxic to birds. The LC50 for bobwhite quail fed diuron is 1,730 parts per million (ppm). However, an LC50 of greater than 5,000 ppm for Japanese quail, ring-necked pheasants, and mallard ducks indicates low toxicity in other bird species.

Effects on fish: Diuron is moderately to highly toxic to fish. It is unclear whether diuron will bioaccumulate (build up) in fish.

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[1]	>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

[1]The toxicity of diuron is species dependent. The two highlighted categories in the *Birds* specify the range of toxicity for diuron use cited in this fact sheet.

Effects on aquatic insects: Diuron is moderately to highly toxic to aquatic (water) insects.

Environmental Fate

The half-life of diuron in soil ranges from 30 to 365 days with a typical time of 90 days (see Half-life text box). Diuron is moderately mobile, and minor residues have been found in groundwater following land applications.

Microbes break down diuron in water; the breakdown products are less mobile. Diuron easily moves into the roots of plants but has less movement through the leaves and stems.

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 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.

Products that contain diuron pose a potential low risk of adverse non-cancer effects to the public under some of the average exposure scenarios. The hazard quotients for these scenarios range from 1.1 to 2.7. Hazard quotients for all other average public exposure scenarios are below 1. Under maximum exposure conditions, diuron poses potentially low to high adverse non-cancer risk to the public. Values range from 4.0 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 face potential low to moderate risks of adverse non-cancer effects from diuron under average exposure scenarios. The hazard quotients for this scenario range from 8.6 to 12. Workers engaged in broadcast spray applications could be at high risk from diuron given the maximum case assumptions. The hazard quotients for this exposure scenario range from 270 to 292. The estimated cancer risks are negligible for WSDOT workers and the public for all average exposure scenarios. Under maximum exposure conditions, cancer risk potential for WSDOT workers and the public are negligible, low, or moderate (see Human Cancer/Non-cancer text box and Human Risk Classifications under Conditions of Average Exposure table).

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**[1]
Greater than 100	Greater than 4 in 1,000	**High**

Note: Highlighted categories specify the range of potential risk for specific exposure scenarios involving diuron.
[1]Moderate risks involving diuron are associated with WSDOT workers making broadcast applications.

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 diuron residues with their skin or eyes or when they inhale diuron vapors or particulates. WSDOT's current application rates and use patterns for diuron pose a negligible to moderate risk to wildlife. The estimated dietary doses to rats, mice, and meadow voles are approximately 60 to 500 times lower that the rat LD50 of 3,160 mg/kg. This estimated exposure poses a negligible risk to rats and a low risk to deer mice and meadow voles. The estimated dietary doses of diuron to quail, marsh wrens, and American robins are approximately 14 to 160 times lower than the bobwhite quail LD50 of 1,730 mg/kg. This estimated exposure poses a low risk to quail and a moderate risk to wrens and American robins.

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 water insect exposure to diuron occurs primarily through direct contact with contaminated surface waters. Diuron does not bioaccumulate (build up) in aquatic organisms. Diuron ranges from moderately toxic to highly toxic in fish and aquatic insects (see Wildlife Toxicity Category table). WSDOT's current use of diuron poses a low risk to fish and aquatic insects in all areas of the state except the Puget Trough, where the risks are moderate.

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)