ATTACHMENT B

Herbicide Information

syngenta

Reward® *Landscape and Aquatic Herbicide*

Low Toxicity, Low or No Exposure = Low Risk

What happens to Reward after application?

Reward rapidly dissipates after application because it is very water soluble and because it binds very tightly to vegetation and particulate matter. This binding is strong and complete (>99.9%), and the chemical is rendered biologically inactive for uptake by organisms. Instantaneous concentrations of 0.37 ppm fall to about 0.1 ppm after 24 hours and 0.01 ppm by 4 days. Our understanding of this extremely rapid dissipation is based on numerous aquatic field studies.

Drinking:

An adult would have to drink over **15,700 gallons of water a day for a lifetime,** every day at the EPA-established limit in water of 0.02 mg/liter to absorb an amount of Reward equivalent to levels that caused ***no*** effects in animal studies. Since Reward rapidly dissipates and is below 0.02 or is not detectable in treated water within 1–3 days after application at maximum rates, the daily possibility of drinking water containing Reward is nonexistent.

Swimming:

Reward is very poorly absorbed through the skin. Consequently, an adult would need to swim continuously for **447 hours** in water treated at the maximum rate to absorb and ingest an amount of Reward equivalent to levels that caused ***no*** effects in animal studies (NOEL).

Livestock:

Because Reward dissipates so rapidly and is so poorly absorbed, the EPA agrees that livestock can drink Reward-treated water within 24 hours after an application. Furthermore, any small amounts of Reward that are absorbed by the animal are quickly excreted and are not accumulated in meat, milk, or fat.

Fish:

A person would have to eat **13 pounds** of fish every day **for a lifetime** to achieve an amount of Reward equivalent to levels that cause ***no*** effects in animal studies (NOEL). This assumes that the person obtains fish daily that contain the EPA-established limit of 0.06 parts per million. Given the quick dissipation of Reward in water and its rapid elimination from the fish, this degree of concentration and exposure is ***highly*** improbable.

SAFETY TESTING

Reward was tested over many years in a multitude of animal tests to establish what effects it could cause and at what level of exposure. In these tests, animals are exposed to a range of daily exposure levels, from very low to very high, and over a wide span of time, from one single dose to a lifetime of daily exposure. From these tests, the level that caused no harm to the animal is determined and is called the No-Effect Level, or ***NOEL.***

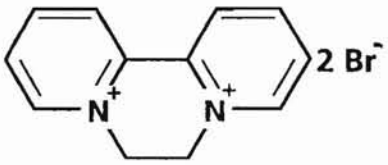
Call 1-800-395-8873 to contact your local Syngenta sales representative and learn more about Reward.

REWARD®

Landscape and Aquatic Herbicide

(37.3% Diquat Dibromide + 62.7% inerts)

Chemical Structure



Chemical Nomenclature:
1,1'-ethylene-2, 2'-bipyridium ion, dibromide salt;
6,7-dihydrodipyrido [1,2-a:2',1'-c] pyrazdiium ion, dibromide salt

CAS No.:
85-00-7 (dibromide)
2764-72-9 (cation)
6385-62-2 (dibromide monohydrate)

Use:
Non-selective contact herbicide and desiccant

Molecular Formula:
$C_{12}H_{12}N_2Br_2$

Molecular Weight:
344.0 g/mol (dibromide)
184.2 g/mol (cation)
362.0 g/mol (monohydrate)

Physical Properties:

State:	Liquid (red-brown)
Boiling Point:	100°C
Sp. Gravity:	1.22–1.27 g/ml @ 20°C
pH:	6.0–7.5

Physicochemical Properties:

Aq. Solubility:	718,000 mg/l @ 20°C
Log Kow:	-4.6 @ 20°C
Log Koc:	4.5–6.9 ml/g
Vapor Pres:	10^{-7} Torr; $<10^{-8}$ Kpa @ 25°C

Chemical Stability:

Aq. Photolysis ($t_{1/2}$):	74 days (lab)
Aq. Hydrolysis ($t_{1/2}$):	stable (acidic or neutral solutions)
Volatility:	non-volatile

Environmental Fate Profile:
Reward® rapidly dissipates in water due to the naturally high water solubility and adsorptive characteristics of the active ingredient (diquat cation). Exposure is further reduced by microbial degradation in plants and water, and by photodegradation from the action of sunlight.

Reported Pond-Water Dissipation Rate ($t_{1/2}$): <1–2 days

Ecotoxicological Profile:

Birds:	oral LD_{50} = moderately toxic dietary LC_{50} = moderately to slightly toxic
Bees:	contact LD_{50} = practically non-toxic
Fish:	acute LC_{50} = moderately toxic
Invertebrates:	acute EC_{50} = highly to moderately toxic
Plants/Algae:	acute EC_{50} = highly to moderately toxic

Application Rates:
Applied at 1–2 pounds diquat cation per acre maximum; equivalent to an instantaneous maximum concentration of 0.37 mg cation/l (ppm cation). Instantaneous concentrations of 0.37 ppm cation fall to about 0.1 ppm after 24 hours and 0.01 ppm by 4 days.

Margin of Safety (Environmental Exposure):
Based on an instantaneous maximum concentration of 0.37 mg cation/l, the corresponding 48 and 96 hour post-application margins of safety to bluegill sunfish are 376X (at 48 hours) and 1522X (at 96 hours), respectively.

Environmental Overview

The safety of a chemical in the environment and potential risk to non-target plants and animals is a function of exposure to the chemical and toxicity. In the absence of chemical exposure, there is no opportunity for toxicological effects. Exposure is determined by the fate of the chemical in the environment. It is the fate characteristics of diquat dibromide, in conjunction with a moderate toxicity, that result in the exceptional environmental safety of diquat dibromide. In aquatic environments, diquat exposure is rapidly reduced after application by adsorption onto target plants. Exposure is further reduced by microbial degradation in plants and in water and by photodegradation from the action of sunlight. Similar degradation processes occur in terrestrial environments. Diquat rapidly and strongly binds to soil particles. In aquatic environments, diquat is also adsorbed to suspended sediments, including clay particles. Once adsorbed, diquat dibromide is no longer bioavailable and the opportunity for exposure to non-target species is minimized. In addition, diquat is immobile once adsorbed and does not move into surrounding soil or sediment or leach into groundwater. Therefore, there is minimal risk of contamination of surface water or groundwater. Following labeled application rates, the window of opportunity for exposure to non-target organisms is small because of the rapid dissipation of diquat. Laboratory toxicity studies that are conducted in the absence of mitigating environmental conditions show that diquat dibromide is only moderately toxic to aquatic organisms and terrestrial birds and wildlife. The toxicity of diquat dibromide has been extensively studied with more than 200 aquatic toxicity data points covering 26 species of fish and 20 species of aquatic invertebrates. Diquat is also rapidly excreted from organisms and does not bioaccumulate in aquatic organisms or cause biomagnification in food chains. Thus, when used according to label recommendations, diquat dibromide will not cause unreasonable risk to the environment.

Consumer Information

Common Questions and Answers on Reward

Q. Why is Reward diquat being recommended for aquatic weed control?

A. It is frequently decided that chemical treatment for weeds in lakes is necessary to preserve the recreational use of the lake during summer months. Other options are available, such as harvesting or dredging, but these are often dismissed as being ineffective or, in the case of dredging, too expensive. A draw-down of the water in the winter may be effective in reducing the weeds in areas left underwater during the draw-down. It is not feasible to draw the lake down much further because this would damage and eliminate habitat for populations of fish and other aquatic organisms. Mechanical harvesting is not effective against some of the weed species, since the fragments generated by the harvesting process can root in new areas. It is also ineffective where the weed problem is severe due to the density of the vegetation. Also, mechanical harvesting indiscriminately damages fish and other aquatic organisms as they are caught in the weeds being removed. In contrast, Reward is in part registered on the basis of a worst-case scenario risk assessment where effects on any single non-target organism are unacceptable.

Q. How do State Departments of Agriculture regulate this type of activity?

A. The Department of Agriculture can regulate aquatic pesticide applications from three perspectives. First, the chemical to be used in the state must be registered by the State and Federal governments. The second area of regulation is the requirement that any aquatic application must receive the necessary approval and/or permits if required by the state. Consult the responsible state agencies (e.g., Department of Ecology, Fish and Game Agency or Department of Natural Resources) for further information. The review process may involve an assessment and/or comparison of the chemical, application rate, and water use of the area to be treated. The result assures that the appropriate herbicide is selected for the water body and type of weed species to be controlled and that the proper rate is used. The final area of regulation is the certification of pesticide applicators if required by the state. The applicators must pass a written and oral examination of the category of application they intend to perform.

Q. Can water be used for other purposes after treatment with diquat?

A. Yes. Diquat may only be used in accordance with label instructions which require certain time restrictions for some types of water use. There are no restrictions for recreational activities (swimming or fishing). The restrictions for potable water (drinking) do not exceed 3 days, non-food crop irrigation (e.g., turf, ornamentals, etc.) has a maximum of 3 days, livestock consumption has a maximum of 1 day, and food crop irrigation has a maximum of 5 days. Irrigation has the greatest restriction because of the possible concern for phytotoxicity to crop plants. Restrictions are based on not exceeding the Maximum Contaminant Level Goal (MCLG) of 0.02 mg cation/l.

Q. What type of plants are commonly treated?

A. The most common plants treated are exotic species often referred to as "noxious weeds" (e.g., hydrilla, watermilfoils, waterhyacinth, waterlettuce). These plants are not native to North America and consequently do not have as many natural enemies as many native plants. They can also spread and grow rapidly resulting in dense areas that are unsuitable habitat for fish and aquatic organisms. They also compete with the native vegetation and can eliminate natural plant populations

that provide habitat for fish and other aquatic organisms. This can seriously impair the recreational value of a lake, river, or pond invaded by these exotic weeds. Harvesting is not effective against some of the species, since the fragments generated by the harvesting process can spread the infestation to other locations when they root after drifting back into the lake. Often chemical control is the only effective and practical method of managing aquatic weeds.

Q. What are the characteristics of diquat?

A. Diquat is a commonly used aquatic herbicide and commonly marketed under the trade name Reward. It has been used widely throughout the world for weed control and as a crop desiccant for over 30 years, and consequently a considerable amount is understood about the properties and risk associated with the use of diquat. It is very water soluble, dissipates rapidly in the water, and kills plants by disrupting photosynthesis. A very important characteristic of diquat is its rapid and strong binding to soil or sediment particles. More than half the residues in aquatic bodies will have disappeared from the water phase within 12 hours. The binding of diquat to soil and sediment also means that its potential for leaching into groundwater is negligible.

Q. Will diquat accumulate in fish or the environment?

A. No. Diquat does not have any potential for bioaccumulation because of its very high solubility in water. It is rapidly excreted by fish and other animals if ingested. Consequently, there is no potential for biomagnification through food chains.

Q. Is diquat degraded after application? What is the method of degradation?

A. Yes. Diquat undergoes microbial degradation on plants, in water, and in sediment. Sunlight also degrades diquat by the process of photodegradation.

Q. What happens to diquat in the sediment?

A. Diquat becomes rapidly and strongly bound to sediment particles. Once adsorbed to sediments it is not bioavailable for uptake by aquatic organisms including plants. This lack of bioavailability is demonstrated by the fact that sensitive rooted plants repeatedly recolonize diquat treated areas.

Q. Usually very water-soluble materials are prone to leaching, why is diquat different?

A. Diquat is not prone to leaching through the soil profile because it binds very strongly and completely to soil particles. Diquat will not leach in any soil types. In fact, the soil adsorption values for diquat are an order of magnitude greater than required for chemical to be classified as immobile.

Q. How much diquat will be in the water?

A. Very little and usually only in a portion of the water body. The instantaneous maximum concentration will be approximately 0.37 ppm (parts per million) in shallow waters, 2 ft in depth. When that concentration is diluted through the 6 ft of average depth in the treated area, the concentration would be less than 0.2 ppm. Usually only "spot applications" or no more than 1/3 of the lake would be treated, leaving untreated areas of refuge for fish. However, these levels refer to the instantaneous concentrations. The actual exposure concentrations will be lower since absorption to target plants, adsorptions onto sediments, and removal from the water is very rapid.

Q. Will diquat deplete the oxygen in the water and suffocate fish?

A. No. The microorganism activity in decomposing plant material uses up oxygen, and oxygen depletion can occur if there are dense areas of decaying weeds covering the entire water body. Where weed beds are dense, diquat can only be applied to 1/2 to 1/3 of the water body, with 14 days between each application. Therefore, fish and other aquatic organisms will not be affected as there will be a refuge area.

Q. Is diquat toxic to fish?

A. No. The toxic dose of diquat to fish ranges from 0.5 to 240 ppm, depending on the species of fish and the hardness of the water. Given the expected concentrations from label directions, there is an adequate safety margin for fish, i.e., maximum concentrations possible from label use are considerably less that the fish toxicity values. Fish can be killed by oxygen depletion when very heavy weed populations are all killed at once. The decay process depletes the oxygen in the water, causing fish suffocation. However, this scenario is unlikely to occur because under these conditions the label states that only 1/3 to 1/2 of the dense areas are to be treated at one time, which gives the fish an untreated refuge.

Q. Why is "toxic to aquatic invertebrates" required on the label?

A. This statement is based on EPA labeling requirements for "Environmental Hazards." The toxicity statements triggered are based only on acute laboratory toxicity studies conducted with technical grade active ingredient in clean water. The toxic effects of the chemical in a real water situation is not considered. In aquatic systems, the properties of diquat cause it to become rapidly bound to particulate matter where it is unavailable to cause toxic effects.

Q. How do toxic effects on fish measured in the laboratory relate to actual effect in the environment?

A. They do not relate directly. Toxicity studies are conducted in the laboratory in clean water (sediment-free) where there is no sediment or plant material present to mitigate exposure. Toxicity in the actual pond will be considerably less, particularly for diquat, as diquat rapidly binds to sediment and plants, and becomes unavailable biologically. This can be seen in comparative laboratory studies conducted with *Hyalella azteca* (an amphipod that lives on the sediment surface) where the toxicity is 140X less in a test system that mimics a real water body (sediment present) in comparison to the regular "water-only" test system.

Q. What will happen if aquatic herbicides are not used to control noxious weeds?

A. Exotic weeds can completely devastate lakes and rivers if left unmanaged. These species have the capacity to completely eliminate communities of native plants and cause both direct and indirect effects in other animals such as invertebrates and fish. Managed aquatic vegetation beds can provide excellent habitat for invertebrates and fish in early life stages. In contrast, dense weed beds do not, as they severely impact the water quality including dissolved oxygen levels. There are several success stories where diquat has been used to treat a severe weed situation, allowing natural plant communities to recolonize and the lake to return to the balance necessary for healthy aquatic organism populations.

Q. Is diquat more harmful to fish and other aquatic organisms than mechanical weed harvesters?

A. No. Regulation of diquat by the US Environmental Protection Agency does not allow for effects on any individual organism. In fact, there also has to be a safety margin. In contrast, mechanical weed harvesters are not regulated, and in the process of harvesting weeds, many fish and invertebrates are physically destroyed.

Q. Is diquat harmful to microbial organisms?

A. No. Once bound to the sediment diquat is generally not bioavailable to living organisms including microbial organisms. Small amounts of diquat that do become available are actually degraded by microbial organisms.

Information Request	Fact
What is the maximum amount of diquat that can be applied to a water body?	2 gals/surface acre (4 lb cation) in 4 ft depth 1 gal/surface acre (2 lb cation) in 2 ft depth
What is the typical worst case concentrations following application to water?	0.37 ppm (max. label rate scenario of 2 gals/acre in 4 ft or 1 gal/acre in 2 ft)
Does diquat persist in the water after application?	0.37 ppm (instantaneous concentration) falls to about 0.1 ppm after 24 hours and to 0.01 ppm after 4 days
How much diquat could enter a water body from surface runoff?	0.78 ppb or 0.00078 ppm (from modeling a worst case scenario)
How much diquat could enter a water body from spray drift after aerial application?	80.1 ppb or 0.08 ppm (5% of maximum application rate)
Does diquat bioaccumulate?	Low fish bioconcentration factors of <2.5X. Low aquatic invertebrate bioconcentration factors of 32X. Rapid elimination of diquat following exposure in all organisms tested.
What is the toxicity of diquat to fish?	Slightly to moderately toxic.
What is the toxicity of diquat to birds?	Slightly to moderately toxic.

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TECHNICAL BULLETIN

For more information, please contact
Jim Petta
Syngenta Field Technical Manager
at 361-215-0551

Review of the Aquatic Toxicology and Fate of Reward® (Diquat Dibromide)

Executive Summary
This document reviews the effects and fate of Reward® (diquat dibromide) in aquatic environments, following its use as an aquatic herbicide, using published literature references and registration documents on file with the EPA.

Diquat dibromide is a herbicide that has been used throughout the United States for over 45 years to control invasive aquatic weeds and algae. Because it is applied directly to water, it can come into contact with fish and other aquatic organisms. For this reason, an extensive database on its environmental safety has been developed. Minimal risk to humans and aquatic organisms following application of Reward has been demonstrated over decades of use, in laboratory studies, and in state and federal registration programs.

Following aquatic application, dissipation of Reward is very rapid. The half-life of Reward in water is typically one to two days (EPA, 2002). This dissipation occurs initially through mixing and dilution in the water column. Reward is subsequently very tightly bound to aquatic plants, sediment, and suspended particles. Once Reward becomes bound to sediment, it is inactivated and biologically unavailable.

The United States EPA has reviewed all of the available data on diquat (Reward) and determined that sufficient information is available regarding the potential for adverse human health effects and potential adverse effects in fish, wildlife, and the environment. The Agency has concluded that labeled uses of diquat products will not pose unreasonable risks or adverse effects to humans or the environment if used according to label instructions (EPA, 1995). A 2002 review under the Food Quality Protection Act further confirmed that diquat is not a mutagen nor carcinogen, poses no dietary risks, and that (EPA 2002a; 2002b):

> "Exposures from diquat dibromide to surface or ground water sources for both terrestrial and aquatic uses are not of concern to the Agency. Diquat dibromide is essentially immobile in the environment, indicating that it will most likely be associated with the soil and sediment instead of water. Significant residues of diquat dibromide are not expected to reach ground or surface water. Therefore, no risk mitigation measures are necessary to address drinking water risks from diquat dibromide use."

In summary, based on 45 years of data and modern reassessments, the EPA has concluded that Reward applications in accordance with labeled use pose no unreasonable risk to humans or to fish and other aquatic organisms.

Environmental Fate of Diquat Dibromide/Reward

Before considering the potential effects of Reward in animals and humans, it is useful to consider the fate of the product in aquatic systems. Reward is highly water soluble (700 grams per liter/5.9 pounds per gallon; British Crop Protection Council, 2000) and is relatively stable in pure water (EPA, 2002). Reward will slowly photodegrade (photodegradation half-life of 74 days in laboratory studies with clean water; Tegala and Skidmore, 1987) and is resistant to microbial degradation under most conditions (EPA, 2002). Diquat dibromide is a salt with a very low vapor pressure (British Crop Protection Council, 2000), indicating that diquat does not readily evaporate. The risk of exposure from inhalation is therefore negligible (USEPA, 1995).

Reward in water initially becomes diluted through mixing in the water column, and hot spots near the site of application are quickly eliminated via mixing and binding to organic matter (Coats et al., 1964; Sewell, 1969; Langeland and Warner, 1986; Fujie, 1988). The primary route of dissipation of Reward in water is adsorption. Reward rapidly disappears from water in natural systems by adsorption to sediment, aquatic vegetation, and particulate matter (e.g. EPA, 2002; WHO, 1984). Upon introduction into water, Reward quickly binds to these matrices and is thereby removed from the water column, becoming essentially immobile and inactivated in the environment (EPA, 2002). The aquatic half-life of the product in natural waters is approximately 1–2 days (EPA, 2002). Because of its rapid dissipation, aquatic animal exposure to Reward would be limited to short-term, acute durations (Washington State Department of Ecology, 2002). However, the extensive database currently available on the environmental safety of diquat includes chronic environmental toxicology results. These are discussed on the following pages

Potential Toxicity of Diquat to Aquatic Organisms

The Washington State Department of Ecology (2002) and the EPA (EPA 1995; 2002a; 2002b) have concluded that aquatic application of Reward according to label requirements does not pose unacceptable acute or chronic risk to aquatic animals.

Fish and Amphibians

Washington State Department of Ecology (2002) conducted a risk assessment using well-established methods (EPA, 1986; Campbell et al., 2000) that involved comparing expected environmental concentrations with environmental toxicology values and determining if these "risk quotients" exceeded levels of concern.

Laboratory studies in exposure vessels without sediment have demonstrated that 96-h acute LC50 toxicity values for all verified studies on fish are greater than 0.5 mg/L c.e. (cation equivalents; Washington State Department of Ecology, 2002). Based on the short-term expected environmental exposure concentration of 0.021 mg/L (Washington State Department of Ecology, 2002), the acute Risk Quotient for Reward with early-life stage largemouth bass and striped bass is [0.021 mg/L/0.5 mg/L] = 0.04. This acute RQ is well below the acute levels of concern (0.1) for these sensitive species and life stages. Field studies have confirmed the low potential for acute and chronic toxicity of Reward to fish (EPA, 1995).

The low toxicity of Reward to fish has been recognized by the FDA, USGS, and US Fish and Wildlife Service in treatment trials for control of bacterial gill disease and columnaris infections in salmon. While not yet approved by the U.S. Food and Drug Administration for disease control in food fishes, a 10-year, ongoing program in which hatchery salmon can be exposed to 2–4 mg diquat cation/L for treatment of bacterial diseases (US Fish and Wildlife Service, 2004; USGS, 1990) is being conducted.

Applications of Reward could result in exposure of amphibians as eggs, larvae, and adults, and environmental toxicity data are available for the potential toxicity of the product to several species of amphibians. Bimber and Michell (1976) exposed eggs of *Rana pipiens* (Northern leopard frog) to 100 mg diquat/L and reported no effects on hatching, but larval development and survival was adversely affected at this level. The relevance of these data is questionable, however, as exposure concentrations were 1000x expected field concentrations 24 hours after application. The most sensitive amphibian tested appears to be *Xenopus laevis* (African Clawed Frog), with a 96-h LC50 of approximately 0.75 mg/L, which is of similar sensitivity to the most sensitive fish (Anderson and Prahlad, 1976). However, dissipation data demonstrate that amphibians, like fish, will not be exposed in the field to even 0.5 mg/L for as long as 24 hours.

As discussed above, because of the rapid dissipation of Reward in water and the low application rates for this herbicide, calculation of risk from chronic exposure is not necessary (Campbell et al., 2000; Washington State Department of Ecology, 2002). However, chronic laboratory and field studies have confirmed the low potential for long-term toxicity of diquat to aquatic organisms (EPA, 1995; Washington State Department of Ecology, 2002), and confirmed that using diquat according to the label poses no significant acute or chronic risk to aquatic animals (Washington State Department of Ecology, 2002).

Invertebrates

Invertebrates are more sensitive to diquat than fish. The most sensitive invertebrate studied is the amphipod, *Hyalella azteca*. Testing in vessels containing only water and no sediment resulted in Acute Risk Quotients for *H. azteca* of 0.38 (i.e., 0.021 mg/L/0.048 mg/L), which is greater than the level of concern of 0.1. However, when considering studies in which sediment was added to vessels to improve environmental realism, the risk quotient drops significantly to an acceptable level of 0.003 (i.e , 0.021 mg/L/6.8 mg/L) (Washington State Department of Ecology, 2002). Wilson and Bond (1969) demonstrated that the addition of sediment to the system could increase the 96-h LC50 for *H. azteca* by ~140x, from 0.048 mg/L to 6.8 mg/L. The practical level of concern of 0.1 for protection of biota is therefore not exceeded, and no acute risk to invertebrates is expected (Washington State Department of Ecology, 2002). Inactivation of Reward following sorption to sediments was further demonstrated in a study with the aquatic invertebrate *Chironomus riparius* (Ashwell, 1999). Diquat spiked into sediment at 100 mg/kg (dry sediment weight) had no effect on the survival or development of *C. riparius* in a chronic study (Ashwell, 1999).

Field studies have confirmed that *H. azteca* can be sensitive to Reward (Wilson and Bond, 1967), although it is unclear whether these effects were due to acute or chronic exposure. Hilsenhoff subsequently demonstrated that reductions in invertebrate densities, including *H. azteca* populations, may be due to the loss of habitat as the nuisance plant species were eliminated following Reward treatment (Hilsenhoff, 1966).

Lack of Bioaccumulation of Reward in Aquatic Animals

The physical and chemical properties of Reward are not conducive to accumulation in animal tissues, and the bioaccumulation of diquat has not been seen in fish or other animals (EPA, 2002; Washington State Department of

Ecology, 2002; WHO, 1984). Bioaccumulation is the process by which a contaminant accumulates in the tissues of an individual organism via all exposure routes (inhalation, diet, and across the skin and other tissues). There are a number of factors that will determine a chemical's potential to bioaccumulate, including its solubility in water and in fat. Generally, only chemicals that can dissolve in fat or fat-like matrices, "lipophilic" compounds, will have significant potential for bioaccumulation. Diquat is a polar molecule that is non-lipophilic and highly water soluble (British Crop Protection Council, 2000), and therefore has a very low propensity to bioaccumulate (EPA, 2002). Furthermore, Reward is not readily bioavailable once bound to organic matter, soil, or sediments (EPA, 2002; Washington State Department of Ecology, 2002; WHO, 1984).

Laboratory and field experiments demonstrate that the bioconcentration factor of Reward is generally 1000 times less than the trigger limit that would categorize a compound as bioaccumulative under the EPA classification system (EPA, 1999). The very low bioaccumulation potential of Reward has been demonstrated in a number of laboratory studies using benchtop methods (e.g. British Crop Protection Council, 2000), and in laboratory and field studies with fish. A standardized laboratory study with bluegill sunfish conducted in support of the registration of Reward found that diquat does not bioconcentrate (Hamer et al., 1987). Schultz et al. (1995) exposed catfish to 0.005 and 0.020 ppm Reward in water and did not observe bioconcentration in any tissues (BCF <1.0). In a field study with bluegill in a pond initially treated at 1 ppm Reward, the BCF values never exceeded 0.5 at 10 days after treatment and were below detection limits (<0.01) after 12 weeks (Gilderhaus, 1967). When treated at an exaggerated dose of 3 ppm, the fish BCF values were as high as 1.5 mg diquat/kg fish after 10 days (BCF = 0.5), but completely dissipated below the levels of detection within 12 weeks (Guilderhaus, 1967), further demonstrating the low bioaccumulation potential and rapid depuration of Reward in fish.

Elimination of Reward from Fish

Depuration (elimination) of Reward from fish in clean water is very rapid. In edible species, half of the Reward present is eliminated within 1.5–3 days (Washington State Department of Ecology, 2002). Because depuration is so rapid, magnification of Reward up trophic levels (i.e. biomagnification) is not likely (Washington State Department of Ecology, 2002). Mammalian toxicology results clearly demonstrate that diquat is rapidly excreted in urine (EPA, 1995).

Human Exposure to Diquat

Based on the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) regulations, EPA only reregisters pesticides that can be used without posing unreasonable risk to human health or the environment. EPA critically analyzed all available studies of Reward® and concluded that the product poses no unreasonable risks for adverse effects to humans or the environment (USEPA, 1995) when used according to the label instructions.

In 2002 (EPA 2002a; 2002b), the EPA again considered the toxicology and fate information on Reward and confirmed that diquat is not a mutagen or carcinogen, poses no dietary risks, and that:

> "Exposures from diquat dibromide to surface or ground water sources for both terrestrial and aquatic uses are not of concern to the Agency. Diquat dibromide is essentially immobile in the environment, indicating that it will most likely be associated with the soil and sediment instead of water. Significant residues of diquat dibromide are not expected to reach ground or surface water. Therefore, no risk mitigation measures are necessary to address drinking water risks from diquat dibromide use."

Swimming, Fishing, and Other Uses

Based on the rapid dissipation of Reward, detailed risk assessments by the EPA concluded that fishing and swimming are allowed on the same day of application of Reward, pond water may be used for drinking within one to three days of application, pond water may be used for livestock consumption one day after application, and pond water may be used for irrigation of turf and food crops within one to five days following application (see Reward label at: http://www.syngentaprofessionalproducts.com/labels/).

Conclusions

The minimal risk that Reward poses to humans and aquatic organisms following application according to label instructions has been demonstrated in field and laboratory studies reflecting decades of use, and has been recognized in state and federal registration programs for this herbicide. Reward applied to water rapidly dissipates and becomes inactivated by organic matter, soil, and sediments. Expected environmental concentrations of Reward do not pose acute risks to aquatic animals, and the rapid dissipation of the product via adsorption indicates that chronic exposures are not likely. Reward does not bioaccumulate or biomagnify along trophic levels, and the risk to humans swimming in or consuming fish from treated waters is negligible.

Additional information on the environmental safety of diquat dibromide/Reward is available from the Environmental Protection Agency's website (www.epa.gov), or from Syngenta.

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