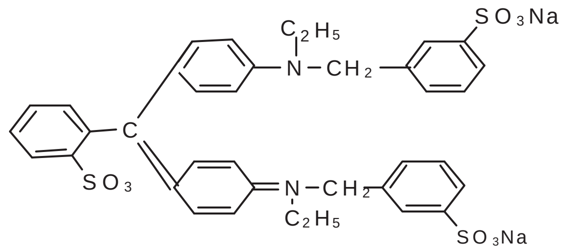
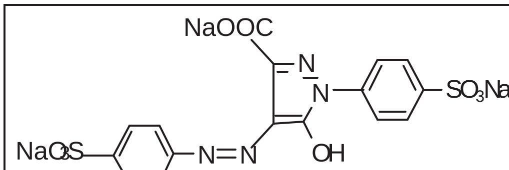
## III.7 AQUATIC DYES

As of the time of publication of this document, only products containing the aquatic dye Aquashade are currently registered for use in Massachusetts.




ACID BLUE 9




ACID YELLOW 23

## SUMMARY

### Active ingredients in AQUASHADE

Aquashade is a water-soluble mixture of blue and yellow dyes, which is used as a nonselective herbicide to control young, bottom-growth of plants in contained lakes and ponds (Applied Biochemists, Inc., 1992a). The principle active ingredient in Aquashade is Acid Blue 9 (n-ethyl-n-[4-[[4-[ethyl[(3-sulfophenyl)methyl]amino]- phenyl](2-sulfophenyl)-methylene)]2,5-cyclohexadien-1-ylidene]-3-sulfobenzenemethanaminium hydroxide inner salt, disodium salt (also prepared as the diammonium salt) (The Merck Index, 1983). The other active ingredient is acid yellow 23 (4,5-dihydro-5-oxo-1-(4-sulfophenyl)-4-[(4-sulfophenyl)azo]-1H-pyrazole-3-carboxylic acid trisodium salt) (The Merck Index, 1983). Aquashade filters out the red-orange and blue-violet wavelengths of light from the sunlight spectrum, thus interfering with the photosynthetic process in plants. The half-life for Aquashade in water is about 4 weeks. Over time, Aquashade is removed from a water body through a combination of dilution, photodegradation, and some biodegradation (Applied Biochemists, Inc., 1992a).

Although Aquashade was registered by the Environmental Protection Agency (EPA), it did not receive an EPA Registration Standard prior to the effective date of the 1988 Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) (HSDB, 1995). FIFRA 1988 requires that by 1997, each registered pesticide product containing an active ingredient initially registered before November 1, 1984 be reregistered (USEPA, 1994). Pesticides for which EPA did not issue Registration Standards prior to FIFRA 1988 were divided into three lists based upon their potential for exposure and other factors, with list B being of highest concern and list D of least. Aquashade was placed on list D and its current status is "Awaiting Data/Data in Review" (USEPA, 1994).

Currently, very little data exist on the toxicological and/or environmental effects of Aquashade. Once the EPA registration process has been completed, the impacts of this pesticide on human health and the environment can be evaluated.

## REGISTERED PRODUCTS IN MASSACHUSETTS

The current list of aquatic herbicides containing Aquashade that are registered in Massachusetts can be accessed at http://www.state.ma.us/dfa/pesticides/water/Aquatic/Herbicides.htm on the Massachusetts Department of Agricultural Resources (DAR) Aquatic Pesticide Website. The DAR updates this list regularly with changes. In addition, the DAR can be contacted directly at (617) 626-1700 for more specific questions regarding these products.

## AQUASHADE USES AND APPLICATION

Aquashade is intended to be used for the control of young plant growth on the bottom of contained bodies of water. Aquashade has also been shown to reduce the growth rate of algae (Applied Biochemists, Inc., 1992a). It is most effective in ponds with depths of two feet or greater.

The best time to apply Aquashade is at the beginning of the growing season, when young plants are just beginning to develop. Floating-leaf plants, which have already emerged, are not affected by Aquashade (Applied Biochemists Inc., 1992).

Application of Aquashade can be made in a number of ways. Manually, the herbicide can be poured along the water's edge, allowing it to disperse quickly with natural water movements to achieve even coloration. For quicker dispersion, the water can be applied over the surface of the water using a sprayer, can be injected into water pumps or can be applied near aerators or waterfalls (Applied Biochemists, Inc., 1992a).

Because Aquashade is a nonselective herbicide, it can affect a large number of young, bottom-growing plant species. In one study, nine species of aquatic plants were subjected to dye concentrations ranging from 0.5 to 15 ppm in 62 liter drums. Five of these plants, including elodea (*Elodea canadensis*), leafy pondweed, sago pondweed (*Potamogeton pectinatus*), curlyleaf pondweed (*Potamogeton crispus*) and brittle naiad (*Najas minor*), showed a significant reduction in weight over a four-week period at 1-5 ppm. One plant, whorled milfoil (*Myriophyllum verticillatum*), exhibited an increase in growth rate at concentrations of 1 ppm and above (White *et al.*, 1975).

Aquashade may be used in conjunction with other herbicides to achieve an effective year-round control and maintenance program for a variety of plant species at their various stages of development (Applied Biochemists Inc., 1992).

For specific information on recommended application rates, the product label should be consulted. The USEPA Office of Pesticide Programs (OPP) has a link to a database of product pesticide labels at http://www.epa.gov/pesticides/pestlabels/. The product labels should also be consulted for any recommended use restrictions.

## MECHANISM OF ACTION

Aquashade controls plant growth by competing with photosystem II pigments in plants. The blue and yellow dyes in Aquashade screen out the red-orange and blue-violet wavelengths of the sunlight spectrum which are required by plants and algae for photosynthesis (Applied Biochemists Inc, 1992; Spencer, 1984a). Aquashade is most effective in ponds which are greater than two feet deep since at this depth most of the critical wavelengths of sunlight can be absorbed by the dyes before they reach the bottom growth (Aquashade, Inc. (brochure)) .

## ENVIRONMENTAL FATE/TRANSPORT

Information on the fate and transport of Aquashade is limited. The normal half-life of this product is reported to be four weeks and coloration is gradually lost by dilution, photodegradation and some biodegradation over time (Applied Biochemists Inc., 1992). However, as conditions among various bodies of water differ, there is a range of variation in this estimate. In one study in which Aquashade was applied to earthen catfish ponds with high seepage rates, it was estimated that about one-half of the dye applied initially was lost by seepage every 2 months (Boyd and Noor, 1982). In another study, the half-life of Aquashade in a test pond with no outlet was found to be about two months whereas in other test ponds, factors such as water outflow and evaporation affected the dye concentrations (White *et al.*, 1975).

In a pond to which Aquashade was applied to achieve a concentration of 3.0 ppm, the actual concentration varied from 1.5 to 3.5 ppm. The variation was attributed to dilution by heavy rains rather than to photo-oxidation. It was estimated that the dye holds its concentration for approximately three months during exposure to light (Osborne, 1979).

No information was found regarding the potential for Aquashade to bioconcentrate in organisms.

## PHARMACOKINETICS

No information was found on the pharmacokinetics of Aquashade. Limited pharmacokinetic information was found for its principle active ingredient, acid blue 23. In male and female rats administered a single oral dose of either 30 or 3 mg/kg acid blue 9 dye, substantially all of the dose was excreted unchanged in feces within 72 hours. Similar findings were noted with mice and guinea pigs. When male rats were pretreated with unlabeled dye in the diet for 21 days and subsequently dosed with $^{14}C$-labeled dye, no difference was noted in the route of excretion or the time taken to eliminate all of the label. In all three species noted, the lack of absorption and metabolism of the labeled dye in the gastrointestinal tract of the animals was confirmed by examining isolated loops of small intestine (HSDB, 1995).

Studies in rats, dogs and guinea pigs indicate that only a very small percentage of ingested dye is absorbed and that it is excreted mainly in the feces. Following its intravenous injection in rats, over 90% of the dye was excreted in the bile within 4 hours (IARC, 1978).

No information was located on the pharmacokinetics of acid yellow 23.

## HEALTH EFFECTS

Very little information is currently available on the toxicity of Aquashade to plants and animals. Most of the limited available toxicological information was obtained from the manufacturer. Once FIFRA reregistration of Aquashade has been completed, additional data will become available. Limited information was also found on the toxicity of the principle active ingredient, acid blue 9. Very little information was found on the toxicity of acid yellow 23.

### Avian:

Only two studies were located on the acute toxicity of Aquashade to birds. These include two LC50 studies conducted by the manufacturer, one in mallard ducks and the other in bobwhite quail. For both species, the acute dietary LC50 (i.e., concentration found to be lethal to half of the test population) was greater than 5620 ppm of Aquashade, indicating that the acute toxicity of this product to birds through ingestion is very low (Applied Biochemists, Inc. 1995a).

### Mammalian:

Contact exposure to Aquashade may cause slight irritation and redness of the eyes and slight irritation of the skin. Inhalation of Aquashade may produce slight nausea. Ingestion may cause gastric disturbances (Applied Biochemists, Inc., 1992b).

No toxicological studies on the acute, subchronic or chronic health effects of Aquashade were located. However, limited information on the health effects of its principle active ingredient was obtained.

A subcutaneous LD50 of 4.6 g/mg for acid blue 9 was identified in rats. An oral LD50 for an unspecified salt of acid blue 9 was greater than 2.0 g/kg body weight. (Lu and Lavalle, 1974 as cited in IARC, 1978).

In 1978, the International Agency for Research on Cancer (IARC) concluded that subcutaneous injections of the disodium salt of acid blue 9 were carcinogenic to rats (IARC, 1978). They later determined that these data provided insufficient evidence of the carcinogenicity of Aquashade to animals (Applied Biochemists, Inc., 1992b).

Charles River albino rats and CD-1 mice were fed acid blue 9 in the diet over their lifetimes. The rat study had an in utero phase in which F0 generation rats were administered the dye in their diets at concentrations of either 0.0%, 0.1%, 1.0% or 2.0%. Randomly selected offspring of the F1 generation were exposed to the same concentrations for a lifetime. The maximum exposure times were 116 and 111 weeks for males and females respectively. No- observed-adverse-effect-levels (NOAELs) were identified as 2.0% for males (1,072 mg/kg/day) and 1.0% (631 mg/kg/day) for females based on a decrease in terminal body weight and decreased survival rate in the high-dose females as compared to controls. The CD-1 mice received dietary concentrations of either 0.0%, 0.5%, 1.5% or 5.0% for their lifetimes. The maximum exposure time for both males and female was 104 weeks. The NOAEL for this study was identified as 5.0% (7354 mg/kg/day and 8966 mg/kg/day for male and female mice respectively) (HSDB, 1995).

The FDA established a maximum acceptable daily intake for acid blue 9 of about 12 mg/kg/day. The U.S. FDA concluded that acid blue 9 is nonirritating when applied daily to intact or abraded skin. In addition, lifetime application of acid blue 9 to the skin of mice did not produce carcinogenicity (Fed. Regist. (47), 1982).

Both of the dyes contained in Aquashade have been reviewed by the Food and Drug Administration (FDA). Acid blue 9 has been approved by the FDA for use in food, drugs and cosmetics, excluding use in the eye area (The Merck Index, 1983; Fed. Regist.(47), 1982). Acid yellow 23 has been approved by the FDA for use in food and ingested drugs, and provisionally listed for externally applied drugs and cosmetics (The Merck Index, 1983; Fed. Regist.(44), 1979). The FDA requires that food containing acid yellow 23 be labeled accordingly, due to data indicating that an allergic reaction to this dye may result, especially in individuals who are allergic to aspirin (Fed. Regist. (44) 1979).

No health advisories or toxicity criteria have been developed for Aquashade.

## ECOLOGICAL TOXICITY

### Aquatic Organisms:

Limited studies on the toxicity of Aquashade to aquatic organisms have been conducted. Acute 96-hour toxicity studies were conducted by the manufacturer in bluegill sunfish and rainbow trout. LC50 values calculated from these studies were greater than 96 mg/l, indicating that the toxicity of Aquashade to these species is low (Applied Biochemists, Inc, 1995a). A 48-hour LC50 value greater than 97 mg/l was identified for the invertebrate, *Daphnia magna*, indicating that the toxicity of Aquashade to this organism is also very low (Applied Biochemists, Inc., 1995a). In another study, no differences were found in the oxygen consumption rates of crayfish (*Orconectes propinquus*) exposed to water containing 5, 10 or 15 ppm of Aquashade relative to that of control crayfish (Spencer, 1984b). In two channel catfish ponds treated with 4 mg/l of Aquashade, the average net fish production rate was calculated as 3,641 kg/hectare relative to an average of 3,010 kg/hectare in three control ponds. Because no improvement in water quality was noted from the treatment, the greater fish production in the treated ponds was attributed to random variation rather than to an effect by Aquashade. A third treated pond could not be included in the calculation of net fish production due to a fish kill which was unrelated to the dye treatment (Boyd and Noor, 1982).

**Plants:**

Literature reports on the efficacy of Aquashade in controlling aquatic plants indicate a spectrum of effectiveness ranging from unsuccessful to very successful. In the study of channel catfish ponds discussed above, there was no difference in bottom coverage of underwater weeds between dye-treated and control ponds (Boyd and Noor, 1982). Application of Aquashade to small ponds did not prevent establishment of weeds at depths up to 2.5 m; however, the heaviest infestations occurred at depths of less than 1 m (White *et al.*, 1975). Very successful results with Aquashade have been obtained when Aquashade is applied following application of another herbicide or another treatment. A test pond in central Florida was initially treated with Hydrothol 191 herbicide in the fall at double strength (10 gal/acre) in order to remove the parent hydrilla (*Hydrilla verticillata Royle*) population. The pond was then immediately (i.e., two days later) treated with Aquashade at a concentration of about 2-3 ppm in order to reduce incoming red light to 1-3% of full sunlight intensity at a depth of 1 m. The percent frequency of occurrence of *Hydrilla* declined exponentially from November though May and no *Hydrilla* was found in the water at any depth from May through September. In comparison, pronounced *Hydrilla* growth was noted when only herbicide (with no subsequent Aquashade application) was applied to the pond during the previous year. The authors concluded that Aquashade can be used effectively to control *Hydrilla* regrowth from vegetative propagules when applied at a rate greater than 2 ppm before the spring, following an herbicide application (Osborne, 1979).

The Adirondack Lake Association in Indian Lake, New York successfully used Aquashade to control bass weed (*Potamogeton amplifolius*) in Adirondack Lake, after a series of unsuccessful attempts with other methods. The Aquashade was applied to the lake (which has an average depth of 7 feet) in May at a concentration of about 0.7-1.0 mg/l after a winter in which the lake water level was lowered 7 feet in an attempt to kill weed roots. Another touch-up Aquashade application was applied in August after the Aquashade water concentration was found to have fallen to 0.3 mg/l. The Adirondack Lake Association found that 3-5" weed sprouts that had already sprouted before the first Aquashade application grew to a height of 18-24", but they attributed this weed growth to the period of low dye concentration. The bass weed was reported to be well out of sight and out of the way in at least 90% of the lake, in contrast to past years when the weed heads broke the surface of the water, interfering with lake recreation (Purdue).

There is also evidence that Aquashade is effective against microalgae. One study found a 50% reduction in the photosynthetic rate of algal cultures exposed to 1-3 ppm Aquashade. In separate experiments, the same study found a reduced growth rate of microalgae at Aquashade application rates greater than 5 ppm (Spencer, 1984a). The manufacturer recommends an Aquashade application rate of 1 ppm for aquatic weed control (Spencer, 1984a). The fact that Aquashade may be effective against microalgae should be considered when making a decision as to its appropriateness for use in controlling macrophytes. In a natural water system that depends upon microalgae as a source of primary production, inhibition of microalgae growth may potentially disrupt the aquatic food chain, leading to an eventual reduction in food supply for the entire trophic structure of that water body.

The phytotoxicity of Aquashade to nontarget species (such as cattails (*Typha*) and spatterdock (*Nuphar*)) was low when poured directly onto plants due to the plants' waxy cuticles which repelled the dye droplets (White *et al.*, 1975). When the concentrated dye was sprayed onto foliage either with or without surfactant, it caused severe contact burns of the foliage. No translocation of the dye throughout the plant was noted (White *et al.* 1975).

## Aquashade References

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