ChemicalWatch Factsheet

NALED

ChemicalWatch Stats

CAS Registry Number: 300-76-5
Trade Names: Dibrom, Trumpet, Fly Killer-D
Use: Organophosphate insecticide used for control of mosquitoes, blackflies, aphids, and mites in residential areas and food and non-food field crop sites.
Toxicity rating: Toxic
Signal words: Danger
Health Effects: Eye and skin irritation, associated with neurological and neuromuscular effects.
Environmental Effects: Toxic to birds, fish, aquatic organisms, and bees.

General Use and Registration Status

Naled is a registered organophosphate insecticide with the U.S. Environmental Protection Agency (EPA), first introduced by Chevron Chemical Company in 1956 and registered for use by EPA in 1959. It is used primarily for controlling mosquitoes, blackflies, and aphids but is also used on food and feed crops, and in greenhouses.[1] After EPA conducted an updated cumulative risk assessment for organophosphates in 2006, as required under the Food Quality Protection Act, naled was found to be eligible for reregistration by the agency despite its neurotoxic risk to human health. In naled's 2006 Reregistration Eligibility Decision (RED), EPA stated that naled may no longer be used in and around the home by residents or professional applicators[2] but residents may still be exposed through mosquito control operations. Approximately 1-2 million pounds of naled are applied annually[3], making it the fourth most widely used organophosphate insecticide in the U.S., with 70% used in mosquito control and 30% in agriculture.[4]

Naled and the Organophosphates

Organophosphates (OP), derived from World War II nerve poisons, are a common class of chemicals used as pesticides. This class of pesticides affect neurodevelopment, weaken the immune system, and impair respiratory function, amongst other severe health risks. Many OP insecticides, including naled, are already banned in the European Union because their risk to human health and the environment was deemed unacceptable by the reviewing Council.[5] Despite numerous OP poisonings of farmworkers, homeowners, and children, EPA has allowed the continued registration of many of these products due to its reliance on risk mitigation for individual OPs instead of phasing them out entirely.

Following the banning of many organochlorine insecticides such as DDT and dieldrin in the 1970s, pesticide companies turned to OPs to replace these toxic chemicals. OPs have been one of the leading insecticide chemical families since 1970 and their peak usage occurred around 1975 with 142 million pounds of active ingredient.[6] As of 2007, 33 million pounds of OP active ingredients were used in the U.S., representing 35% of all insecticide usage.[7] Certain OPs, including malathion and naled, have been used for mosquito control around the U.S. with controversy surrounding these programs. According to EPA, naled is currently being applied by aerial spraying to approximately 16 million acres as part of routine mosquito control.[8]

A meta-analysis conducted by researchers at University College London found that long-term low-level exposure to organophosphate pesticides produces lasting damage to neurological and cognitive functions, such as information processing and working memory.[9] This research pulled data from 14 studies with data assimilated from more than 1,600 participants, in order to provide a quantitative analysis of the current literature on the chronic effects of OP exposure. Unfortunately, there is little independent data on naled's toxicity outside of industry generated data.

Mode of Action

Naled, like all other organophosphate insecticides, works to kill insects by inhibiting important enzymes of the nervous system, specifically acetylcholinesterase (AChE). This inhibition causes a buildup of acetylcholine, resulting in restlessness, convulsions, and paralysis.[10] The breakdown product of naled in soil and water is dichlorvos, another organophosphate insecticide with similar acute and chronic effects.

Acute Toxicity

EPA considers naled to be highly toxic and severely irritating for dermal and eye irritation and moderately toxic and moderately irritating by oral, dermal, and inhalation exposure routes.[11] Symptoms following exposure to naled formulations include: headaches, muscle twitching, diarrhea, nausea, difficulty breathing, seizures, and at very high exposures, respiratory paralysis and loss of consciousness.[12]

Chronic Toxicity

EPA has stated that chronic dietary exposure for food and drinking water do not exceed the agency's level of concern but that certain occupational scenarios currently exceed their level of concern and have outlined mitigation measures and application restrictions.[13] There is also the potential for chronic exposure from repeated mosquito control applications in residential areas. This is especially pronounced in areas that are hard hit by mosquitoes like Puerto Rico and southern Florida, where mosquito-borne viruses like the Zika virus was detected in 2016.

Naled has long-tern health implications affecting the nervous, circulatory, reproductive, and immune systems. Rat studies conducted by naled manufacturers found that oral exposure of 10 mg/kg per day for 4 weeks and skin exposures of 20 mg/kg per day for 4 weeks resulted in inhibition of AChE, which also occurred in a year-long study in dogs.[14] In this same long-term feeding study of dogs by the manufacturer, naled caused anemia at all but the lowest dose level, reduced the number of red blood cells and the amount of hemoglobin in the dogs' blood. A separate study implicated naled with immune system function, in finding that naled and its breakdown product, dichlorvos, inhibited an enzyme in white blood cells that are crucial in removing virus-infected cells from the body.[15]

EPA has classified naled as a Group E carcinogen- evidence of non-carcinogenicity for humans – based on the lack of convincing evidence of carcinogenicity in adequate studies. But dichlorvos, the main breakdown product of naled, has been classified as a Group C "possible human carcinogen."[16] Exposure to dichlorvos during pregnancy or during childhood has been linked to increased incidence of brain tumors and leukemia.[17 18]

Occupational Exposures

Naled is more potent through inhalation and dermal exposures compared to exposures that occur through eating or drinking contaminated products. A study by toxicologists at the University of California found that inhalation of naled was 20 times more toxic to rats than oral dosing,[19] which was further verified by tests submitted to the EPA by naled's manufacturer.[20] EPA states that for mosquito control and agricultural uses of naled, workers who mix, load, or apply these products may exceed the agency's level of concern. Instead of removing these uses of concern, the agency has resorted to mitigating risks to an "acceptable level with label restrictions."[21]

The naled RED also prohibits hand-held foggers, backpack sprayers, and human flaggers due to unacceptable risks, and creates post-application reentry times to address occupational exposure routes. The agency states that agricultural scenarios are assumed to be representative of mosquito/blackfly uses for occupational handlers. There is uncertainty in using agricultural use scenarios as a surrogate for mosquito applicator uses, and the agency even notes that it "has insufficient data to determine if exposures to pilots from agricultural aerial applications are similar to the exposures to pilots applying mosquito control agents." Further, EPA's identification of the need for restricted-entry intervals following any naled application for agricultural crops or insect control poses a concern for both applicators and residential bystanders.

Residential Exposures

One area of concern that EPA did not adequately address in its 2006 review of naled was post-application residential inhalation exposure. While the occupational assessment addressed dermal and inhalation exposures, despite several uncertainties in extrapolating from agricultural data, the agency does not identify a separate residential inhalation assessment, even though this is the primary route of human exposure resulting from mosquito applications. In contrast, the EPA did assess the potential risk from the inhalation route of exposure for both the aerial ULV and ground-based applications of the malathion in its RED.[22] EPA believes that its naled assessment is protective of residential bystanders through its occupational exposure assessment in the naled RED, even though there are no data or calculations for bystander exposure. Without this information, it is misleading for EPA to state that there are no risks to bystanders.

Environmental Fate

Screening models created by EPA determined that under aquatic, terrestrial and forestry field conditions naled dissipated rapidly with half-lives of less than two days in all cases. Naled generally has a half-life of less than 8 hours in soils and less than 25 hours in aqueous solutions.[23] Naled and its degradants also have low bioaccumulation potential.[24] However, there is significant potential for surface water contamination through spray drift and direct application for mosquito control. According to entomologists from the University of Florida, "no-spray buffer zones greater than 750 meters in width must be placed around ecologically sensitive areas"[25] to protect non-target species from naled drift.

Studies on environmental fate of naled are limited, but one study on the deposition and air concentrations of naled used for adult mosquito control point to the insufficiencies of the models employed by EPA in their assessments. This study ended up finding lower concentrations of naled following truck-mounted ULV application compared to the levels modeled in previous assessments. Despite this discovery, the authors state that the use of AGDISP or AgDrift to "estimate environmental concentrations of insecticides after ULV applications could result in an underestimation of exposures and, thus, risks."[26] Another study done to monitor the distribution and persistence of naled in the Florida Keys National Marine Sanctuary (FKNMS) detected tidal transport of sublethal levels of naled and dichlorvos in the waters adjacent to FKNMS.[27]

Effects on Non-Target Animals

Naled, used for mosquito control and in agricultural settings, affects a variety of non-target animals, including fish, insects, aquatic invertebrates, and honey bees. On an acute basis, EPA registration documents note that naled is moderately toxic to mammals, moderately to very highly toxic to freshwater fish and birds, highly toxic to honey bees, and very highly toxic to freshwater aquatic invertebrates and estuarine fish and invertebrates.[28]

Elevated mortality rates among honey bees have been documented after nighttime aerial ULV applications of naled.[29] Additionally, average yield of honey per hive is significantly lower in exposed hives.[30] Naled is highly toxic to honey bees (LD50 0.48 micrograms/bee)[31] and some have observed that naled killed bees at 30 and 60 meters from the path of ground ULV applications.[32] Consequently, ground application and the subsequent deposition on surfaces show a positive correlation with bee mortality.[33] Adult bees are more sensitive to naled than younger bees, though studies show a significant decrease in residual toxicity from 3 to 24 hours post-treatment.[34] Salvato (2001), who examined the toxicity of naled, malathion, and permethrin to five species of butterflies, including larval and adult stages, found that naled and permethrin were the most toxic to all life stages.[35]

In late August 2016, aerial spraying of naled for mosquito control in Dorchester County, South Carolina resulted in acute pesticide poisoning and the death of over two million honey bees,[36] triggering public outcry over the safety of naled in the environment.

Naled and Mosquito Control

Community mosquito-spraying varies by state and locality. Many states allow spraying by mosquito abatement districts, which operate based on perceived need, during periods when there are public health concerns and mosquito-transmitted diseases are high. However, with elevated concerns surrounding mosquito-borne viruses like Zika and others, many communities are quick to resort to spraying potentially harmful pesticides. The efficacy of adulticidal pesticide applications has been called into question over the years. A large part of this has to do with the inability, especially in an urban environment, to hit target insects with typical ground spraying from trucks or by aerial application. Given the potential health risks and environmental impacts of adulticiding, monitoring and prevention techniques must be heavily emphasized.[37]

Common mosquito pesticides, like naled, are highly toxic to bees, other insect pollinators, as well as birds and aquatic organisms. Widespread spraying of naled and other designated mosquito-control insecticides is not a long-term solution for controlling mosquito populations. Adulticiding fails to sufficiently control mosquito populations, promote pesticide resistance, and kill other species that act as natural predators to mosquitoes. The long-term implications of deploying naled to control for mosquito-borne illness, such as the Zika virus, must be fully assessed before being used.

Growing Mosquito Resistance

Naled has been used for aerial spraying in several communities in Florida since the detection of the Zika virus in the area in the summer of 2016 as well as being used extensively across Florida in 2004 following an extreme hurricane season.[38] One of the primary reasons that naled has been used is due to documented resistance amongst mosquito populations to synthetic pyrethroids that would otherwise be used, as well as already documented resistance to malathion, another OP used in mosquito control. In Sri Lanka, where antimalarial activities depend largely on the use of malathion, a high level of resistance was detected among the A. culicifacies population.[39] As with any other widely used insecticide, mosquito resistance to naled is inevitable.

Pyrethroid pesticides like permethrin, phenothrin, pyrethrin, and allethrin are routinely used for mosquito control across the county. However, resistance to pyrethroids has been increasing at a dramatic rate which further reduces the efficacy of insecticide-treatments to control mosquito-borne diseases.[40] In particular, resistance to permethrin has been occurring in Aedes aegypti mosquitoes through knockdown resistance,[41] or the reduction in effectiveness of insecticides due to mutations in genetic makeup of the insect. In the Caribbean, wild populations of Ae. aegypti showed high levels of resistance to deltamethrin and naled.[42] And in Puerto Rico, which has been battling Zika cases since early 2016, permethrin insecticides have been ineffective in mosquito control, leading to the CDC's endorsement of aerial spraying with naled on July 6th, 2016.[43] However, despite the acknowledgment that naled failed to stop a dengue fever outbreak in Puerto Rico in the late 1980s, the CDC continues to advocate for naled use.

Alternatives to Naled

The CDC has stated that spraying pesticides intended to kill adult mosquitoes is usually the least efficient mosquito control technique.[44] Preventative approaches such as removing mosquito breeding areas and using larvicides to kill mosquito larvae are much more efficient in eliminating mosquito threats. Monitoring is an essential part of an effective mosquito management program, and should be done regularly throughout the season. Tracking larval and adult population numbers, species types, and breeding locations provides critical information used to determine when, where, and what control measures might be needed. Spraying should only be done after carefully evaluating the likelihood of pesticide-related illnesses and the contributing factors to a human epidemic of mosquito-borne diseases. Less-toxic alternatives that contain pyrethrins, a botanical insecticide for adult mosquito control, can be used once the decision to spray has been made. These products have similar toxicity to synthetic pyrethroids, but less residual action and often do not contain piperonyl butoxide (PBO), which is an improvement compared to many of the synthetic pyrethroids.

Endnotes

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