DIAZINON
TECHNICAL FACT SHEET

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NPIC Technical Fact Sheets provide information that is complex and intended for individuals with a scientific background and/or familiarity with toxicology and risk assessment. This document is intended to promote informed decision-making. Please refer to the General Fact Sheet for less technical information.

Chemical Class and Type:

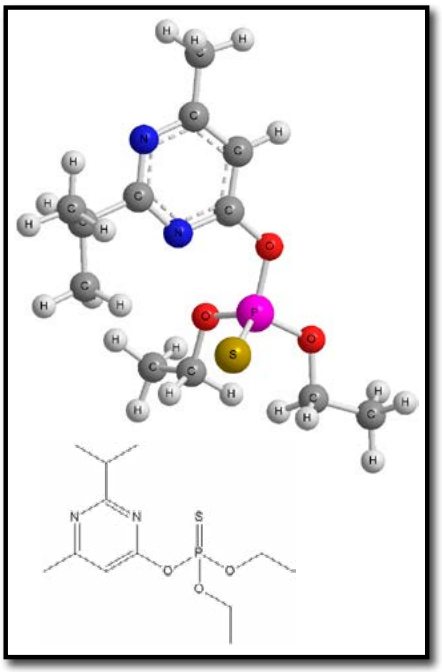
- Diazinon is the common name for a synthetic organophosphate pesticide first registered in the United States in 1956. Diazinon is used as an insecticide, acaricide, and nematicide.[1]
- The diazinon Chemical Abstracts Service (CAS) registry number is 333-41-5. The CAS name for diazinon is O, O-diethyl O-[6-methyl-2-(1-methylethyl)-4-pyrimidinyl] phosphorothioate and the International Union of Pure and Applied Chemistry (IUPAC) name is O,O-diethyl O-2-isopropyl-6-methylpyrimidin-4-yl phosphorothioate.[1,2] See the text box on **Laboratory Testing**.

Laboratory Testing: Before pesticides are registered by the U.S. EPA, they must undergo laboratory testing for short-term (acute) and long-term (chronic) health effects. Laboratory animals are purposely given high enough doses to cause toxic effects. These tests help scientists judge how these chemicals might affect humans, domestic animals, and wildlife in cases of overexposure.

Physical / Chemical Properties:

- Pure diazinon is a colorless oil. Technical grade diazinon (≥90% active ingredient) is an amber to brown liquid.[1]
- Vapor pressure[1,3]: 1.40×10^{-4}, 8.4×10^{-5} mmHg at 20 °C
- Octanol-Water Partition Coefficient (K_{ow})[1,3]: 2.5×10^{4}; ($\log K_{ow}$)[4]: 3.3, 3.81
- Henry's constant may be determined by estimation or experimentally derived. Reported values include: 1.4×10^{-6} atm·m^3/mol and 1.13×10^{-7} atm·m^3/mol, depending on the technique used.[3,5]
- Molecular weight[1]: 304.3 g/mol
- Solubility (water)[1,3,4,6]: 0.040 g/L (40 mg/L) at 20 °C and 30 °C, however other values between 0.054 and 0.069 g/L (54 mg/L and 69 mg/L) have been reported in the 20-40 °C temperature range. Diazinon is completely miscible in acetone, benzene, ethanol, toluene, xylene and is soluble in petroleum oils.
- Soil Sorption Coefficient (K_{oc})[3,5]: Reported values range from 40 to 854 L/kg$_{oc}$

Molecular Structure - Diazinon



Uses:

- Diazinon is a non-systemic insecticide used in agriculture to control soil and foliage insects and pests on a variety of fruit, vegetable, nut and field crops. Diazinon is also used on non-lactating cattle in an insecticidal ear tag. Prior to the cancellation of all residential uses by 2004, diazinon was used outdoors on lawns and gardens, indoors for fly control and in pet collars designed to control fleas and ticks.[7] Uses for individual diazinon products vary widely. Always read and follow the label when applying pesticide products.
- Diazinon products are formulated as dusts, granules, liquids, concentrates, microencapsulations, wettable powders, seed dressings and impregnated materials.[1]
- Diazinon is produced and marketed under a variety of names with signal words ranging from Caution to Danger.[8] The signal word reflects the combined toxicity of the active ingredient and other ingredients in the product. See the pesticide label on the product and refer to the NPIC fact sheets on ***Signal Words*** and ***Inert or "Other" Ingredients***.

- Diazinon was one of the most widely used insecticides for household and agricultural pest control. In 2000, the United States Environmental Protection Agency (U.S. EPA) announced an agreement with the registrants of diazinon to cancel all residential uses of diazinon. Indoor uses were cancelled in 2002 and outdoor uses in 2004, leaving only agricultural uses for diazinon.[7]
- Current agricultural uses of diazinon are limited to selected crops, and diazinon products (other than cattle ear tags) are regulated as restricted use pesticides.[1]
- To find a list of products containing diazinon which are registered in your state, visit the website http://npic.orst.edu/reg/state_agencies.html select your state then click on the link for "State Products."

Mode of Action:

Target Organisms

- Diazinon is a contact insecticide which kills by altering normal neurotransmission within the nervous system of target organisms.[9] Diazinon inhibits the enzyme acetylcholinesterase (AChE), which hydrolyzes the neurotransmitter acetylcholine (ACh) in cholinergic synapses and neuromuscular junctions. This results in abnormal accumulation of ACh in the nervous system.[10]
- Diazinon shares a common mechanism of toxicity with other organophosphate insecticides such as chlorpyrifos, malathion and parathion, thus, diazinon would not be effective against organophosphate-resistant insect populations.[9,11]
- Diazinon is metabolized within organisms to form diazoxon (sometimes referred to as "activation," see metabolism section below), and diazoxon is a more potent cholinesterase (ChE) inhibitor compared to diazinon itself.[12]

Non-target Organisms

- Diazinon toxicity to non-target organisms is similar to the mode of action for target organisms.[5] The enzyme AChE, which removes the neurotransmitter ACh, is inhibited by diazinon.[5] This inhibition interferes with normal neurotransmission in cholinergic synapses and neuromuscular junctions of the nervous system.[13] In wildlife, even slight ChE inhibition has the potential to make animals more susceptible to environmental factors such as predation, which can in turn effect the survival of the organism.[9]
- Non-target organisms can be exposed to diazinon by inhalation, ingestion and/or dermal exposure.[1,13]

Acute Toxicity:

Oral

- Diazinon has a low acute oral toxicity in male and female rats. The acute oral LD_{50} for female rats was 1160 mg/kg and 1340 mg/kg for male rats.[13] Other reported LD_{50} values (in mg/kg) include: 300-850 (rats), 80-135 (mice), 250-355 (guinea pigs), 130 (rabbits), 8 (hens), 3 (pheasants), 3.5 (ducks) and 100 (pigs).[2,15] See the text boxes on **Toxicity Classification** and **LD_{50}/LC_{50}**.
- Diazinon causes acute neurotoxicity in rats at sub-lethal oral doses. One neurotoxicity study found a NOAEL of 0.25 mg/kg/day based on plasma ChE inhibition.[1] See the text box on **NOAEL, NOEL, LOAEL**, and **LOEL** (page 4).

LD_{50}/LC_{50}: A common measure of acute toxicity is the lethal dose (LD_{50}) or lethal concentration (LC_{50}) that causes death (resulting from a single or limited exposure) in 50 percent of the treated animals. LD_{50} is generally expressed as the dose in milligrams (mg) of chemical per kilogram (kg) of body weight. LC_{50} is often expressed as mg of chemical per volume (e.g., liter (L)) of medium (i.e., air or water) the organism is exposed to. Chemicals are considered highly toxic when the LD_{50}/LC_{50} is small and practically non-toxic when the value is large. However, the LD_{50}/LC_{50} does not reflect any effects from long-term exposure (i.e., cancer, birth defects or reproductive toxicity) that may occur at levels below those that cause death.

TOXICITY CLASSIFICATION - DIAZINON

	High Toxicity	Moderate Toxicity	Low Toxicity	Very Low Toxicity
Acute Oral LD_{50}	Up to and including 50 mg/kg (≤ 50 mg/kg)	**Greater than 50 through 500 mg/kg (> 50 – 500 mg/kg)**	**Greater than 500 through 5000 mg/kg (> 500 – 5000 mg/kg)**	Greater than 5000 mg/kg (> 5000 mg/kg)
Inhalation LC_{50}	Up to and including 0.05 mg/L (≤ 0.05 mg/L)	Greater than 0.05 through 0.5 mg/L (>0.05 – 0.5 mg/L)	Greater than 0.5 through 2.0 mg/L (> 0.5 – 2.0 mg/L)	**Greater than 2.0 mg/L (> 2.0 mg/L)**
Dermal LD_{50}	Up to and including 200 mg/kg (≤ 200 mg/kg)	Greater than 200 through 2000 mg/kg (> 200 - 2000 mg/kg)	**Greater than 2000 through 5000 mg/kg (>2000 – 5000 mg/kg)**	Greater than 5000 mg/kg (> 5000 mg/kg)
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or other eye irritation clearing in 8 – 21 days	Corneal involvement or other eye irritation clearing in 7 days or less	**Minimal effects clearing in less than 24 hours**
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring)	Severe irritation at 72 hours (severe erythema or edema)	Moderate irritation at 72 hours (moderate erythema)	**Mild or slight irritation at 72 hours (no irritation or erythema)**

The highlighted boxes relfect the values in the "Acute Toxicity" section of this fact sheet. Modeled after the U.S. Environmental Protection Agency, Office of Pesticide Programs, Label Review Manual, Chapter 7: Precautionary Labeling. http://www.epa.gov/oppfead1/labeling/lrm/chap-07.pdf

Dermal

- Diazinon is low in toxicity following dermal exposure. The acute dermal LD_{50} is greater than 2020 mg/kg.[1,14]
- Diazinon is a minimal eye irritant and slight dermal irritant based on tests using rabbits.[1]
- Diazinon is not a skin sensitizer based on tests in guinea pigs.[1]

Inhalation

- Diazinon has very low acute inhalation toxicity in rats. Acute inhalation studies with rats found the LC_{50} to be greater than 2.33 milligrams per liter over four hours (mg/L/4 hours).[1,14]

Signs of Toxicity - Animals

- Clinical signs of toxicity from acute exposure to diazinon include lacrimation, salivation, anorexia, coughing, miosis, urination and/or defecation, dyspnea, bradycardia, abdominal pain and distress, as well as vomiting (emesis). Typically these symptoms are followed by head and body tremors, muscle tetany, stiffness, weakness with paresis and paralysis. Tachycardia and mydriasis are also possible with massive oral exposures. Central nervous system signs and symptoms may also be present such as restlessness and/or hyperactivity, depressed respiration, anxiety, depression, clonic-tonic seizures, and coma.[16] Severe exposures can also lead to bradycardia and convulsions.[17] These symptoms have been seen in mammals as well as reptiles, fish and birds.[9,16] Birds exposed to diazinon have also demonstrated wing spasms, wing drop, hunched back, tenesmus, diarrhea, ptosis of eyelid, prostration, opisthotonos-like seizures or wing-beat convulsions.[9]
- The onset of acute symptoms can occur within minutes of exposure or be delayed as long as 12-24 hours after the exposure (depending on the formulation and route of exposure) and the duration of symptoms can be several days or even weeks.[17]
- Severe diazinon poisoning may cause acute pancreatitis in dogs and guinea pigs.[18] In rats, 200 mg/kg of diazinon can cause acute pancreatitis and histopathological changes in the liver.[19]
- Exposure to organophosphate insecticides such as diazinon (or a combination of diazinon and other organophosphate

insecticides) can occasionally lead to an intermediate syndrome.[16,20] Intermediate syndrome can be seen in dogs, cats and other animals as a result of prolonged stimulation of cholinergic receptors with ACh, leading to interference of normal nerve signal transmission. Clinical signs of intermediate syndrome generally occur within hours to days after the exposure, but may not appear for 3 to 10 days following exposure.[20] Symptoms include anorexia, diarrhea, generalized weakness, muscle tremors, abnormal posturing and behavior, depression and death.[20]

Signs of Toxicity - Humans

- Symptoms of acute diazinon exposure develop in minutes to hours following exposure, depending of the exposure pathway. Initial symptoms include nausea, dizziness, salivation, headache, sweating, lacrimation, and rhinorrhea. The symptoms can progress to vomiting, abdominal cramps, diarrhea, muscle twitching, weakness, tremor, and a lack of coordination. Dark or blurred vision, anxiety and restlessness, as well as psychiatric symptoms such as depression, memory loss, and confusion have been reported.[13,21]
- Because diazinon is fat soluble, there is potential for delayed toxicity if significant amounts of diazinon are stored in fatty tissues.[13]
- Intermediate syndrome (see discussion in animal section above) generally occurs within 24-96 hours after exposure. Intermediate syndrome in humans is characterized by difficulty breathing and muscular weakness, often in the face neck and proximal limb muscles. Cranial nerve palsies and depressed tendon reflexes have also been reported.[13,22]
- Studies have suggested that exposure to some organophosphate pesticides can result in long-term neurological problems including organophosphate-induced delayed neuropathy (weakness or paralysis as well as paresthesia in the extremities);[13,21] however, reports of these symptoms following diazinon exposures are rare.[23,24]
- Human poisoning victims have shown increased levels of serum amylase and glucose as well as elevated urinary diastase levels accompanied by symptoms considered to be indicative of acute pancreatitis.[12,18]
- Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to discuss an incident with the National Pesticide Information Center, please call 1-800-858-7378.

Chronic Toxicity:

Animals

- Laboratory rats were exposed to diets containing diazinon for 98 weeks at doses up to 12.0 mg/kg/day. The NOAEL based on ChE inhibition was 0.005 mg/kg/day, and the LOAEL was 0.060 mg/kg/day. No other toxic effects were observed in the rats.[14] See the text box on **NOAEL, NOEL, LOAEL**, and **LOEL**.

NOAEL: No Observable Adverse Effect Level
NOEL: No Observed Effect Level
LOAEL: Lowest Observable Adverse Effect Level
LOEL: Lowest Observed Effect Level

- Beagles were fed diets containing diazinon at doses up to 9.1 mg/kg/day for 52 weeks. At the highest doses tested, researchers observed decreases in body weight gain, suppressed appetite and ChE inhibition. The NOAEL for ChE inhibition was 0.0037 mg/kg/day and the LOAEL was 0.0200 mg/kg/day.[14]
- Rhesus monkeys were given diazinon oral doses of 0, 0.1, 1.0 and 10.0 mg/kg body weight for 34 days and then doses were lowered to 0.05, 0.50, and 5.00 mg/kg body weight for the remaining 102 weeks. The highest dose groups showed tremors, and soft stools were noted for the two highest doses. All treatment groups showed slightly decreased weight gain. The NOAEL for the study was 0.5 mg/kg/day based on ChE inhibition.[18]

Humans

- Applicators with extensive occupational exposure to diazinon may have a slight asymptomatic reduction in ChE activity.[25] See the text box on **Exposure**.

Exposure: Effects of diazinon on human health and the environment depend on how much diazinon is present and the length and frequency of exposure. Effects also depend on the health of a person and/or certain environmental factors.

Endocrine Disruption:

- Rats exposed to diazinon in the air (11.6 mg/m^3) for six hours/day, five days per week for three weeks showed no gross or histological damage to the adrenal gland.[12]
- Rats exposed orally to diazinon doses up to 212 mg/kg/day for 13 weeks demonstrated no treatment-related damage to the adrenal gland. In another oral exposure study, rats fed doses up to 12 mg/kg/day for 98 weeks showed no histological evidence of treatment-related effects on the adrenals, pituitary or thyroid glands.[12]
- Diazinon exposure has been found to cause pancreatic damage in rats by increasing oxidative stress.[26] Beagles receiving oral doses of 10 mg/kg/day for eight months showed evidence of pancreatic atrophy and interstitial fibrosis in males but not females.[12]
- Diazinon is included in the draft list of initial chemicals for screening under the U.S. EPA Endocrine Disrupter Screening Program (EDSP). The list of chemicals was generated based upon exposure potential, not based on whether the pesticide is a known or likely potential cause of endocrine effects.[27]

Carcinogenicity:

Animals

- In order to test diazinon for the potential to cause cancer, researchers fed rats 98% pure diazinon at doses of 20 or 40 milligrams per kilogram body weight per day (mg/kg/day) for 103 weeks. No evidence of carcinogenicity was found.[14] In a similar study, researchers exposed mice to daily oral doses of diazinon at 14 and 29 mg/kg/day for 103 weeks and found no evidence of carcinogenicity.[14,18]

Humans

- The U.S. EPA has classified diazinon as "Group D - not classifiable as to human carcinogenicity" based on the lack of evidence of carcinogenicity found in the mice and rat studies listed above.[14] See the text box on **Cancer**.

Cancer: Government agencies in the United States and abroad have developed programs to evaluate the potential for a chemical to cause cancer. Testing guidelines and classification systems vary. To learn more about the meaning of various cancer classification descriptors listed in this fact sheet, please visit the appropriate reference, or call NPIC.

- Several case-control studies have suggested possible links between exposure to diazinon and childhood cancers and non-Hodgkin's lymphoma.[12] In one study, families who used diazinon in their gardening were found to have an increased incidence of childhood cancers.[28] Another study found farmers using organophosphate insecticides, including diazinon, had higher rates of non-Hodgkin's lymphoma compared to non-farmers.[29] In both studies however, it was not possible to conclusively attribute the increased cancer risk to diazinon exposure.[12, 30]

Reproductive or Teratogenic Effects:

Animals

- In a prenatal developmental toxicity study, pregnant rats were fed diazinon doses up to 100 mg/kg/day during days 6 through 15 of gestation. Pregnant rats experienced decreases in body weight gain at the highest dose. Increased fetal weights, declines in the number of live fetuses and increased pre- and post-implantation losses were also found at the highest dose.[14]
- Laboratory tests with pregnant rabbits fed diazinon (89.2% purity) at doses up to 100 mg/kg/day during days 6-18 of gestation found maternal mortality at the highest dose tested. No effects on the fetuses were noted at any dose.[14]
- A multi-generational reproductive study exposed rats to diazinon for ten weeks before mating at doses up to 41.43 mg/kg/day. Offspring of the treated animals were then mated to produce a second generation of rats. The pregnant offspring of the animals receiving 6.69 mg/kg/day or more had decreased weight gain during pregnancy and their second-generation offspring had increased pup mortality and decreased weight gain.[14]
- Beagles exposed orally to diazinon at doses ranging from 2.5 to 20.0 mg/kg/day for 8 months showed testicular atrophy and arrested spermatogenesis in some animals from the high dose groups.[12]
- Pregnant hamsters orally exposed to diazinon doses of 0.125 and 0.250 mg/kg/day during fetal organ development showed maternal cholinergic symptoms but no developmental effects were noted in the offspring.[12]
- Rat pups were found to be more sensitive to ChE inhibition compared to adult rats. Rat pups given a 75 mg/kg single oral dose of diazinon showed a 75% brain ChE inhibition compared to 38% in adult rats.[11]
- Recent studies of neonatal exposure to diazinon in rats have shown that diazinon doses below those that elicit ChE response can create lasting effects on neural cell development, ACh synaptic function and behavior.[31]
- Research suggests that ACh and AChE play multiple roles in developing nervous systems. It is not known how much alteration is necessary or what effects may be observed as a result of altered ACh or ChE levels in the developing nervous system.[11] Behavioral effects were confirmed in rat neurotoxicity studies indicating a need to further study the developmental neurotoxicity of diazinon.[10]

Humans

- Studies suggest diazinon can be transferred to developing fetuses based on correlations between personal air sampling devices worn by mothers during pregnancy and maternal and umbilical cord plasma diazinon concentrations.[32]
- No studies were found on the developmental or reproductive effects of diazinon in humans following inhalation, oral or dermal exposure to diazinon.

Fate in the Body:

Absorption

- Studies in rats have shown that diazinon given orally is rapidly absorbed. Following oral doses of 80 mg/kg diazinon, the average time required for rats to absorb half the administered dose was 2.6 hours and maximum plasma concentrations were found within 2.0 hours of exposure. The study found that about 35% of the oral dose was systemically bioavailable.[10]
- Rapid oral adsorption has also been documented in humans, beagles, goats, sheep and cows.[12]
- Human volunteers exposed to radio-labeled diazinon dermally for 24 hours absorbed little of the dose. Researchers found about 2-4% of the applied dose was absorbed by the skin regardless of the site of application or the vehicle used to administer the diazinon (lanolin or acetone).[12,14]

- *In vitro* studies using a glass flow-through cell with human cadaver skin indicate a higher dermal absorption rate of 14.1%; however, the results were also more variable (± 9.2%).[10]

Distribution

- Animal tissue studies and autopsy reports of human deaths from diazinon have shown that it is widely and rapidly distributed throughout the body of humans, rats, sheep and cows.[10,12]
- Rats exposed orally to 23 mg/kg diazinon had detectable levels of diazinon in the blood, adipose tissue, muscle, liver and brain. All levels peaked at day 4 except muscle and liver concentrations, which peaked at 12 and 8 days, respectively. Detectable levels were no longer found in any samples after 30 days.[12]
- Much of the absorbed diazinon (89-99%) may be bound to plasma protein. Tissue binding likely also occurs, affecting the time required to clear diazinon from the body.[10]
- Cows treated dermally with diazinon had trace amounts in their milk 24 hours after the application.[33]
- No studies were identified that investigated the distribution of diazinon following inhalation exposure in animals or humans.

Metabolism

- Diazinon metabolism has been studied in mice, rats, guinea pigs, dogs, hens, cattle and sheep.[34] The primary metabolic route was cleavage of the P-O-pyrimidine group followed by oxidation and dealkylation of the alkyl substituents on the pyrimidine ring.[34]
- Diazinon is oxygenated to an intermediate compound, phosphooxythiran, which in turn undergoes desulfurization to form diazoxon. Diazoxon is a more potent ChE inhibitor compared to diazinon itself.[12] Diazoxon can be detoxified by paraoxanase 1/arylestase (PON1) enzymes[35] and can be deactivated by hydrolysis, desulfurization and deoxygenation to form 2-isopropyl-4-methyl-6-hydroxypyrimidine (IMHP), diethylthiophosphate (DETP) and diethylphosphate (DEP).[12]
- In rats orally exposed to diazinon, liver metabolism reduced the systemically bioavailable amount of diazinon by 65% during the first pass through the liver.[10]
- Diazinon is rapidly metabolized with most metabolites being excreted in the urine within 48 hours.[34]

Excretion

- Diazinon is rapidly excreted from the bodies of animals. Studies have reported blood half-lives for diazinon ranging from 2.5–5.0 hours.[10]
- Fifty percent of single 4 mg/kg oral doses of radio-labeled diazinon given to rats were excreted within 12 hours. Most (69-80%) of the metabolites were found in the urine, and 18-25% were excreted in the feces.[12]
- In another study of rats orally exposed to radio-labeled diazinon, most diazinon was metabolized and excreted in the urine (58.2% of dose in females and 93.3% in males) within 24 hours and small amounts (less than 2.5%) were excreted in the feces. After seven days, less than 1% of the labeled dose remained in the tissues, with the highest levels found in the blood.[14]
- Human volunteers who ate diazinon excreted 60% of the applied dose as urinary metabolites within two hours of the exposure.[36]
- In one study, human volunteers were exposed dermally to diazinon for eight hours. After eight hours, most of the applied diazinon (90%) was recovered from the application site with only 1% of the applied dose being recovered in the urine.[36] Another human study found that dermal exposure to radio-labeled diazinon for 24 hours resulted in 3-4% of the administered dose being excreted in the urine over seven days following the exposure.[12]

Medical Tests and Monitoring:

- Blood samples can be evaluated for decreased plasma pseudocholinesterase and red blood cell AChE levels. The enzyme depression is usually apparent within a few minutes to hours after exposure and may persist for several days to weeks.[13] The activity of plasma can be depressed in some people without exposure to diazinon or similar pesticides because about 3% of humans have a genetically determined low level of plasma pseudocholinesterase.[13]
- The alkyl phosphate metabolites of diazinon exposure can be detected in the urine within 48 hours of absorption of diazinon, and may be useful in diagnosing low level exposures that would not result in cholinergic effects.[13]
- The diazinon metabolites DEP, DETP and IMHP have all been measured in the urine of humans as part of a national human exposure assessment.[37]
- Diazinon toxicosis can be diagnosed in some animals by testing the ChE activity of heparinized whole blood. Other testing that can be performed by laboratories to detect diazinon exposure in animals may include testing of stomach contents, vomitus, hair, or suspected baits.[16]

Environmental Fate:

Soil

- Diazinon released into the environment is moderately persistent and moderately mobile.[1,3] Studies of diazinon applied to several soils show that it is not likely to adsorb to soils. One study looked at 25 soils and found diazinon to be mobile in 80% of the soils tested, while another study found diazinon leached more in light-textured soils with low organic matter content.[9]
- Soil metabolism studies report soil half-lives for diazinon ranging from 21 to 103 days depending on the type of soil.[4] In most tests, diazinon was detected in soils at a maximum depth of 18 inches.[1] See the text box on **Half-life**.

The "half-life" is the time required for half of the compound to break down in the environment.

1 half-life = 50% remaining
2 half-lives = 25% remaining
3 half-lives = 12% remaining
4 half-lives = 6% remaining
5 half-lives = 3% remaining

Half-lives can vary widely based on environmental factors. The amount of chemical remaining after a half-life will always depend on the amount of the chemical originally applied. It should be noted that some chemicals may degrade into compounds of toxicological significance.

- Microbial degradation in soils is the primary route of diazinon dissipation from the environment.[9] Lab studies investigating diazinon soil metabolism showed half-lives of 1-5 weeks for diazinon in non-sterile soils, and 6-12 weeks in sterile soils.[3] The soil half-life in sandy loam has been reported to be 37 days at pH 5.4 and 39 days at pH 7.8. The aerobic soil metabolism half-life of diazinon was determined to be 37.4 days in one study[5] and 38.0 days in another.[5] Diazinon can also degrade under anaerobic conditions.[9]
- Diazinon is also degraded in the environment by hydrolysis. Measured rates of hydrolysis were fastest under acidic conditions ($t_{1/2}$ = 12 days at pH 5).[1] Diazoxon is the primary degradate of diazinon hydrolysis, however diazoxon is rapidly hydrolyzed to oxypyrimidine which is more mobile in the environment compared to the parent compound.[9]
- In addition, diazinon can be broken down by photolysis with soil surface half-lives estimated to be between 17.3 and 37.4 hours.[3]
- Ultimately, diazinon applied to soils is broken down to carbon dioxide.[34]

Water

- The persistence and mobility of diazinon and its metabolites suggest the potential for groundwater contamination.[1] Diazinon has been detected in groundwater samples collected in the United States and Canada.[12]
- Diazinon was the most frequently detected insecticide in surface waters prior to the phase-out of urban uses in 2004.[1,38] Since that time, diazinon concentrations have declined in 90% of sampled streams in the Midwestern and northeastern United States, many showing declines of 50% or more during the summer months.[38]

- Diazinon degrades in water as a result of hydrolysis, especially under acidic conditions. In sterile water, diazinon was determined to have a half-life of only 12 days in acidic water (pH = 5) and 138 days in neutral water (pH = 7).[1]
- Diazinon breakdown is faster at warmer water temperatures, degrading 2-4 times faster in water at 21 °C compared to water at 10 °C.[39]
- Diazinon is stable to photolysis in water.[1]
- The major environmental degradate of diazinon is diazoxon, which rapidly hydrolyzes to oxypyrimidine under most circumstances. Diazoxon has been found in field studies, but not in laboratory experiments looking at the environmental fate of diazinon.[9]
- Oxypyrimidine is very mobile in the environment and has been measured up to 72 inches below the surface of soils.[9] Oxypyrimidine appears to be more persistent under at least some conditions compared with diazinon.[5]
- Diazinon is not expected to volatilize readily from water based on its vapor pressure and Henry's Law constant. However, in some studies, as much as 50% of the applied diazinon volatilized from the water. Diazinon has been detected in rain at concentrations up to 2 μg/L and in fog at concentrations of up to 76 μg/L.[9]
- In constructed wetlands designed to mitigate agricultural diazinon runoff, 43% of applied diazinon was found to be associated with aquatic plant material, 34% with the water and 23% associated with aquatic sediments.[39]

Air

- Diazinon volatilizes into the air at room temperature. Atmospheric concentrations have been measured as high as 306 ng/m^3 in air.[9]
- Diazinon is expected to exist in the particulate and vapor phases when released to the atmosphere.[3]
- Diazinon adsorbs light above 290 nm wavelength, thus may be subject to direct photolysis.[3, 12]
- Diazinon undergoes transformation to diazoxon (a more potent ChE inhibitor compared to diazinon) in the atmosphere with an estimated half life of 4 hours.[12] Diazoxon has been detected in rain and fog.[5]

Plants

- Diazinon applied to soils can be absorbed by plant roots and translocated in plants.[33]
- Diazinon degrades rapidly in leafy vegetables, forage crops, and grass. Half-lives range from 2 to 14 days. Low temperature and high oil content increase the persistence of diazinon in plants.[33]
- Diazinon metabolites in plants include the primary hydrolysis product, pyrimidinol, as well as hydroxypyrimidinol. Diazoxon is also found in plants (and the measured pyrimidinol may result from the hydrolysis of diazoxon rather than diazinon itself).[34]

Indoor

- Concentrations of diazinon were measured as high as 13 μg/m^3 in indoor air when diazinon was registered for home use.[40] Retail garden store indoor air diazinon levels were measured at 3.400 μg/m^3 and pest control company buildings showed concentrations ranging from 0.163 to 0.284 μg/m^3.[3]
- Small amounts of diazinon applied outdoors can be carried indoor by air, dust, soil and pets creating the potential for exposure.[41]

Food Residue

- The 2006 United States Department of Agriculture (USDA) Pesticide Data Program (PDP) reports that 8102 samples of food commodities were tested for diazinon residues and 8289 samples were tested for the metabolites of diazinon. Of all the samples tested, diazinon residues were found in 49 samples (0.6% of the samples tested) in the range of 0.003-0.140 ppm, concentrations well below the range of tolerances for those commodities (tolerances ranged from 0.50 to 0.75 ppm). A diazinon metabolite was measured in one spinach sample at 0.005 ppm. No tolerances currently exist for diazinon metabolites on food.[42] Almost 600 raw and finished drinking water samples were also analyzed for the presence of diazinon and its oxygenated metabolite; no measurable amount of either was found in any of the samples.[42]

Ecotoxicity Studies:

Birds

- Diazinon is very highly toxic to birds, with acute oral LD_{50} values ranging from 1.44 (mallard duck) to 69.0 mg/kg (brown-headed cow bird).[1] Diazinon has been linked to a number of bird kills following outdoor applications.[1, 9]
- Mallard ducks show reproductive toxicity as a result of chronic diazinon exposure. Concentrations of 16.3 mg/L in the diet resulted in a reduction in the number hatchlings reaching 14 days of age.[5,9]
- The intermediate degradate diazoxon is also very highly toxic to birds on an acute oral basis. Oxypyrimidine, the terminal degradation product, is practically non-toxic to birds.[5,9]

Fish and Aquatic Life

- Studies investigating the toxicity of diazinon to freshwater fish have found diazinon to be moderately to highly toxic to freshwater fish on an acute basis with LC_{50} values ranging from 90 to 7800 µg/L. Chronic exposure to diazinon in freshwater fish has also been studied in brook trout with concentrations of 0.55 µg/L effecting growth and causing neurological symptoms.[1,5] Diazinon caused histopathological changes in the gill structure of bluegill (*Lepomis macrochirus*) at water concentrations as low as 15 µg/L.[43]
- Diazinon is also moderately to highly toxic to estuarine and marine fish with acute LC_{50} values for marine and estuarine fish ranging from 150 to 1500 µg/L.[1] Salmon behavior and olfactory responses were altered at diazinon concentrations below those known to be toxic (levels as low as 1.0 µg/L).[5]
- Diazinon water concentrations ranging from 0.2 to 5.2 mg/L have been associated with fish kills.[44]
- In bluegill sunfish exposed to 2 µg/L of radio-labeled diazinon, diazinon was found to bioaccumulate in fish tissues. Reported fish bioconcentration factors are 542x for the edible portions of fish and 583x for the inedible portions.[9] Depuration (the loss of diazinon from the tissues) was rapid with 96% of the diazinon being eliminated from the fish tissues within 7 days.[5] Other reported bioconcentration factors range from 4.9x in crayfish to 200.0x in sheepshead minnow.[3]
- Diazinon has very high acute toxicity to freshwater aquatic invertebrates with EC_{50} values ranging from 0.21 to 35.0 µg/L.[5] No adverse effects were observed in *Daphnia magna* chronically exposed to diazinon at 0.17 µg/L. At 0.32 µg/L invertebrate mortality increased.[5] See the text box on **EC_{50}**.
- Diazinon is moderately to very highly toxic to marine and estuarine invertebrates, with LC_{50} values ranging from 4.2 to >1000.0 µg/L. The acute No Observable Adverse Effect Concentration (NOAEC) in shrimp was <2.7 µg/L. When shrimp were exposed chronically, less than one sixth of that dose effected the growth (weight) of the shrimp.[1]

EC_{50}: The median effective concentration (EC_{50}) may be reported for sublethal or ambiguously lethal effects. This measure is used in tests involving species such as aquatic invertebrates where death may be difficult to determine. This term is also used if sublethal events are being monitored.

Newman, M.C.; Unger, M.A. *Fundamentals of Ecotoxicology*; CRC Press, LLC.: Boca Raton, FL, 2003; p 178.

- Mesocosm studies in ponds treated with diazinon weekly for 6 weeks resulted in concentrations ranging from 5.7 to 91.5 µg/L of pond water. Aquatic invertebrate populations were reduced at concentrations higher than 11 µg/L. The experiments did not show any significant direct or indirect effects on fish, despite significant fluctuations in aquatic macroinvertebrate populations.[5]
- Available data on the acute toxicity of diazinon to amphibians indicate amphibians are less sensitive to diazinon compared to fish (96 hour LC_{50} = 7500 µg/L in yellow-legged frog) and that the metabolite diazoxon is roughly an order of magnitude more toxic than diazinon (96 hour LC_{50} = 760 µg/L). The LD_{50} for terrestrial phase bullfrogs (*R. catesbiana*) was found to be >2000 mg/kg.[5]
- No data currently exist on the toxicity of diazinon to vascular plants, however one study in green algae (*Pseudokirchneriella subcapitata*) resulted in a 7-day LC_{50} of 3700 µg/L, suggesting that green algae are not very sensitive to the toxicity of diazinon.[5]
- Studies in constructed wetlands suggest diazinon bound to aquatic sediments has a lower bioavailability compared to aqueous diazinon.[45]
- Environmental degradates of diazinon include diazoxon and oxypyrimidine. Diazoxon is higher in toxicity to aquatic organisms compared with the parent compound. However, diazoxon is short-lived in the environment and its concentrations are expected to be low compared to the parent compound.[5] Oxypyrimidine is practically non-toxic to freshwater fish and invertebrates (LC_{50} >101 mg/L and 102 mg/L, respectively) and is practically non-toxic to green algae with an EC_{50} >109 mg/L.[5]

Terrestrial Invertebrates

- Diazinon is known to be highly toxic to bees and other beneficial insects following acute contact exposure. The acute LD_{50} for bees is 0.22 µg/bee.[1]
- Diazinon is slightly toxic to the earthworm *Eisenia foetida* with a reported LC_{50} of 130 mg/kg of soil.[2,18]

Regulatory Guidelines:

- The acute reference dose (RfD) for diazinon is 0.0025 mg/kg/day.[1] The chronic RfD is 0.0002 mg/kg/day.[1] See the text box on **Reference Dose (RfD)**.
- The U.S. EPA has classified diazinon as "Group D - not classifiable as to human carcinogenicity" based on the lack of evidence of carcinogenicity found in mice and rat studies.[14] See the text box on **Cancer** (page 5).

Reference Dose (RfD): The RfD is an estimate of the quantity of chemical that a person could be exposed to every day for the rest of their life with no appreciable risk of adverse health effects. The reference dose is typically measured in milligrams (mg) of chemical per kilogram (kg) of body weight per day.

U.S. Environmental Protection Agency, Technology Transfer Network, Air Toxics Health Effects Glossary, 2009. http://www.epa.gov/ttnatw01/hlthef/hapglossaryrev.html#RfD

- The acute Population Adjusted Dose (aPAD) is 0.0025 mg/kg/day.[1]
- The chronic Population Adjusted Dose (cPAD) is 0.0002 mg/kg/day.[1]
- No drinking water standards exist for diazinon. The U.S. EPA has set a lifetime health advisory at 0.001 mg/L for diazinon in drinking water, however this health guidance level is not enforceable.[46]
- The National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL) is 0.1 mg/m^3 (time-weighted average).[47]

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