

# Chemicals Used In Military Operations During The Vietnam War

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## General use:

- Insecticide, DDT - Pyrethrum aerosol, G-1152, 12-oz, can.\*
- Insecticide, Dichlorvos, 20% impregnated strips
- Insecticide, Lindane, 1% dusting powder, 2-oz. can\*\*
- Insecticide, Pyrethrum, 0.6% aerosol, 12-oz. can
- Insecticide, Pyrethrum, 0.4% solution, 1-gal. can
- Repellent, Clothing and personal application, m 75% DEET, 6-oz. (aerosol can)
- Repellent, Clothing and personal application, m 75% DEET, 2-oz. (plastic bottle)
- Repellent, Clothing and personal application, m 75% DEET, ½-oz. (bottle, component of survival kit)
- Rodenticide, Anticoagulant, Ready mixed bait, 5-lb can
- Rodenticide, bait block, diphacin, 8-oz. block

## Supervision Required:

- Insecticide, Aluminum phosphide, tablets, can
- Insecticide, Aluminum phosphide, pellets, flask
- Insecticide, Baygon, 1% solution, 1-gal. can
- Insecticide, Baygon, 2% bait, 5-lb. bottle
- Insecticide, Carbaryl, 80% powder, 15-lb. pail
- Insecticide, Carbaryl-DDT, Micronized dust, 1-gram\*\*\*
- Insecticide, Carbaryl-DDT, Micronized dust, 5-gram\*\*\*
- Insecticide, Carbaryl-DDT, Micronized dust, 13-gram\*\*\*
- Insecticide, Chlordane, 72% emulsifiable concentrate, 5-gal. pail
- Insecticide, Chlordane, 5%-6% dust, 25-lb. pail
- Insecticide, Diazinon, 0.5% solution, 1-gal. can
- Insecticide, Diazinon, 48% emulsifiable concentrate, 1-gal. can
- Insecticide, Dieldrin, 15% emulsifiable concentrate, 5-gal. pail
- Insecticide, DDT, 25% emulsifiable concentrate, 5-gal. pail

For disinsectization of aircraft in compliance with Public Health Quarantine.

\* For use in control of body lice.

\*\* For disinsectization of aircraft in compliance with Agricultural Quarantine.

- Insecticide, DDT, 75% wettable powder, 20-lb. pail
- Insecticide, Dichlorvos, 20% impregnated pellets, 30-lb. pail
- Insecticide, Dursban, 40.8% emulsifiable concentrate
- Insecticide, Lindane, 12% emulsifiable concentrate, 5-gal. pail
- Insecticide, Lindane, 1% dusting powder, 25-lb. pail
- Insecticide, Malathion, 57% emulsifiable concentrate, Grade A, (1-gal. can)

- Insecticide, Malathion, 57% emulsifiable concentrate, Grade B, (55-gal. drum)
- Insecticide, Malathion, 57% emulsifiable concentrate, Grade A, (5-gal. pail)
- Insecticide, Malathion, 95% solution concentrate 55-gal. Drum
- Insecticide, Methyl bromide, 98%, 150-lb. cylinder
- Insecticide, Methyl bromide, 98%, 1-lb. can
- Insecticide, Naled, 85% solution concentrate, 15-gal. drum
- Repellent, Clothing application, M-1960, 1-gal. can
- Repellent, Clothing application, 90% Benzyl benzoate, 1-gal. can
- Rodenticide, Anticoagulant, Universal concentrate, 1-lb. can
- Rodenticide, Calcium cyanide, 42% powder, 1-lb. can
- Rodenticide, Zinc phosphide, 80% powder, 1-oz. bottle
- Fungicide, Pentachlorophenol, 5% moisture retardant, 55-gal. drum
- Soil fumigant, SMDC (VAPAM) 32.7% solution
- Herbicide, Borate-Bromacil mixture, 50-lb. bag
- Herbicide, Bromacil, 80% powder, 50-lb. drum
- Herbicide, Chlorate-Borate mixture, 50-lb. bag
- Herbicide, Dacthal, 75% powder, 50-lb bag
- Herbicide, Dalapon, 85% powder, 50-lb. drum
- Herbicide, Dicamba, 49% solution, 1-gal. bottle
- Herbicide, Diquat, 35.3% solution, 5-gal. drum
- Herbicide, Diuron, 80% powder, 50-lb. drum
- Herbicide, DSMA, 63% disodium methylarsonate, 100-lb. drum
- Herbicide, Monuron, 80% powder, 50-lb. drum
- Herbicide, Picloram + 2,4-D, 5-gal. drum
- Herbicide, Picloram, 11.6% pellets, 50-lb. drum
- Herbicide, Silvex, Low Volatile Ester, 4-lb/gal., 5-gal. drum
- Herbicide, Simazinc, 80% powder, 5-lb. can
- Herbicide, 2,4-D, Low Volatile Ester, 4-lb/gal., 5-gal. can
- Herbicide, 2,4-D, Amine, 4-lb/gal., 5-gal. can
- Herbicide, 2,4,5-T, Low Volatile Ester, 4-lb/gal., 55-gal. drum
- Herbicide, 2,4,5-T, Low Volatile Ester, 4-lb/gal., 5-gal. pail

## Tactical:

- Herbicide, Cacodylic Acid (Blue), 55-gal. drum
- Herbicide, Picloram + 2,4-D, (White), 55-gal. drum
- Herbicide, 2,4-D + 2,4,5-T, High Volatile ester (Orange), 55-gal. drum

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Update: February 24, 2004

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## ATSDR RESOURCES

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## Public Health Statement for

# DDT, DDE, and DDD

### CAS#

DDT 50-29-3

DDE 72-55-9

DDD 72-54-8

### September 2002

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*This Public Health Statement is the summary chapter from the Toxicological Profile for DDT, DDE, and DDD. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, you may call the ATSDR Information Center at 1-888-422-8737.*

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This public health statement tells you about DDT, DDE, and DDD and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. DDT, DDE, and DDD have been found in at least 442 of the 1,613 current or former NPL sites. However, the total number of NPL sites evaluated for these substances is not known. As more sites are evaluated, the sites at which DDT, DDE, and DDD are found may increase. This information is important because exposure to these substances may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

**ToxFAQs™**

whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with them. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

While this document is specifically focused on the primary forms or isomers of DDT, DDE, and DDD (namely *p,p'*-DDT, *p,p'*-DDE, and *p,p'*-DDD), other isomers of these compounds will be discussed when appropriate. In some cases, the term DDT will be used to refer to the collection of all forms of DDT, DDE, and DDD. Should this not be clear from the context, the term S DDT (S is used to mean sum of) will be used.

**1.1 What are DDT, DDE, and DDD?**

DDT (1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane) is a pesticide that was once widely used to control insects on agricultural crops and insects that carry diseases like malaria and typhus, but is now used in only a few countries to control malaria. Technical-grade DDT is a mixture of three forms, *p,p'*-DDT (85%), *o,p'*-DDT (15%), and *o,o'*-DDT (trace amounts). All of these are white, crystalline, tasteless, and almost odorless solids. Technical grade DDT may also contain DDE (1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene) and DDD (1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane) as contaminants. DDD was also used to kill pests, but to a far lesser extent than DDT. One form of DDD (*o,p'*-DDD) has been used medically to treat cancer of the adrenal gland. Both DDE and DDD are breakdown products of DDT.

DDT does not occur naturally in the environment. After 1972, the use of DDT was no longer permitted in the United States except in cases of a public health emergency. It is, however, still used in some other areas of the world, most notably for controlling malaria. The use of DDD to kill pests has also been banned in the United States.

You will find further information on the physical properties and uses of DDT, DDE, and DDD in Chapters 4 and 5 of this profile.

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**1.2 What happens to DDT, DDE, and DDD when they enter the environment?**

Before 1973 when it was banned, DDT entered the air, water, and soil during its production and use as an insecticide. DDT is present at many waste sites, including NPL sites; releases from these sites might continue to contaminate the environment. Most DDT in the environment is a result of past use; DDD was also used as a pesticide to a limited extent in the past. DDT still enters the environment because of its current use in other areas of the world. DDE is only found in the environment as a result of

contamination or breakdown of DDT. DDD also enters the environment during the breakdown of DDT.

Large amounts of DDT were released into the air and on soil or water when it was sprayed on crops and forests to control insects. DDT was also sprayed in the environment to control mosquitos. Although the use of DDT is no longer permitted in the United States, DDT may be released into the atmosphere in other countries where it is still manufactured and used, including Mexico. DDT, DDE and DDD may also enter the air when they evaporate from contaminated water and soil. DDT, DDE, and DDD in the air will then be deposited on land or surface water. This cycle of evaporation and deposition may be repeated many times. As a result, DDT, DDE, and DDD can be carried long distances in the atmosphere. These chemicals have been found in bogs, snow, and animals in the Arctic and Antarctic regions, far from where they were ever used. Some DDT may have entered the soil from waste sites. DDT, DDE, and DDD may occur in the atmosphere as a vapor or be attached to solids in air. Vapor phase DDT, DDE, and DDD may break down in the atmosphere due to reactions caused by the sun. The half-life of these chemicals in the atmosphere as vapors (the time it takes for one-half of the chemical to turn into something else) has been calculated to be approximately 1.5-3 days. However, in reality, this half-life estimate is too short to account for the ability of DDT, DDE, and DDD to be carried long distances in the atmosphere.

DDT, DDE, and DDD last in the soil for a very long time, potentially for hundreds of years. Most DDT breaks down slowly into DDE and DDD, generally by the action of microorganisms. These chemicals may also evaporate into the air and be deposited in other places. They stick strongly to soil, and therefore generally remain in the surface layers of soil. Some soil particles with attached DDT, DDE, or DDD may get into rivers and lakes in runoff. Only a very small amount, if any, will seep into the ground and get into groundwater. The length of time that DDT will last in soil depends on many factors including temperature, type of soil, and whether the soil is wet. DDT lasts for a much shorter time in the tropics where the chemical evaporates faster and where microorganisms degrade it faster. DDT disappears faster when the soil is flooded or wet than when it is dry. DDT disappears faster when it initially enters the soil. Later on, evaporation slows down and some DDT moves into spaces in the soil that are so small that microorganisms cannot reach the DDT to break it down efficiently. In tropical areas, S DDT may disappear in much less than a year. In temperate areas, half of the S DDT initially present usually disappears in about 5 years. However, in some cases, half of the S DDT initially present will remain for 20, 30, or more years.

In surface water, DDT will bind to particles in the water, settle, and be deposited in the sediment. DDT is taken up by small organisms and fish in the water. It accumulates to high levels in fish and marine mammals (such as seals and whales), reaching levels many thousands of times

higher than in water. In these animals, the highest levels of DDT are found in their adipose tissue. DDT in soil can also be absorbed by some plants and by the animals or people who eat those crops.

More information about what happens to DDT, DDE, and DDD in the environment can be found in Chapter 6.

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### 1.3 How might I be exposed to DDT, DDE, and DDD?

People in the United States are exposed to DDT, DDE, and DDD mainly by eating foods containing small amounts of these compounds. Although not common today, exposure to DDT could also occur through inhalation or absorption through the skin during the handling or application of DDT. Even though DDT has not been used in this country since 1972, soil may still contain some DDT that may be taken up by plants and eaten by animals and people. DDT from contaminated water and sediment may be taken up by fish. The amount of DDT in food has greatly decreased since DDT was banned and should continue to decline. In the years 1986 to 1991, the average adult in the United States consumed an average of 0.8 micrograms (a microgram is a millionth of a gram) of DDT a day. Adults consumed slightly different amounts based on their age and sex. The largest fraction of DDT in a person's diet comes from meat, poultry, dairy products, and fish, including the consumption of sport fish. Leafy vegetables generally contain more DDT than other vegetables, possibly because DDT in the air is deposited on the leaves. Infants may be exposed by drinking breast milk.

DDT or its breakdown products are still present in some air, water, and soil samples. However, levels in most air and water samples are presently so low that exposure is of little concern. DDT levels in air have declined to such low levels that it often cannot be detected. In cases where DDT has been detected in air, it is associated with air masses coming from regions where DDT is still used or from the evaporated DDT from contaminated water or soil. *p,p'*-DDT and *p,p'*-DDE concentrations measured in air in the Great Lakes region in 1990 reached maximum levels of 0.035 and 0.119 nanograms (a nanogram is a billionth of a gram) of chemical per cubic meter of air ( $\text{ng}/\text{m}^3$ ), respectively. Levels were generally much lower, especially during the winter months. In 1995-1996, soils in the corn belt, where DDT was heavily used in the past, contained on the average about 10 nanograms of DDT in a gram of soil. In recent years, most surface water has not contained detectable amounts of DDT.

People who work or live around NPL sites or work with contaminated soil or sediment would most likely be exposed by accidentally swallowing soil, having skin contact with the soil, inhaling DDT vapor, or breathing in DDT in dust.

You can find more information on exposure to DDT, DDE, and DDD in Chapter 6 of this profile.

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#### **1.4 How can DDT, DDE, and DDD enter and leave my body?**

Today in the United States, DDT, DDE, or DDD enters the body mainly when a person eats contaminated food. The actual amounts of DDT, DDE, and DDD absorbed from foods depends on both the concentration of chemical in the food and the amount of food eaten. Small amounts of DDT, DDE, and DDD may also be breathed in and absorbed into the body. DDT, DDE, and DDD are often attached to particles too large to pass very far into the lungs after air containing them is breathed. These particles are more likely to be carried upward in the mucus of the air passages and swallowed than for the DDT to be absorbed in the lungs. DDT, DDE, and DDD do not enter the body through the skin very easily.

Once inside the body, DDT can break down to DDE or DDD. DDE and DDD, in turn, break down to other substances (called metabolites). DDT, DDE, and DDD are stored most readily in fatty tissue, especially DDE. Some of these stored amounts leave the body very slowly. Levels in fatty tissues may either remain relatively the same over time or even increase with continued exposure. However, as exposure decreases, the amount of DDT in the body also decreases. DDT metabolites leave the body mostly in urine, but may also leave by breast milk and pass directly to nursing infants. See Chapter 3 for more information on how DDT, DDE, and DDD enter and leave the body.

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#### **1.5 How can DDT, DDE, and DDD affect my health?**

Eating food with large amounts (grams) of DDT over a short time would most likely affect the nervous system. People who swallowed large amounts of DDT became excitable and had tremors and seizures. They also experienced sweating, headache, nausea, vomiting, and dizziness. These effects on the nervous system went away once exposure stopped. The same type of effects would be expected by breathing DDT particles in the air or by contact of the skin with high amounts of DDT. Tests in laboratory animals confirm the effect of DDT on the nervous system.

No effects have been reported in adults given small daily doses of DDT by capsule for 18 months (up to 35 milligrams [mg] every day). People exposed for a long time to small amounts of DDT (less than 20 mg per day), such as people who worked in factories where DDT was made, had some minor changes in the levels of liver enzymes in the blood. A study in humans showed that increasing concentrations of *p,p'*-DDE in human



breast milk were associated with reductions in the duration of lactation. An additional study in humans found that as the DDE levels in the blood of pregnant women increased, the chances of having a pre-term baby also increased. It should be mentioned, however, that the levels of DDE in the blood at which this was noticed were higher than those currently found in women from the general population in the United States, but not higher than those that may be found in women in countries where DDT is still being used.

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Animal studies show that long-term exposure to moderate amounts of DDT (20-50 mg per kilogram [kg] of body weight every day) may affect the liver. Tests in animals also suggest that short-term exposure to DDT and metabolites in food may have a harmful effect on reproduction. In addition, we know that some breakdown products of DDT can cause harmful effects on the adrenal gland. This gland is situated near the kidney and produces hormones (substances produced by organs and released to the bloodstream to regulate the function of other organs).

Studies in animals have shown that oral exposure to DDT can cause liver cancer. Studies of DDT-exposed workers did not show increases in deaths or cancers. Based on all of the evidence available, the Department of Health and Human Services has determined that DDT is reasonably anticipated to be a human carcinogen. Similarly, the International Agency for Research on Cancer (IARC) has determined that DDT is possibly carcinogenic to humans. EPA has determined that DDT, DDE, and DDD are probable human carcinogens. See Chapter 3 for more information on the health effects associated with exposure to DDT, DDE, and DDD.

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### **1.6 How can DDT, DDE, and DDD affect children?**

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

Children can be exposed to DDT, DDE, or DDD by eating food or drinking breast milk contaminated with these compounds. DDT is a pesticide, and even though it has not been used in this country since 1972, soil has small amounts and, under certain conditions, contaminated soil transfers DDT to crops. Children can be exposed also by eating food imported from countries where DDT is still being used. Because of their smaller weight, intake of an equivalent amount of DDT by children and adults would result in a higher dose (amount of DDT ingested per kilogram of body weight) in children than in adults. In the United States between 1985 and 1991, the average 8½-month-old infant consumed 4 times as much DDT for each pound of body weight than the average adult. However, the amounts of DDT consumed were much smaller than the amounts that have been tested in studies in animals.

DDT from the mother can enter her unborn baby through the placenta. DDT has been found in amniotic fluid, human placentas, fetuses, and umbilical cord blood. DDT has been measured in human milk; therefore, nursing infants are also exposed to DDT. In most cases, however, the benefits of breast-feeding outweigh any risks from exposure to DDT in mother's milk. Nevertheless, women with unusually high amounts of DDT or metabolites in their bodies (compared to background amounts measured in the general population) should be informed of the potential exposure of the fetus if they become pregnant and the potential risks of breast-feeding.

We do not know whether children differ from adults in their susceptibility to health effects from DDT. There are few studies of young children exposed to DDT. A child who drank DDT in kerosene only once vomited and had tremors and convulsions and eventually died; however, we do not know how much of this was caused by the kerosene. Adults who swallowed DDT in much greater amounts than those found in the environment had effects on their nervous systems. The same harmful effects will probably happen to young children if they eat food or drink liquids with large amounts of DDT. However, because DDT is no longer used or made in the United States, such exposure is not likely to happen. Two studies have shown a higher dose of DDT is needed to kill newborn and young rats than adult rats. In one study, when the dose was divided up and given over 4 days, the same dose of DDT killed rats of all ages.

There is no evidence that exposure to DDT at levels found in the environment causes birth defects in people. One study in U.S. children 12 to 14 years of age found that boys whose mothers had higher DDE levels in their bodies when they were pregnant were taller than those whose mothers had lower DDE levels. A study of German children found that girls with higher DDE in the blood at 8 years of age were shorter than those with lower DDE levels. The reason for the discrepancy between the two studies is unknown. Studies in animals have shown that DDT given during pregnancy can slow the growth of the fetus. Exposure

to DDT or its metabolites during development may change how the reproductive and nervous systems work. This seems to be caused by the property of DDT or its metabolites to mimic the action of natural hormones. Male rats exposed to the DDT breakdown product, *p,p'*-DDE, as fetuses or while nursing, showed changes in the development of their reproductive system. One study found that the beginning of puberty is delayed in male rats given relatively high amounts of *p,p'*-DDE as juveniles. Also, one study showed that exposure of mice to DDT during the first weeks of life resulted in neurobehavioral problems when tests were done later in life. These studies raise concerns that exposure to DDT early in life might cause harmful effects that remain or begin long after exposure has stopped.

More information regarding children's health and DDT and related compounds can be found in Section 3.8.

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### **1.7 How can families reduce the risk of exposure to DDT, DDE, and DDD?**

If your doctor finds that you have been exposed to significant amounts of DDT, DDE, and DDD, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

At this time, most people are exposed to DDT and its breakdown products as a result of eating foods or drinking liquids that may be contaminated with small amounts of DDT. DDT is a pesticide, but it was banned in the United States in 1972. However, because of its chemical characteristics, it has stayed in the environment and low levels of DDT may be present in foods (i.e., fruits, vegetables, meat, and fish) for many years. Studies have shown that cooking will reduce the amount of DDT in fish. Many other countries still use DDT; therefore, food brought into the United States from these countries may contain DDT. The Food and Drug Administration (FDA) analyzes a wide variety of imported food items (coffee, tropical fruits, etc.) as well as domestic products to insure that pesticide residues are below FDA tolerances. DDT has been found in both root and leafy vegetables. DDT attaches to the roots of plants, but it does not easily move to other parts of the plants. DDT in the air can be deposited on to the surfaces of plants. Washing fruits and vegetables before eating them is a healthful practice.

You and your children may be exposed to DDT by eating certain types of fish or wildlife caught from certain locations. Some states, Native American tribes, and U.S. territories have issued fish and wildlife advisories to warn people about DDT-contaminated fish and turtles. Each state, Native American tribe, or U.S. territory sets its own criteria for issuing fish and wildlife advisories. A fish advisory will specify which

bodies of water have restrictions. The advisory will tell you what type and sizes of fish are of concern. The advisory may completely ban eating fish or tell you to limit your meals of a certain fish type. For example, an advisory may tell you to eat a certain type of fish no more than once a month. The advisory may tell you only to eat certain parts of the fish or turtle and how to prepare or cook the fish or turtle to decrease your exposure to DDT. The fish or wildlife advisory may be stricter to protect pregnant women, nursing mothers, and young children. To reduce your children's exposure to DDT, obey fish and wildlife advisories. Information on fish and wildlife advisories in your state is available from your state health or natural resources department. Signs may also be posted in certain fishing areas.

More information regarding exposure to DDT can be found in Sections 6.5, 6.6, and 6.7.

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### **1.8 Is there a medical test to determine whether I have been exposed to DDT, DDE, and DDD?**

DDT, DDE, and DDD can be measured in fat, blood, urine, semen, and breast milk. Samples of blood and urine are easy to get, and levels in these samples may help show the amount of exposure. These tests are not readily available at your doctor's office, but your doctor can tell you where they can be done. Tests may show low, moderate, or excessive exposure to these compounds. However, such tests cannot show the exact amount of DDT, DDE, or DDD to which a person was exposed, or predict the chance of health effects in the person. See Chapters 3 and 7 for more information on tests to detect these compounds in the body.

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### **1.9 What recommendations has the federal government made to protect human health?**

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that

affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for DDT, DDE, and DDD include the following:

All uses of DDT were banned by EPA in 1972, except in cases of public health emergencies. DDT was banned because the chemical was building up in the environment and possibly hurting wildlife. Also, some cancer tests in laboratory animals showed positive results. Although DDT is no longer used in the United States, federal regulations still control the amounts of DDT allowed in food and water.

OSHA states that workers may not be exposed to amounts of DDT greater than 1 milligram of DDT per cubic meter of air (1 mg/m<sup>3</sup>) for an 8-hour workday, 40-hour work week. EPA estimates that drinking 2 liters of water per day containing 0.59 nanograms of DDT per liter of water (1 nanogram is one billionth of a gram) and eating 6.5 grams of fish and shellfish per day (from waters containing 0.59 nanograms DDT per liter) would be associated with an increased lifetime cancer risk of one in one million. Fish and shellfish tend to concentrate DDT from the surrounding water in their tissues. FDA has set action levels for DDT/DDE/DDD; these are limits at or above which FDA will take legal action to remove products from the market. Action levels for a variety of products are listed in Table 8-1. See Chapter 8 for more information on regulations.

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### **1.10 Where can I get more information?**

If you have any more questions or concerns, please contact your community or state health or environmental quality department or

Agency for Toxic Substances and Disease Registry  
Division of Toxicology  
1600 Clifton Road NE, Mailstop E-29  
Atlanta, GA 30333  
Web site: <http://www.atsdr.cdc.gov>

\* Information line and technical assistance

Phone: 1-888-42-ATSDR (1-888-422-8737)  
Fax: 1-404-498-0057

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

\* To order toxicological profiles, contact

National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161  
Phone: 1-800-553-6847 or 1-703-605-6000

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### References

Agency for Toxic Substances and Disease Registry (ATSDR). 2002. Toxicological profile for DDT, DDE, and DDD. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

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This page was updated on October 23, 2002

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U.S. Department of Health and Human Services

## 4. CHEMICAL AND PHYSICAL INFORMATION

### 4.1 CHEMICAL IDENTITY

When we refer to DDT, we are generally referring to *p,p'*-DDT, which was produced and used for its insecticidal properties. However, technical grade DDT, the grade that was generally used as an insecticide, was composed of up to fourteen chemical compounds, of which only 65–80% was the active ingredient, *p,p'*-DDT. The other components included 15–21% of the nearly inactive *o,p'*-DDT, up to 4% of *p,p'*-DDD, and up to 1.5% of 1-(*p*-chlorophenyl)-2,2,2-trichloroethanol (Metcalf 1995).

The chemical formulas, structures, and identification numbers for *p,p'*-DDT, *p,p'*-DDE, *p,p'*-DDD, *o,p'*-DDT, *o,p'*-DDE, and *o,p'*-DDD are listed in Table 4-1. The latter five compounds are either impurities or metabolites of technical DDT.

### 4.2 PHYSICAL AND CHEMICAL PROPERTIES

Technical DDT is a white amorphous powder that melts over the range of 80–94 °C (Metcalf 1995). Physical and chemical properties of *p,p'*-DDT, *p,p'*-DDE, *p,p'*-DDD, *o,p'*-DDT, *o,p'*-DDE, and *o,p'*-DDD are listed in Table 4-2.

Table 4-1. Chemical Identity of *p,p'*- and *o,p'*-DDT, DDE, and DDD<sup>a</sup>

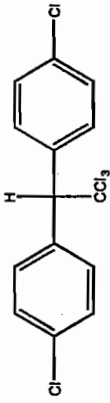
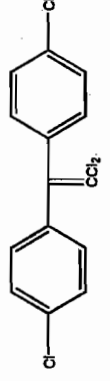
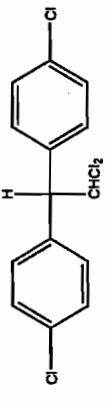
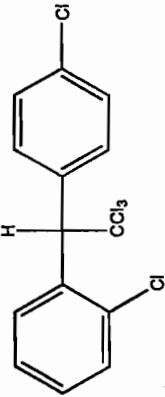
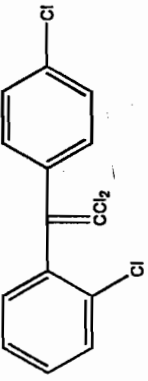
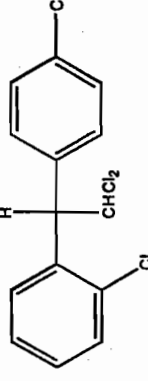
Characteristic	<i>p,p'</i> -DDT	<i>p,p'</i> -DDE	<i>p,p'</i> -DDD
Synonym(s)	4,4'-DDT; 1,1,1-trichloro-2,2-bis( <i>p</i> -chlorophenyl)ethane; dichlorodiphenyl trichloroethane; DDT; 1,1'-(2,2,2-trichloroethylidene)bis(4-chlorobenzene); $\alpha$ - $\alpha$ -bis( <i>p</i> -chlorophenyl)- $\beta$ , $\beta$ , $\beta$ -trichloroethane	4,4'-DDE; dichlorodiphenyl-dichloroethane; 1,1-dichloro-2,2-bis( <i>p</i> -chlorophenyl) ethylene; 1,1'-(2,2-dichloroethylidene)bis(4-chlorobenzene); DDE	4,4'-DDD; DDD; 1,1-dichloro-2,2-bis( <i>p</i> -chlorophenyl)ethane; 1,1-bis(4-chlorophenyl)-2,2-dichloroethane; TDE; tetrachlorodiphenylethane
Registered trade name(s)	Genitox, Anofex, Detoxan, Neocid, Gesarol, Pentachlorin, Dicophane, Chlorophenothane <sup>b</sup>	No data	DDD; Rothane; Dilene, TDE
Chemical formula	$C_{14}H_9Cl_5$	$C_{14}H_8Cl_4$	$C_{14}H_7Cl_4$
Chemical structure			
Identification numbers:	50-29-3 CAS registry KJ3325000 NIOSH RTECS UO61 EPA hazardous waste 7216510 OHMTADS DOT/UN/NA/IMCO 6.1; UN2761 200 HSDB C00465 NCI	72-55-9 KV9450000 No data No data No data 1625 C00555	72-54-8 KI0700000 U060 7215098 NA2761; TDE 285 C00475



Table 4-1. Chemical Identity of *p,p'*- and *o,p'*-DDT, DDE, and DDD<sup>a</sup> (continued)

Characteristic	<i>o,p'</i> -DDT	<i>o,p'</i> -DDE	<i>o,p'</i> -DDD
Synonym(s)	4,4'-DDT; 1,1,1-trichloro-2-( <i>o</i> -chlorophenyl)-2-( <i>p</i> -chlorophenyl)ethane; <i>o,p'</i> -dichlorodiphenyltrichloroethane	2,4'-DDE; 1,1-dichloro-2-( <i>o</i> -chlorophenyl)-2-( <i>p</i> -chlorophenyl)ethylene; 1-chloro-2-(2,2-dichloro-1-(4-chlorophenyl)ethenyl)benzene	2,4'-DDD; Mitotane; <i>o,p'</i> -DDD; 1,1-dichloro-2-( <i>o</i> -chlorophenyl)-2-( <i>p</i> -chlorophenyl)ethane; <i>o,p'</i> -TDE; Choditane; 2-( <i>o</i> -chlorophenyl)-2-( <i>p</i> -chlorophenyl)-1,1-dichloroethane
Registered trade name(s)	No data	No data	Lysodren
Chemical formula	C <sub>14</sub> H <sub>9</sub> Cl <sub>5</sub>	C <sub>14</sub> H <sub>9</sub> Cl <sub>4</sub>	C <sub>14</sub> H <sub>10</sub> Cl <sub>4</sub>
Chemical structure			
Identification numbers:			
CAS registry	789-02-6	3424-82-6	53-19-0
NIOSH RTECS	No data	No data	KH7880000
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data
HSDB	No data	No data	3240
NCI	No data	No data	C04933

<sup>a</sup>All information obtained from HSDB 1999a, 1999b, 1999c, 1999d, or Howard and Neal 1992 except where noted.

<sup>b</sup>Klassen et al. 1991

CAS = Chemical Abstracts Service; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-2. Physical and Chemical Properties of *p,p'*- and *o,p'*-DDT, DDE, and DDD<sup>a</sup>**

Property	<i>p,p'</i> -DDT	<i>p,p'</i> -DDE	<i>p,p'</i> -DDD
Molecular weight	354.49 <sup>b</sup>	318.03 <sup>b</sup>	320.05 <sup>b</sup>
Color	Colorless crystals, white powder <sup>c</sup>	White	Colorless crystals, white powder
Physical state	Solid <sup>d</sup>	Crystalline solid	Solid
Melting point	109 • C <sup>b</sup>	89 • C <sup>b</sup>	109–110 • C <sup>b</sup>
Boiling point	Decomposes	336 • C <sup>b</sup>	350 • C <sup>b</sup>
Density	0.98–0.99 g/cm <sup>3</sup>	No data	1.385 g/cm <sup>3</sup>
Odor	Odorless or weak aromatic odor <sup>e</sup>	No data	Odorless
Odor threshold:			
Water	0.35 mg/kg <sup>c</sup>	No data	No data
Air	No data	No data	No data
Solubility:			
Water	0.025 mg/L at 25 • C <sup>b</sup>	0.12 mg/L at 25 • C <sup>b</sup>	0.090 mg/L at 25 • C <sup>b</sup>
Organic solvents	Slightly soluble in ethanol, very soluble in ethyl ether and acetone <sup>f</sup>	Lipids and most organic solvents	No data <sup>g</sup>
Partition coefficients:			
Log K <sub>ow</sub>	6.91 <sup>b</sup>	6.51 <sup>b</sup>	6.02 <sup>b</sup>
Log K <sub>oc</sub>	5.18 <sup>h</sup>	4.70 <sup>i</sup>	5.18 <sup>j</sup>
Vapor pressure	1.60x10 <sup>-7</sup> at 20 • C, torr <sup>b</sup>	6.0x10 <sup>-6</sup> at 25 • C, torr <sup>b</sup>	1.35x10 <sup>-6</sup> at 25 • C, torr <sup>b</sup>
Henry's law constant	8.3x10 <sup>-6</sup> atm-m <sup>3</sup> /mol <sup>b</sup>	2.1x10 <sup>-5</sup> atm-m <sup>3</sup> /mol <sup>b</sup>	4.0x10 <sup>-6</sup> atm-m <sup>3</sup> /mol <sup>b</sup>
Autoignition temperature	No data	No data	No data
Flashpoint	72.2–77.2 • C	No data	No data
Flammability limits	No data	No data	No data
Conversion factors			
ppm(v/v) to mg/m <sup>3</sup> in air at 20 • C	Not applicable <sup>k</sup>	Not applicable <sup>k</sup>	Not applicable <sup>k</sup>
mg/m <sup>3</sup> to ppm(v/v) in air at 20 • C	Not applicable	Not applicable	Not applicable
Explosive limits	No data	No data	No data

## 4. CHEMICAL AND PHYSICAL INFORMATION

**Table 4-2. Physical and Chemical Properties of *p,p'*- and *o,p'*-DDT, DDE, and DDD<sup>a</sup> (continued)**

Property	<i>o,p'</i> -DDT	<i>o,p'</i> -DDE	<i>o,p'</i> -DDD
Molecular weight	354.49 <sup>b</sup>	318.03 <sup>b</sup>	320.05 <sup>b</sup>
Color	White crystalline powder <sup>c</sup>	No data	No data
Physical state	Solid <sup>d</sup>	No data	Solid
Melting point	74.2 • C <sup>e</sup>	No data	76–78 • C
Boiling point	No data	No data	No data
Density	0.98–0.99 g/cm <sup>3</sup>	No data	No data
Odor	Odorless or weak aromatic odor <sup>e</sup>	No data	No data
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water	0.085 mg/L at 25 • C <sup>b</sup>	0.14 mg/L at 25 • C <sup>b</sup>	0.1 mg/L at 25 • C <sup>b</sup>
Organic solvents	No data <sup>g</sup>	No data <sup>g</sup>	Soluble in ethanol, isooctane, carbon tetrachloride <sup>l</sup>
Partition coefficients:			
Log K <sub>ow</sub>	6.79 <sup>h</sup>	6.00 <sup>b</sup>	5.87 <sup>b</sup>
Log K <sub>oc</sub>	5.35 <sup>j</sup>	5.19 <sup>j</sup>	5.19 <sup>j</sup>
Vapor pressure	1.1x10 <sup>-7</sup> at 20 • C, torr <sup>b</sup>	6.2x10 <sup>-6</sup> at 25 • C, torr <sup>b</sup>	1.94x10 <sup>-6</sup> at 30 • C, torr <sup>b</sup>
Henry's law constant	5.9x10 <sup>-7</sup> atm-m <sup>3</sup> /mol <sup>b</sup>	1.8x10 <sup>-5</sup> atm-m <sup>3</sup> /mol <sup>b</sup>	8.17x10 <sup>-6</sup> atm-m <sup>3</sup> /mol <sup>b</sup>
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors			
ppm(v/v) to mg/m <sup>3</sup> in air at 20 • C	Not applicable <sup>k</sup>	Not applicable <sup>k</sup>	Not applicable <sup>k</sup>
mg/m <sup>3</sup> to ppm(v/v) in air at 20 • C	Not applicable	Not applicable	Not applicable
Explosive limits	No data	No data	No data

<sup>a</sup>All information obtained from HSDB 1999a, 1999b, 1999c, 1999d unless otherwise noted

<sup>b</sup>Howard and Meylan 1997

<sup>c</sup>Verschueren 1988

<sup>d</sup>NIOSH 1985

<sup>e</sup>Sax 1979

<sup>f</sup>Lide 1998

<sup>g</sup>Chemical is expected to be soluble in most organic compounds.

<sup>h</sup>Swann et al. 1981

<sup>i</sup>Sablejic 1984

<sup>j</sup>Meylan et al. 1992 (values estimated from a fragment constant method)

<sup>k</sup>Exists partially in particulate form in air. Conversion factors are only applicable for compounds that are entirely in the vapor phase.



Section 5:

## Definitions

Organochlorines: DDT, DDE, Chlordane, Aldrin, Dieldrin, Endrin, Heptachlor epoxide, PCI  
Dioxin

Inorganics: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc

Other Carbamates, Hexachlorobenzene, Hydrocarbons, Organophosphate,  
contaminants: Chlorophenols

### Organochlorines

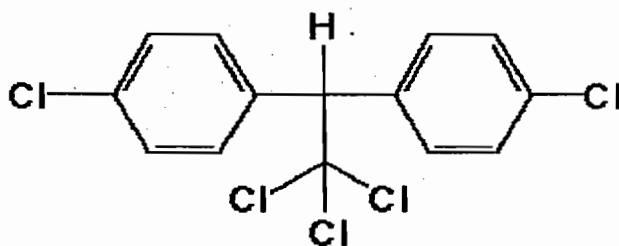
Organochlorines are compounds that contain carbon, chlorine, and hydrogen. Their chlorine-carbon bond is very strong which means that they do not break down easily. They are highly insoluble in water, but are attracted to fats.

Since they resist metabolism and are readily stored in fatty tissue of any animal ingesting them, they accumulate in animals in higher trophic levels. This may occur when birds eat fish that have been exposed to the contaminant. It may also affect humans if they drink milk of a dairy cow that has ingested the chemical because the chemical is excreted in its milk fat. This is called biological magnification.

The intentional production and the unintentional release have elevated levels of these chemicals in the biosphere far beyond natural background levels.

**DDT and related organochlorines:** (return to top)

#### DDT



DDT (originally named *dichloro diphenyl trichloroethane* - also known as *trichloroethylene*) was first synthesized in 1873 by a German graduate student but it was forgotten about until 1938 when Dr. Paul Müller rediscovered it while searching for a long-lasting insecticide against the clothes moth. It was extremely effective against flies and mosquitoes and was used extensively in North America as a domestic and agricultural pesticide until it was banned by the EPA on January 1, 1973 due to its long *arsenic* *Hydrocarbon* residual life and its accumulation in food chains.

The terms DDT or DDTs are often used to refer to a family of isomers (p,p'-DDT and o,p'-DDT) and their breakdown products (p,p'-DDE, o,p'-DDE, p,p'-DDD, p,p'-DDD). DDT data are often expressed as the sum of these six components.

**Relatives of DDT** (return to top)

#### DDE

Dichlorodiphenyldichloroethylene (DDE) is a product of the breakdown of DDT in an organism's body. It is produced in most animals when the body tries to rid itself of DDT.

One major problem related to contaminants identified in fish-eating birds is the thinning of eggshells. This is caused by the presence of DDE in female birds. Eggshells are made of calcium carbonate which is made of calcium and carbon dioxide in the bird's body. This reaction takes a specific enzyme which is inhibited by *Hydrocarbon*

DDE. Since the eggshell does not contain as much calcium carbonate as it should it is thinner than normal and more prone to breakage during incubation by the adult.

*Hydrocarbon Hydrocarbon arsenic*  
**DDD** (1,1-dichloro-2,2-bis(p-chlorophenyl)ethane)- DDD is produced by metabolism of DDT in some organisms.

**Dicofol:** Dicofol is an organochlorine miticide used on a wide variety of fruit, vegetable, ornamental and crops. It is manufactured from DDT, however, modern manufacturing processes can produce technical dicofol which contains less than 0.1% DDT. Dicofol is moderately persistent in soil, with a half-life of 60 days. It is susceptible to chemical breakdown in moist soil and is subject to degradation by UV light. It is practically insoluble in water and adsorbs very strongly to soil particles. It is therefore nearly immobile in soil and unlikely to infiltrate groundwater.

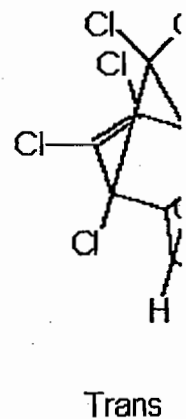
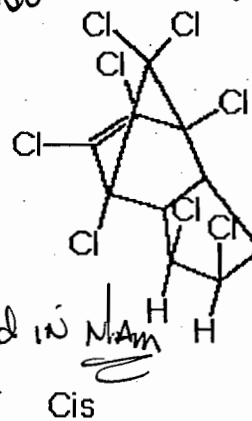
Three other relatives of DDT are methoxychlor, ethion, and chlorobenzilate. These are all pesticides which stick strongly to soil particles. They do not dissolve easily in water nor evaporate easily into the air. They may take several months to break down.

### Other organochlorines: (return to top)

**Cyclodienes:** Cyclodienes were developed after World War II. Generally they are persistent insecticides which are stable in soil. They have been used in greatest quantity as soil insecticides for the control of termites and other soil-borne insects.

**Chlordane** is a cyclodiene that was used extensively in home and agricultural applications. Chlordane is a term that represents a group of a large number (140) of individual compounds. Some of them are: cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane. Chlordane data are usually expressed as the sum of several of the most abundant and persistent components and metabolites of the technical chlordane mixture. Like DDT, chlordane compounds are very persistent in the environment, resistant to metabolism, have a strong affinity for lipid, and biomagnify in aquatic food webs.

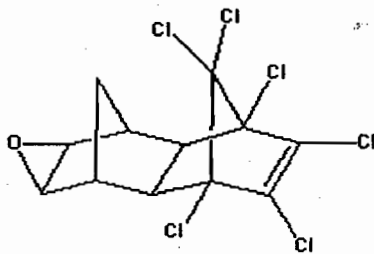
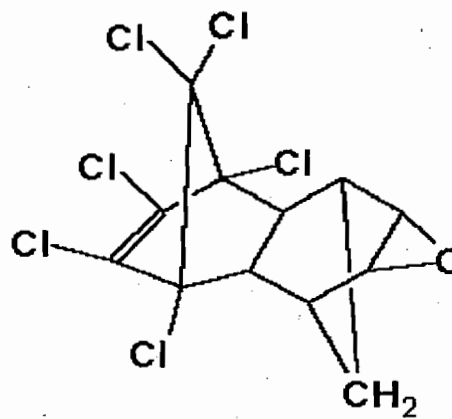
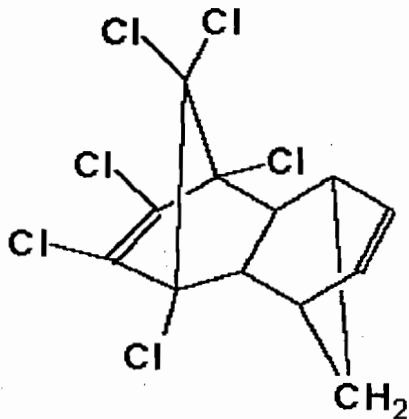
*Chloro = Hydro Carbon Chlorinated*



**Trans-Nonachlor** is one of the major constituents of the insecticide chlordane. It was used extensively prior to 1983. Its use was canceled after 1988 due to concern about the risk of cancer. Trans-nonachlor is the most bioaccumulative of the chlordanes.

### Aldrin and Dieldrin: (return to top)

Aldrin and dieldrin are insecticides with similar structures. Sunlight and bacteria change aldrin to dieldrin. We mostly find dieldrin in the environment. From 1950-1970, aldrin and dieldrin were popular pesticides on crops like corn and cotton. They bind tightly to soil and slowly evaporate to the air. Dieldrin is stored in the fat of a body and leaves the body very slowly. Because of concerns about damage to the environment and potential harm to human health, EPA banned all uses of aldrin and dieldrin in 1974 except to control termites. In 1987, EPA banned all uses.



#### **endrin- (return to top)**

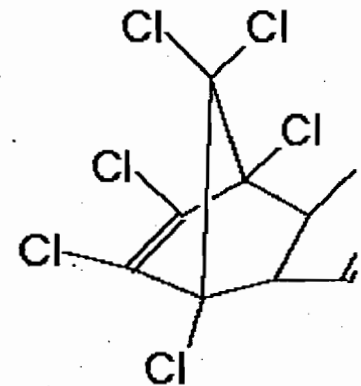
Endrin is more acutely toxic than the rest of the cyclodiene group, but is less persistent in the environment

#### **Heptachlor epoxide- (return to top)**

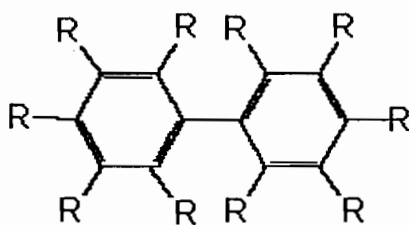
Heptachlor epoxide is the biological conversion product of Heptachlor which is an insecticide used in the control of termites and it has been used in the cotton industry. The epoxide is more toxic than the parent heptachlor pesticide.

**Action:** All organochlorine insecticides are nerve poisons but DDT has a different action than the chlorinated cyclodienes. DDT acts on the sodium channels in the nervous system so that the passage of an 'action potential' along the nerve is disrupted. It causes uncontrolled repetitive spontaneous discharges along the nerve. Uncoordinated muscle tremors and twitches are characteristic symptoms. The chlorinated cyclodienes act on the GABA receptors which function as a channel for chloride ions through the nerve membranes. They bind to the GABA receptors and reduce the flow of chloride ions. Typical symptoms include convulsions.

(return to top)



#### **PCBs (return to top)**

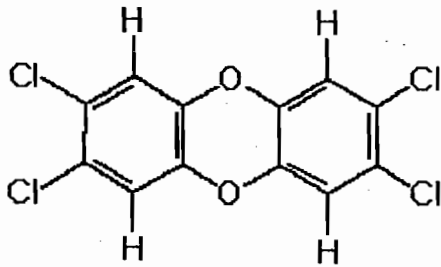


PCBs (polychlorinated biphenyls) were first introduced into commerce in 1929 and became widely used in electrical transformers, cosmetics, varnishes, inks, carbonless copy paper, pesticides and for general weatherproofing. They are used as fire-resistant coatings to wood and plastic. Because PCBs degrade very slowly in the environment and build up in the food chain. They have been banned from further production in many countries. There are 209 different PCB compounds called congeners. A congener may have between 1 and 7 chlorine atoms.

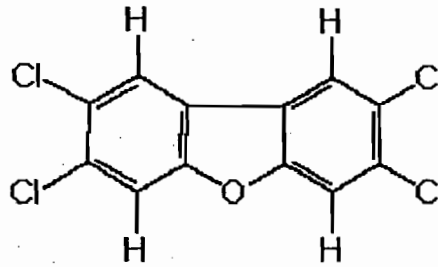
chlorine atoms, which may be located at various positions on the PCB molecule.

*Hydrocarbons*  
ortho-PCBs, are congeners of PCBs that have one or more chlorines in ortho-position (positions 2 or 6). Non-ortho-PCBs can assume a completely flat (planar) conformation, which is close to that of dioxins. Chlorines in para-positions seem to be more easily biodegraded, thus ortho-congeners are present in the environment at higher concentrations than non-ortho congeners.

### Dioxin (return to top)



2,3,7,8-TCDD

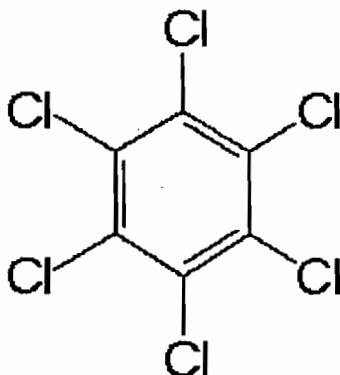


2,3,7,8-TCDF

Dioxin is the popular name class of organochlorines known as polychlorinated dibenzodioxins (PCDDs) or dibenzofurans (PCDF). The entire "dioxin" family consists of 75 different dioxins and 11 different furans.

*Chlorinated Hydrocarbon*  
Dioxins and furans are by-products of the production of certain chemicals (such as those used to produce some pesticides and wood preservatives), of the chlorination process used in some pulp and paper mills, and of the incomplete combustion of materials that contain both chlorine atoms and organic matter. Although they are most often associated with industrial activities, some natural occurrences such as forest fires are believed to make a small contribution to the presence of dioxins and furans in the environment.

The dioxin 2,3,7,8-tetrachloro-p-dibenzo-dioxin (2,3,7,8-TCDD) is the most toxic of the dioxins and furans. The toxicity of mixtures of dioxins and furans is usually expressed in terms of this substance, that is, in terms of 2,3,7,8-TCDD toxic equivalents (TCDD EQs or TEQs) which is the concentration of 2,3,7,8-TCDD that would be expected to produce the same type and degree of response as the chemicals involved. In egg yolk extracts this is measured using the H411E-extract bioassay.



### HCB (hexachlorobenzene)- (return to top)

*Chlorinated Hydrocarbon*  
HCB has been used extensively in Australia as a fungicide for the protection of grain in storage. It also occurs as a contaminant in the production of other chlorinated solvents (eg carbon tetrachloride) and in the production of nitroso-rubber for tires so it can enter the environment via surface runoff from roads.

### Chlorophenols- (return to top)

Chlorophenols are synthetic organic compounds which have fungicidal and bactericidal properties. They



primarily been used for long-term wood preservation and for short-term wood protection to control sap and mold on freshly cut lumber. Two of the main members of this family used for wood preservation are pentachlorophenol (PCP) and tetrachlorophenol (TCP).

### Organophosphates (return to top)

Organophosphates (OPs) is a generic term to include all the insecticides containing phosphorus. They are often called organic phosphates, phosphorus insecticides, nerve gas relatives, phosphates, phosphate insecticides, and phosphorus esters or phosphoric acid esters. They are all derived from phosphoric acid and are generally the most toxic of all pesticides to vertebrate animals. They are chemically unstable so they virtually replaced the persistent organochlorine compounds. They exert their toxic action by inhibiting the cholinesterase enzymes of the nervous system which results in the accumulation of acetylcholine. This interferes with neuromuscular junctions producing rapid twitching of the voluntary muscles and eventual paralysis.

There are three main groups of organophosphates:

Aliphatic are simple phosphoric acid derivatives bearing short carbon chains. Some of these are malathion, trichlorfon, monocrotophos, dimethoate, dicrotophos, oxydemetonmethyl, disulfoton, dichlorvos, mevin methamidophos, and acephate.

Phenyl derivatives contain a benzene ring with one of the ring hydrogens displaced by attachment to phosphorus and others are frequently displaced by other groups. These are generally more stable than aliphatic OPs so their residues are longer lasting. Some of these are parathion, stirofos, profenophos, sulprofos, and isofenphos.

*used in Agent Orange & in cleaning solvents for guns and other metals.*

Heterocyclic derivatives contain ring structures which are composed of different or unlike atoms. One or more of the carbon atoms is displaced by oxygen, nitrogen, or sulfur and their rings may have three, five or six atoms. Some of these are diazinon, azinphosmethyl, chlorpyrifos, methidathion, phosmet, and dialif. These are complex molecules and generally have longer lasting residues than many of the aliphatic or phenyl OPs. They also have many breakdown products which makes it difficult to measure their residues in the laboratory.

### Carbamates (return to top)

The carbamate are derivatives of carbamic acid. They also inhibit the enzyme cholinesterase. These insecticides have very low mammalian oral and dermal toxicity and they can be used for a broad spectrum insect control.

### Hydrocarbons (return to top)

Hydrocarbons are compounds that contain only carbon and hydrogen. They are classified as aliphatic or aromatic. Aliphatic hydrocarbons are not linked together to form a ring. Compounds include the alkanes, alkenes, and alkynes, and substances derived from them by replacing one or more hydrogen atoms by one or more of other elements or groups of atoms. Aromatic hydrocarbons have elements linked together in rings.

Polycyclic aromatic hydrocarbons (PAHs) are a family of chemical compounds made up of carbon and hydrogen atoms, with a molecular structure consisting of at least two fused aromatic rings, each with five or six carbon atoms. The PAH family includes about 100 substances, differing in the number and position of rings.

PAHs are generally formed from the incomplete combustion of organic matter. Today, most of the PAHs present in the environment come from human activities. PAHs can enter the aquatic environment directly through industrial and municipal effluents, accidental crude oil spills and PAH emissions from creosote materials used in water (for example, on pilings). Nearly all types of organic fuel combustion can produce PAHs. The most important sources are the incomplete combustion of fossil fuels from domestic heating systems and transportation (car exhaust fumes), garbage incineration, aluminum reduction smelting for aluminum production, catalytic cracking of crude oil and coal liquefaction and gasification. All these human activities release PAHs into the atmosphere, where they tend to adhere to particles in suspension, some of which will enter the aquatic environment through atmospheric fallout. Owing to their low solubility and affinity for particulate matter, PAHs are not usually found in water in notable concentrations. Their presence in surface water or groundwater is an indication of a source of pollution.

### Inorganics: (return to top)

Arsenic	A relatively common element that occurs in air, water, soil, and tissues. Large quantities are released each year as a result of agricultural and industrial activities. Large quantities may be hazardous to fish and wildlife. It is present in water contaminated by mine tailings, smelter v and natural mineralizations. (return to top)
Cadmium	A heavy metal released into the environment in a variety of ways such as smelting, burning c and oils, and from wear of vehicle tires. Effects of cadmium poisoning include bone damage suppressed egg production, eggshell thinning in birds and kidney damage. (return to top)
Chromium	At high concentrations chromium is a mutagen and a carcinogen. It is introduced into the environment from sewage and solid wastes. (return to top)
Copper	Copper is an essential element for many animals and is a component of many metalloenzyme respiratory pigments. It is one of the the most common contaminants found in urban runoff. generally more toxic to aquatic organisms than to birds or mammals. (return to top)
Lead	All measured effects of lead are adverse. It reaches the aquatic environemnt through industr municipal discharges, atmospheric deposition, weathering processes and highway runoff. It usually inhibits the formation of heme, and adversely affects blood chemistry. It way also ca neurological effects such as degenerative lesions present in the meylin of brachial nerves. (re to top)
Mercury	Mercury is a metal that can exist in a range of organic and inorganic forms with varying degr toxicity. It is a mutagen, teratogen, and a carcinogen and causes embryocidal, cytochemica histopathological effects. In aquatic organisms it adversely affects reproduction, growth, bel osmoregulation, and oxygen exchange. It may also cause kidney lesions, neurological dama and reduced food intake leading to weight loss, progressive weakness in wings and legs and inability to coordinate muscle movements in marine birds. It can enter the environment thro industrial and domestic coal combustion, waste incineration, gold mining, and the dumping o sewage sludge. (return to top)
Nickel	Nickel enters the environment as a contaminant through mining and smelting operations, combustion of fossil fuels, and other industrial processes. It has been shown that when injec chicken eggs the nickel produced embyronic malformations and death. (return to top)
Selenium	Selenium has the ability to bioaccumulate in aquatic food chains and thereby contaminate the and induce reproductive effects in fish and birds. One source is the weathering of rocks. Tv major human related causes are the processing and combustion of fossil fuels and the irrigati seleniferous solids or with selenium contaminated water. Sensitivity to selenium vaies from class of organisms to another. (return to top)
Zinc	Zinc is required for normal growth and development in animals. Excess zinc may suppress o

ZINC inhibit tumor proliferation and can be teratogenic to frog and fish embryos. [\(return to top\)](#)

The structural formulas on this page came from the [UNEP Chemical site for Persistent Organic Pollutants](#)





## Chemical Properties

Agent PURPLE	A formulation of <u>2,4-D</u> and <u>2,4,5-T</u> used between 1962 and 1964.
Agent GREEN	Contained <u>2,4,5-T</u> and was used 1962-1964.
Agent PINK	Contained <u>2,4,5-T</u> and was used 1962-1964.
Agent ORANGE	A formulation of <u>2,4-D</u> and <u>2,4,5-T</u> used between 1965 and 1970.
Agent WHITE	A formulation of <u>Picloram</u> and <u>2,4-D</u> .
Agent BLUE	Contained <u>cacodylic acid</u> .
Super ORANGE	A formualtion of <u>2,4-D</u> and <u>2,4,5-T</u> used in 1968 and 1969
DINOXOL	A formulation of <u>2,4-D</u> and <u>2,4,5-T</u> . Small quantities tested in Vietnam 1962-1964.
TRINOXOL	Contained <u>2,4,5-T</u> . Small quantities tested in Vietnam 1962-1964.
BROMACIL	Small quantities were tested in Vietnam, 1962-1964.
DIQUAT	Small quantities were tested in Vietnam, 1962-1964.
TANDEX	Small quantities were tested in Vietnam, 1962-1964.
MONURON	Small quantities were tested in Vietnam, 1962-1964.
DIURON	Small quantities were tested in Vietnam, 1962-1964.
DALAPON	Small quantities were tested in Vietnam, 1962-1964.

Reference: <http://www.lewispublishing.com/herbs1.htm>

## Summary By Chemical Agent

(Herbicide drums were identified by a 4-inch-wide circular band of paint colored in correspondence with these color codes.)

CHEMICAL AGENT	TOTAL GALLONS PROCURED BY DOD	TOTAL GALLONS USED	PERCENT OF TOTAL USED	TOTAL GALLONS REMAINING
Green	8,208	8,208	0.04%	0
Pink	122,792	122,792	0.6%	0
Purple	145,000	145,000	0.7%	0

Blue	2,166,656	2,166,656	11.2%	0
White	5,600,000	5,239,853	27.0%	360,147
Orange	13,927,985	11,712,860	60.4%	2,215,125
<b>TOTAL:</b>	<b>21,970,641</b>	<b>19,395,369</b>		<b>2,575,272</b>

The 15,480 drums of agent orange stockpiled at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi were transferred to the Dutch-owned ship the Vulcanus and destroyed between 15-24 July 1977.

The 24,795 drums of agent orange stored on Johnston Island were subsequently incinerated on the Vulcanus in two loads.

The last of the herbicide orange once destined for the jungles of Vietnam burned on September 3, 1977.

Reference: <http://www.gmlink.com/arison/orange.html>

### 2,4-D

Synonyms:	2,4-Dichlorophenoxyacetic Acid
Trade Names:	Weedtrine-II, Aqua-Kleen, Barrage, Plantgard, Lawn-Keep, Planotox and Malerbane.
Status:	Still in use. The product carries the DANGER signal word on the label indicating that it is highly toxic.
Organ Toxicity:	Most symptoms disappear within a few days but there is a report of liver dysfunction from long term exposure.
Reference:	<a href="http://www.24d.org/">http://www.24d.org/</a> <a href="http://pmep.cce.cornell.edu/profiles/extoxnet/24d-captan/24d-ext.html">http://pmep.cce.cornell.edu/profiles/extoxnet/24d-captan/24d-ext.html</a>

### 2,4,5-T

<b>Synonyms:</b> ✕	2,4,5-Trichlorophenoxyacetic acid ✕ Acetic acid, (2,4,5-trichlorophenoxy)
<b>Trade Names:</b>	Weedone
<b>Status:</b>	The use of 2,4,5-T in the United States has been cancelled since 1985. As of January 1991, all uses were cancelled.
<b>Reference:</b>	<a href="http://www.speclab.com/compound/c93765.htm">http://www.speclab.com/compound/c93765.htm</a> <a href="http://pmep.cce.cornell.edu/profiles/fung-nemat/aceticacid-etridiazole/acetic-acid/acetic-acid-9-92-rereg.html">http://pmep.cce.cornell.edu/profiles/fung-nemat/aceticacid-etridiazole/acetic-acid/acetic-acid-9-92-rereg.html</a>

### Picloram

<b>Synonyms:</b> ✕	4-Amino-3,5,6-trichloro-2-pyridinecarboxylic acid
<b>Trade Names:</b> ✕	Grazon and Tordon
<b>Status:</b>	Use is restricted in the U.S. Requires the signal word CAUTION on its label.
<b>Reference:</b>	<a href="http://www.speclab.com/compound/c1918021.htm">http://www.speclab.com/compound/c1918021.htm</a> <a href="http://pmep.cce.cornell.edu/profiles/extoxnet/metiram-propoxur/picloram-ext.html">http://pmep.cce.cornell.edu/profiles/extoxnet/metiram-propoxur/picloram-ext.html</a>

### Cacodylic Acid

<b>Synonyms:</b> ✕	Hydroxydimethylarsine oxide
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<b>Trade Names:</b>	X Ansar 138, Arsan, Bolls-Eye, Broadside, Check-Mate, Cotton Aide HC, Moncide, Montar, Phytar, Phytar 138, Phytar 600, Rad-E-Cate 25, Dilic, Silvisar 510, Sylvicor.
<b>Status:</b>	Products containing cacodylic acid must bear the signal word "Caution"
<b>Reference:</b>	<a href="http://pmep.cce.cornell.edu/profiles/extoxnet/24d-captan/cacodylic-acid-ext.html">http://pmep.cce.cornell.edu/profiles/extoxnet/24d-captan/cacodylic-acid-ext.html</a> <a href="http://pmep.cce.cornell.edu/profiles/herb-growthreg/cacodylic-cymoxanil/cacodylic-acid/herb-prof-cacodylic-acid.html">http://pmep.cce.cornell.edu/profiles/herb-growthreg/cacodylic-cymoxanil/cacodylic-acid/herb-prof-cacodylic-acid.html</a>

X  
Dinoxol

<b>Synonyms:</b>	
<b>Trade Names:</b>	
<b>Status:</b>	
<b>Reference:</b>	<a href="http://hammock.ifas.ufl.edu/txt/fairs/15470">http://hammock.ifas.ufl.edu/txt/fairs/15470</a> <a href="http://www.vvaa.org.au/chemicals.htm">http://www.vvaa.org.au/chemicals.htm</a>

X  
Trinoxol

<b>Synonyms:</b>	X 2,4-D ✓ (2,4-Dichlorophenoxy)acetic acid X Hedonal
<b>Trade Names:</b>	
<b>Status:</b>	
<b>Reference:</b>	<a href="http://www.inweh.unu.edu/447/waterguidelines/casname2.html">http://www.inweh.unu.edu/447/waterguidelines/casname2.html</a>

Bromacil

Synonyms:	<p>✓ 5-Bromo-3-sec-butyl-6-methyluracil</p> <p>× Borea</p> <p>✓ Bromax</p> <p>× Urox 'B'</p>
Trade Names:	<p>✓ Borea, Bromax 4G, Bromax 4L, Borocil, Rout, Cynogan, Uragan, Isocil, Hyvar X, Hyvar XL, Urox B, Urox HX, Krovar.</p>
Status:	Still in use.
Toxicity:	Liquid formulations of bromacil are moderately toxic.
Reference:	<p><a href="http://www.speclab.com/compound/c314409.htm">http://www.speclab.com/compound/c314409.htm</a></p> <p><a href="http://pmep.cce.cornell.edu/profiles/extoxnet/24d-captan/bromacil-ext.html">http://pmep.cce.cornell.edu/profiles/extoxnet/24d-captan/bromacil-ext.html</a></p>

Diquat

Synonyms:	<p>✓ 1,1'-ethylene-2,2'-dipyridylum</p> <p>✓ 6,7-Dihydrodipyrido[1,2-a:2',1'-c]pyrazinedium</p>
Trade Names:	<p>✓ Aquacide, Dextrone, Reglone, Reglox, Weedtrine-D, Aquakill, Vegetrole, Deiquat, Reglon, Tag.</p>
Status:	Still in use. As a moderately toxic material, containers of diquat bear labels with the signal word, "WARNING"
Toxicity :	Cataract formation is the most significant effect of chronic exposure to diquat that is currently recognized. Poisoning by diquat may affect the liver and kidneys. Dehydration.
Reference:	<p><a href="http://pmep.cce.cornell.edu/profiles/extoxnet/dienochlor-glyphosate/diquat-ext.html">http://pmep.cce.cornell.edu/profiles/extoxnet/dienochlor-glyphosate/diquat-ext.html</a></p> <p><a href="http://www.epa.gov/OGWDW/dwh/t-soc/diquat.html">http://www.epa.gov/OGWDW/dwh/t-soc/diquat.html</a></p>

Tandex

<b>Synonyms:</b>	X karbutilate X CGA 61837
<b>Trade Names:</b>	
<b>Status:</b>	
<b>Reference:</b>	<a href="http://www.v-c-g.com/agranova/herbhist.htm#Synopsis">http://www.v-c-g.com/agranova/herbhist.htm#Synopsis</a>

Monuron

<b>Synonyms:</b>	X Urea, N'-(4-chlorophenyl)-N,N-dimethyl- X CMU X 1-(4-Chlorophenyl)-3,3-dimethylurea X Telvar
<b>Trade Names:</b>	Monurex
<b>Status:</b>	Registration with EPA for use as a herbicide was cancelled in 1977; may still be manufactured for export.
<b>Reference:</b>	<a href="http://www.speclab.com/compound/c150685.htm">http://www.speclab.com/compound/c150685.htm</a> <a href="http://pmep.cce.cornell.edu/profiles/herb-growthreg/fatty-alcohol-monuron/monuron/herb-prof-monuron.html">http://pmep.cce.cornell.edu/profiles/herb-growthreg/fatty-alcohol-monuron/monuron/herb-prof-monuron.html</a>

X Diuron

Synonyms: X	3-(3,4-Dichlorophenyl)-1,1-dimethylurea
X	DCMU
Trade Names:	Di-on, Crisuron, Diater, Karmex, and Unidron.
Status:	Still in use.
Reference:	<a href="http://www.speclab.com/compound/c330541.htm">http://www.speclab.com/compound/c330541.htm</a> <a href="http://pmep.cce.cornell.edu/profiles/extoxnet/dienochlor-glyphosate/diuron-ext.html">http://pmep.cce.cornell.edu/profiles/extoxnet/dienochlor-glyphosate/diuron-ext.html</a>

### Dalapon

Synonyms: X	2,2-Dichloropropanoic acid
Trade Names: X	Dowpon, Basinex P, Devipon, Gramevin, Kenapon, Liropon, Unipon, Dalapon-Na (Dalapon-Sodium), Revenge, AlateX, Ded-Weed, DPA, Dalacide, Radapon.
Status:	Still in use. Containers of the herbicide must bear labels with the EPA warning word "CAUTION."
Reference:	<a href="http://www.speclab.com/compound/c75990.htm">http://www.speclab.com/compound/c75990.htm</a> <a href="http://pmep.cce.cornell.edu/profiles/extoxnet/carbaryl-diclotophos/dalapon-ext.html">http://pmep.cce.cornell.edu/profiles/extoxnet/carbaryl-diclotophos/dalapon-ext.html</a>

These chemicals to be added soon:

BINOCTAL

X  
CHLORDANE

DAPSONE

DDT

DEET (Diethyl Toluamide)

EPA

LINDANE

~~MALATHION~~

UROX 22

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