



DDT and DDE:

Sources of Exposure and How to Avoid Them

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SUMMARY

Recent work by the Centers for Disease Control (CDC) on the leukemia cluster investigation in Churchill County, Nevada found the chemical DDE in relatively high concentrations in urine samples. DDE is produced by natural degradation of the pesticide DDT. The pesticide has been out of use in the United States for more than three decades, but it persists in the environment, especially in soil. Exposure to DDT, and DDE occurs mostly from eating foods containing small amounts of these compounds, particularly meat, fish and poultry. People may also come into contact with DDT residues in airborne dust. This publication discusses **DDE and DDT** and **where these chemicals are most likely to be found in the environment**. It also discusses the health implications of exposure to DDE and DDT. Finally, the publication offers advice about how to avoid exposure to DDT and DDE and how to dispose of leftover stocks of pest control chemicals.

Background

DDT and DDE - What they are

A German chemistry student first developed DDT in 1873. However, there was no known use for the compound. In 1939, Paul Muller of Geigy Pharmaceuticals in Switzerland discovered the usefulness of DDT as an insecticide while working on a project to develop an alternative to mothballs. Because of the application for controlling disease-bearing insects, he was awarded the Nobel Prize in medicine and physiology in 1948 (7). The first large-scale application of DDT was in Naples, Italy in WW II where it was used to stop a typhus epidemic (11). DDT, with low acute toxicity to warm blooded animals, broad spectrum efficiency, long residual effects (6), and very low toxicity to plants appeared at the time to be the perfect pesticide for household and agricultural use (4).

After World War II, use of DDT surged, especially for controlling mosquitoes that carried malaria and lice that transmitted typhus. It has been estimated by the World Health Organization that up to twenty five million lives were saved by the use of DDT to combat these pests (7). By using DDT and other insecticides against the mosquitoes that carry malaria, India was able to dramatically lower the rate of mosquito-borne infections in rural populations (11). Unfortunately DDT was so extensively applied that some of the target insects developed resistance. By 1984 as many as 233 species of insects were resistant (13). Concerns about its persistence in the environment and possible health effects from bioaccumulation (9), (13) led to restrictions and bans throughout the world. Countries that restricted or banned the pesticide include Australia in 1967, Sweden and Cuba in 1970, the United States in 1972, Germany in 1974, Poland in 1976, the United Kingdom in 1984, Chile in 1985, South Korea and Switzerland in 1986, and Canada in 1989. Internationally, DDT remains in use for agricultural purposes and mosquito control. It is still commercially manufactured in China, India, Indonesia, and possibly Mexico.



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In a pure state, DDT is a cream-white to pale-yellow waxy solid with a fruity, almond-like odor. The technical chemical name for the compound is **Dichlorodiphenyltrichloroethane** (1). DDE forms from DDT after application, as a result of environmental processes

(continued inside)

that degrade the original chemical form. The technical chemical name for DDE is **Dichlorodiphenyldichloroethylene**.

For use as a dusting powder DDT is mixed with talc, diatomaceous earth, or rock dust and then milled to a fine powder. These materials are inert and they do not absorb water easily from the air. DDT formulations that are used as a liquid are compounded with kerosene, trichloroethylene, or mineral oil. If the liquid material is to be mixed with water, a detergent is added to mix the DDT into a solution. Wettable powders are finely ground mixtures of DDT, a material to prevent clumping and an emulsifying agent. Home aerosol formulations use a solvent such as kerosene or trichloroethyl-

ene and, for pressurized sprays, a propellant such as vinyl chloride, Freon, or propane.

USE

Between its first successful commercial applications in WW II and the severe usage restrictions in 1972, DDT was commonly used in households and agriculture because it does not wash off readily with water. It was the active ingredient in many aerosol fly sprays and a key ingredient in vegetable dusts and lawn and garden sprays. It was incorporated in plastic kitchen shelf linings to keep weevils out of food and applied to home carpets to prevent flea infesta-

Some trade names, forms and uses for products that contained DDT (3), (4), (8), (9), (12), (15)

| TRADE NAME | FORM | USE |
|---|-------------------|--|
| Agritan | Dust | Seed preservative |
| Aerocide Aerosol Fly Spray | Aerosol | Household flying insect spray |
| Anofex | Wettable Powder | General insecticide |
| Boracure | Liquid | Liquid insecticide and tree paint ingredient |
| Bosan | Liquid | Wood preservative |
| Bovidermal | Liquid | Cattle dip |
| Chlorophenothane | Wettable Powder | General insecticide |
| Chlorophenotoxum | Wettable Powder | General insecticide |
| Coopers Cabbage Dust | Dust | Home garden insecticide |
| Coopers Lawn Food | Granular | Insecticidal lawn fertilizer |
| Coopers Mothaire | Flake | DDT version of mothballs |
| Deo 5 Garden Dust | Dust | Home garden insecticide |
| Deoval Wettable | Powder | General Insecticide |
| Dicophane | Dust | Miticide |
| Digmar | Liquid | General insecticide |
| Dykol | Granular | Miticide |
| Estonate | Wettable Powder | Additive to dormant oil for use in orchards |
| Genitox | Liquid | General insecticide |
| Gesarol | Dust | The original delousing powder of World War II |
| Harrisons Bulb Booster | Liquid | Home garden fertilizer |
| Harrisons Manure for Acid Loving Plants | Dark Brown Powder | Home garden fertilizer |
| Isodete Grub Dust | Dust | Home garden soil treatment |
| Isodex | Liquid | General Insecticide |
| Keatings Flea Powder | Dust | Flea powder for dogs |
| Kopsol | Powder | Seed treatment |
| Mutoxan | Wettable Powder | General insecticide |
| Neocid | Liquid, Aerosol | Soil fumigant, home fly spray |
| Ruskseam | Liquid | General insecticide |
| Shell Grass Grub Concentrate | Granular | Insecticide for lawns |
| Trimort Carpet Preserver | Dust | Combination deodorant and insecticide for wool carpets |
| Tartan Vegetable Dust | Dust | Home garden insecticide |
| Woolworths Fly Spray | Aerosol | Home fly spray |
| Zerdane | Liquid | General insecticide |

tions (3). The annual usage of DDT in the United States reached a peak of about 36,000 tons in 1959. Peak production occurred in 1963 when 81,000 tons were produced, most of which went to export markets (13). DDT has not been banned entirely in the United States. It is still registered for emergency health purposes, to control mosquitoes that carry malaria and yellow fever. There are also regulated formulas available by prescription in which DDT is one of the ingredients used to control body lice.

DDT IN THE ENVIRONMENT

DDT and DDE persist in the environment, especially in soils in areas treated with DDT in the past. DDT is also volatile and can be evaporated and transported away from application sites as a gas. Neither dissolves well in water and they combine quite strongly with soil particles. As a result these compounds concentrate in sediments and can be transported from application sites as dust and eroded sediment carried by water. These chemicals are very rarely found in groundwater samples, because the chemical is only slightly soluble in water and is more likely to stick to soil particles than to flow with groundwater in an aquifer. Because DDT and DDE do not degrade quickly in the environment, the amounts that may be left behind from applications that ceased three decades ago may be significant.

DDT in Air

DDT can be found in air as a gas or in small aggregations of dust particles. In warm weather the chemical may evaporate after application and be spread long distances by the atmosphere as a gas. For example, tests conducted in Arizona showed that six months after application, DDT was detected in the air above a field and up to 50% of the DDT evaporated out of the soil within 5 months. Similar studies conducted in Medford, Oregon (where the climate is cooler, damper and soils generally have more organic matter than in Arizona) found that only 17% to 18% of the DDT evaporated over a five-year period (9). As a vapor, DDT has a half-life of 2 days (8). In other words if 1 pound of DDT were evaporated today, in two days 1/2 pound of DDT vapor would remain, and the rest would be degraded to other compounds.

DDT in Soil:

DDT and DDE are usually concentrated in the top few inches because of their low solubility and tendency to strongly attach to soil particles, including organic matter (4). When applied to soil DDT is digested by bacteria and slowly converted into DDE (5), which is even more persistent in the environment and at least as toxic as DDT (4). Under the proper conditions, biological destruction of DDT will remove it from the natural soil system, though this does not occur quickly. DDT and DDE degrade more rapidly in warm, damp conditions in soils with little sulphate. Studies have shown that DDT has a half-life in the soil of between 2 and 15 years (8), depending upon moisture and temperature conditions. This means that if one pound of DDT

were applied to the soil in 1972, between a negligible amount and 23% of the original amount would be left in 2003. A study showed that six years after DDT was banned there was a 90% reduction in the DDT content of fish in Lake Michigan (7).

DDT in Plants

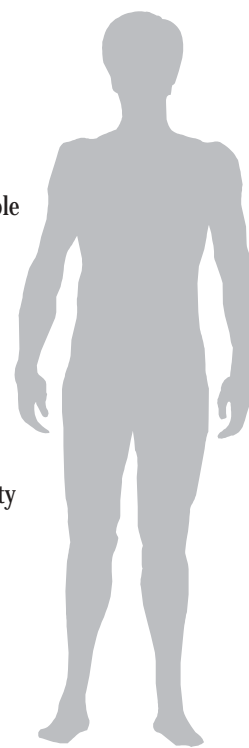
Studies have shown that plants growing in soils that contain typical levels of DDT in general do not uptake or store DDT and DDE in their tissues. DDT and DDE were not found in alfalfa grown on DDT treated soils and only trace amounts were found in carrots, radishes, and turnips grown in these same soils. There was some accumulation of DDT reported for corn, rice, and wheat but the material was found in the roots, not the grain (9).

HUMAN HEALTH ISSUES: DDT in the Body

When humans ingest DDT the amount of the chemical actually absorbed into the body is dependent upon what the DDT is mixed with when ingested. DDT and DDE are more soluble in fats and oils and are more available when mixed with these materials (9). Due to their relative insolubility in water compared with oils, DDT and DDE tend to be concentrated in fat deposits in the body (4). These chemicals are poorly absorbed in the gastrointestinal system when ingested in a chemically pure form. DDT and DDE are typically found in fatty tissues at levels several hundred times that found in the blood (9). Because humans consume foods high in fats and oils (meat, milk, and eggs) DDT and DDE began to be detected in humans in the 1950's and 60's, with unknown health implications.

Once absorbed into the body the liver slowly metabolizes these chemicals and, over time, converts them to water-soluble compounds that are excreted in urine. Once DDT is absorbed into the body it has a half-life of 8 years. In other words if a gram of DDT were absorbed into body fat, after eight years half a gram would remain (7). If a person had 1 gram of DDT in their body in 1972 (when most uses of DDT in the United States were banned) and was not exposed to any additional DDT in their ensuing years from dietary sources, they would still have 0.12 grams of DDT in their body fat in 1996 and would retain 0.06 grams by 2004.

Although there is serious debate about the chronic toxicity of DDT in humans and its effects on other mammals, there is no doubt that it is highly toxic to insects and other cold-blooded species, including most fish. Some of the medical conditions that have been tentatively linked to DDT exposure by some studies include breast



cancer, reproductive difficulties, and changes to the nervous system. (5), (11), (14), (15). DDT has been shown, like many other synthetic organochlorine chemicals, to act as an endocrine disruptor in numerous studies. (20), (21), (22). An endocrine disruptor is a chemical that can interfere with, or take the place of, naturally occurring hormones in the human body. Many of these compounds have been associated with developmental, reproductive, and other health problems in wildlife and laboratory animals at some concentrations. Some experts suggest that these compounds may also affect humans in a similar way (22). A major difficulty in interpreting these studies is that humans are exposed to a significant and varying background of naturally occurring endocrine disruptors known as phytoestrogens in their normal diet. Natural phytoestrogens are found in at least 300 plants from 16 different plant families. Dietary sources of these compounds include soybeans, wheat, rice, carrots, potatoes, apples, cherries, garlic, parsley, and coffee (22). Plants produce these chemicals as a natural pesticide to help protect themselves from insect and disease attacks.

DDT, like many other synthetic and natural endocrine disruptors, may be linked to reproductive disorders, impaired immune system responses, liver damage and some cancers when found in sufficient concentrations in the environment (10), (14), (22).

EXPOSURE

The most common exposure to DDT and DDE in the United States is through food consumption. It has been out of general use in the United States for slightly more than three decades. Residues are most likely to be found on fruits and vegetables that are imported from tropical regions where agricultural usage is permitted and prevalent. As an example, a shipment of jasmine tea from China was tested upon arrival in Spain in 2000 and found to contain residual DDT at a level of 0.38 ppm, which is far in excess of the European standard of 0.20 ppm (2). Tissue storage of DDE in the general population results almost entirely from dietary DDE intake rather than DDT converting to DDE in the body (8). Currently it is estimated that the average daily intake of DDT and DDE in the United States is 0.002 milligrams per day or about 0.7 milligrams a year (9).

DDT and DDE are most likely to be found in:

- ◆ Contaminated imported foods, such as root crops and leafy vegetables, fatty meats, fish, and poultry, especially from countries that still allow the use of DDT to control pests.
- ◆ Contaminated air, dust and water near waste sites and landfills that contain high levels of these chemicals.
- ◆ Breast milk from mothers who have been exposed (19).

Health effects of exposure to DDT and DDE

DDT and DDE mostly affect the nervous system. If someone ingests enough DDT or DDE, they may suffer an acute effect. Early signs of poisoning include tingling in the face, hands and feet,

headache, dizziness, nausea, vomiting, incoordination, and tremors. When exposure stops, these symptoms abate. People who worked with DDT for a long time also had some changes in liver enzymes, but their condition improved after their exposure was eliminated. In animal studies, short term exposure to large amounts of DDT damaged the nervous system and over a longer period resulted in liver damage. Laboratory animal studies also indicated that short-term exposure to DDT might harm reproduction (8).

DDT and DDE exposure could possibly cause cancer in humans. This is based upon several studies in animals and humans (9), (10), (13), (22). Other studies however, have shown no such link (10), (11), (15), (22). Liver cancer occurred in lab mice that were fed large amounts of DDT. Some studies in humans linked DDT levels in the body with breast cancer while other studies have not made this link (10), (11), (14). Other studies in humans have suggested that exposure may be linked to lymphoma, leukemia, and pancreatic cancer. However, no definitive association with exposure to DDT or DDE and illness with these cancers have been made (10). Industrial workers heavily exposed to DDT during its manufacture and compounding have not had a higher incidence of cancer than workers not exposed to DDT (8). Hospital examinations of workers in DDT manufacturing plants showed no abnormalities that could be related to DDT even though their body fat contained up to 648 ppm DDT (15).

Preventing exposure

In Churchill County, DDT and DDE were not found in residential dust samples and were found in local soil samples at levels below those of regulatory concern (17). DDE was found in 15 of 29 local sediment samples while DDT was found in 3 of these samples (18). Of 79 soil samples obtained from residential settings in Churchill County, 23 had detectable levels of DDE and 10 had detectable levels of DDT. It would appear that DDT and DDE residues found in samples of local residents' blood are of a historic origin, from somewhere in the food supply or as a result of past application practices. The CDC's study indicated that the only significant source of environmental DDT and DDE was found to be the sulphidic muds of the drain ditches. This is to be expected as the last remaining source of environmental exposure because the biological degradation of DDT and DDE is inhibited by the ample levels of sulphate and sulphide found in the drains. In general, contact with these ditches is avoided because they are full of mosquitoes, tend to be overgrown, and the sulphidic mud has a disagreeable odor.



Because plants do not take up DDT, washing fruit and vegetables will remove most DDT from their surface.

In general, most families will be exposed to DDT by eating food or drinking liquids contaminated with small amounts of DDT. Several steps can be taken to reduce the amount of DDT and DDE ingested in this way. First, cooking reduces the amount of DDT in fish (19). Also, because most food crops do not uptake DDT from the environment at levels of concern, washing fruits and vegetables prior to consumption will remove the majority of any residual levels that may be present. Finally, it is not always possible to determine where food in the supermarket comes from, but if possible follow health advisories that tell you about consumption of fish and wildlife caught in areas known to be contaminated with DDT or where DDT is applied as part of crop production. Current information on health advisories related to the consumption of fish and wildlife can be obtained from the Nevada Division of Wildlife. The division has local phone numbers in Elko: 775-777-2300, Fallon: 775-423-3171, Las Vegas: 702-486-5127, and Reno: 775-688-1500.

DISPOSING OF PESTICIDES THAT MAY CONTAIN DDT

Many homeowners and business owners have accumulated pesticides that they no longer need or can use. Because of the popularity and widespread usage of DDT and because it was banned from general distribution in 1972, leftovers may have been stored and forgotten. Home and business owners may find stocks of products, particularly when homes or businesses change hands. Because DDT is banned from general use, it is important to make arrangements to dispose of old stocks. You may make arrangements for disposal of banned or waste pesticides by calling the Nevada Department of Agriculture. They will help you to remove unusable stocks of unregistered or leftover pesticide free of charge.

For further information, advice, or help:

Call the State of Nevada Department of Agriculture (775) 688-1180.

The Department has the following local offices:

| | |
|------------|----------------|
| Reno | (775) 688-1180 |
| Winnemucca | (775) 623-6501 |
| Las Vegas | (702) 486-4690 |
| Elko | (775) 738-8076 |

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Glossary

ATSDR: Agency for Toxic Substances and Disease Registry is directed by congressional mandate to perform specific functions concerning the effect on public health of hazardous substances in the environment. These functions include public health assessments of waste sites, health consultations concerning specific hazardous substances, health surveillance and registries, response to emergency releases of hazardous substances, applied research in support of public health assessments, information development and dissemination, and education and training concerning hazardous substances.

Absorb: To take up liquid or other matter.

Bioaccumulation: The process by which organisms accumulate chemicals or elements directly from their environment.

Compounding: To combine to form a whole; mix.

DDE: (Dichlorodiphenyldichloroethylene): A chemical similar to DDT that contaminates commercial DDT preparations. DDE has no commercial use. DDE enters the environment as a contaminant or breakdown product of DDT.

DDT: (Dichlorodiphenyltrichloroethane): A white, crystalline, water-insoluble solid, $C_{14}H_9C_{15}$ usually derived from chloral by reaction with chlorobenzene in the presence of fuming sulfuric acid. Used as an insecticide, a scabicide, and a pediculicide. Agricultural use prohibited in the U.S. since 1973.

Dissolve: To make a solution of.

Emulsifying: The process of creating a suspension of small globules of one liquid in a second liquid with which the first will not mix.

Excreted: To separate and discharge (waste matter) from the blood, tissues, or organs.

Extract: To obtain from a substance by chemical or mechanical action, as by pressure, distillation, or evaporation.

Evaporation: To convert or change into a vapor.

Fumigant: A chemical compound used in its gaseous state as a pesticide or disinfectant.

Gastrointestinal: Pertaining to the stomach and intestines.

Globules: A small spherical mass, especially a small drop of liquid.

Half-life: The time necessary for half of an initial amount of material to be removed from a system by transformation, biodegradation, biochemical degradation, or physical removal.

Inert: Unable to move or act. Not readily reactive with other elements; forming few or no chemical compounds.

Insecticide: A chemical substance used to kill insects.

Metabolize: The chemical processes occurring within a living cell or organism that are necessary for the maintenance of life. In metabolism some substances are broken down to yield energy for vital processes while other substances, necessary for life, are synthesized.

Pediculicide: An agent used to destroy lice.

Propellant: A compressed inert gas, such as a fluorocarbon, that acts as a vehicle for discharging the contents of an aerosol container.

Refrigerant: A substance, such as air, ammonia, water, or carbon dioxide, used to provide cooling either as the working substance of a refrigerator or by direct absorption of heat.

Scabicide: A drug that destroys the itch mite that causes scabies.

Solvent: A substance, usually a liquid, capable of dissolving another substance.

Solubility: The quality or condition of being soluble. The amount of a substance that can be dissolved in a given amount of solvent.

Suspension: The state in which the particles of a substance are mixed with a fluid, but are undissolved.

Trichloroethylene: A heavy, colorless, toxic liquid, C_2HCl_3 , used to degrease metals, as an extraction solvent for oils and waxes, as a refrigerant, in dry cleaning, and as a fumigant.

Uptake: An act of taking in or absorbing, especially into a living organism.

Vapor: The gaseous state of a substance that is liquid or solid under ordinary conditions.

Volatile: Evaporating readily at normal temperatures and pressures.

WHO: World Health Organization: A United Nations agency to coordinate international health activities and to help governments improve health services.

References for Glossary

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