SPRECHER INSTITUTE
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Program on Breast Cancer & Environmental Risk Factors

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TOPICS

*Pesticides and Breast Cancer Risk: An Evaluation of Dibromochloropropane (DBCP)**

Dibromochloropropane (DBCP) is a pesticide that was used for over 20 years to control worms that cause damage to crops and other plants. Though it is no longer used or produced in the United States (US), DBCP is still found in groundwater in areas with past high use. There is evidence that DBCP can cause mammary (breast) tumors in female rats, and it can cause damage to DNA. There have not been adequate studies done in humans to conclude whether or not DBCP causes breast cancer in people. More carefully done studies are needed to evaluate DBCP's cancer risk in humans. DBCP was banned by the US Environmental Protection Agency (US EPA) in 1977 after it was found to cause infertility in DBCP-exposed male workers, and because of its potential to cause tumors in the breast, lung and other organs in laboratory animals. While DBCP has been detected in the groundwater in several states, filtration systems can be used to remove DBCP from community and private drinking water sources. This fact sheet provides an overview of the cancer risk of DBCP, other health effects, its regulation by federal agencies, and areas in which more cancer research is needed. Information is also provided on where DBCP is found in the environment, and how to reduce exposure.

**The information contained in this fact sheet is derived from a longer BCERF technical assessment called a "Critical Evaluation." BCERF Critical Evaluations provide extensive review and critique of the available scientific literature on the potential risk for breast cancer for chemicals identified as potentially causing breast cancer.*

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CORNELL

What is DBCP and why was it chosen to be evaluated?

Dibromochloropropane, also known as DBCP, is a pesticide that was widely used on a variety of crops in the US between 1955 and 1977. As a fumigant, DBCP was injected into soil to control parasitic thread-like worms called nematodes that damage the roots of crops and other plants.

For many years DBCP was one of the most heavily used pesticides in the US, and it remains a groundwater contaminant in many places. In some areas, groundwater supplies are used for drinking water. It is important for scientists and the public to understand the health risks of pesticides that persist in the environment.

Does DBCP cause breast cancer in humans?

Currently there is not enough scientific information to determine whether or not DBCP causes breast cancer in people. Very few studies have been done on women who were exposed to DBCP. Of the studies that have included women, not enough women were included to be able to draw conclusions about breast cancer risk. Many studies did not control for other factors, called confounding factors, which affect breast cancer risk. Many studies also lack adequate information on exposure to DBCP. The following paragraphs summarize and discuss some of the few studies that have been done to date.

One study looked at whether DBCP exposure increased health problems, including cancer rates, in a small population in Kunia, Hawaii, on the island of Oahu. DBCP was found in the community's only source of drinking water. The study compared cancer rates between the residents of Kunia and residents of another town nearby that did not have DBCP in its drinking water. Results of the study showed a higher incidence of cancer in general (all types combined) in Kunia than in the similar community nearby. Information on actual levels of DBCP in the water was not reported. No information on specific types of cancer, such as breast cancer, was provided in the study.

Another study looked at cancer incidence in banana plantation workers in Costa Rica. All workers on banana company payrolls from 1972 to 1979 were included in the study. Of almost 35,000 workers, approximately 4,900 were women. Incidence of cancer among all of the workers was followed from 1981 to 1992. Higher rates of breast cancer were not found in female banana plantation workers when compared to the general public. No information on specific levels of exposure to DBCP was reported. There was a relatively short follow-up period for some workers. Ample follow-up time (thirty years or more) is necessary in order to accurately assess cancer risks.

Carefully conducted studies are needed in which women exposed to DBCP are matched with similar women who have not been exposed. To adequately assess the breast cancer risk of DBCP, a variety of factors must be considered. Specific exposure information is needed along with ample follow-up time. Large sample sizes are needed to control for confounding factors that may also affect breast cancer risk. These factors include age, timing of exposure, whether a woman has given birth, age at first birth, and exposure to other chemicals, including alcoholic beverages. Without thorough studies that take these factors into account, it is not possible to conclude whether or not exposure to DBCP increases breast cancer risk in humans.

Table 1. Chemical Information for Dibromochloropropane (DBCP)*

Type of pesticide: nematocide (for controlling parasitic worms)

Pesticide use: soil fumigant

Chemical name: 1,2-dibromo-3-chloropropane

First manufactured: 1955

Banned from production and use in the US: 1977 (except pineapples); 1985 (pineapple use banned)

Chemical Abstract Service (CAS) registry number: 96-12-8

Breakdown products in soil: *n*-propanol, bromide ion, chloride ion, allyl chloride, allyl alcohol

**Trade names and synonyms for DBCP are included at the end of this fact sheet.*

Does DBCP cause breast cancer in laboratory animals?

Studies using laboratory animals show that DBCP exposure causes mammary (breast) tumors in female rats. Different studies tested the effects of DBCP on rats and mice. DBCP was given to groups of rats and mice by mouth. In another study, groups of rats and mice were exposed to DBCP in the air.

Results showed clear evidence that female rats exposed

to DBCP by mouth had more mammary tumors than unexposed female rats. In addition, there was some evidence that female rats exposed to DBCP by air had more tumors than unexposed female rats. In mice, however, DBCP-exposed females did not have a greater number of mammary tumors than the unexposed control animals.

In these studies many animals died long before each study was complete. This reduced the possibility of observing cancers that form late in life including mammary tumors. Despite these limitations, these results do show that DBCP can cause mammary tumors in female rats exposed to DBCP by mouth.

Does DBCP cause other types of cancer in humans?

Researchers have also looked for potential associations between DBCP and other cancers in humans. Few studies, however, have found any association. The complexity of studying the effects of environmental factors in human populations makes it difficult to find clear associations.

Higher levels of cervical cancer were seen in female banana plantation workers compared to the general public in Costa Rica. However, these workers were likely exposed to other chemicals in addition to DBCP. Specific information on worker exposure to DBCP and other chemicals was not available.

Another study assessed cancer death rates in over 1,000 male chemical manufacturing plant workers. These workers may have been exposed to other chemicals in addition to DBCP. Workers exposed to DBCP did not have generally higher death rates or higher rates of death specifically from cancer than unexposed workers. No women were included in the study, so cancers found most often in women, such as breast cancer, were overlooked.

Another study also compared death rates of chemical workers who were likely exposed to DBCP (exact exposure data was not available). The gender breakdown of this group of workers was not specified in the study. Higher death rates were not observed in workers exposed to DBCP when compared to overall US death rates for white men. A ten-year follow-up to this study with the same group of workers also did not find any increases in most cancers. One exception was higher rates of lung cancer. However, a ten-year follow-up time is not enough time to detect tumors that may take several decades to develop. It is not known if DBCP was responsible for the lung cancer or if the higher lung cancer rates were due to past use of tobacco products.

In California, stomach cancer and leukemia were studied in relation to exposure to DBCP in drinking water. An individual's risk of getting stomach cancer and leukemia was compared to death rates of these cancers in the general population. No increased risk of developing either stomach cancer or leukemia was found for DBCP-exposed populations.

Does DBCP cause other types of cancer in laboratory animals?

Studies in laboratory animals show that DBCP causes a variety of other tumors in addition to mammary tumors.

In one study, male and female rats were given DBCP by mouth. Higher rates of tumors of the stomach were found in rats treated with DBCP than in the control group not treated with DBCP.

In another study, male and female rats were exposed to DBCP in the air. More tumors of the tongue and nasal cavity were observed in DBCP-exposed rats of both sexes than in unexposed control rats. In addition, more tumors of the pharynx and adrenal gland were observed in exposed female rats than in unexposed controls.

Male and female mice were also tested in these studies. Higher rates of tumors of the stomach were observed in both male and female mice given DBCP by mouth compared to unexposed controls. Higher rates of tumors of the lungs and nasal cavity were observed in both male and female mice exposed by breathing DBCP in air. In these studies, many animals died long before the study was complete. The small number of surviving animals reduced the possibility of observing tumors that form late in life.

Male and female mice were exposed to DBCP through the skin. Exposed mice also developed more tumors of the lung and stomach than unexposed mice. This finding, along with increased mammary tumors in female rats, shows that DBCP can cause harm in parts of the body distant from the point of first exposure.

Do we know how DBCP can cause cancer?

DBCP is a mutagen. Mutagens are chemicals that can cause changes in a cell's genetic code (DNA). Mutagens can increase the risk of forming cancerous tumors. Many types of tests have been used to study the mutagenic effects of DBCP. These tests have used the DNA of bacteria, fruit flies, rats and mice, and cells from rabbits, hamsters, rats, pigs and humans. Results from these tests provide strong evidence that DBCP can cause damage to DNA, including mutations and DNA strand breakage.

Can DBCP disrupt hormones?

Yes. DBCP can disrupt hormones that act as the body's "chemical messengers." Synthetic chemicals that mimic the action of various hormones may increase breast cancer risk or affect reproduction. Studies in both animals and humans have found that DBCP can cause hormonal changes that cause damage to the testes and to male reproductive function. DBCP can cause low sperm counts and infertility in men. Most of the studies conducted so far have focused on males.

Some evidence suggests that DBCP may play a role in influencing the female hormone prolactin. Prolactin has been linked to an increased risk of breast cancer in some women, especially post-menopausal women. However, data are currently inadequate to fully evaluate the effect of DBCP on women and breast cancer risk.

How was DBCP used?

DBCP was applied to the soil of more than 40 different crops. Its most extensive use was on soybeans. DBCP was also used on the soil of vegetable crops, vineyards, fruit orchards, and in other farm settings to protect grapes, tomatoes, citrus fruits, peaches and cotton. In addition, DBCP was used extensively on pineapple plantations in Hawaii and banana plantations in Costa Rica and Israel. DBCP was also used on plants in nurseries and greenhouses as well as on lawns and golf courses.

What is the current regulatory status of DBCP?

The US EPA and state governments regulate the use of pesticides. In 1977 the US EPA banned the use of DBCP, except on pineapples. In 1985, use of DBCP on pineapples was banned. DBCP is no longer registered for production or use as a pesticide in the US. Small quantities, however, may be used for research purposes and as an intermediate in the synthesis of some organic chemicals.

Table 2. Past Agricultural Use of DBCP in the US*

DBCP was first commercially produced in the US in 1955. Total annual use of DBCP prior to its suspension in 1977 has been estimated at 32.4 million lbs/yr.

Crop	Millions of lbs/yr
Soybeans	12.4
Fruit and nut groves	10.5
Vegetable crops	3.4
Peanut fields	3.2
Vineyards	3.2
Cotton fields	2.7

**Examples of largest uses. This is not a comprehensive list of all uses.*

Is DBCP found in soil?

Not usually. Chemicals in the environment often break down when exposed to sunlight, bacteria, or air. A chemical's "half-life" is the amount of time it takes for half of that chemical to break down. In soil, the half-life for DBCP is about six months, according to the US EPA. DBCP in soil tends to evaporate into the air or travel downward to groundwater. Since DBCP has not been used in over fifteen years, it is unlikely that significant levels of DBCP would be found in soil.

Is DBCP found in groundwater?

DBCP is among the pesticides most frequently found in groundwater. In 1992, the US EPA's Pesticides in Ground Water Database reported that DBCP was detected in almost 10% of 20,545 groundwater wells sampled across the US. DBCP is a groundwater contaminant. States with the highest past use of DBCP include Arizona, Hawaii, Maryland, North Carolina, South Carolina, and particularly California's Central Valley.

In most areas, DBCP has not been used for over 20 years. However, in many areas where DBCP was used, the pesticide can still be found in the groundwater. Movement of water underground is complex and cannot be easily predicted. Scientists have found that studying pesticides in groundwater over large areas and for long periods of time provides more reliable information than short-term studies looking at only small areas.

Has DBCP been found in drinking water?

In some areas of the country, DBCP has been found in drinking water supplies. In 1990, US EPA conducted the National Survey of Pesticides in Drinking Water Wells. DBCP was one of five pesticides that exceeded drinking water standards in wells around the country. This survey detected DBCP in approximately 370 community water system wells (0.4%) and approximately 38,000 rural domestic wells (0.4%).

In areas where public drinking water sources are contaminated with DBCP, wells are either closed, or cleanup technologies are used to ensure that federal and state requirements for drinking water are met. But treatment systems must be properly monitored and maintained to ensure DBCP is removed from the water. Private wells not connected to community water systems may also contain DBCP and should be checked for DBCP levels each year in areas where DBCP was used.

Is DBCP regulated in drinking water and food?

The US EPA has set a limit on the amount of DBCP allowed in public drinking water supplies. This amount is called the "maximum contaminant level" or "MCL." The federal MCL for DBCP is set at no more than one-fifth of a microgram per liter of water (0.2 µg/L). (One microgram is equal to one millionth of a gram, and one liter is approximately one quart.) Some states establish state MCLs that are more stringent than the federal MCL. For example, in Hawaii, the state MCL for DBCP is 0.04 micrograms per liter.

Since DBCP is no longer used in the US, exposure to the pesticide through food is believed to be minimal. However, food grown in fields irrigated with water contaminated with DBCP may contain very small amounts of DBCP.

The US EPA establishes limits called tolerances for the highest level of pesticides allowed in food. DBCP can break down into other chemicals, including bromide ions. The US EPA has set maximum levels of bromide ion residues in food. These tolerances are used in routine testing of food. In 2000, the US Food and Drug Administration studied levels of pesticides found in the typical American diet. Neither DBCP nor bromide residues were found in any of the foods tested in this study.

Who might be exposed to DBCP?

Since DBCP is no longer made or used in the US, the possibility for exposure of the general public with this pesticide is low. However, the possibility for exposure to DBCP-contaminated drinking water still exists in some areas.

Those who may have been exposed to DBCP in the past include:

- Manufacturing workers at plants where DBCP was produced
- Agricultural workers in fields where DBCP was used
- Workers in nurseries and greenhouses where DBCP was used
- Pesticide applicators who mixed or applied DBCP to soil
- Residents or business owners near sites where DBCP was used
- Those who drank or showered with domestic water contaminated with DBCP

Those who may be currently exposed to DBCP include:

- People drinking water from private wells contaminated with DBCP
- People drinking water from community water systems contaminated with DBCP (e.g., due to a malfunctioning treatment system)
- People in the immediate vicinity of treatment systems that release DBCP from groundwater into the air
- People showering or watering the lawn using untreated contaminated water (skin exposure)

What is being done to remove DBCP from drinking water supplies?

Although DBCP was banned nearly two decades ago, monitoring of DBCP in public water supplies continues. In areas of heavy DBCP contamination, such as California's Central Valley and parts of Hawaii, ongoing efforts to remove DBCP are taking place using several technologies, such as granular activated carbon (GAC) and air stripping. Hundreds of GAC units have been installed on private wells contaminated with DBCP in the Fresno, California area.

How can I find out if DBCP is in my drinking water?

- Many community water supply systems test drinking water for pesticides. Contact your local water company to find out whether your drinking water has been tested for DBCP.
- If your drinking water is from a private well, you may want to have your water tested if you believe DBCP may have been used in your area.

Is more research being done?

Currently, research on DBCP is being done to better understand how fertility in DBCP-exposed males can be restored by manipulating various hormones. We did not find any research currently being conducted on DBCP and its possible relationship to breast cancer.

Table 3. Trade Names* and Synonyms for DBCP

BBC 12	Nemafume	Nemaset
1-chloro-2,3-dibromopropane	Nemagon	Nematocide
3-chloro-1,2-dibromopropane	Nemagon 20	Nematox
Fumagon	Nemagon 20G	Nemazon
Fumazone	Nemagon 90	OS 1987
Fumazone 86	Nemagon 206	Oxy DBCP
Fumazone 86E	Nemagon soil fumigant	RCRA waste numberU066
NCI-C00500	Namanax	SD-1897
Nemabrom	Nemapaz	UN 2872

**Trade names are used herein for convenience and for informational purposes only. No endorsement of products is intended, and no criticism of unnamed products in implied.*

Where is more research needed?

More research on DBCP and its potential to cause breast cancer is needed in the following areas:

- Human studies are needed that include adequate numbers of women and which control for a variety of confounding factors
- Studies on the hormonal effects of DBCP in women are needed, especially focusing on how DBCP may affect prolactin production and breast cancer risk
- If more studies on laboratory animals are to be done, studies are needed in which animals live long enough to adequately assess tumors that develop late in life.

Conclusions

Based on the scientific evidence summarized below, we conclude that DBCP is a "possible breast carcinogen" in humans.

- DBCP causes breast tumors in female rats (but not in mice)
- DBCP causes a variety of other tumors in laboratory animals including tumors of the lung, nasal cavity, tongue, adrenal gland, stomach, tunica vaginalis and pharynx
- DBCP can cause damage to DNA which may increase the risk of cancer
- DBCP can disrupt the functioning of certain hormones

Currently, human exposure to DBCP may occur via contaminated groundwater and drinking water sources in areas of high past use, such as California's Central Valley; Oahu and Maui, Hawaii; Arizona, Maryland and North and South Carolina. Community water systems use carbon filtration and other technologies to clean contaminated drinking water to meet state and federal drinking water standards. People who depend on private drinking water wells in areas of past high use should ensure that home water treatment systems are working properly. ■

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A complete bibliography of references used in the preparation of this fact sheet on "Pesticides and Breast Cancer Risk: An Evaluation of Dibromochloropropane (DBCP)" is available on the BCERF web site at http://envirocancer.cornell.edu

We hope you find this fact sheet to be informative. We welcome your comments. (BCERF, Sprecher Institute for Comparative Cancer Research, Box 31, Cornell University, Ithaca, NY 14853-6401; phone (607) 254-2893, FAX: (607) 254-4730, Email: breastcancer@cornell.edu).