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ETHYLENE DIBROMIDE

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ABSTRACT

Much attention has recently been focused on the chemical ethylene dibromide (EDB). This chemical has been widely used in leaded gasoline, and has also been used to treat grains, citrus and other crops. It has been found in foods and in groundwater. This paper examines the possible health effects of exposure to EDB, as well as its regulation. The possible health effects and regulation of various chemical and physical alternatives to EDB are also examined. This paper concludes with some policy considerations pertinent to EDB.

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INTRODUCTION

Ethylene dibromide (EDB) is an organic, i.e., carbon-containing, chemical also known as 1,2 dibromoethane, ethylene bromide, and sym-dibromoethane. It has been used in several ways: as a fumigant for ground pest control, for stored grain and grain milling machinery, for citrus and other tropical fruits; as an additive to leaded gasoline (to clean lead deposits out of gasoline engines); as a constituent of fire extinguishing chemicals, gauge fluids, and waterproofing preparations; and as a solvent for celluloid, fats, oils and waxes. About 200 million pounds of EDB were produced in this country in 1980, with about 143 million pounds used domestically. An estimated 110 million pounds of EDB went into leaded gasoline in 1980; this was about 77 percent of domestic use. About 15 million pounds of EDB were used as a pesticide in 1980 (about 10 percent of domestic use). 1/ While use of the chemical in leaded gasoline is a major source of EDB emissions (with EDB evaporating during fuel pumping and from fuel tanks and carburetors), recent concerns have focused on EDB as a pesticide.

Previously, nematodes and other soil pests were controlled by fumigation with EDB of the soil prior to planting several types of fruits and vegetables. 2/ Soil fumigation with EDB occurred primarily in California,

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1/ Chemical Economics Handbook. SRI International. Nov. 1982

2/ Pineapple, cotton, tobacco, soybeans, peanuts, citrus and fruit trees, and 30 other fruit and vegetable crops

Hawaii, and the Southern States; the groundwater in California, Hawaii, Florida, and Georgia have been found to contain EDB residues. Consequently, permission to use EDB as a soil fumigant was suspended by the U.S. Environmental Protection Agency (EPA) in September 1983.

On February 3, 1984, the EPA also ordered the termination of use of EDB as a spot fumigant of grain and milling machinery, to take effect one month after the announcement. EDB has been found in grain and grain products, e.g., breads and cake mixes, at concentrations up to several thousand parts per billion (ppb) in raw grain products, and up to several hundred ppb in baked goods. EPA has known of the presence of EDB in grains and baked goods for some years. An EPA document of 1980 cites studies from 1978 reporting that EDB does not completely dissipate from grains and baked goods. The State of Florida had ordered a halt to the sale of various grain products, including cake mixes, grits, and flour, found to contain at least 1 ppb of EDB. Massachusetts, Maine, Texas, and California are four of at least 20 States now testing for EDB residues. The February 3, 1984 announcement by the EPA included three voluntary guidelines for state officials to use in determining safe residue levels in certain food:

Raw grain............................not to exceed 900 parts per billion

Intermediate finished
goods, e.g., flour, mixes..........not to exceed 150 parts per billion

Ready-to-eat
foods, e.g., bread, cookies........not to exceed 30 parts per billion

Soybeans had already been regulated at 1 ppb.

Besides soil fumigation and fumigation of grain, EDB has been used to fumigate citrus to prevent the spread of fruit flies. Treated fruits have been found to contain up to 5000 ppb of EDB. The February 3, 1984 EPA announcement contained no guidelines for safe residue levels in citrus.

The EPA had published "health advisories" regarding EDB in drinking water well before the February 3, 1984 announcement. EPA estimates that lifetime exposure to EDB in drinking water at the following concentrations would produce the corresponding excess cancer risks:

0.02 ppb (0.02 microgram/liter) .... 3 $\times 10^{-5}$

0.1 ppb (0.1 microgram/liter) .... 1.5 $\times 10^{-4}$

1 ppb (1 microgram/liter) .... 1.5 $\times 10^{-3}$

Several other environmental chemicals have been regulated around the point where their excess cancer risk is 1×10^{-6} (i.e., one in a million), or 1×10^{-5}; all the risks indicated above exceed those values.

The February 3, 1984 EPA announcement contained no guidelines for EDB in gasoline.

The announcement of the presence of EDB in groundwater, citrus, and grains and baked goods has prompted much concern.

HEALTH EFFECTS OF EDB

Acute Effects 3/

EDB in extended contact with the skin may cause reddening, blistering, and sores; these reactions sometimes may not be visible for 1-2 days. The skin may become sensitized to EDB, i.e., smaller amounts of the chemical would lead to reactions with future exposures. EDB vapor is a severe irritant to the eyes and mucous membranes of the respiratory tract. Inhalation of the vapor may result in severe acute respiratory injury, reduction

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3/ Sittig, Marshall. Handbook of Toxic and Hazardous Chemicals. New Jersey, Noyes Publications, 1981.
Gosselin, Robert. Clinical Toxicology of Commercial Products. Baltimore, Williams and Wilkins Co., 1976.

in the functioning of the central nervous system, and severe vomiting. Persistence of symptoms is dependent upon the magnitude and duration of exposure, general health of the individual, and promptness and extent of medical intervention. When death occurs, it appears to be due to respiratory or circulatory failure, complicated by fluid in the lungs, with possible liver and kidney damage. A 150 pound person ingesting between 1 teaspoon and 1 ounce of EDB would probably die.

Long-term Effects 4/

The International Agency for Research on Cancer (IARC) has positively determined that EDB causes cancer in animals.

On Dec. 14, 1977 the EPA issued a rebuttable presumption against registration (RPAR) for EDB for pesticide uses on the basis of the chemical's capacity to cause tumors, mutate genes, and adversely affect reproduction. Adverse reproductive effects in mice have been observed at doses as small as 20 parts per million (ppm) in air. Tumorigenesis has been observed in rats breathing 10 ppm EDB in air. Other rats developed tumors after eating feed mixed with 2 grams of EDB per kilogram of body weight (2 g/kg).

HEALTH EFFECTS OF ALTERNATIVES TO EDB

It is because of EDB's possible health effects that interest has been expressed in finding alternatives to the chemical. Several chemicals currently are approved by the EPA as alternatives to EDB for various uses: carbon

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4/ The Registry of Toxic Effects of Chemicals. National Institute for Occupational SAfety and Health. 1983.
Sittig, op. cit.

disulfide; carbon tetrachloride; ethylene dichloride; and methyl bromide. All are designed to kill pests; as such, none is "safe" in an absolute sense. The Canadian government suspended the use of carbon disulfide, carbon tetrachloride, ethylene dichloride, allyl alcohol, and ethylene dibromide on Jan. 23, 1984 because of their potential adverse health effects. Ten other chemicals (aluminum phosphide, chloropicrin, dazomet, chlorinated C_3 hydrocarbons, 1,3-dichloropropene, ethylene oxide, hydrogen cyanide, methyl bromide, metam sodium, and methyl isothiocyanate) also face regulatory action and potential cancellation of their Canadian registrations for use as fumigants.

Acute Effects 5/

Carbon Disulfide

Exposure to carbon disulfide can result in irritated eyes, stomach, mucous membranes and respiratory tract; blistered, burned, or sensitized skin; altered hormonal balances; and psychological and behavioral disorders including uncontrollable anger, suicidal tendencies, and extreme irritability. The probable lethal oral dose for a 150 pound person is between 1 ounce and 1 pint.

Carbon Tetrachloride

Carbon tetrachloride removes oils from the skin and can cause skin to become dry and cracked. It can irritate the eyes. The functioning of the central nervous system can be reduced following exposure to carbon tetrachloride. Nausea, vomiting, diarrhea, liver and kidney damage, jaundice, blood in urine, and coma can also result from

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5/ Sittig, Marshall. Handbook of Toxic and Hazardous Chemicals. New Jersey, Noyes Publications, 1981.
Gosselin, Robert. Clinical Toxicology of Commercial Products. Baltimore, Williams and Wilkins Co., 1976.

exposure to the chemical. The EPA issued an RPAR for carbon tetrachloride on Oct. 15, 1980 on the basis of the chemical's capacity to damage the liver and kidney (hepatotoxicity and nephrotoxicity). A 150 pound person ingesting between 1 teaspoon and 1 ounce of the chemical will probably die.

Ethylene Dichloride

Like the previously mentioned alternatives, exposure to ethylene dichloride can result in dry and cracked skin. Liquid or vapor forms of the chemical can damage the eyes. Nausea, vomiting, confusion, dizziness, fluid in the lungs, and respiratory and circulatory failure can occur following exposure to the chemical. The probable lethal oral dose for a 150 pound person is between one ounce and one pint.

Methyl Bromide

Exposure to methyl bromide can result in irritated eyes, skin, and mucous membranes. Fluids can accumulate in the lungs. Malaise, visual disturbances, headaches, nausea, vomiting, and tremor can occur following exposure. The probable lethal oral dose for a 150 pound person is between one teaspoon and one ounce.

Long-term Effects 6/

Carbon Disulfide

Atherosclerosis and coronary heart disease are two possible long-term effects of exposure to carbon disulfide. The peripheral nerves can also degenerate in time. Adverse effects on reproduction have been observed in rats breathing 50 milligrams of carbon disulfide per cubic meter of air (50 mg/m^3 air). There are no reports of data pertaining to the capacity of this chemical to cause tumors.

6/ The Registry of Toxic Effects of Chemicals. National Institute for Occupational Safety and Health. 1983.

Sittig, Marshall. Handbook of Toxic and Hazardous Chemicals. New Jersey, Noyes Publications, 1981.

Carbon Tetrachloride

Adverse effects on reproduction have been observed in rats breathing 250 ppm carbon tetrachloride in air, or ingesting 2 g/kg of the chemical. Tumors have developed in hamsters after eating 3 g/kg carbon tetrachloride in feed. Rats developed tumors when carbon tetrachloride was administered under their skins at 31 g/kg. The EPA issued an RPAR for carbon tetrachloride on Oct. 15, 1980 on the basis of the chemical's capacity to cause tumors.

Ethylene Dichloride

There are no reports of data pertaining to the capacity of this chemical to cause adverse reproductive effects. Tumors developed in rats and mice breathing 5 ppm ethylene dichloride in air. Other rats ate 5 g/kg ethylene dichloride in their feed and developed tumors, as did mice at 3.5 g/kg. Gastrointestinal problems, neurological changes, liver and kidney damage, and death are the principal long-term health effects in humans exposed to the chemical. An equal dose of ethylene dichloride will usually cause less severe damage to the liver and kidneys than carbon tetrachloride.

Methyl Bromide

There are no data reported pertaining to the capacity of this chemical to cause adverse reproductive effects or tumors. Lethargy, mental confusion, and disturbances in speech, visual, and sensory functions are the most common long-term complaints associated with exposure to methyl bromide.

According to the EPA, not only have these chemicals been approved as substitutes for EDB for many uses, they are also less costly to purchase. Agricultural firms and workers may prefer EDB partially because it is easier to apply and work with (e.g., proper use of some chemical alternatives to EDB requires that the building containing grain milling machinery be sealed; further, the sticky nature of some of the alternatives makes them more difficult to work with), and partially because of familiarity with working with EDB. 7/

Two physical alternatives to some uses of EDB have been proposed and used on limited bases: irradiation, and long-term cold storage. The U.S. Food and Drug Administration presently does not allow irradiated foods in commerce, although U.S. Dept. of Health and Human Services Secretary Heckler announced on Feb. 14, 1984 that irradiation of some foods may be allowable in the near future. There remain concerns that irradiating foods may produce chemicals in the foods which may have adverse health effects (for details, please see CRS white paper "Preservation of Food by Irradiation" by Donna Porter, June 21, 1983). Long-term cold storage has been used as an alternative to EDB for a shipment of citrus fruits to Japan. There are current questions about the cost and availability of both irradiation and cold storage facilities as alternatives to EDB for fruit if used on a national scale.

STANDARDS

Table 1 summarizes the Federal standards pertaining to EDB and the chemical alternatives previously described. The Federal occupational exposure standards for ethylene dichloride were established to prevent toxic effects other than cancer, and thus may not provide adequate protection from potential carcinogenicity. 8/

7/ Personal communications with James Roliff and Diane Hicks of EPA in Jan. 1984.

8/ Sittig, Marshall. Handbook of Toxic and Hazardous Chemicals. New Jersey, Noyes Publications, 1981.

POINTS FOR FURTHER CONSIDERATION

1) Should the Federal Government allow the blending of grains containing high levels of EDB with grains containing low levels to produce grains containing acceptable levels of EDB?

2) Should the EPA guidelines (for foods and groundwater) be made into regulations, with binding authority in all fifty States?

3) Should labels be required warning of possible hazards in eating unbaked dough, e.g., cookie or cake dough?

4) Should there be Federal monitoring for EDB residues in foods and water?

5) Should there be Federal requirements for the amount of time and degree of ventilation of stored grains (to allow for the dissipation of EDB)?

6) Will a complete ban of EDB force the timely and economically acceptable development of alternative chemicals with all of EDB's qualities and none of its faults?

7) How feasible are long-term cold storage and/or irradiation as substitutes for EDB?

8) What should the Federal role be in the reclamation of groundwater resources contaminated with EDB?

9) What should the Federal government do about human exposures to EDB via leaded gasoline?

10) What impact will the EPA actions regarding EDB have on foreign trade (both imports and exports, e.g., to the Soviet Union and from the Caribbean nations)?

11) What can be done to protect the public health from EDB in citrus fruits?

12) Are the levels chosen by the EPA truly protective of human health, including infants and children?

13) Are current chemical testing requirements adequate to protect human health from possible adverse health effects from chemicals that are new (i.e., not yet on the market) or old (i.e., have been in commerce for years and were tested, if at all, years ago)?

14) How would a uniform Federal cancer policy, as yet nonexistent, handle chemicals like EDB (in use for years, with no obviously better chemical alternatives, and with regulation belonging to different agencies)?

Congress may wish to consider some or all of these questions.

TABLE 1. Comparison of Ethylene Dibromide and Chemical Alternatives: Regulations; Some Health Effects

Methyl Bromide	Ethylene Dichloride	Carbon Tetra-chloride	Carbon Disulfide	Ethylene Dibromide	
4 est.	3	4	3	4	Acute toxicity rating
NI	50	10	20	20 (0.1)	Federal 8-hr. Time-Weighted Average work exposure ppm (proposed)
20	100	25	30	30	Federal ceiling work exposure ppm
NI	200/5	200/5	100/30	50/5 (0.5/15)	Federal peak work exposure ppm/mins (proposed)
NI	15/15	2/60	10/15	0.13/15	Federal peak work exposure ppm/mins
5	10	5	10	NI	ACGIH Time-Weighted Average work exposure ppm
15	15	20	NI	NI	ACGIH Short-Term work Exposure Limit ppm
NC	118,000	35,200	NC	NC	Federal freshwater acute exposure µg/l
NC	20,000	NI	NC	NC	Federal freshwater chronic exposure µg/l
NC	113,000	50,000	NC	NC	Federal saltwater acute exposure µg/l
NC	NI	NI	830	NC	Federal ambient human protection µg/l
10^{-5} @ 1.9	10^{-5} @ 9.4	10^{-5} @ 4	NI	3×10^{-5} @ 0.02	Federal drinking water excess cancer risk @ µg/l concentration
				900	Raw grain ppb EPA
				150	Flour, mixes ppb EPA
				30	Ready-to-eat foods ppb EPA

TABLE 1 (cont.) Comparison of Ethylene Dibromide and Chemical Alternatives: Regulations; Some Health Effects

Methyl Bromide	Ethylene Dichloride	Carbon Tetra-chloride	Carbon Disulfide	Ethylene Dibromide	
NA	NA	15 Oct 80	NA	14 Dec 77	RPAR date
NA	NA	Y	NA	Y	RPAR oncogenicity
NA	NA	NA	NA	Y	RPAR mutagenicity
NA	NA	NA	NA	Y	RPAR reproductive effects
NA	NA	Y	NA	NA	RPAR nephrotoxicity
NA	NA	Y	NA	NA	RPAR hepatotoxicity
NI	Rat, mice 5 ppm	NI	NI	Rat 10 ppm	Animal tumors inhalation
NI	Rat 5 Mice 3.5	Hamster 3	NI	Rat 2	Animal tumors ingestion g/kg
NI	NI	Rat 31	NI	NI	Animal tumors under skin g/kg
NI	NI	Rat 250 ppm	Rat 50 mg/m^3	Mice 20 ppm	Animal reproductive effects inhalation
NI	NI	Rat 2	NI	NI	Animal reproductive effects ingestion g/kg
EPA potential	NCI; IARC animal	IARC animal	NI	IARC animal	Carcinogen
NI	EPA	EPA	EPA	EPA	Hazardous substance
EPA	EPA	EPA	EPA	EPA	Hazardous waste
EPA	EPA	EPA	NI	NI	Priority toxic

TABLE 1 (cont.) Comparison of Ethylene Dibromide and Chemical Alternatives: Regulations; Some Health Effects

Legend: Acute toxicity rating 3 = Probable lethal oral dose for 150 lb person between 1 ounce and 1 pint

4 = Probable lethal oral dose for 150 lb person between 1 teaspoon and 1 ounce

4 est. = Estimated to be a "4"

ACGIH = American Conference of Governmental Industrial Hygienists
NI = No Information
NC = No Criteria
Y = Yes
NA = Not Applicable
ppm = parts per million
ppb = parts per billion
IARC = International Agency for Research on Cancer
EPA = U.S. Environmental Protection Agency
NCI = National Cancer Institute
RPAR = rebuttable presumption against registration