84-622 SPR

Congressional Research Service
The Library of Congress

Washington, D.C. 20540

ETHYLENE DIBROMIDE: HISTORY, HEALTH EFFECTS, AND POLICY QUESTIONS

Michael M. Simpson
Analyst in Life Sciences
Science Policy Research Division

May 3, 1984

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.

CONTENTS

ETHYLENE DIBROMIDE: HISTORY, HEALTH EFFECTS, AND POLICY QUESTIONS

A Study in the Regulation of a Carcinogen

INTRODUCTION

If you were in Florida around the holidays last year and wanted to prepare blueberry muffins from a mix, you probably noticed that the grocery stores did not have the well-stocked shelves and wide selection to which you are accustomed. Blueberry muffin mixes were not the only products missing. Grits, a variety of cakes mixes, and other grain-based products were also absent. And when you returned to the Washington area following the holidays, you may have seen some grocery clerks checking the lot numbers on boxes of grain-based products. The presence of ethylene dibromide (EDB) in these grain-based products prompted their removal, as well as a flurry of controversy and concern. This controversy concerns not only EDB in foods, but encompasses issues of worker protection, overlapping jurisdiction of Federal agencies in regulating chemicals, and timeliness of regulation following the discovery of new health effects data or new assumptions of exposure and risk.

CHEMICAL AND PHYSICAL PROPERTIES OF EDB

EDB is a carbon-containing chemical also known as 1,2 dibromoethane, ethylene bromide, and symdibromoethane. It is a colorless, nonflammable liquid at room temperature with a mildly sweet aroma which can be detected by humans at levels ranging upward from ten parts per million (ppm) of air. The boiling point of EDB is 268°F (131°C). The chemical reacts as an alkylating agent, releasing bromine.

USE

EDB has been used in several ways: as a fumigant for ground pest control, stored grain and grain milling machinery, and 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. In 1981 the U.S. Environmental Protection Agency (EPA) estimated that the annual domestic production of EDB had been about 340-360 million pounds up to that time. About 230 million pounds of EDB each year had gone and continue to go into leaded gasoline, making this its primary use. About 20 million pounds had been used each year in the manufacture of pesticides. More than eleven times the amount of EDB goes into leaded gasoline as went into pesticides.

Until 1981, approximately 18 million pounds of EDB each year were injected directly into fields in California, Hawaii, and the Southern States to control nematodes and other soil pests; this amounted to about 90 percent of the use of EDB as a pesticide. Soil so treated was used to grow more than 30 fruit and vegetable crops including pineapple, cotton, tobacco, soybeans, peanuts, citrus and other fruit trees. Some varieties of fruits and vegetables imported into the U.S., exported to Japan, or shipped across various State lines, have been fumigated with EDB to prevent the spread of fruit flies and other pests. Approximately 83,500 pounds were used in 1977 for this purpose.

In 1982, approximately 57,500 pounds of EDB were poured directly into grain in storage to control insect infestations. The primary grain treated in this way was wheat. Insect infestations in grain milling machinery were controlled by injection of EDB through openings in the equipment. About 465,000 pounds of the chemical were used this way in 1977. Small quantities of EDB have also been used to control pests in beehives, vault-stored clothes, and felled logs.

More than 100 pesticides have been formulated with EDB by at least 18 chemical companies.

HISTORY OF RESEARCH AND REGULATION

Reports of the use of EDB as an insecticide date back to 1925. Beginning in 1927, reports describe deaths and damage to kidneys, livers, hearts, and other organs in animals exposed to the chemical. EDB was first available commercially as an insecticide in 1946. The LD_{50} for the chemical, i.e., the dose of the substance necessary to kill half the test animals exposed to it, was first reported in 1952; LD_{50} testing was introduced about 1926. The U.S. Food and Drug Administration (FDA) was petitioned by the Dow Chemical Company in 1955 to establish tolerances for inorganic bromide residues (resulting from soil fumigation of EDB) on a number of commodities. Limited by the detection technologies of the time, the FDA exempted EDB from tolerance requirements in 1956 because available evidence indicated that EDB would dissipate and not be present in foods for human comsumption. The number of permitted uses of the chemical increased after 1956.

By 1973, a number of studies reported that EDB caused certain cancers and mutations in test animals. FDA was officially informed of this fact at that time. Two years later EPA was petitioned by the Environmental Defense Fund to study the carcinogenicity of EDB residues and to either suspend or cancel the EDB registrations. The Federal Register in December 1977 carried a Notice of Rebuttable Presumption Against Registration (RPAR) by EPA describing EDB's capacity to cause cancers, genetic mutations, and other adverse health effects in test animals, and reporting the detection of EDB in food. The FDA began monitoring food for EDB residues in 1978, upon the request of EPA. Finding that the presumptions for carcinogenicity, mutagenicity, and adverse reproductive effects not rebutted, EPA proposed on December 10, 1980 to cancel many uses of EDB including fumigation of grain and treatment of fruits and vegetables.

An Advance Notice of Proposed Rulemaking was published by the U.S Occupational Safety and Health Administration (OSHA) in the Federal Register in December 1981 to reduce the permissible occupational exposure level for EDB to 0.13 ppm from the current 20 ppm, as an eight-hour time-weighted average.

EDB was found in groundwater in Georgia in March 1982. The chemical was later found in groundwater in Florida, California, and Hawaii.

EPA released its final determination regarding the EDB RPAR on September 27, 1983. This document contained an Emergency Suspension Order regarding the use of EDB as a soil fumigant, a cancellation order for use of EDB as a spot and grain fumigant, and a cancellation order, effective September 1, 1984, for use of EDB as a fruit and vegetable fumigant. The delay until September 1984 was to allow for the development of alternative pest control technologies. EDB would continue to be allowed for minor uses such as the control of wax moths and Japanese beetles.

The State of Florida began sampling food for EDB residues in September 1983. By December 20, 1983, Florida had prohibited the sale of grain-based products containing more than one part per billion (ppb) EDB, the lower level of detection.

On October 7, 1983 OSHA proposed to reduce the permissible occupational exposure level from 20 ppm to 0.1 ppm, and to require exposure monitoring, employee education, and personal protective devices.

On February 3, 1984, EPA Administrator William Ruckelshaus announced the emergency suspension of the use of EDB on grain, and the recommended maximum acceptable levels of EDB in various grain-based foods: 900 ppb EDB in raw grain; 150 ppb in intermediate finished goods, such as flour and mixes which require further processing; and 30 ppb in ready-to-eat foods. Several States established standards stricter than the EPA's values: Massachusetts has a 1 ppb standard for any food; Maine allows 40 ppb in intermediate finished grain products; New York allows 10 ppb in ready-to-eat foods, 50 ppb in intermediate foods, and 300 ppb in raw grain. Those States are joined by Florida, California, Texas, and Ohio in adopting a zero tolerance for EDB in baby foods. California plans to follow EPA's levels until July 1985, when it will adopt the standard of Massachusetts. Except for baby foods, Florida has agreed to use the EPA's values.

On March 2, 1984, the EPA announced an interim tolerance of 250 ppb on citrus and papaya whole fruit, which is approximately equivalent to 30 ppb in the edible portions. After Sep. 1, 1984, no EDB residues will be allowed on these products, whether domestic or imported.

On April 23, 1984, the EPA's EDB guidelines for grain-based foods were made mandatory nationwide. States would be allowed to set or continue with standards stricter than those of the EPA. Food companies can also begin or continue to redistribute to States with laxer EDB standards commodities with EDB concentrations exceeding the more stringent standards of certain States.

HEALTH EFFECTS OF EDB

Acute Effects

In extended contact with the skin, EDB 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 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 one teaspoon and one ounce of EDB would probably die.

Long-Term Effects

On December 14, 1977 EPA issued an 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 were observed at doses as small as 20 ppm in air to which the mice were exposed. Tumorigenesis was observed in rats breathing 10 ppm EDB in air. Other rats developed tumors after eating feed mixed with two grams of EDB per kilogram of body weight. Subsequent test results increased support for the presumptions against registration. On December 10, 1980 EPA announced that those presumptions had not been rebutted.

The International Agency for Research on Cancer has positively determined that EDB causes cancer in animals. The National Toxicology Program and the National Cancer Institute have concluded that EDB causes tumors in rats and mice. The evidence for animal carcinogenicity is very clear, coming as it does from different species, both sexes, various organs, different routes of exposure, alone and in combination with other chemicals, and at several dose levels including relatively small ones. Other testing clearly shows the chemical causes mutations and adverse reproductive effects in test animals.

There are few epidemiological studies of people exposed to EDB, and these do not have the statistical capability to adequately assess the potential carcinogenic risk to humans of exposure to EDB.

HUMAN EXPOSURE TO EDB

Occupational

The following table summarizes those occupations which have or until recently had the potential to expose workers to EDB:

- cabbage growers
- corngrowers
- EDB workers
- fat processors
- fruit fumigators
- fumigant workers
- gasoline blenders
- grain elevator workers
- grain fumigators
- gum processors
- motor fuel workers
- nematode controllers
- oil processors
- organic chemical synthesizers
- seed corn maggot controllers
- soil fumigators
- termite controllers
- wood insect controllers
- wool reclaimers

makers of: antiknock compounds; celluloid; drugs; fire extinguishers; lead scavengers; resins; tetraethyl lead; waterproofing compounds; wax.

Including those workers who until recently were exposed to EDB, such as grain fumigators, OSHA estimated in 1983 that about 57,000 workers may receive a significant exposure to EDB. The largest group of exposed workers are those engaged in manufacturing gasoline and pesticides; this group numbers about 12,500. Those workers who applied EDB to grain, fruits, and vegetables were the most likely to have been exposed to the highest levels of the chemical. The National Institute for Occupational Safety and Health (NIOSH), as well as private investigators, have measured EDB levels in various occupational settings and found the levels to range from undetectable to 23.4 ppm. The latter value exceeds the present OSHA standard by 3.4 ppm. It is important to note that carcinogenic effects were observed in laboratory animals exposed to 10 ppm EDB in air; the calculated excess cancer risk over a lifetime of occupational exposure is very high. It is also important to note that use restrictions recently imposed by EPA will have the effect of eliminating certain EDB-related jobs and thus reducing certain occupational exposures to the chemical.

Nonoccupational

EDB has been detected in grain-based products, fruits, vegetables, and some drinking water. EDB has also been detected in ambient air, especially in cities and around leaded-gasoline pumping facilities.

Drinking Water

While there are presently no EPA standards for EDB in drinking water, the Agency has estimated that lifetime exposure to EDB in drinking water alone at the following concentrations would produce the corresponding excess cancer risks:

0.02 ppb (0.02 microgram/liter)	3×10^{-5}
0.1 ppb (0.1 microgram/liter)	1.5×10^{-4}
1 ppb (1 microgram/liter)	1.5×10^{-3}

Several other environmental chemicals have been regulated around the point where their excess cancer risk on a lifetime basis is 1×10^{-6} (i.e., one in a million), or 1×10^{-5}; all the risks indicated in the table exceed those values. In Sep. 1983 EPA published a notice in the Federal Register that EDB, along with several other chemicals, was on their priority list for regulatory review; following the usual rulemaking schedule, it has been estimated that EPA standards for EDB in drinking water could be in effect by the end of 1986.

Leaded Gasoline

EPA has set neither standards nor guidelines for EDB exposure from leaded gasoline, saying that such exposure is insignificant relative to agricultural exposures. Criticism of this position has been expressed. For example, the State of New York assessed the risks of EDB to New Yorkers and found a significantly greater risk than that calculated by the EPA, partially because the New York study included a significant contribution to the estimated EDB exposure level from ambient air. EPA has expressed interest in accelerating its phasedown of leaded gasoline, i.e., quickening the pace at which leaded gasoline will be phased out. Such action would quicken the pace at which atmospheric exposure to EDB from leaded gasoline would be diminished. Proponents of the accelerated phasedown emphasize the health benefits of a faster pace of diminishing exposures to lead and EDB, and the economic benefits of reduced maintenance costs for most automobile owners. Opposition to the accelerated phasedown has been expressed by the Ethyl Corporation, a major producer of lead for gasoline, and drivers of old and classic cars requiring leaded gasoline.

Food

EPA's standards for EDB in grain-based foods, and their interim tolerance for citrus and papaya, were set to protect the American public from being exposed to an excessive level of EDB, and the resulting excessive risk of cancer. The constituents of the average American's diet, e.g., the volume of orange juice consumed in a year, or the amount of bread eaten in a day, were last estimated by the EPA in the second half of the 1970s. EPA used their estimated average American diet to calculate the maximum concentration of EDB in grain-based foods and citrus which would not lead to an excessive cancer risk. This calculation formed the basis for the EPA's EDB food standards and interim tolerance. Critics have charged that the EPA's dietary estimate does not accurately reflect current "real-world" American diets. Critics have also voiced concerns about the risk assessment assumptions used by the Agency. These assumptions are models or theories about how cells become cancerous. The assumptions result in a level which EPA and its proponents describe as appropriate and tending toward the cautious. However, the Grocery Manufacturers of America claim that the calculated risk levels are too high, and some health professionals consider them to be too low, especially with regard to the risk of cancer for infants and children. Partially because of the disagreement about the levels of ambient and dietary exposures, as well as the uncertainty surrounding the risk calculations (which are concerned only with cancer and not adverse reproductive effects or mutations) some States have opted for standards stricter than those set by EPA.

ALTERNATIVES TO EDB

Several other chemicals are currently approved by EPA as alternatives to EDB for grain fumigation: aluminum phosphide; carbon disulfide; carbon tetrachloride; ethylene dichloride; and methyl bromide. Despite the fact that these chemicals tend to cost less than EDB, agricultural firms and workers may have preferred EDB partially because the chemical alternatives sometimes are more difficult to work with, and partially out of familiarity with EDB. Further, all of these alternative chemicals have adverse acute and/or long-term health effects very similar to those of EDB. EPA is currently reviewing the toxicity of all these chemical alternatives. On January 23, 1984 the Canadian Government suspended the use of carbon disulfide, carbon tetrachloride, ethylene dichloride, EDB, and allyl alcohol as grain fumigants, because of their potential adverse health effects. Aluminum phosphide, methyl bromide, and eight other chemicals (chloropicrin, dazomet, chlorinated C_3 hydrocarbons, 1,3-dichloropropene, ethylene oxide, hydrogen cyanide, metam sodium, and methyl isothiocyanate) also face regulatory action and potential cancellation of their Canadian registrations for use as fumigants.

There are two possible chemical alternatives to EDB for soil fumigation. The safety of one of these chemicals, 1,3-dichloropropene (sold under one U.S. trade name as Telone II), and its possible presence in groundwater, is under investigation in both Canada and the U.S. The other, fenamiphos (a U.S. trade name is Nemacur), is being tested for effectiveness.

Industry analysts say that they do not expect EDB to be replaced with a chemical substitute for spot fumigation of milling equipment: more frequent cleaning, better sanitation practices, and new equipment designed to reduce pest infestation will probably be the chosen courses of action.

It appears unlikely now that other chemicals will be substituted for EDB for post-harvest fumigation of fruits and vegetables because other chemicals tend to cause cosmetic damage to the commodities. Three physical alternatives may be possible: long-term cold storage; steam treatment; and irradiation. Long-term cold storage is a process which has been used for treating fruits destined for Japan. Steam treatment is a process which has been known in limited circles for some time. There are problems associated with both processes. They require significant amounts of energy and time to be effective. In addition there presently are not enough cold or steam facilities to handle the volume of fruits and vegetables consumed by the U.S. population. Exposing fruits and vegetables to gamma radiation may be an alternative to EDB, but such treatment is presently not allowed for foods in commerce in the U.S. On February 14, 1984 FDA proposed rules to allow irradiation for several purposes including treatment of citrus. Unlike the other physical alternatives to EDB, irradiation is not yet permitted for treating fruits and vegetables, but like the other physical processes, there are questions concerning the availability of facilities and economics of the operation. There are also questions concerning occupational safety and health.

Pest reinfestation can be a problem with all these physical alternatives to EDB. EDB residues, which were part of the problem with EDB, helped prevent reinfestation of the commodities by pests. The physical alternatives are not as effective as EDB at preventing reinfestation. Changes may be necessary in the way commodities are handled following physical treatment to rid the foods of pests to prevent reinfestation.

POLICY QUESTIONS

The story of EDB involves more than the recall of grits and the inspection of oranges. The history of EDB is particularly interesting because of the policy questions it raises. While these questions are asked separately, their contents merge into one another.

It was noted earlier that cancers were observed in laboratory animals exposed to EDB at concentrations equal to or lower than that allowed for workplace exposures. It was also noted that EPA calculated significant cancer risk values associated with very small concentrations of EDB in drinking water, yet no standards exist for EDB in drinking water. The policy questions that arise include: what should the acceptable level of cancer risk be for Federal agencies?, and how much should they be allowed to vary across agencies and programs?

Controversy surrounds EPA's estimate of the contents of the current American diet. There is also concern about the model EPA used to assess the cancer risk for children and adults. Controversy also surrounds the estimates of the costs and benefits related to the suspension of use of EDB in agriculture. Finally, when dealing with EDB concentrations around 1 ppb, it is not unusual for different laboratories, testing the same sample, to report EDB concentrations which vary by as much as ten-fold. These facts are caused by and contribute to scientific uncertainty, which often underlies disputes among Federal agencies, the regulated parties, and outside critics. What role does uncertainty play in the workings of the regulatory agencies and Congress? How, if at all, should economic cost estimates be weighed against possible health benefits?

Different States and different nations have different standards for the amount of EDB they will allow in their foods. This fact has led to the redistribution of foods containing different levels of the chemical. The general question which can be asked is: what impacts on trade (imports and exports, interstate and international) will result from the actions taken in relation to EDB by EPA, the individual States, and foreign nations? Is there a need for preemption of State standards by a Federal standard? Is there a need for a coordinated international policy concerning EDB in foods?

The vast majority of EDB has been sold for use in leaded gasoline. The manufacturers of EDB, deriving only a small part of their income from agriculturally-related sales of the chemical, may have little incentive to spend what could be significant amounts of money to develop, test, register, and sell a chemical alternative to EDB with all of its qualities and none of its potential health problems. The argument can be made that chemical alternatives to EDB are akin to orphan drugs, i.e., products which are of vital importance to a relatively small market. Should Federal policies designed to encourage the development, testing, licensing, and sale of orphan drugs be applied to chemical alternatives to EDB? Can the same position be taken in relation to physical alternatives to EDB?

The vast majority of EDB has been sold for use in leaded gasoline. The EDB use restrictions imposed by EPA effectively reduce many agriculturally related occupational exposures to the chemical, but have no effect upon those people occupationally exposed in other jobs, e.g., making antiknock compounds or pumping leaded gasoline. Nonoccupational nonagricultural exposure to EDB, a portion of which comes from leaded gasoline, is also unaffected by the EPA's EDB standards for grain-based products and interim tolerance for certain fruits. Concern has been expressed that EPA underestimated nonagricultural nonoccupational exposures to EDB. Are the EPA's interests in accelerating the phasedown of leaded gasoline sufficient to protect human health?

Some groundwater in four States has been found contaminated with EDB. What should the Federal and State roles be in the monitoring of groundwater? What requirements exist in the Federal Insecticide, Fungicide, and Rodenticide Act with regard to monitoring? What efforts are being made to research and develop practical methods for reclaiming contaminated groundwater resources?

Following are a series of statements which are intimately related.

The presently allowed chemical alternatives to EDB have adverse acute and/or long-term health effects very similar to those of EDB. The health effects of eating irradiated foods are still being examined and debated.

The exemption from a tolerance for EDB was granted in 1956, and it was a decade ago that EDB's capacity to readily cause cancers, mutations, and adverse reproductive effects was reported in the scientific literature.

> The FDA, EPA, U.S. Department of Agriculture, OSHA, and NIOSH all shared and continue to share an interest in EDB.
>
> The National Academy of Sciences stated in their 1984 report Toxicity Testing that "...of the tens of thousands of commercially important chemicals, only a few have been subjected to extensive testing and most have scarcely been tested at all". Thousands of new chemicals enter the market each year.

These statements together are related by their relevance to Federal policy for the regulation of chemicals, especially those with clear capacity to cause cancers, mutations, and adverse reproductive effects. Such a policy needs to reflect awareness of advancements in scientific knowledge and capabilities, and progress in risk assessment methodology. Policy in this area needs to take account of scientific uncertainty, yet perform appropriate regulatory actions in a timely fashion. The story of EDB, which has policy-related elements which are neither new nor unique, clearly tells of the controversy and concern which can arise in the formulation of a policy. It is unlikely that thoughtful, coordinated policy will arise unless it is developed through the joint workings of policymakers, regulators, and the scientific community. The Interagency Regulatory Liaison Group in the Carter Administration, and the Interagency Risk Management Council in the current Administration, represent formal efforts to develop such a coordinated policy. The work continues.