

4. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

4.1 PRODUCTION

Endosulfan was first introduced into the United States in 1954 by Farbwerke Hoechst A.G. under the registered trademark, "Thiodan[®]" (Maier-Bode 1968). The main method of production involves the Diels-Alder addition of hexachlorocyclopentadiene and cis-butene-1,4-diol in xylene. This step is followed by a hydrolysis of the adduct to the cis-diol or dialcohol (Melnikov 1971). The endosulfan end product is then obtained by treating this bicyclic dialcohol with thionyl chloride (SOCl₂) (NRCC 1975; Sittig 1980). Pure endosulfan may be found as two different conformations, α and β . Technical-grade endosulfan, which must contain 94% endosulfan according to the specifications of the Food and Agricultural Organization of the United Nations (FAO), consists mainly of the α - and β -isomers in approximately a 7:3 ratio, as well as a few impurities or degradation products including endosulfan-ether, -alcohol, and -sulfate (Maier-Bode 1968; NRCC 1975). Technical endosulfan may also contain but not exceed concentrations of 2% endosulfan alcohol and 1% endosulfan ether. One degradation or reaction product, endosulfan sulfate, has chemical properties similar to the pure substance and is formed from photolysis (in solid or gas phase), biotransformation, or oxidation of endosulfan (EPA 1979). In the environment, both isomers of endosulfan can be metabolized to endosulfan sulfate by a variety of organisms (Maier-Bode 1968).

Several formulations containing endosulfan are presently on the market, and pesticide manufacturers make use of various inert ingredients (such as alcohol solvent emulsifiers; petroleum distillate emulsifiers; suspension agents, water, clay, and wetting agents; and talc) to produce these formulations (NRCC 1975). Formulated (processed) endosulfan exists in several forms (most of which are registered under the name "Thiodan[®]"). The main forms are the following: wettable powder with 17.5, 35, or 50% active ingredient (technical) with clay and wetting agents as inert ingredients; and emulsifiable concentrate with 17.5 or 35% active agent mixed with petroleum distillates or alcohol plus emulsifiers (as inert ingredients) (Coleman and Dolinger 1982).

Epichlorohydrin was reported to have been used in technical-grade endosulfan at one time as a stabilizer (Hoechst 1990). However, it is unclear when this practice was discontinued.

Few details are available on endosulfan's production volume. In 1974, the annual production of endosulfan in the United States was estimated at 3 million pounds (Sittig 1980). However, domestic

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production was near 5,000 pounds in 1977 (HSDB 1999). The major U.S. manufacturer of endosulfan was FMC Corporation, formerly called the Niagara Chemical Division of Food and Machinery Corporation. FMC Corporation's annual production of endosulfan active ingredient for 1971 was estimated at about 2 million pounds (EPA 1972). According to Coleman and Dolinger (1982), however, this figure may be a low estimate. Endosulfan has not been produced in the United States since 1982 (HSDB 1999); therefore, worldwide production volumes listed after 1982 do not include data for the United States. Worldwide production of endosulfan in 1984 was estimated at 10,000 metric tons (WHO 1984). Current estimates of worldwide production or domestic formulation were not located.

Although endosulfan is no longer produced in the United States, it is still used in chemical formulations. Formulation sites for endosulfan around the United States include FMC Corporation, Chemical Group, Agricultural Chemical Division, Fresno, California and Jacksonville, Florida (SRI 1989); Drexel Chemical Company, Memphis, Tennessee (CIS 1988); and SureCo, Inc. (formerly known as Security Chemical Company), Fort Valley, Georgia (SRI 1989). Several corporations around the world continue to produce endosulfan, including All India Medical Corporation, Bombay, India; Bharat Pulverizing Mills Pvt., Ltd., Bombay, India; Dupont Conid S.P.A., Amonn Fitichimica Division, Bolzano, Italy; Excel Industries, Ltd., Bombay, India; FBC Limited, Cambridge, Great Britain; Krishi Rasayan, Calcutta, India; Makhteshim Chemical Works, Ltd., Beer-Sheva, Israel; Mewar Oil and General Mills, Ltd., Udaipur, India; Mictionion Industries Corporation, Taipei, Taiwan; and Productos Químicos de Chihuahua, S.A., Chihuahua, Mexico (CIS 1988). Farbwerke Hoechst A.G. in Frankfurt, West Germany, is a major producer worldwide (Coleman and Dolinger 1982). No production volume data were available for these companies. From the available information, it is unclear whether these sites represent producers of technical-grade endosulfan or manufacturers of endosulfan formulations.

There is currently only one facility that produces or processes endosulfan in the United States (SRI 1997).

4.2 IMPORT/EXPORT

Little is known about import volumes of endosulfan, but they are assumed to be substantial. Imports of endosulfan for 1982 were estimated at 182,000 kg (HSDB 1999).

Technical endosulfan is no longer produced in the United States; therefore, it is no longer exported. Data on export of formulated products containing endosulfan were not located.

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4.3 USE

Endosulfan is registered in the United States as a contact and stomach insecticide for over 60 food and nonfood crops. It is applied to crops to control over 100 different insect pests (EPA 1980b). It is particularly effective against the Colorado potato beetle, the peach tree borer, the cabbage worm, the tarnished plant bug, the leafhopper, and various aphids including the woolly apple aphid. Endosulfan exhibits low toxicity to bees. The pesticide is applied on crops before harvest as soon as insects appear; repeated applications follow if necessary (FAO/WHO 1975a; NRCC 1975). It is most often applied using air-blast equipment or boom sprayers (HSDB 1999). Minimum intervals observed after spraying and harvest vary according to crop (FAO/WHO 1975a). Worldwide, endosulfan is used on food crops such as tea, vegetables, and deciduous fruits (and nuts), as well as nonfood crops such as tobacco and cotton. This pesticide is also used on forage crops such as alfalfa (Coleman and Dolinger 1982).

Endosulfan formulations are used in commercial agriculture and home gardening (Coleman and Dolinger 1982). They are also used for wood preservation (HSDB 1999).

In the United States, endosulfan is mainly applied to tobacco and fruit crops. In the state of California, however, spraying of lettuce, tomatoes, and artichokes accounts for half of the total use. The six major crops protected by endosulfan in California, according to 1977 figures, are tomatoes, cotton, lettuce, strawberries, pears, and grapes in decreasing order of amount of endosulfan used for each crop. Grapes, strawberries, and pears account for most of the endosulfan used on fruit, and alfalfa accounts for most of its use on forage in California. Use of endosulfan in California has decreased from 1,077,711 pounds in 1971 to 718,593 pounds in 1977 with the use levels dropping to 401,298 pounds in 1976 (Coleman and Dolinger 1982).

4.4 DISPOSAL

Endosulfan is listed as a toxic substance under Section 313 of the Emergency Planning and Community Right to Know Act (EPCRA) under Title III of the Superfund Amendments and Reauthorization Act (SARA) (EPA 1995c). Disposal of wastes containing endosulfan is controlled by a number of federal regulations (see Chapter 7).

According to EPA (1974), pesticides such as endosulfan should be destroyed at high temperature in an approved incinerator with a hydrochloric acid scrubber, if available. Any sludges or solid residues

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generated from this process are to be disposed of in a manner approved by all applicable federal, state, and local pollution control requirements. EPA strongly recommends that if incineration of excess pesticides is not possible, organic pesticides should be buried in a designated landfill site.

It has also been suggested that remaining endosulfan residues may be emptied in diluted form into a deep pit avoiding groundwaters (FAO/WHO 1975a). EPA, however, does not recommend well injection unless all other reasonable alternatives, including biodegradation and temporary storage, have been explored (EPA 1974). Moreover, pesticide residues and contaminated soil should be packaged in 17H epoxy-lined drums and disposed of at an EPA-approved chemical waste landfill (OHM/TADS 1989). Local toxic waste disposal and regulatory officials should be informed of the disposal process (OHM/TADS 1989).

Other methods of endosulfan disposal have previously been suggested by the Working Group on Pesticides (1970). The group outlined six possible methods for ground disposal of pesticides, their residues, spillage, and contaminated containers. The first method proposed for pesticide disposal was deep-well, given the wells are located far below freshwater aquifers and are separated from them by impervious geologic strata. Thorough geologic and hydrologic studies usually precede construction of deep wells to determine whether the location is sound. A sanitary landfill was another option for underground disposal of hazardous pesticides presented by the Working Group on Pesticides (1970). Pesticide wastes are placed in the landfill (which is usually located away from underground water sources), compacted, and covered with a layer of soil to prevent dispersal of dangerous residues. Disposal pits or dumps were a third alternative for pesticide waste removal. When this method has been used, no immediate efforts have been made to cover waste materials in the pits with earth (it is not clear whether the pits were located near local groundwater sources). A fourth suggested method of disposing of liquid formulations was by impounding waste materials in a lagoon, which is a shallow excavation or natural depression in the earth. Pesticides are allowed to oxidize, biodegrade, or evaporate in the open. Solids settle to the bottom during this process. Where especially hazardous chemicals are involved, an effort may be made to line the sides and bottom of the lagoon with cement, bentonite clay, asphalt, or bitumen. Ground surface disposal offered another alternative; wastes are spread out on a soil surface thereby taking advantage of natural processes of microbial metabolism, photochemical transformation, and aerobic oxidation of pesticides. Disposal via the city sewage system was the final alternative. Homeowners, home gardeners, businesses, and operators of small nurseries usually have taken advantage of this simple method of disposal, which poses a serious hazard to the surface water. Generally, EPA

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does not recommend water dumping of pesticides (e.g., disposal through the city sewage system) (EPA 1974).

Spills of endosulfan, according to FAO/WHO (1975a), should be cleaned up by first washing with 5% sodium hydroxide solution and then rinsing with large quantities of water. In addition, empty containers that held endosulfan residues should be rinsed two or three times with water while the sides are scrubbed, and once with 5% sodium hydroxide solution. Thus decontaminated, the empty containers can be recycled and used by pesticide manufacturers to package a chemical similar to endosulfan if the containers remain in good condition and if such reuse is not prohibited by federal, state, or local laws. No food or beverages should be packaged in such a decontaminated container. If the empty, decontaminated containers are damaged, they should first be punctured and then incinerated or transported to a designated landfill for scrap burial (EPA 1974; FAO/WHO 1975a; HSDB 1999).

