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

4.1 PRODUCTION

Chlorpyrifos is prepared commercially by several methods (Rigterink 1966). In a preferred method, the final step in the synthesis is reacting 3,5,6-trichloro-2-pyridinol (TCP) and O,O-diethylphosphorochloridothioate under basic conditions in dimethylformamide (Sittig 1985). Chlorpyrifos was introduced in 1965 by Dow Chemical Company under the protection of U.S. Patent 3,244,586. It is produced under many trade names including Brodan®, Detmol UA®Dowco 179®, Dursban®, Empire®, Equity®, Eradex®, Lentrek®, Lock-On®, Lorsbanv®, Pageant®, Piridane®, and Stipend® Producers of chlorpyrifos in the United States are DowElanco in Midland, Michigan and Lafayette, Indiana, and SureCo, Inc. in Fort Valley, Georgia (SRI 1994). Production volumes have not been located.

No information is available in the Toxics Release Inventory (TRI) database on total environmental releases of chlorpyrifos from production facilities, because chlorpyrifos is not included under SARA, Title III, and, therefore, is not one of the chemicals that facilities are required to report (EPA 1993c).

4.2 IMPORT/EXPORT

Information on import/export volumes was not located.

4.3 USE

Chlorpyrifos is a broad spectrum organophosphate insecticide/acaricide which is used to control a variety of insects. First introduced into the non-crop specialty market, it was marketed in the late 1960s to control pests in turfgrass and omamentals, and to control indoor pests. Chlorpyrifos was first registered for termiticide use in the United States in 1980 (Racke 1993). Products are available for both professional pest control workers and homeowners. Agricultural commercial products were introduced in the mid-1970s. As a foliar pesticide for alfalfa and cotton, it is used to control aphids, armyworms, pillbugs, chinch bugs, common stalk borers, corn borers, corn earworm, corn rootworm adults, cutworms, flea beetle adults, grasshoppers, and lesser cornstalk borers. It also controls peach tree borer and overwinter scale on dormant fruit trees and is used as a slurry seed treatment for seed

corn maggot. It has additional uses as a foliar and soil applicant on sorghum, soybeans, sugarbeets, and sunflowers, and as a soil applicant for peanuts. Dursban ®is used to control fire ants, ornamental plant insects, stored-product insects, and turf- and wood-destroying insects. Lorsban® is used as a soil insecticide for pillbugs, corn rootworms, cutworms, flea beetle larvae, grubs, lesser cornstalk. borer, seed corn beetle, seed corn maggot, symphylan, and wireworm on corn (Farm Chemicals Handbook 1994). At one time, it was used to kill mosquitoes in the immature, larval stage of development, a use that involved application of formulated product directly to bodies of water, but hlorpyrifos is no longer registered for this purpose (EPA 1986). Other discontinued uses are spray-dip or pour-on applications of chlorpyrifos for cattle and sheep (Racke 1993).

Formulations for chlorpyrifos include emulsifiable concentrate, dust, flowable, granular wettable powder, microcapsule, pellet, and spray. Chlorpyrifos acts on pests primarily as a contact poison, with some action as a stomach poison. It is a nonsystemic contact chemical, meaning that it acts only where it comes into direct contact with plant tissues, and is not transported to other plant parts. It interferes with the activity of acetylcholinesterase, an enzyme that is essential for the proper working of the nervous systems of both humans and insects.

There is currently no federal requirement to report sales or use of pesticides; consequently, the only figures available are estimates (Felsot 1991). From data collected from usage surveys conducted by USDA, EPA, and the Department of Food and Agriculture of the State of California, the usage of chlorpyrifos is estimated to be 7,023,190 pounds active ingredient per year (Gianessi 1986). Agricultural uses account for most of its applications. In 1982, total agricultural use of chlorpyrifos was estimated at 2.2-3.2 million kg (4.8-7.0 million pounds), and industrial uses ranged between 0.68 and 1.04 million kg (1.5-2.3 million pounds) (EPA 1982). The State of Ohio Agricultural Extension Service estimates that 36.33 metric tons (80,093 pounds) of chlorpyrifos were used in the Lake Erie Basin in 1986 (Baker and Richards 1988). In 1984, about 0.15 million kg (0.33 million pounds) of chlorpyrifos was applied to about 600,000 hectares (1.48 million acres) of wetlands in the United States for mosquito control (Odenkirchen and Eisler 1988); this use has since been discontinued.

Chlorpyrifos is used significantly in urban settings, where it has replaced chlordane and other chlorinated cyclodiene termiticides. Therefore, its use can be estimated based on former chlordane use; the annual application of chlorpyrifos for termite control is estimated at approximately 1.7 million

pounds of active ingredient (Cink and Coats 1993). Each year, the pesticides used to control structural pests account for about 15% of California's nonagricultural use of conventional pesticides. Structural pest control encompasses treatment of private residences, office buildings, schools, hotels, hospitals, restaurants, and other publicly used buildings. In 1990, 604,713 pounds of chlorpyrifos were used as structural pesticides in California, and 693,354 pounds were used in 1991 (Robinson et al. 1994). Pesticides for commercial landscape maintenance account for about 2% of nonagricultural use in California. The landscaping use figures for chlorpyrifos in 1990 and 1991 were 45,267 pounds and 32,118 pounds, respectively. Nationally, chlorpyrifos is ranked twelfth in frequency of indoor pesticide applications and fifth in frequency of outdoor pesticide applications (Robinson et al. 1994).

4.4 DISPOSAL

The recommended treatment and disposal methods for chlorpyrifos are incineration, adsorption, and landfilling (IRPTC 1989). For small amounts, the recommended disposal is adsorption onto materials such as sand and burying in locations away from domestic water supplies. For the decontamination of containers, the triple rinse and drain procedure is recommended. The use of a caustic soda-methanol or caustic soda-detergent rinse solution is also effective in decontaminating the container, but the rinse solutions must be disposed of either by incineration or burial in an area away from water supplies (IRPTC 1989).

Small-scale farm operators have a pressing need for methods to dispose of unused concentrated and dilute formulated chlorpyrifos suspensions or solutions such as rinsate. The use of solid state fermentation techniques to dispose of pesticide waste may be a viable alternative to other disposalmethods that are either too expensive or technically too sophisticated. Chlorpyrifos was evaluated in bioreactors by Berry et al. (1993), who reported that chlorpyrifos levels were reduced to 0.6% (by solvent extraction) in 290 days in wheat straw/horse manure reactors, and that leachability studies showed that of the 28 µg chlorpyrifos in the soil column, only 72 ng leached.

While not strictly a disposal method, it is worth pointing out that NaOH-methanol and sodium hypochlorite can be used to degrade (but not necessarily detoxify) chlorpyrifos. For example, on exposed surfaces, the use of caustic soda-methanol or caustic soda-detergent rinse solution can also be effective in decontaminating containers used to store chlorpyrifos, but these rinse solutions must be

disposed of either by incineration or proper burial (Dillon 1981). A full discussion of regulations regarding disposal of chlorpyrifos is given in Chapter 7.