United States
Environmental Protection
Agency

Office of Pesticides and Toxic Substances
Office of Pesticide Programs (TS-766C)
Washington, DC 20460

540/FS-88-120

EPA Pesticide Fact Sheet

Name of Chemical: TERBUFOS
Reason for Issuance: Revised Registration Standard
Date Issued: September 9, 1988
Fact Sheet Number: 5.2

1. Description of Chemical

Common Name: Terbufos
Chemical Name: S-[[(1,1-dimethylethyl)thio]methyl]O,O-diethyl phosphorodithioate
Other Chemical Nomenclature: S-([tert-butylthio)methyl]O,O-diethyl phosphorodithioate (IUPAC); S-(t-butylthio) methyl O,O-diethyl-phosphorodithioate (CA, 8th Collective Index); S-tert-butylmercaptomethyl O,O-diethyl dithiophosphate
Trade Names: Contraven; Counter; AC 92,100; CL 92,100; and ST-100
Chemical Abstracts Service (CAS) Number: 13071-79-9
EPA Shaughnessy Code: 105001
Year of Initial Registration: 1974
Pesticide Type: Insecticide-Nematicide
Chemical Family: Organophosphate
U.S. Registrant: American Cyanamid Company

2. Use Patterns and Formulations

Application Sites: Terrestrial food crop use on corn; grain sorghum; and sugar beets.

Formulations: Granular

Methods of Application: Broadcast (nonsoil-incorporated) with air or ground equipment; and soil-incorporated with ground equipment.

3. Science Findings

Summary Science Statement: Technical terbufos is highly acutely toxic by the oral, dermal, and inhalation routes of exposure (Toxicity Category I for all three routes). Terbufos does not demonstrate an acute neurotoxic, oncogenic, mutagenic, reproductive, or teratogenic potential. Animal studies have shown that the chemical is a cholinesterase inhibitor reducing plasma, brain, and red blood cell cholinesterase activity. The use of

terbufos poses a potential risk to loaders and applicators and to persons reentering treated fields following nonsoil-incorporated broadcast application of the chemical. This is due to the high acute toxicity and the cholinesterase inhibiting properties of the chemical.

Based on the plasma cholinesterase inhibition no-effect-level of 0.00125 mg/kg/day as defined in a 4-week dog study and, using a safety factor of 10, the acceptable daily dietary intake for humans in 0.000125 mg/kg/day. The theoretical maximum residue contribution from the established tolerances is estimated to be 0.000052 mg/kg/day. This is equivalent to 42 percent of the acceptable daily intake for the average U.S. population. Due to the numerous gaps in residue chemistry data, the Agency is unable to complete a tolerance reassessment of terbufos.

Terbufos is highly toxic to birds, fish, and aquatic invertebrates. The acceptable short-term field study shows significant acute mortalities of birds, mammals, reptiles, and fish resulting from broadcast application of terbufos to corn fields at 1 pound active ingredient per acre (1 lb ai/A). In the same study, the application of terbufos as a soil-incorporated treatment to corn fields at 2 lb ai resulted in acute mortalities to birds and reptiles.

The limited environmental fate data are not sufficient to assess the mobility and leaching properties of tebufos. Terbufos residues were reported to occur in well water sampling in Iowa and Minnesota. These reports, however have not been confirmed in the laboratory and a resampling of the same Iowa wells a year later, in 1986, showed no detections for terbufos or its degradates. Terbufos is one of the pesticides the Agency is sampling for in the National Well Water Survey.

Chemical/Physical Characteristics of the Technical Material:

Color: Clear, brownish
Physical State: Liquid
Odor: Mercaptan-like
Boiling Point: 55 °C at 0.02 mmHg
Stability: Relatively stable in water under neutral or slightly acidic conditions but is subject to hydrolysis under alkaline conditions.

Toxicology Characteristics

- Acute Oral: Toxicity Category I (1.6 and 1.3 mg/kg for male and female rats, respectively).

- Acute Dermal: Toxicity Category I (0.81 and 0.93 mg/kg for male and female rabbits, respectively).

- o Acute Inhalation: Toxicity Category I ($\leq$ 0.2 mg/L).

- o Delayed Neurotoxicity: No evidence of acute delayed neurotoxicity at the 40 mg/kg dosage level tested in hens.

- o Subchronic Feeding: The NOEL for both systemic effects and cholinesterase inhibition in a rat subchronic study is 0.25 ppm.

- o Subchronic Dermal: The NOEL for systemic effects in a 30-day rabbit study is 0.020 mg/kg.

- o Mutagenicity: Terbufos did not exhibit mutagenic potential in the Ames assay, the in vivo cytogenetic assay, and the dominant lethal test.

- o Teratogenicity: The NOEL for developmental toxicity in a rat teratology study is 0.1 mg/kg/day.

- o Reproduction: The NOEL for reproductive effects in a three-generation rat reproduction study is 0.25 ppm.

- o Oncogenicity: No oncogenic effects observed in an 18-month mouse study and a 2-year rat study at doses up to and including 12.0 ppm (1.8 mg/kg/day) and 8.0 ppm (0.4 mg/kg/day), respectively.

- o Chronic Toxicity: The NOEL for plasma cholinesterase (ChE) inhibition from a 4-week dog feeding study is 0.00125 mg/kg/day; the NOEL for brain/red blood cell ChE from a 1-year dog study is 0.060 mg/kg/day. The NOEL for plasma and brain ChE from a 1-year rat feeding study is 0.5 ppm.

- o Metabolism: Terbufos was rapidly excreted as the diethyl phosphoric acid and other polar metabolites (83%) in urine within 168 hours of administration to male rats. Terbufos and its metabolites were not noted to accumulate in tissues.

Ecological Characteristics:

Based on acceptable laboratory data, technical terbufos is highly toxic to birds, fish, and aquatic invertebrates.

Acute Avian Toxicity: 28.6 mg/kg (bobwhite).
Dietary Avian Toxicity: 143 and 157 ppm (from two bobwhite studies).
Avian Reproduction: Terbufos was not considered to produce avian reproductive effects based on results of a bobwhite quail study and a mallard duck study.
Freshwater Fish Acute Toxicity: Ranges from 0.77 to 20.00 ppb.
Freshwater Invertebrate Acute Toxicity: 0.31 ppb for Daphnia magna.
Marine/Estuarine Fish Acute Toxicity: Data gap.
Marine/Estuarine Invertebrate Toxicity: Data gap.
Marine/Estuarine Mollusk Toxicity: Data gap.

Terrestrial Field Study (Level 1): Both soil-incorporated (2 lb ai/A) and nonsoil-incorporated (1 lb ai/A) resulted in nontarget mortalities, with the latter application much more severe in its effects.

Based on the adverse effects observed in the level 1 field study described above, level 2 terrestrial field studies are required to assess the potential effects on populations of birds, mammals, and reptiles. Based on the high acute toxicity to aquatic organisms and results of initial modeling[1] conducted by the Agency for the 1983 Terbufos Registration Standard, the estimated environmental concentration (EEC) of terbufos residues likely to occur in the aquatic environment may pose an acute hazard for freshwater and marine/estuarine species. This modeling was conducted for the soil-incorporated application of terbufos.

Potentially greater hazards are likely for aerial applications of terbufos granules since soil-incorporated applications typically provide less exposure than aerial broadcast applications.

Although these theoretical calculations and modeling indicate that the use of terbufos may result in significant adverse effects to aquatic species, actual field monitoring data are not available to support this finding. Moreover, the environmental fate characteristics of terbufos are not accurately defined by available data. Thus, the models can be used only on a limited basis.

Aquatic residues monitoring studies are required to determine actual residues in aquatic systems exposed to runoff and spray drift. Although these studies were previously requested in the 1983 Terbufos Registration Standard, their initiation was delayed pending the Agency's recalculation of the EECs. Prior to the completion of this task, reports of fish kill incidents demonstrating the potential exposure to aquatic organisms under actual field use conditions became available. These fish kills reportedly resulted from aerial applications of terbufos to corn fields during conduct of the level 1 terrestrial field study. In addition, several environmental fate studies previously found acceptable do not meet current guideline requirements and need to be repeated.

Terbufos has been identified by the Office of Endangered Species (OES), U.S. Fish and Wildlife Service (USFWS), as being likely to jeopardize the continued existence of certain endangered species

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[1]The Agency used computer models (SWRRB) and EXAMS) to simulate runoff from granular application of terbufos and to predict aquatic concentrations of the chemical. SWRRB is a hydrology model combined with a pesticide runoff model. EXAMS is a hydrologic model to predict "steady-state" and "pulseload" behavior of organic toxicants in aquatic ecosystems.

when used on corn and sorghum. Based on this determination, OES specified reasonable and prudent alternatives to avoid jeopardizing the continued existence of the identified species. EPA is working with USFWS and other Federal and State agencies to implement the alternatives in a technically sound manner.

Formal consultation will be initiated with OES under Section 7 of the Endangered Species Act regarding the potential exposure to endangered species resulting from the registered use of terbufos on sugar beets.

Environmental Characteristics:

Results of an acceptable hydrolysis study indicate that terbufos hydrolyzes at pH 5, 7, and 9 with a half-life of 2.2 weeks. Formaldehyde was the major degradate detected in this study. Results of an acceptable aerobic soil metabolism study indicate that terbufos degrades in silt loam soil with a half-life of 26.7 days. The major degradates detected in this study included carbon dioxide, terbufos sulfoxide, and terbufos sulfone.

Results of a field dissipation study, classified as supplementary, indicate that terbufos residues have a half-life of less than 40 days in field plots of loam soil located near Arcola, Illinois, and sandy loam soil located near Greeley, Colorado treated with a 15 percent granular formulation at an application rate of 1 lb ai/A. The sampling protocol was inadequate to accurately assess the dissipation of terbufos residues in field soil and a new study is required.

The available data reviewed by the Agency are not sufficient to fulfill data requirements nor to assess the environmental fate of terbufos. Four studies previously reviewed and found acceptable under the 1983 Terbufos Registration Standard do not meet the requirements of the Agency's current guidelines and new studies are required. These are: anaerobic soil metabolism, leaching, fish accumulation, and field dissipation.

In addition, several new studies are now required due to the additional method of nonsoil-incorporated, broadcast (air or ground equipment) application which was not registered at the time of the 1983 Terbufos Registration Standard.

Tolerance Assessment:

Tolerances for combined residues of terbufos and its ChE-inhibiting metabolites in or on food commodities are published under Section 180.352 of Title 40 of the Code of Federal Regulations (40 CFR 180.352). These tolerances range from 0.05 to 0.5 ppm.

Residue Data:

In the Terbufos Registration Standard dated June 1983, no outstanding data gaps were identified for residue chemistry. However, subsequent amendments to registered uses for terbufos and addenda to the Pesticide Assessment Guidelines (Subdivision O) for Residue Chemistry have made it necessary to reevaluate portions of the data base previously reviewed under the June 1983 Standard. As a result, some of the original conclusions regarding adequacy of the data and support for tolerances have been modified in this revised Registration Standard.

Based on the available plant metabolism studies, the nature of residues in plants is adequately understood. Of the phosphorylated metabolites, terbufoxon sulfoxide and terbufos sulfoxide comprised $\leq$ 30 percent of the residues, and terbufos sulfone and terbufoxon sulfone comprised $\leq$ 7 percent. The major nonphosphorylated metabolite which comprised $\leq$ 30 percent of the organosoluble residues was nonphosphorylated terbufoxon sulfone. The available poultry and ruminant feeding studies do not meet current Guideline requirements for data depicting the metabolism of terbufos in livestock and new studies are required. The basic GLC analytical procedure published as Method I in PAM Vol. II is adequate for collection of data pertaining to the combined residues of terbufos and its ChE-inhibiting metabolites on commodities with established tolerances. Method validation data pertaining to recovery of individual metabolites from representative plant commodities are being required. The adequacy of the available methods for detection of terbufos residues of concern in animal products will be evaluated upon receipt of the required animal metabolism data. Field trial studies are required for all crops for which there are terbufos tolerances. Processing studies are also required in addition to storage stability residue data.

The available poultry and ruminant feeding studies show that no detectable residues occur in eggs, chicken tissues, milk, or cattle tissues from animals fed exaggerated dietary levels of terbufos and its ChE-inhibiting metabolites. However, additional animal metabolism data are required and a determination regarding the need for and nature of tolerances for residues in meat, milk, poultry, and eggs will be made upon receipt and evaluation of these data.

The established tolerances for terbufos are presently expressed in terms of terbufos and its ChE-inhibiting metabolites without specifying the latter as phosphorylated metabolites. The Agency

will propose revising 40 CFR 180.352 by changing the wording to read:

". . . terbufos . . . and its phosphorylated (cholinesterase-inhibiting) metabolites:

- o Phosphorothioic acid, S-(t-butyl-thio) methyl O,O-diethyl ester.
- o Phosphorothioic acid, S-(t-butyl-sulfinyl) methyl O,O-diethyl ester.
- o Phosphorothioic acid, S-(t-butyl-sulfonyl) methyl O,O-diethyl ester.
- o Phosphorodithioic acid, S-(t-butyl-sulfinyl) methyl O,O-diethyl ester.
- o Phosphorodithioic acid, S-(t-butyl-sulfonyl) methyl O,O-diethyl ester."

Acceptable Daily Intake:

Based on the plasma ChE inhibition NOEL as defined in a 4-week dog study (0.00125 mg/kg/day) and using a safety factor of 10, the acceptable daily intake or reference dose (RfD) for humans is 0.000125 mg/kg/day.

4. Summary of Regulatory Positions and Rationales

Terbufos is not being placed in special review at this time. Field studies are needed to completely assess the potential risk to wildlife, including endangered species. The Agency is conducting a comparative avian risk assessment of various granular pesticides, including terbufos. When this assessment is completed, further regulatory action may be taken.

The restricted use classification of the 15 percent granular end-use product based on the high acute oral and dermal toxicity to humans is being retained.

A level II terrestrial field study; monitoring studies in soil, water, sediment, and fish; and aquatic organism field studies are being required for the completion of the Agency's assessment of the potential risk to both avian and aquatic species.

A special 21-day dermal study in rats and a dislodgeable residue study are being required for the completion of the Agency's assessment of the potential risk to workers reentering corn fields following a nonsoil-incorporated application of terbufos.

Due to the lack of pertinent environmental fate data, no conclusions regarding the potential for terbufos to contaminate ground water can be made.

EPA is developing a program to reduce or eliminate exposure to endangered species to a point where use does not result in jeopardy, and will issue notice of any necessary labeling revisions when the program is developed. No additional labeling is required at this time. Labeling requirements issued in PR Notices 87-4 and 87-5 have been withdrawn pending reissuance.

5. Summary of Required Label Modifications

An updated Environmental Hazard statement is required.

Updated worker safety rules and protective clothing statements are required.

A 7-day reentry interval statement is required for use of terbufos as a broadcast application to corn.

A label statement prohibiting use of terbufos as a broadcast application to seed corn prior to detasseling activities is required.

6. Summary of Outstanding Data Requirements

Data	Due Date[1/]
Toxicology	
Special 21-day rat dermal	12 Months
Rabbit teratology	15 Months
Fish & Wildlife	
Acute toxicity to estuarine and marine organisms	12 Months
Fish early life stage	15 Months
Aquatic organism accumulation	12 Months

1/Due date is measured from the date of receipt of the Standard by the registrant unless otherwise specified.

Data	Due Date[1/]
Fish & Wildlife (cont'd)	
Terrestrial field study	[2/]
Aquatic organism field study	6 Months for protocol
Reentry	
Dislodgeable residue study	27 Months
Environmental Fate	
Photodegradation in water	9 Months
Photodegradation on soil	9 Months
Photodegradation in air	9 Months
Anaerobic soil metabolism	27 Months
Leaching and absorption/desorption	12 Months
Lab volatility	12 Months
Soil field dissipation	27 Months
Rotational crop (field)	50 Months
Fish accumulation	12 Months
Monitoring study (soil, water, sediment, fish)	6 Months (protocol)
Residue Chemistry	
Crop field trials	18 Months
Processing studies	24 Months
Storage stability	15 Months
Ruminant and poultry metabolism	18 Months
Residue analytical methodology data	15 Months
Product Chemistry	
Majority of data	6-15 Months

1/Due date is measured from the date of receipt of the Standard by the registrant unless otherwise specified.

2/1st Annual Report . . . . . December 31, 1989
2nd Annual Report* . . . . . December 31, 1990
3rd Annual Report* . . . . . December 31, 1991
Final Report** . . . . . December 31, 1992

*A determination may be made at this time to conclude the study, in which case a final report will be due 3 months after notification.

**The due date applies if the study has not been determined to be concluded by earlier reviews.

7. Contact person at EPA

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