Ecotoxicological Risk Assessment for Roundup® Herbicide
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Contents

I. Introduction .......................................................... 35
II. Problem Formulation .................................................. 36
   A. Risk Assessment Methodology .................................... 36
   B. Characteristics of Roundup® Formulations and Components .... 42
III. Exposure Assessment ................................................ 45
   A. Use Patterns ..................................................... 45
   B. Environmental Fate and Transport ................................ 47
   C. Environmental Concentrations from Terrestrial Uses .......... 54
   D. Environmental Concentrations from Aquatic Uses ............ 60
   E. Nontarget Organism Exposure Analysis ....................... 61
IV. Toxicity Assessment ................................................ 65
   A. Aquatic Organisms ............................................... 65
   B. Soil Organisms .................................................. 75
   C. Terrestrial Organisms ......................................... 77
   D. Summary of Toxicity Reference Values ....................... 86
V. Risk Characterization .............................................. 87
   A. Hazard Quotient Analyses ..................................... 87
   B. Terrestrial Uses ................................................ 89
   C. Aquatic Uses .................................................. 100
VI. Uncertainty Analysis .............................................. 101
Summary ................................................................. 102
Acknowledgments ....................................................... 104
References ............................................................... 104

I. Introduction

Glyphosate-based weed control products are among the most widely used broad-spectrum herbicides in the world. The herbicidal properties of glyphosate were discovered in 1970, and commercial formulations for nonselective weed control were first introduced in 1974 (Franz et al. 1997). Formulations of glyphosate,
including Roundup® Herbicide (RU)\(^1\) (Monsanto Company, St. Louis, MO), have been extensively investigated for their potential to produce adverse effects in nontarget organisms. Governmental regulatory agencies, international organizations, and others have reviewed and assessed the available scientific data for glyphosate formulations and independently judged their safety. Conclusions from three major organizations are publicly available and indicate RU can be used with minimal risk to the environment (Agriculture Canada 1991; USEPA 1993a; WHO 1994). Several review publications are available on the fate and effects of RU or glyphosate in the environment (Carlisle and Trevors 1988; Smith and Oehme 1992; Malik et al. 1989; Rueppel et al. 1977; Sullivan and Sullivan 1997; Forestry Canada, 1989). In addition, several books have been published about the environmental and human health considerations of glyphosate and its formulations (Grossbard and Atkinson 1985; Franz et al. 1997). In addition, RU and other glyphosate formulations have been selected for use in a number of weed control programs for state and local jurisdictions in the United States. Many of these uses require that ecological risk assessments be conducted in the form of Environmental Impact Statements or Environmental Assessments. These documents are comprehensive and specific to local use situations. Documents are available for risk assessments in Texas, Washington, Oregon, Pennsylvania, New York, Virginia, and other states (USDA 1989, 1992, 1996, 1997; USDI 1989; Washington State DOT 1993).

The purpose of this assessment was to expand the available ecotoxicology data and apply current ecological risk assessment methodologies to the evaluation of potential acute and chronic effects of RU (technical glyphosate acid and a surfactant) on nontarget species in the environment. The sources of information used in this assessment include both published and proprietary research reports on RU, glyphosate, and the major metabolite of glyphosate (aminomethylphosphonic acid, AMPA), as well as the surfactant used in formulations. In this effort, the authors have had the cooperation of the Monsanto Company, St. Louis, MO, which has provided complete access to its database of studies and other documentation. In general, the scientific studies carried out by Monsanto were conducted for regulatory purposes and comply with accepted protocols. Studies on glyphosate products commercially available from other manufacturers have been conducted, but this information was not available for use in this assessment.

**II. Problem Formulation**

A. Risk Assessment Methodology

The framework used for this ecological risk assessment includes three major phases: (1) a problem formulation phase; (2) a data analysis phase (exposure

\(^1\)Abbreviations: a.e., acid equivalents; AMPA, aminomethylphosphonic acid; HQ, hazard quotient; IPA, isopropylamine; LOEL, lowest-observed effect level; NML, no-mortality level; NOAEC, no-observed-adverse-effect concentration; NOAEL, no-observed-adverse-effect level; NOEC, no-observed-effect concentration; NOEL, no-observed-effect level; NTP, National Toxicology Program; POEA, polyethoxylated tallowamine; RU, Roundup®; TRV, toxicity reference value; USEPA, United States Environmental Protection Agency; WHO, World Health Organization.