



Toxicological Profile for Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene

April 2025



U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

CS274127-A

DISCLAIMER

Use of trade names is for identification only and does not imply endorsement by the Agency for Toxic Substances and Disease Registry, the Public Health Service, or the U.S. Department of Health and Human Services.

FOREWORD

This toxicological profile is prepared in accordance with guidelines developed by the Agency for Toxic Substances and Disease Registry (ATSDR) and the Environmental Protection Agency (EPA). The original guidelines were published in the *Federal Register* on April 17, 1987. Each profile will be revised and republished as necessary.

The ATSDR toxicological profile succinctly characterizes the toxicologic and adverse health effects information for these toxic substances described therein. Each peer-reviewed profile identifies and reviews the key literature that describes a substance's toxicologic properties. Other pertinent literature is also presented, but is described in less detail than the key studies. The profile is not intended to be an exhaustive document; however, more comprehensive sources of specialty information are referenced.

The focus of the profiles is on health and toxicologic information; therefore, each toxicological profile begins with a relevance to public health discussion which would allow a public health professional to make a real-time determination of whether the presence of a particular substance in the environment poses a potential threat to human health. The adequacy of information to determine a substance's health effects is described in a health effects summary. Data needs that are of significance to the protection of public health are identified by ATSDR.

Each profile includes the following:

- (A) The examination, summary, and interpretation of available toxicologic information and epidemiologic evaluations on a toxic substance to ascertain the levels of significant human exposure for the substance due to associated acute-, intermediate-, and chronic-duration exposures;
- (B) A determination of whether adequate information on the health effects of each substance is available or in the process of development to determine levels of exposure that present a significant risk to human health due to acute-, intermediate-, and chronic-duration exposures; and
- (C) Where appropriate, identification of toxicologic testing needed to identify the types or levels of exposure that may present significant risk of adverse health effects in humans.

The principal audiences for the toxicological profiles are health professionals at the Federal, State, and local levels; interested private sector organizations and groups; and members of the public.

This profile reflects ATSDR's assessment of all relevant toxicologic testing and information that has been peer-reviewed. Staffs of the Centers for Disease Control and Prevention and other Federal scientists have also reviewed the profile. In addition, this profile has been peer-reviewed by a nongovernmental panel and was made available for public review. Final responsibility for the contents and views expressed in this toxicological profile resides with ATSDR.



Christopher M. Reh, Ph.D.
Associate Director

Agency for Toxic Substances and Disease Registry
Centers for Disease Control and Prevention

VERSION HISTORY

Date	Description
April 2025	Final toxicological profile released
May 2024	Draft for public comment toxicological profile released
June 2005	Final toxicological profile released
August 1995	Final toxicological profile released
December 1990	Final toxicological profile released

CONTRIBUTORS & REVIEWERS

CHEMICAL MANAGER TEAM

Gaston Casillas, Ph.D. (Lead)
Franco Scinicariello, M.D., M.P.H.
Mohammad Shoeb, Ph.D.
Breanna Alman, M.P.H

Heather Carlson-Lynch, M.S., D.A.B.T.
Claire Heit, Ph.D.
Savannah Sierco, M.S.
Mario Citra, Ph.D.

ATSDR, Office of Innovation and Analytics,
Toxicology Section, Atlanta, GA

SRC, Inc., North Syracuse, NY

REVIEWERS

Interagency Minimal Risk Level Workgroup:

Includes ATSDR; National Center for Environmental Health (NCEH); National Institute for Occupational Safety and Health (NIOSH); U.S. Environmental Protection Agency (EPA); National Toxicology Program (NTP).

Additional reviews for science and/or policy:

ATSDR, Office of Community Health Hazard Assessment; ATSDR, Office of Capacity Development and Applied Prevention Science; ATSDR, Office of Science; NCEH, Division of Laboratory Sciences; NCEH, Division of Environmental Health Science and Practice; EPA, Office of Research and Development; EPA, Office of Water.

PEER REVIEWERS

1. Chunrong Jia, Ph.D., M.S.; Professor of Environmental Health; Division of Epidemiology, Biostatistics, and Environmental Health; School of Public Health; The University of Memphis, Memphis, Tennessee.
2. Alan Buckpitt, Ph.D.; Professor Emeritus; Molecular Biosciences; The University of California, Davis, Veterinary Medicine; Davis, California.
3. Xinxin Ding, Ph.D.; Cancer Biology Program; The University of Arizona; Tucson, Arizona.

These experts collectively have knowledge of toxicology, chemistry, and/or health effects. All reviewers were selected in conformity with Section 104(I)(13) of the Comprehensive Environmental Response, Compensation, and Liability Act, as amended.

ATSDR scientists review peer reviewers' comments and determine whether changes will be made to the profile based on comments. The peer reviewers' comments and responses to these comments are part of the administrative record for this compound.

The listing of peer reviewers should not be understood to imply their approval of the profile's final content. The responsibility for the content of this profile lies with ATSDR.

CONTENTS

DISCLAIMER	ii
FOREWORD	iii
VERSION HISTORY	iv
CONTRIBUTORS & REVIEWERS	v
CONTENTS	vi
LIST OF FIGURES	viii
LIST OF TABLES	ix
CHAPTER 1. RELEVANCE TO PUBLIC HEALTH	1
1.1 OVERVIEW AND U.S. EXPOSURES	1
1.2 SUMMARY OF HEALTH EFFECTS	2
1.3 MINIMAL RISK LEVELS (MRLs)	10
CHAPTER 2. HEALTH EFFECTS	18
2.1 INTRODUCTION	18
2.2 DEATH	63
2.3 BODY WEIGHT	65
2.4 RESPIRATORY	68
2.5 CARDIOVASCULAR	76
2.6 GASTROINTESTINAL	79
2.7 HEMATOLOGICAL	80
2.8 MUSCULOSKELETAL	85
2.9 HEPATIC	86
2.10 RENAL	88
2.11 DERMAL	91
2.12 OCULAR	92
2.13 ENDOCRINE	96
2.14 IMMUNOLOGICAL	97
2.15 NEUROLOGICAL	100
2.16 REPRODUCTIVE	103
2.17 DEVELOPMENTAL	106
2.18 OTHER NONCANCER	110
2.19 CANCER	111
2.20 GENOTOXICITY	114
CHAPTER 3. TOXICOKINETICS, SUSCEPTIBLE POPULATIONS, BIOMARKERS, CHEMICAL INTERACTIONS	124
3.1 TOXICOKINETICS	124
3.1.1 Absorption	124
3.1.2 Distribution	128
3.1.3 Metabolism	130
3.1.4 Excretion	138
3.1.5 Physiologically Based Pharmacokinetic (PBPK)/Pharmacodynamic (PD) Models	141
3.1.6 Animal-to-Human Extrapolations	147
3.2 CHILDREN AND OTHER POPULATIONS THAT ARE UNUSUALLY SUSCEPTIBLE	149

3.3	BIOMARKERS OF EXPOSURE AND EFFECT	154
3.3.1	Biomarkers of Exposure.....	155
3.3.2	Biomarkers of Effect.....	156
3.4	INTERACTIONS WITH OTHER CHEMICALS	157
CHAPTER 4. CHEMICAL AND PHYSICAL INFORMATION		159
4.1	CHEMICAL IDENTITY	159
4.2	PHYSICAL AND CHEMICAL PROPERTIES	159
CHAPTER 5. POTENTIAL FOR HUMAN EXPOSURE.....		162
5.1	OVERVIEW	162
5.2	PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL	164
5.2.1	Production	164
5.2.2	Import/Export.....	168
5.2.3	Use	168
5.2.4	Disposal.....	169
5.3	RELEASES TO THE ENVIRONMENT.....	170
5.3.1	Air	170
5.3.2	Water.....	176
5.3.3	Soil	177
5.4	ENVIRONMENTAL FATE	178
5.4.1	Transport and Partitioning.....	178
5.4.2	Transformation and Degradation	181
5.5	LEVELS IN THE ENVIRONMENT.....	184
5.5.1	Air	186
5.5.2	Water.....	190
5.5.3	Sediment and Soil	193
5.5.4	Other Media	198
5.6	GENERAL POPULATION EXPOSURE.....	208
5.7	POPULATIONS WITH POTENTIALLY HIGH EXPOSURES	215
CHAPTER 6. ADEQUACY OF THE DATABASE.....		219
6.1	INFORMATION ON HEALTH EFFECTS.....	219
6.2	IDENTIFICATION OF DATA NEEDS	219
6.3	ONGOING STUDIES.....	232
CHAPTER 7. REGULATIONS AND GUIDELINES		233
CHAPTER 8. REFERENCES		236
APPENDICES		
APPENDIX A.	ATSDR MINIMAL RISK LEVEL WORKSHEETS	A-1
APPENDIX B.	LITERATURE SEARCH FRAMEWORK FOR NAPHTHALENE, 1-METHYLNAPHTHALENE, AND 2-METHYLNAPHTHALENE	B-1
APPENDIX C.	FRAMEWORK FOR ATSDR'S SYSTEMATIC REVIEW OF HEALTH EFFECTS DATA FOR NAPHTHALENE, 1-METHYLNAPHTHALENE, AND 2-METHYLNAPHTHALENE	C-1
APPENDIX D.	USER'S GUIDE.....	D-1
APPENDIX E.	QUICK REFERENCE FOR HEALTH CARE PROVIDERS	E-1
APPENDIX F.	GLOSSARY	F-1
APPENDIX G.	ACRONYMS, ABBREVIATIONS, AND SYMBOLS.....	G-1

LIST OF FIGURES

1-1. Health Effects Found in Animals Following Inhalation Exposure to Naphthalene.....	3
1-2. Health Effects Found in Animals Following Oral Exposure to Naphthalene.....	4
1-3. Health Effects Found in Animals Following Inhalation Exposure to 1-Methylnaphthalene.....	5
1-4. Health Effects Found in Animals Following Oral Exposure to 1-Methylnaphthalene.....	5
1-5. Health Effects Found in Animals Following Inhalation Exposure to 2-Methylnaphthalene.....	6
1-6. Health Effects Found in Animals Following Oral Exposure to 2-Methylnaphthalene.....	6
1-7. Summary of Sensitive Targets of Naphthalene – Inhalation	11
1-8. Summary of Sensitive Targets of Naphthalene – Oral	12
1-9. Summary of Sensitive Targets of 1-Methylnaphthalene – Inhalation	14
1-10. Summary of Sensitive Targets of 1-Methylnaphthalene – Oral	14
1-11. Summary of Sensitive Targets of 2-Methylnaphthalene – Inhalation	16
1-12. Summary of Sensitive Targets of 2-Methylnaphthalene – Oral	16
2-1. Overview of the Number of Studies Examining Naphthalene Health Effects.....	22
2-2. Overview of the Number of Studies Examining 1-Methylnaphthalene Health Effects.....	23
2-3. Overview of the Number of Studies Examining 2-Methylnaphthalene Health Effects.....	24
2-4. Levels of Significant Exposure to Naphthalene – Inhalation	30
2-5. Levels of Significant Exposure to Naphthalene – Oral	42
2-6. Levels of Significant Exposure to 1- and 2-Methylnaphthalene – Inhalation	52
2-7. Levels of Significant Exposure to 1- and 2-Methylnaphthalene – Oral	58
3-1. Scheme for Naphthalene Metabolism and Formation of Multiple Reactive Metabolites that may be Involved in Naphthalene Toxicity.....	131
3-2. Metabolism of 2-Methylnaphthalene.....	136
5-1. Number of NPL Sites with Naphthalene and Methylnaphthalene.....	162
6-1. Summary of Existing Health Effects Studies on Naphthalene by Route and Endpoint	220
6-2. Summary of Existing Health Effects Studies on 1-Methylnaphthalene by Route and Endpoint	221
6-3. Summary of Existing Health Effects Studies on 2-Methylnaphthalene by Route and Endpoint	222

LIST OF TABLES

1-1. Minimal Risk Levels (MRLs) for Naphthalene.....	13
1-2. Minimal Risk Levels (MRLs) for 1-Methylnaphthalene.....	15
1-3. Minimal Risk Levels (MRLs) for 2-Methylnaphthalene.....	17
2-1. Levels of Significant Exposure to Naphthalene – Inhalation	25
2-2. Levels of Significant Exposure to Naphthalene – Oral	34
2-3. Levels of Significant Exposure to Naphthalene – Dermal	48
2-4. Levels of Significant Exposure to 1- and 2-Methylnaphthalene – Inhalation (ppm).....	50
2-5. Levels of Significant Exposure to 1- and 2-Methylnaphthalene – Oral (mg/kg/day).....	55
2-6. Levels of Significant Exposure to 1- and 2-Methylnaphthalene – Dermal	62
2-7. Summary of Epidemiological Studies of Naphthalene Exposure and Obesity-Related Effects.....	66
2-8. Summary of Epidemiological Studies of Naphthalene Exposure and Respiratory Effects	69
2-9. Summary of Epidemiological Studies of Naphthalene Exposure and Cardiovascular Effects.....	77
2-10. Summary of Epidemiological Studies of Naphthalene Exposure and Hematological Effects	82
2-11. Summary of Epidemiological Studies of Naphthalene Exposure and Immunological Effects	97
2-12. Summary of Epidemiological Studies of Naphthalene Exposure and Reproductive Effects	104
2-13. Summary of Epidemiological Studies of Naphthalene Exposure and Developmental Effects	107
2-14. Genotoxicity of Naphthalene <i>In Vitro</i>	114
2-15. Genotoxicity of Naphthalene Metabolites <i>In Vitro</i>	115
2-16. Genotoxicity of Naphthalene <i>In Vivo</i>	116
2-17. Genotoxicity of Naphthalene Metabolites <i>In Vivo</i>	117
2-18. Genotoxicity of 1-Methylnaphthalene and 2-Methylnaphthalene <i>In Vitro</i>	122
4-1. Chemical Identity of Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene	159
4-2. Physical and Chemical Properties of Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene.....	160
5-1. Facilities that Produce, Process, or Use Naphthalene.....	166
5-2. Releases to the Environment from Facilities that Produce, Process, or Use Naphthalene	170

5-3. National Emission Inventory (NEI) Total National Emissions (pounds) for Naphthalene and Methylnaphthalenes Estimated by Sector 2017.....	174
5-4. Lowest Limit of Detection Based on Standards for Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene	185
5-5. Summary of Environmental Levels of Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene.....	185
5-6. Naphthalene and Methylnaphthalene Levels in Water, Soil, and Air of National Priorities List (NPL) Sites.....	186
5-7. Summary of Annual Concentrations of Naphthalene and Methylnaphthalenes ($\mu\text{g}/\text{m}^3$) Measured in Ambient Air at Locations Across the United States	187
5-8. Summary of Naphthalene and Methylnaphthalenes ($\mu\text{g}/\text{m}^3$) Measured in Outdoor Air	188
5-9. Summary of Concentrations of Naphthalene and Methylnaphthalenes ($\mu\text{g}/\text{L}$) Measured in Surface and Groundwater Across the United States.....	191
5-10. Summary Naphthalene and Methylnaphthalenes ($\mu\text{g}/\text{kg}$) Measured in Soil/Sediment Across the United States, Reported in the Water Quality Portal.....	194
5-11. Summary of Naphthalene and Methylnaphthalenes ($\mu\text{g}/\text{kg}$) Measured in Ambient Soil and Sediment.....	195
5-12. Summary of Concentrations of Naphthalene and Methylnaphthalenes ($\mu\text{g}/\text{kg}$) Measured in Biota Samples Across the United States.....	199
5-13. Summary of Naphthalene and Methylnaphthalenes Measured in Food, Beverages, and Supplements	202
5-14. Summary of Naphthalene Measured in Consumer Products	205
5-15. Summary of Naphthalene and Methylnaphthalenes Measured in Tobacco Products.....	207
5-16. Geometric Mean of the Urine Concentration ($\mu\text{g}/\text{L}$) of 1- and 2-Hydroxynaphthalene in the U.S. Population (2015–2016).....	210
5-17. Geometric Mean of the Urine Concentration ($\mu\text{g}/\text{L}$) of 1-Hydroxynaphthalene and 2-Hydroxynaphthalene in the U.S. Adult Smoking Population (2015–2016).....	211
5-18. Reasonable Maximum Estimate of Naphthalene Daily Inhalation and Dermal Doses from Showering by Exposure Group	214
6-1. Ongoing Studies on Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene	232
7-1. Regulations and Guidelines Applicable to Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene.....	233