



Emerging Contaminant - N-Nitrosodimethylamine (NDMA)

April 2008



FACT SHEET

At a Glance

- ❖ Classified as a B2 carcinogen - reasonably anticipated to be a human carcinogen.
- ❖ Formerly used in the production of rocket fuel, antioxidants, and softeners for copolymers. Currently used only for research purposes.
- ❖ Unintended byproduct of chlorination of wastewater at wastewater treatment plants that use chloramines for disinfection, causing significant concern as a drinking water contaminant.
- ❖ Highly mobile in soil, with potential to leach into ground water.
- ❖ Oral route is the primary human exposure pathway.
- ❖ Listed as a priority pollutant by EPA, but no federal standards have been established for drinking water.
- ❖ Most common treatment method is via photolysis by ultraviolet radiation ranging in wavelengths of 225 to 250 nanometers.
- ❖ Potential for aerobic and anaerobic biodegradation exists.

Introduction

An “emerging contaminant” is a chemical or material that is characterized by a perceived, potential, or real threat to human health or the environment or a lack of published health standards. A contaminant may also be “emerging” because a new source or a new pathway to humans has been discovered or a new detection method or treatment technology has been developed (DoD 2006). This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a brief summary for N-Nitrosodimethylamine (NDMA), including physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information.

NDMA is an emerging drinking water contaminant that is of interest to the environmental community because of its miscibility with water, as well as its carcinogenicity and toxicity. This fact sheet is intended for use by site managers and other field personnel addressing NDMA contamination at a cleanup site or in a drinking water supply.

What is NDMA?

- ❖ Synonyms include dimethylnitrosamine (DMNA), nitrosodimethylamine, N-methyl-N-nitrosomethanamine, and N,N-dimethylnitrosamine (EPA IRIS 2006).
- ❖ NDMA is not currently produced in pure form or commercially used, except for research purposes. It was formerly used in production of liquid rocket fuel, antioxidants, and softeners for copolymers (ATSDR 1999; HSDB 2007).
- ❖ NDMA can be produced and released from industrial sources through chemical reactions, such as those involving alkylamines with nitrogen oxides, nitrous acid, or nitrite salts. Potential industrial sources include byproducts from tanneries, pesticide and rocket fuel manufacturing plants, rubber and tire manufacturers, alkylamine manufacture and use sites, fish processing facilities, foundries, and dye manufacturers (ATSDR 1989).
- ❖ NDMA is also an unintended byproduct of chlorination of wastewater and drinking water at treatment plants that use chloramines for disinfection (Mitch and others 2003; Bradley and others 2005).
- ❖ NDMA is currently on the DoD Emerging Contaminant Watch List (Yaroschak 2006).

Exhibit 1: Physical and Chemical Properties of N-Nitrosodimethylamine
(CHEMFATE 2003; ATSDR 1989)

Property	Value/Description
CAS Number	62-75-9
Physical Description (physical state at room temperature)	Yellow liquid with no distinct odor
Molecular weight (g/mol)	74.08
Water solubility (g/L at 25°C)	Miscible
Boiling point (°C)	154
Specific gravity (g/mL)	1.0059
Vapor pressure at 25°C (mm Hg)	2.7
Log organic carbon partition coefficient (log K _{oc})	1.079
Log octanol-water partition coefficient (log K _{ow})	-0.57
Henry's Law Constant (atm m ³ /mol)	2.63 x 10 ⁻⁷

Notes: g/mol – Grams per mole; g/mL – Grams per milliliter; g/L – Grams per liter; °C – Degrees Celsius; mm Hg – Millimeters of mercury.

What are the environmental impacts of NDMA?

- ❖ NDMA contamination may be found in air, water, and soil, from the various sources described earlier (ATSDR 1989).
- ❖ In water, NDMA is completely miscible and does not sorb onto solid particles or sediment (HSDB 2007).
- ❖ When released to soil, NDMA can be highly mobile and has the potential to leach into ground water (ATSDR 1999; HSDB 2007).
- ❖ When released to the air, NDMA is broken down very quickly by sunlight (ATSDR 1999).
- ❖ NDMA has been found at high concentrations (3,000 nanograms per liter [ng/L] or parts per trillion [ppt]) in ground water near rocket engine testing facilities and also downgradient of drinking water wells, especially in locations where wastewater effluent was used for aquifer recharge (Mitch and others 2003).

What are the health effects of NDMA?

- ❖ NDMA exposure may occur through ingestion of food containing nitrosamines, such as smoked or cured meats and fish; beer; contaminated drinking water; and breathing or inhaling cigarette smoke. Workplace exposure can occur at tanneries, pesticide manufacturing plants, and rubber and tire plants (ATSDR 1989).
- ❖ The oral route is the primary human exposure pathway for NDMA (OEHHA 2006).
- ❖ Exposure to high levels of NDMA may cause liver damage in humans. Symptoms of overexposure include headache, fever, nausea, jaundice, vomiting, and dizziness (ATSDR 1999; HSDB 2007).
- ❖ NDMA is classified as a B2 carcinogen – reasonably anticipated to be a human carcinogen (ATSDR 1999; EPA IRIS 2006; USDHHS 2002).

Are there any existing federal and state guidelines and health standards for NDMA?

- ❖ Drinking Water Standards:
 - Although NDMA is listed as a priority pollutant (CFR 2001), no federal maximum contaminant level (MCL) has been established for drinking water. A MCL is not necessary for establishing cleanup levels.
 - At a Superfund site in California, EPA established a cleanup level of 0.7 ng/L NDMA in ground water, based on a 1 in 10⁻⁶ lifetime excess cancer risk in drinking water (EPA 2001).

Are there any existing federal and state guidelines and health standards for NDMA? (continued)

- EPA Regions 3 and 6 have calculated 0.42 ng/L as the non-enforceable screening level for NDMA in tap water, based on a 1 in 10^{-6} lifetime excess cancer risk (EPA 2007a and b).
- California has established a public health goal of 3 ng/L in drinking water, based on a 1 in 10^{-6} lifetime excess cancer risk (OEHHA 2006).
- ❖ Workplace Exposure Limits:
 - Although no permissible exposure limits (PEL) or other occupational exposure limits have been established by the Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), or the American Conference of Industrial Hygienists (ACGIH), NDMA is regulated along with 13 other chemicals as a “potential occupational carcinogen” (OSHA 2006).
 - OSHA regulations promulgated in the Code of Federal regulations (CFR) (29 CFR 1910.1003 and 29 CFR 1910.1116) state that exposure by all routes to NDMA should be reduced to the lowest possible levels.

What detection and site characterization methods are available for NDMA?

- ❖ The following methods can be used to analyze for NDMA:
 - For wastewater, EPA Method 607 uses methylene chloride extraction, gas chromatography (GC), and a nitrogen-phosphorus detector (EPA 2002).
 - For drinking water, EPA Method 521 uses solid phase extraction (SPE) and capillary column GC with large-volume injection and chemical ionization tandem MS (MS/MS) (Munch and Bassett 2004).
 - For wastewater, EPA Method 1625 uses isotope dilution, GC and MS (EPA 2002).
 - An analytical method has also been developed specifically for NDMA precursors such as alkylamines in waste or wastewater (Mitch, Gerecke, and Sedlak 2003).
 - A recently developed method using liquid chromatography tandem MS (LC/MS/MS) detects both thermally stable and unstable nitrosamines (Zhao and others 2006).

What technologies are being used to treat NDMA?

- ❖ The most common method to treat NDMA in drinking water systems is photolysis by ultraviolet (UV) radiation in the wavelength range of 225 to 250 nanometers (nm). This treatment cleaves the N–N bond, yielding nitrite and small quantities of dimethylamine (Mitch and others 2003).
- ❖ Recent studies have shown that aerobic and anaerobic biodegradation of NDMA water may be possible (Bradley and others 2005).
- ❖ Biological treatment, microfiltration, and reverse osmosis treatment may be used to remove NDMA precursors from wastewater prior to chlorination (Mitch and others 2003).

Where can I find more information about NDMA?

- ❖ Agency for Toxic Substances and Disease Registry (ATSDR). 1989. Toxicological Profile for N-Nitrosodimethylamine. Atlanta, Georgia: U.S. Department of Health and Human Services, Public Health Service.
- ❖ ATSDR. 1999. ToxFAQs - N-Nitrosodimethylamine.
- ❖ Bradley, P.M., S.A. Carr, R.B. Baird, and F.H. Chappelle. 2005. “Biodegradation of N-nitrosodimethylamine in soil from a water reclamation facility.” *Bioremediation Journal*. Vol. 9. Pages 115-120.

Where can I find more information about NDMA? (continued)

- ❖ CHEMFATE. 2003. Database Listing for N-Nitrosodimethylamine. www.syrres.com/esc/chemfate.htm.
- ❖ Code of Federal Regulations (CFR). 2001. Title 40, Chapter 1, Part 136.36. July 1 edition.
- ❖ Hazardous Substance Data Bank (HSDB). 2007. Information generated for N-Nitrosodimethylamine on January 23. <http://toxnet.nlm.nih.gov>.
- ❖ Mitch, W.A., A.C. Gerecke, and D.L. Sedlak. 2003. "A N-Nitrosodimethylamine (NDMA) precursor analysis for chlorination of water and wastewater." *Water Research*. Vol. 37. Pages 3733-3741.
- ❖ Mitch, W.A., J.O. Sharp, R.R. Trussell, R.L. Valentine, L. Alvarez-Cohen, and D.L. Sedlak. 2003. "N-Nitrosodimethylamine (NDMA) as a Drinking Water Contaminant: A Review." *Environmental Engineering Science*. Vol. 20 (5). Pages 389-404.
- ❖ Munch, J.W. and M.V. Bassett. September 2004. "U.S. EPA Method 521: Determination of Nitrosoamines in Drinking Water by Solid Phase Extraction (SPE) and Capillary Column Gas Chromatography with Large Volume Injection and Chemical Ionization Tandem Mass Spectrometry (MS/MS)." Version 1.0. National Exposure Research Laboratory, Cincinnati, Ohio. EPA 600-R-05-054.
- ❖ Occupational Safety and Health Administration (OSHA). 2006. Chemical Sampling Information – N-Nitrosodimethylamine. www.osha.gov/dts/chemicalsampling/data/CH_2_58000.html.
- ❖ Office of Environmental Health Hazard Assessment (OEHHA). 2006. Public Health Goals for Chemicals in Drinking Water – N-Nitrosodimethylamine.
- ❖ U.S. Department of Health and Human Services (USDHHS). 2002. Report on Carcinogens. Public Health Service, National Toxicology Program. 10th edition.
- ❖ U.S. Department of Defense. 2006. Emerging Contaminants. www.denix.osd.mil/denix/Public/Library/MERIT/merit.html.
- ❖ U.S. Environmental Protection Agency (EPA). 2001. "Record of Decision for the Western Ground Water Operable Unit OU-3, Aerojet Sacramento Site."
- ❖ EPA. 2002. Methods for Organic Chemicals Analysis. In: Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; National Primary Drinking Water Regulations; and National Secondary Drinking Water Regulations; Methods Update; Final Rule.
- ❖ EPA. 2007a. Region 6. Human Health Medium-Specific Screening Level. www.epa.gov/region6.
- ❖ EPA. 2007b. Region 3. Human Health Risk Assessment – Risk-Based Concentrations Table. www.epa.gov/region3.
- ❖ EPA Integrated Risk Information System (IRIS). 2006. N-Nitrosodimethylamine. www.epa.gov/iris/subst/0045.htm.
- ❖ Yaroschak, P. 2006. "Emerging Contaminants – The New Frontier". Presentation at the December 2006 Federal Remediation Technologies Roundtable (FRTR) Meeting. www.frtr.gov/pdf/meetings/dec06/yaroschak120606.pdf
- ❖ Zhao, Y-Y., J. Boyd, S.E. Hrudey, and X-F. Li. 2006. "Characterization of New Nitrosoamines in Drinking Water Using Liquid Chromatography Tandem Mass Spectrometry." *Environmental Science and Technology*. Vol. 40. Pages 7636-7641.

Contact Information

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