Emerging Contaminant – N-Nitroso-dimethylamine (NDMA)

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FACT SHEET

At a Glance

- Yellow liquid with no distinct color.
- Formerly used in the production of rocket fuel, antioxidants, and softeners for copolymers. Currently used only for research.
- 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.
- Classified as a B2 carcinogen, reasonably anticipated to be a human carcinogen.
- Listed as a priority pollutant by EPA, but no federal standards have been established for drinking water.
- Detection methods include solid phase extraction, gas chromatography, and liquid chromatography.
- Most common treatment method is via photolysis by ultraviolet radiation ranging in wavelength from 225 to 250 nanometers. Potential for aerobic and anaerobic biodegradation also 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 2009). This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a brief summary of the emerging contaminant 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 who may address NDMA contamination at cleanup sites or in drinking water supplies.

What is NDMA?

- NDMA is a semivolatile organic chemical that is currently on the U.S. Department of Defense (DoD) Emerging Contaminant Watch List (Yaroschak 2006).
- Synonyms include dimethylnitrosamine (DMNA), nitrosodimethylamine, N-methyl-N-nitrosomethanamine, and N,N-dimethylnitrosamine (EPA IRIS 2009).
- NDMA is not currently produced in pure form or commercially used, except for research. It was formerly used in production the of liquid rocket fuel, antioxidants, and softeners for copolymers (ATSDR 1999; HSDB 2008).
- NDMA can be produced and released from industrial sources through chemical reactions, such as those that involve 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 the chlorination of wastewater and drinking water at treatment plants that use chloramines for disinfection (Bradley et al. 2005; Mitch et al. 2003).

Exhibit 1: Physical and Chemical Properties of NDMA
(ATSDR 1999)

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
Organic carbon partition coefficient (log K_{oc})	1.07
Octanol-water partition coefficient (log K_{ow})	-0.57
Henry's Law Constant (atm m^3/mol)	2.63×10^{-7}

Notes: g/mol – Grams per mole; g/L – Grams per liter; °C – Degrees Celsius; g/mL – Grams per milliliter; mm Hg – Millimeters of mercury; atm m^3/mol – atmosphere-cubic meters per mole.

What are the environmental impacts of NDMA?

- NDMA contamination may be found in air, soil, and water (ATSDR 1989).
- When released to the air, NDMA is broken down quickly by sunlight (ATSDR 1999).
- When released to soil, NDMA can be highly mobile and has the potential to leach into ground water (ATSDR 1999; HSDB 2008).
- In water, NDMA is completely miscible and does not sorb onto solid particles or sediment (HSDB 2008).
- NDMA has been found at high concentrations (3,000 nanograms per liter [ng/L]) in ground water near rocket engine testing facilities and also downgradient of drinking water wells, especially in locations where wastewater treatment plant effluent was used for aquifer recharge (Mitch et al. 2003).

What are the health effects of NDMA?

- NDMA exposure may occur through (1) ingesting food that contains nitrosamines, such as smoked or cured meats and fish; (2) drinking beer; (3) drinking contaminated water; and (4) breathing or inhaling cigarette smoke. Workplace exposure can occur at tanneries, pesticide and rocket fuel manufacturing plants, and rubber and tire plants (ATSDR 1989).
- The oral route is the primary human exposure pathway for NDMA (CAL/EPA 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 2008).
- NDMA is classified as a B2 carcinogen – reasonably anticipated to be a human carcinogen (ATSDR 1999; DHHS 2002; EPA IRIS 2009).

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

- Drinking Water Standards and Guidelines:
  - Although NDMA is listed as a priority pollutant in the Code of Federal Regulations (CFR) (40 CFR 136.36), no federal maximum contaminant level (MCL) has been established for drinking water. An MCL is not necessary to determine cleanup levels.
  - California has established a public health goal of 3 nanograms per liter (ng/L) in drinking water, based on a 1 in 10^{-6} lifetime excess cancer risk (CAL/EPA 2006).

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

- EPA established a cleanup level of 0.7 ng/L for NDMA in ground water at a Superfund site in California, based on a 1 in 10^{-6} lifetime excess cancer risk in drinking water (EPA 2001).
- 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 2008a, b).

❖ 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), the 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 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?

❖ For drinking water, EPA Method 521 uses solid phase extraction (SPE) and capillary column gas chromatography (GC) with large-volume injection and chemical ionization tandem mass spectroscopy (MS) (Munch and Bassett 2004).

❖ For wastewater, EPA Method 607 uses methylene chloride extraction, GC, and a nitrogen-phosphorus detector (EPA 2002).

❖ For wastewater, EPA Method 1625 uses isotope dilution, GC and mass spectrometry (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 et al. 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 et al. 2003).

❖ Biological treatment, microfiltration, and reverse osmosis treatment may be used to remove NDMA precursors from wastewater before chlorination (Mitch et al. 2003).

❖ Recent studies have shown that aerobic and anaerobic biodegradation of NDMA water may be possible (Bradley et al. 2005).

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.* Volume 9. Pages 115 to 120.

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

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- Code of Federal Regulations (CFR). 2001. Title 40, Chapter 1, Part 136.36. July 1 edition.
- Hazardous Substance Data Bank (HSDB). 2008. Information generated for N-Nitrosodimethylamine on October 1. http://toxnet.nlm.nih.gov.
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- U.S. Environmental Protection Agency (EPA). 2001. "Record of Decision for the Western Ground Water Operable Unit OU-3, Aerojet Sacramento Site."
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- EPA. 2008b. Region 3. Human Health Risk Assessment – Risk-Based Concentrations Table. September. http://www.epa.gov/reg3hwmd/risk/human/index.htm.
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- 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 & Technology.* Volume 40. Pages 7636 to 7641.

Contact Information

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