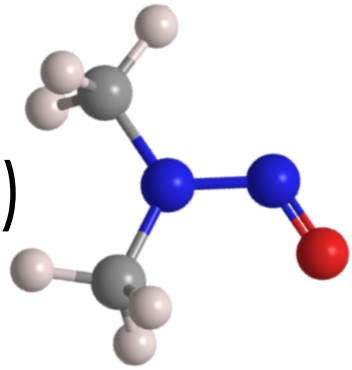
Groundwater Fact Sheet
N-Nitrosodimethylamine (NDMA)



Constituent of Concern
N-Nitrosodimethylamine

Synonym
Dimethylnitrosamine; N-Dimethylnitrosamine; DMNA; N-Methyl-N-nitrosomethanamine; N, N-Dimethylnitrosamine; N, N-Dimethylnitrous amide; NDMA is one of the group of chemicals known as "Nitrosamines".

Chemical Formula
$(CH_3)_2N_2O$ or $C_2H_6NO_2$

CAS Number
62-75-9

Storet Number
34438

Summary
NDMA is an unregulated chemical without an established Maximum Contaminant Level (MCL). The California State Water Resources Control Board (SWRCB) has established a Notification Level (NL) of 0.01 micrograms per liter (µg/L), a Public Health Goal (PHG) of 0.003 µg/L, and a Cancer Potency Factor (CA-CPF) at 0.0022 µg/L. NDMA is of interest because of its miscibility with water, carcinogenicity, and toxicity. Currently, NDMA is used for research and was formerly used in the production of liquid rocket fuel and other industrial applications and consumer products. NDMA is also an unintended byproduct of the chlorination of wastewater and drinking water. NDMA has been reported to be present in foods, beverages, drugs, and tobacco smoke. NDMA and other nitrosamines are considered "emerging contaminants."

Based on SWRCB data from 2007 to 2017, 60 active and standby public water supply wells (of 260 wells tested, 71 detections) had at least one detection of NDMA above the CA-CPF. Most detections of NDMA above the CA-CPF were found in Los Angeles (52), Sacramento (6) county wells.

REGULATORY WATER QUALITY LEVELS[1]

N-NITROSODIMETHYLAMINE (NDMA)

Type	**Agency**	**Concentration**
Federal MCL	EPA[2]	NA
State MCL	SWRCB[3]	NA
Notification level (NL)	SWRCB[3]	0.01 µg/L
CA CPF - Cancer Potency Factor (1/10^6 cancer risk)	SWRCB[3]	0.002 µg/L
Public Health Goal (PHG)	OEHHA[4]	0.003 µg/L

[1]These levels are generally related to drinking water. Other water quality levels may exist. For further information, see "A Compilation of Water Quality Goals", 17th Edition (SWRCB 2016).
[2]EPA – United States Environmental Protection Agency
[3]SWRCB - State Water Resources Control Board.
[4]OEHHA – Office of Environmental Health Hazard Assessment

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NDMA DETECTIONS IN PUBLIC WATER WELL SOURCES[5]	
Number of active and standby public water wells with NDMA concentrations above the CA-CPF of 0.0022 µg/L.[6]	60 of 260 wells tested with 71 detections
Counties that had active and standby public water wells with NDMA concentrations above the CA-CPF of 0.0022 µg/L	Los Angeles (52), Sacramento (6)

[5]Based on 2007-2017 public standby and active well (groundwater sources) data collected by the SWRCB.
[6]Water from active and standby wells is treated to prevent exposure to chemical concentrations above the MCL. Data from private domestic wells and wells with less than 15 service connections are not available.

ANALYTICAL INFORMATION	
Approved EPA methods	521
Detection Limit (µg/L)	0.00028
Notes	Solid Phase Extraction and capillary column Gas Chromatography with large volume injection and chemical ionization tandem Mass Spectrometry (MS/MS)
Known Limitations to Analytical Methods	EPA Method 521 is performed under the supervision of analysts with experience in solid phase extraction and chemical ionization analysis. Nitrosamines can be present in trace amounts of rubber products, so these components must be avoided in sampling, storage, or analytical devises. Samples must be stored at a temperature below 10°C during the first 48 hours after sampling and stored in the lab below 6°C before extraction. Extraction must be done within 14 days of collection.
Public Drinking Water Testing Requirements	NDMA is on the EPA list of unregulated contaminants for which monitoring is required.

NDMA Occurrence

Anthropogenic Sources

NDMA is primarily used in research, and commonly used to induce cancer in mice. NDMA is also used in the production of 1,1-dimethylhydrazine for liquid rocket fuel. Other industrial applications include use in production of pesticides (nematicide), plasticizers for rubber, battery components, solvents, antioxidants, lubricant additives, and polymers/co-polymers. NDMA has also been detected in treated industrial wastewater, chlorinated drinking water and wastewater, treated sewage and high-nitrate well water.

Natural Sources

NDMA can form as a byproduct in reactions involving alkylamines. Eating food with alkylamines can cause NDMA to form in the stomach. NDMA has been reported to be present in tobacco smoke, a variety of foods and beverages, and in prescription drugs.

History of Occurrence

NDMA contamination was discovered in 1998 at a Sacramento County aerospace facility (Aerojet). Samples collected from a nearby drinking water well containing NDMA at a concentration of 0.15 µg/L. NDMA was also detected in 1998 in three drinking water wells in the San Gabriel Basin, which were subsequently removed from service.

In 1999, SWRCB (formerly CDPH) was informed of NDMA detections in treated wastewater. This finding was important because proposed recycled water projects use treated wastewater for groundwater recharge. In addition, testing indicated that NDMA was present at very low levels (<0.01 µg/L) in treated drinking water. The presence of NDMA in drinking water was thought to be related to the chlorination process used to treat drinking water.

In 2000, treated wastewater used for aquifer recharge in Orange County was found to contain detectable concentrations of NDMA. The plant was ordered by SWRCB to reduce the levels of NDMA. NDMA detections associated with contamination from the aerospace industry and from resins used in water treatment for nitrate removal have also been detected in Los Angeles County.

Contaminant Transport Characteristics

NDMA is miscible with water (complete solubility). NDMA has a low vapor pressure and does not readily absorb to airborne particulates. NDMA is rapidly broken down in sunlight. NDMA has a low carbon partition coefficient, which makes it less likely to be adsorbed to soil and more likely to travel with groundwater flow.

Research shows NDMA can form through a reaction between monochloramine (a form of chlorine commonly used in water disinfection) and simple amines contained in urine, feces, algae, and plants. Precursors of NDMA in recycled water include dimethylamine functional groups, trimethylamine, dimethyl amides, the fungicide Thiram, and the herbicide 2,4-D.

Remediation and Treatment Technologies

There are several effective remediation technologies that remove NDMA from drinking water. These include:

UV/Oxidation

Ultraviolet (UV) light technology has been used successfully for the destruction of NDMA to levels below drinking water standards. UV can be coupled with the use of hydrogen peroxide in an advanced oxidation system application for NDMA destruction.

Biological processes

A process using bacteria that feed on propane, which provides a co-metabolic reaction to break apart the NDMA, was pilot tested at a treatment facility at an Envirogen Technologies, Inc. project.

Granulated Activated Carbon (GAC)

Filtration is ineffective as a treatment due to the compound's low affinity for carbon.

Other Methods

Microfiltration and reverse osmosis treatment may be used to remove NDMA and its precursors from wastewater.

Health Effect Information

NDMA causes cancer in laboratory animals such as rats and mice. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in people. Exposure to high levels of NDMA may cause liver damage in humans. Symptoms of overexposure include headache, fever, nausea, jaundice, vomiting, and dizziness. NDMA is not believed to bioaccumulate.

NDMA is identified as a carcinogen under California's Health and Safety Code Section 25249.5, et seq., the Safe Drinking Water and Toxic Enforcement Act of 1986 ("Proposition 65"). In addition, the EPA identifies NDMA as a "probable human carcinogen" (EPA-1997), and the National Toxicology Program lists NDMA as "reasonably anticipated to be a human carcinogen" (NTP, 2014).

Key Resources

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3. California State Water Resources Control Board, NDMA and Other Nitrosamines – Drinking Water Issues (December 2013). http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/NDMA.shtml
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10. Webster, T.S., Hatzinger, P.B., and Zigmond, M., Treatment of N-Nitrosodimethylamine in Groundwater Using a Fluidized Bed Bioreactor (FBR). https://apps.dtic.mil/sti/pdfs/ADA607489.pdf

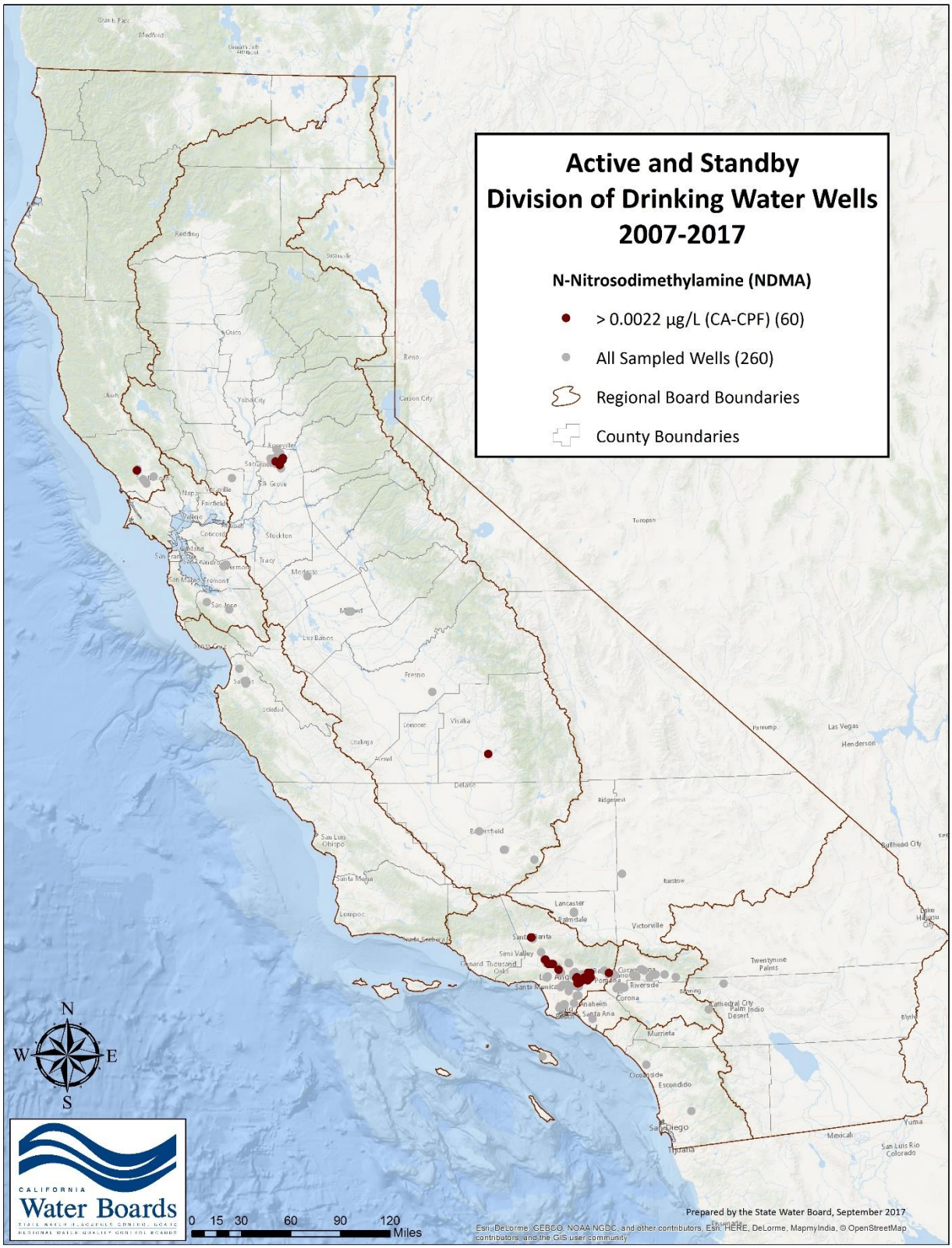

Figure 1. Active and standby public drinking water wells that had at least one detection of NDMA above the CA-CPF, 2007-2017, 60 wells. (*Source: Public supply well data in GAMA GIS*).