



State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary

101 S. Webster St.
Box 7921
Madison, Wisconsin 53707-7921
Telephone 608-266-2621
FAX 608-267-3579
TTY 608-267-6897

May 4, 2007

Dr. Henry A. Anderson, Chief Medical Officer
Bureau of Public Health
Department of Health and Family Services
1 West Wilson St.
Madison, WI, 53701-2659

Subject: **Request for Health Advisory Levels for Dinitrotoluene (DNT) Isomers: 2,3-DNT; 2,5-DNT; 3,4-DNT & 3,5-DNT**

Dear Dr. Anderson:

Staff from the Department's South Central Region Remediation & Redevelopment (R&R) Program have requested health advisory level/interim groundwater standard recommendations for: 2,3-Dinitrotoluene (2,3-DNT) [CAS RN 602-01-7], 2,5-Dinitrotoluene (2,5-DNT) [CAS RN 619-15-8], 3,4-Dinitrotoluene (3,4-DNT) [CAS RN 610-39-9] and 3,5-Dinitrotoluene (3,5-DNT) [CAS RN 618-85-9]. Established health advisory levels/interim groundwater standards will assist the R&R Program in regulating sites where groundwater has been found to be contaminated with these substances.

A search of the Department's Groundwater Retrieval Network (GRN) and Groundwater and Environmental Monitoring System (GEMS) databases shows that the 2,3-DNT, 2,5-DNT, 3,4-DNT and 3,5-DNT isomers of dinitrotoluene have been found in monitoring and water supply wells at the Badger Army Ammunition Plant (BAAP) site. The 2,3-DNT isomer has been detected in 103 wells (3 private water supply and 100 monitoring/groundwater extraction), at concentrations as high as 2,200 µg/L. The 3,4-DNT isomer has been detected in 37 wells (1 private water supply and 36 monitoring) at concentrations as high as 419 µg/L. The 3,5-DNT isomer has been detected in 20 wells (1 private water supply and 19 monitoring) at concentrations as high as 23.9 µg/L. The 2,5-DNT isomer has been detected in 19 wells (1 private water supply and 18 monitoring) at concentrations as high as 1.5 µg/L.

Please review available information on these substances and develop health advisory levels/interim groundwater standards if data supports development of such standards. Thank you.

Sincerely,

Todd L. Ambs, Administrator
Division of Water

cc: Jill Jonas - DG/2

Russ Rasmussen - WT/2

Pat McCutcheon - SCR/Fitchburg

Bill Phelps - DG/2

Suzanne Bangert - WA/3

Jack Sullivan - SS/6

Henry Nehls-Lowe - DHFS

Mark Giesfeldt -RR/3

Mike Scott - LS/5

Hank Kuehling - SCR/Fitchburg



DIVISION OF PUBLIC HEALTH

1 WEST WILSON STREET
P O BOX 2659
MADISON WI 53701-2659

Jim Doyle
Governor

State of Wisconsin

Department of Health and Family Services

Kevin R. Hayden
Secretary

608-266-1251
FAX: 608-267-2832
TTY: 888-701-1253
dhfs.wisconsin.gov

July 3, 2007

Mr. Todd L. Ambs, Administrator
Division of Water
Department of Natural Resources
101 S Webster Street
Madison, WI 53701-7921

Dear Mr. ~~Ambs~~^{Todd}:

In response to your May 4 2007 request, I am forwarding an interim drinking water health advisory for dinitrotoluene residues. This advisory, which was drafted by our senior toxicologist, recommends that the summed concentration of all DNT isomers not exceed 0.05 ug/L. The rationale for this approach is explained in the attached background document.

Please contact me if you have any questions or concerns about this recommendation.

Sincerely,

Henry A. Anderson, MD, Chief Medical Officer
Bureau of Environmental and Occupational Health
Division of Public Health

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JUL 3 2007
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Drinking Water Health Advisory for Dinitrotoluenes

Prepared by Lynda Knobloch, Ph.D., Senior Toxicologist
June 14, 2007

Technical grade dinitrotoluene (TG DNT) is a mixture of six isomers. 2,4- and 2,6-DNT are the most prevalent forms and make up more than 90 percent of the DNT used in commerce. Minor components of TG DNT include the 2,3-, 2,5-, 3,4- and 3,5-DNT isomers. Most toxicological and environmental studies have been conducted using either the technical grade mixture of these isomers, or purified 2,4- or 2,6-DNT. Only a few short-term or *in vitro* studies have been done on the minor isomers. These studies suggest that the minor isomers are toxicologically similar to 2,4- and 2,6-DNT. Effective doses or aquatic concentrations of the six DNT isomers are generally within an order of magnitude of each other. All DNT isomers are capable of inducing cyanosis secondary to methemoglobin formation. At high doses, this is the critical effect that can lead to death. Target tissues include the hematopoietic system, the central nervous system and the male reproductive system. TG DNT, as well as 2,4- and 2,6-DNT are known to cause cancer in animals. Minor isomers have not been tested for this effect. All isomers have shown mutagenic effects in short-term studies. In order to protect against adverse health effects that can result from long-term exposure to DNT, a single health advisory for the summed concentration of all DNT isomers is proposed.

Background

Dinitrotoluenes are produced by nitration of toluene or nitrotoluenes. Approximately 99% of DNT are used for polyurethanes, as an intermediate in the production of toluene di-isocyanate. Manufacturing and processing of DNT is executed in closed systems. However, DNT can be released to the environment as a result of accidental releases and disposal. DNTs are also used as gelatinizing and waterproofing agents in the manufacture of explosives, and in smokeless gunpowders. About 500 US workers are potentially exposed to DNT during the production of munitions and explosives. The main route of exposure at ammunition facilities is inhalation, but dermal contact and inadvertent ingestion can also be substantial.

Human exposure to DNTs has been linked to a variety of health effects, including cyanosis, dizziness, headache, metallic taste, shortness of breath, weakness, loss of appetite, nausea, and vomiting. Other symptoms including pain or paresthesia in extremities, abdominal discomfort, tremors, paralysis, chest pain, and unconsciousness have also been reported. The primary targets of DNT toxicity are the hematopoietic system (pallor, cyanosis, anemia, and leukocytosis), the cardiovascular system (ischemic heart disease), the nervous system (muscular weakness, headache, dizziness, nausea, insomnia, and tingling pains in the extremities) and the reproductive system (reduction of sperm counts, alteration of sperm morphology, and aspermatogenesis). An association between DNT exposure and increased risk of hepatocellular carcinomas and subcutaneous tumors in rats, as well as renal tumors in mice, has been established.

Dinitrotoluene (DNT) is a potent liver toxin and carcinogen in rats. Prolonged exposure causes methemoglobinemia. DNT is also toxic to the nervous system and has reproductive effects in all species tested. Administered orally, DNT has caused hematological effects, including methemoglobinemia, anemia, reticulocytosis, and increases in the number of Heinz bodies in all species tested.

The oral lethal dose of the various DNT isomers range from 216 mg/kg for 3,5-DNT in female rats to 1,954 mg/kg for 2,4-DNT in male mice.

3,5-DNT is more toxic to male and female rats and mice than other isomers. Technical-grade DNT fed to rats for 24-months caused liver discoloration at a dose of 3.5 mg/kg/day and liver nodules and

malignancies at a dose of 14 mg/kg/day. An NCI bioassay also showed that technical-grade DNT causes subcutaneous tissue fibromas in male rats and mammary gland fibroadenomas in female rats. DNT administered orally to dogs caused neurotoxic effects, with tremors, loss of coordination, and convulsions; neurotoxic effects are not seen in either rats or mice until much higher doses are given. Oral administration of DNT to rats, mice, and dogs causes reproductive effects, including testicular and ovarian atrophy, decreased fertility, and decreased sperm count.

Dinitrotoluene causes methemoglobinemia in workers. The first symptom of methemoglobinemia is headache, followed by fatigue, nausea, vomiting, and chest pain. Onset may be delayed as long as 4 hours after exposure. Chronic exposure to dinitrotoluene can cause anemia and jaundice. The effects of dinitrotoluene are exacerbated by alcohol consumption.

In an occupational setting, DNT can be absorbed through the skin in toxic amounts.

Table 1. Screening Level Toxicity Information for DNT Isomers

	2,3-DNT	2,4-DNT	2,5-DNT	2,6-DNT	3,4-DNT	3,5-DNT
Synonym	1-Methyl-2,4-dinitrobenzene	2-methyl-1-nitrobenzene	2-Methyl-1,4-dinitrobenzene	2-Methyl-1,3-dinitrobenzene	4-Methyl-1,2-dinitrobenzene	1-Methyl-3,5-dinitrobenzene
CAS No	602-01-7	121-14-2	619-15-8	606-20-2	610-39-9	618-85-19
% in Tech Grade	1.3%	78%	0.5%	18%	2.4%	<0.1%
LD50 _{low} (rat)	911 mg/kg	270 mg/kg	517 mg/kg	177 mg/kg	177 mg/kg	216 mg/kg
Cancer Class	Not classified	B2 - Known animal carcinogen	Not classified	B2- Known animal carcinogen	Not classified	Not classified
Mutagenicity	Weakly positive with activation	Positive	Positive	Positive	Weakly positive	Weakly positive
NOAEL	Not available		Not available	4 mg/kg/day	Not available	Not available
Subchronic	Not available		Not available	7 mg/kg/day	Not available	Not available
Chronic	Not available	0.2 mg/kg/day	Not available		Not available	Not available
Aquatic toxicity*	1.8 mg/L	32.8 mg/L	1.3 mg/L	18.5 mg/L	1.5 mg/L	22.6 mg/L
USEPA RfD	None	0.002 mg/kg/day	None	0.001 mg/kg/day	None	None
USEPA MCL	None	None	None	None	None	None
WI GWES	None	0.05 ug/L	None	0.05 ug/L	None	None
ACGIH - TLV	1.5 mg/cu m	1.5 mg/cu m	1.5 mg/cu m	1.5 mg/cu m	1.5 mg/cu.m	1.5 mg/cu m

*96-hr static LC50 *Pimephales promelas* Liu, Bailey and Pearson, 1983

Carcinogenicity:

The U.S. EPA classifies both 2,4-DNT and 2,6-DNT as B2 carcinogens (sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans).

In chronic studies, 2,4-DNT produced renal tumors in male mice and was moderately hepatocarcinogenic in rats. 2,6-DNT and technical grade DNT are potent hepatocarcinogens in rats. In all these studies, increases in tumors were statistically significant and dose-related.

One study of workers in a munitions plant found no significant increases in cancer mortality. However, this study was limited by small cohort size.

Mutagenicity:

Both DNT isomers are positive in the *S. typhimurium* histidine reversion assay and the TM 677 forward-mutation assay both with and without metabolic activation but negative in numerous mammalian cell forward reversion assays.

Reproductive Effects:

Male reproductive effects resulting from oral administration of 2,4-DNT include decreased spermatogenesis in rats and dogs at 20-25 mg/kg/day and testicular atrophy at 34 mg/kg/day. In a multigenerational rat study, decreased neonatal viability was noted at 40 mg/kg/day of 2,4-DNT. A study of DNT's reproductive effects in workers showed decreased sperm counts, slight abnormalities in the sperm of workers, and a slight increase in the rate of spontaneous abortions in their wives. A retrospective cohort mortality study of DNT-exposed workers found a significant increase in mortality due to ischemic heart disease. The average DNT exposure of these workers was estimated to be 1 mg/kg/day or less from inhalation, ingestion, and dermal sources.

Interactive Effects:

In a 1942 study, workers exposed to 2,4-DNT were found to be more sensitive to alcohol. Exposure of rats to 2,6-DNT both increased and decreased the rate of phenobarbital metabolism, dependent on the time of exposure.

Environmental Fate:

Atmospheric

The low vapor pressure of the DNTs (2,4-: 0.005 torr at 20°C; 2,6-: 0.018 torr at 20°C) suggests that volatilization from contaminated surface water or soil are unlikely. In the atmosphere, DNT is degraded by photochemically produced OH radicals. The half-life is calculated to be approximately 84 days.

Aquatic

The solubilities of 2,4- and 2,6-DNT in water are 270 and 180 mg/L, respectively. Major routes of DNT degradation are photo-oxidation and biodegradation. The half life of DNT is 3 to 10 hours in sunlit natural waters and 28 days in anaerobic sewage. No studies of DNT persistence in groundwater have been noted, but disappearance of the compounds under these conditions may be negligible.

Terrestrial

DNTs are poorly adsorbed to soils. As a result, "DNTs in buried munition wastes could potentially be released to groundwater or transported as contaminated soil and sediment. No studies have been performed on soil DNT biodegradation.

Analytical Laboratory Methods:

DNTs are extracted from water using methylene chloride and subsequently analyzed by gas chromatography/mass spectrometry using EPA method 625. The detection limit for this procedure is about 3 µg/L. Alternatively, high pressure liquid chromatography with an ultraviolet detector can be used. This method has a detection limit of 10 µg/L.

USEPA and USCDC Regulatory Position:

Reference Dose 2,4-DNT (non-cancer effects):	0.002 mg/kg/day
Reference Dose for 2,6-DNT (non-cancer effects):	0.001 mg/kg/day
MCL	None
Cancer slope factor for 2,4-DNT and 2,6-DNT	0.68 per mg/kg/day
Drinking water concentration at 1-in-a-million:	0.05 ug/L
Ambient Water Quality Criteria: Water & Fish	0.11 ug/L
Ambient Water Quality Criteria: Fish only	9.1 ug/L
ATSDR MRL:	0.002 mg/kg/day

Recommendations and Conclusions:

In accordance directives outlined in Chapter 160 of the Wisconsin State Statutes, the Department of Health and Family Services recommends that all isomeric forms of dinitrotoluene be regulated as a single entity and that the health advisory level limit cancer risk to a theoretical level of 1-in-a-million. This recommendation is based on the following findings:

- 1). A complete toxicological database is available for technical grade DNT, which is a mixture of all isomers, and for the two major isomers (2,4- and 2,6-DNT). Only limited testing has been conducted with the other 4 isomers making independent risk assessments for them impossible. In 2000, the Chemical Manufacturer's Association petitioned the US EPA to remove individual isomers of DNT from the High Production Challenge Program arguing that none of the minor isomers is produced separately in commerce. In a letter to Charles M. Auer, Director of the USEPA's Chemical Control Division, CMA stated, "Separately evaluating each isomer under the HPV program will not result in a better understanding of the adverse health or safety implications of dinitrotoluene." EPA's approval of this request alleviated a requirement for the manufacturers to provide screening level toxicity and environmental fate data for individual DNT isomers and allowed submission of data for technical grade DNT instead.
- 2). Published studies for the minor isomers indicate that their toxic effects are the same as that of TG DNT and that the minor isomers are as toxic or more toxic than 2,4- and 2,6-DNT.
- 3). All isomers of DNT have shown mutagenic activity in short-term studies.
- 4). TG DNT, as well as the purified 2,4- and 2,6- isomers are classified as known animal carcinogens. Minor isomers have not been tested for this effect, but are structurally and toxicologically similar suggesting that they may also have carcinogenic effects.

5) The six isomers of DNT are structurally and toxicological similar. In addition, these isomers have a common commercial source and are frequently found together in the environment.

The recommended Interim Health Advisory Level for total dinitrotoluene residues in Wisconsin groundwater is 0.05 $\mu\text{g/L}$.

References used:

US EPA Drinking Water Health Advisories: Munitions. 1992. Lewis Publishers, CRC Press, Boca Raton FL.

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Letter to Charles M Auer dated March 21, 2000. Chemical Manufacturers Assoc.

NIOSH. Current Intelligence Bulletin: Dinitrotoluenes. July 1985.