March 10, 2000

Madame/Sir:

Attached is the Colorado Department of Public Health and Environment study "Health Effects of Deicing Applications in Colorado". The study examines the potential health risks of magnesium chloride deicers and street sand/salt mixtures. Based on the available data, the results do not suggest a health risk for certain chemicals detected on air monitoring filters for which toxicological analyses were performed. There does not appear to be a difference among the two deicing practices with respect to the risks associated with the chemicals that were analyzed.

The assessment suggests that ambient air in the communities monitored may contain contaminants such as chromium and arsenic at concentrations that exceed a cancer risk of one in one million. It could not be established, however, that these constituents were derived from the application of deicing products. The study could not demonstrate a difference between magnesium chloride and street sand/salt deicing practices with respect to the risks associated with the chemicals that were analyzed. Potential health impacts related to acute exposures to high concentrations of magnesium chloride and sand/salt mixtures were not quantitatively assessed; though it is recognized that such exposures are likely to produce irritating effects to the eyes and airways.

This study does not draw comprehensive conclusions about the safety of magnesium chloride deicers or street sand/salt mixtures. A significant limitation of the study was the absence of quantitative estimates of toxicity for inhalation exposure to many of the chemicals detected on the air monitoring filters. Of the more than 40 elements and compounds detected, a quantitative risk assessment could only be performed for seven of these chemicals. The Department cannot confidently make statements as to the overall safety of magnesium chloride deicers, though it appears that these deicers pose no worse human health impacts than do street sand/salt mixtures. However, it has been our experience that magnesium chloride deicers reduce particulate matter emissions from paved roadways, which is beneficial to human health.

For additional information regarding street sanding and alternative deicers and their environmental impacts, or if you have questions regarding this study, please contact me at (303) 692-3113.

Sincerely,

Michael Silverstein
Planner, Air Pollution Control Division

HEALTH EFFECTS OF DEICING APPLICATIONS IN COLORADO

Prepared by the
Disease Control and Environmental Epidemiology Division
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Colorado Department
of Public Health
and Environment

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1.0 Introduction

The Colorado Department of Public Health and Environment (CDPHE) received inquiries from Colorado citizens and the Colorado Department of Transportation (CDOT) regarding the potential health effects of exposure to magnesium chloride applied as a road deicer and dust suppressant. The CDPHE was also requested to examine the potential health effects of exposure to sand/salt mixtures. This report was prepared to respond to these inquiries.

There are three primary deicing materials that have been applied in the state of Colorado. They include: (1) salt/sand mixtures; (2) magnesium chloride deicer products purchased prior to 1996; and (3) magnesium chloride deicer purchased since 1996 and subject to new specifications. The new specifications are designed to limit trace substances, such as heavy metals, naturally occurring in magnesium chloride source material.

Sand/salt (sodium chloride) mixtures were used in the past to reduce traffic accidents by limiting ice buildup on roadways and improving traction. Although this technique was effective, sodium chloride is very corrosive to automobiles and the sand contributes greatly to particulate matter, a wide spread respiratory pollutant in Colorado.

To reduce the adverse impacts of sand/salt magnesium chloride deicer was introduced. The deicing properties of magnesium chloride are more effective than sand/salt mixtures. In addition, corrosion inhibitors are added to the deicer, which limit damage to automobiles. The deicer also has dust-suppressing properties, which are ideal for reducing levels of particulate matter in the environment.

In more recent years, the northwestern states (Idaho, Oregon and Washington), Montana and Colorado drafted specifications, which limit trace substances originating in magnesium chloride deicing product, parent material. These substances include metals, cyanide, and phosphates. The City and County of Denver has not drafted specifications, but requires that all magnesium chloride deicers purchased by the city meet the product specifications of the manufacturer.

This report addresses three specific questions:
(1) Does the magnesium chloride product used in the state of Colorado meet current state's specifications?
(2) What is known about the potential health effects of magnesium chloride and sand/salt deicing materials?
(3) How is air quality impacted by the deicing applications and what health risks might be associated with inhaling magnesium chloride and sand/salt?

To determine whether magnesium chloride meet Colorado specifications, the chemical analysis results of two samples of magnesium chloride deicing solution purchased by CDOT and the City of Aspen were compared to the State's specifications.

The potential health effects of magnesium chloride and sand/salt deicing materials are characterized qualitatively by presenting a review of the current toxicology literature. Corrosion inhibitors, which are contained in the magnesium chloride road deicing products, are also reviewed as is particulate matter, a common respiratory pollutant and a common by-product of sand/salt mixtures.

Potential health risks associated with inhalation of air borne deicing agents following application is considered by examining deposition of air borne contaminants on particulate sampling filters. These samples were collected on the same day as or subsequent day to deicer material application. These filter samples are assumed to be representative of air quality impacts related to a particular deicer application. By assuming that all contaminants on the filters are related to deicer applications, a conservative estimate of the risk associated with deicers is calculated. Filter samples from Aspen, Denver, and Pagosa Springs were selected for this assessment.

Assessing the potential health risks associated with ingesting or dermally contacting roadway residues of magnesium chloride and sand/salt materials was considered. However, there is a wide variety and source of roadside debris, such as long distance over-the-road transport, this analysis was not consider meaningful.

2.0 COMPARISON OF MAGNESIUM CHLORIDE DEICER TO PUBLISHED SPECIFICATIONS

The Colorado Air Pollution Control Division personnel collected analytical chemistry results of the deicing products. The only results currently available are for metals in two samples of magnesium chloride deicer solution obtained from storage tanks owned by CDOT (located near Aspen) and the City of Aspen. The chemical analysis was by x-ray fluorescence (XRF), and therefore serves only to qualitatively characterize the metal concentrations as abundant, moderate, trace, or not detected. These results can not be compared to the specification published by the northwestern states, Montana and Colorado. Table 1 lists those analytes reported as detectable and are characterized as being present at trace, moderate or abundant concentration and compares these qualitative results to the concentrations found on particulate sampling filters found at the three towns. The specifications for the northwestern states, Montana and Colorado limit phosphates and cyanide. These analytes were not tested.

Table 1. Elements detected in trace, moderate or abundant concentrations in magnesium chloride deicer samples by XRF analysis and range detected on air monitoring filters from Aspen, Denver, and Pagosa Springs.

Analyte	City of Aspen Deicer	CDOT Deicer	Concentration Range on Filter (ug/m^3)
Magnesium	Abundant	Abundant	0.1 –0.4
Chlorine	Abundant	Abundant	0.01 – 1.39
Potassium	Moderate	not detected	ND
Calcium	Moderate	not detected	1.6 – 2.4
Iron	Moderate	moderate	1.6 – 4.3
Copper*	Trace	moderate	0.04 – 0.06
Zinc*	Abundant	not detected	0.1 – 0.08
Bromine	Abundant	abundant	0.002 – 0.01
Molybdenum	Abundant	abundant	0.04 – 0.06

*- metals subject to specifications of the northwestern states, Montana and Colorado
ND – none detected

When these qualitative results are compared with air monitoring filters, the results do not appear to be consistent. One would expect to find chlorine and magnesium ions in high concentration on the filters corresponding to magnesium chloride deicers and high concentrations of sodium and chlorine on filters corresponding to sand and salt applications. Magnesium, chloride and sodium ions were found in high concentrations on the filter. However, the chemical found in the highest concentration on the air filters was iron. The XRF analysis of the deicing products show that iron is found in 'moderate' concentrations. Bromine and molybdenum were detected on the air filters in low concentrations. However, the XRF analysis reports these constituents as 'abundant' in the deicer samples. Therefore, the concentrations of metals found on the air monitoring filters does not appear to correlate with the contaminants found in deicing product samples.

To perform a quantitative comparison of the deicer solutions with state specifications, it is suggested that quantitative analysis of be performed for metals, phosphates, and cyanide.

3.0 POTENTIAL HEALTH EFFECTS OF DEICING AGENTS

A review of the current toxicology literature on deicing agents is presented in this section. Unless otherwise indicated, the source for the information presented is the Toxicology, Occupational Medicine, and Environment Series (TOMES), a computerized database. TOMES contains summarized data from toxicology studies, Material Safety Data Sheets (MSDS), and medical observations of exposures for a wide variety of chemicals.

An in-depth literature search was performed for magnesium chloride. Additionally, the author of MSDS for magnesium chloride deicers was consulted as was National Jewish Medical and Research Center.

3.1 Magnesium Chloride

Most of the toxicological information pertaining to magnesium chloride relates to the ingestion pathway. Studies were mainly conducted in Japan, as magnesium chloride is a food additive used as a coagulating agent for tofu. Tofu products make up a large part of the diet in Asian countries and have grown increasingly popular worldwide (Kurata, et al, 1989). Additionally, medical grade magnesium chloride is used as an electrolyte replenisher in dialysis.

Acute exposure to air borne magnesium chloride, as with magnesium and other magnesium compounds (Key et al, 1977), may produce irritation of the conjunctiva and nasal mucosa.

Carcinogenicity was not observed in a long-term feeding study of mice administered magnesium chloride (Kurata et al, 1989). Magnesium chloride has been classified as a non-mutagen on the basis of both Ames and chromosomal aberration test results, which further supports that carcinogenicity is unlikely.

Magnesium chloride administered to laboratory mice at high dose dietary levels for 13 weeks showed no treatment-related effects (Tananka et al, 1994).

Magnesium salts are absorbed very slowly from the gastrointestinal tract, and normally can be tolerated orally in fairly large amounts. Physicians often use magnesium salts as cathartics. Symptoms reported from magnesium chloride overdose include diarrhea, loss of appetite, hypotension, respiratory depression, neuromuscular impairment, CNS depression, and loss of reflexes. Magnesium chloride is harmless to the eye, although direct contact with the crystals caused temporary spotting of the cornea in rabbits.

No studies on chronic human inhalation exposure to magnesium chloride were identified. However, inhalation of 1.1 or 3.9 mg/m^3 for 4 to 6 weeks caused no ill effects in rabbits.

Magnesium chloride injected into pregnant mice was associated with accelerated development and learning in the offspring. Another study reported adverse reproductive effects of magnesium chloride including impaired spermatogenesis, abnormalities in gonads, and altered sex ratios in the first and second generation of treated rats. Results were not statistically significant. No human reproductive toxicity data were found.

The Reprotext database rates chemicals by general toxicity and reproductive hazard. The general toxicity of magnesium chloride was rated as possibly causing reversible effects but generally not life threatening.” The reproductive hazard was rated as not known to affect animal reproduction.”

Dr. Ronald Balkisoon, a physician specializing in occupational and pulmonary medicine at National Jewish Medical and Research Center was contacted. The CDPHE requested information about the health effects associated with magnesium chloride. Dr. Balkisoon stated that he was unable to identify any more information than is presented in this report (Balkisoon, 1999).

Dr. Paul Rivers, responsible for preparing and publishing MSDS sheets for Reilly Industries, a manufacturer of magnesium chloride deicers, was contacted. Dr. Rivers stated that the health effects for magnesium chloride are comparable to sodium chloride. He also stated that the MSDS sheets for magnesium chloride deicers was based on health effects information of both magnesium chloride and magnesium metal (Rivers, 1999).

3.2 Magnesium Metal

Magnesium is an essential nutrient for normal human protein synthesis and neuromuscular function. Deficiency may cause muscle cramps, hypertension, increased muscular excitability, and convulsions.

Acute exposure to magnesium dust can irritate and mucous membranes of the upper respiratory tract causing atrophic nasopharyngitis. High doses can cause vomiting, apnea, and respiratory arrest. High magnesium exposure, determined by severe elevation of magnesium serum levels, can impair neuromuscular transmission.

No information on chronic toxicity, carcinogenicity, or reproductive toxicity from exposure to magnesium was found except as reported for magnesium chloride.

3.3 Sodium Chloride

Sodium chloride is ordinary table salt. It is used in the sand/salt deicing application. Acute exposure to sodium chloride can be an eye and skin irritant. Ingestion of large quantities can irritate the stomach.

Mild nasal irritation with chronic exposure to high dust levels was found from occupational exposure to sodium chloride. Hypertension was also evident. High dietary intake of sodium chloride may cause a higher incidence of hypertension and cardiovascular disease. Various studies with aerosols have shown that breathing sodium chloride over a long period of time has no adverse effect.

High dietary intake of sodium chloride has been linked with stomach cancer. No studies on the carcinogenic potential from inhalation of sodium chloride were located.

In laboratory experiments, sodium chloride has caused delayed effects on newborns, has been fetotoxic, and has caused birth defects and abortions in rats and mice. High doses injected into mice resulted in embryotoxicity and teratogenic skeletal defects such as clubfoot. No human data were located.

The Reprotext database rated the general toxicity of sodium chloride as "possibly causing reversible effects, but generally not life threatening." The reproductive hazard of sodium chloride was stated as "having multiple reproductive effects in animals."

3.4 Corrosion Inhibitors

3.4.1 Proprietary corrosion inhibitor

The toxicology literature was reviewed for a corrosion inhibitor added to magnesium chloride. This material is not identified here due to proprietary claims. The chemical is used in medicine as a buffer to reduce gastric acidity. This chemical may be irritating to mucous membranes. Overdose through ingestion may cause diarrhea, nausea and vomiting, and convulsions. There is no indication that there is greater risk of congenital anomalies in children of women treated with this chemical during pregnancy.

3.4.2 Zinc sulfate

Exposure to zinc sulfate dust is expected to cause eye, skin, and respiratory tract irritation. Ingestion may produce gastrointestinal symptoms, including nausea, diarrhea, and vomiting. Chronic exposure may produce dermatitis and respiratory tract irritation. It is not known to affect human reproduction. There is no evidence of human carcinogenicity.

3.4.3 Sodium metahexaphosphate

Sodium metahexaphosphate is found in Ice-Stop brand deicer. No data were found on health effects or toxicity for this compound.

3.5 Particulate Matter

Magnesium chloride deicers are not only used to limit ice buildup on roadways, but also to suppress dust, a major component of particulate matter. This section describes the health effects of particulate matter, a respiratory pollutant of concern in Colorado, as well as the terminology, which will be used in subsequent sections of this report. Although particulate mater is not specifically addressed in this assessment, the material in this section is provided for background information useful in considering the exposure ramifications associated with using deicing products.

Particulate matter (PM) is a generic term applied to a broad class of chemically and physically diverse substances that exist as discrete particles.   In terms of chemistry and size, particulate matter is heterogeneous. It is a composite of hundreds of different substances exhibiting high degrees of spatial and temporal variability. PM10 refers to particulate matter that is less than 10 microns in size. Scientists have determined that PM10 is the fraction that is respirable. That is, PM of this size can enter the bronchiolar and alveolar regions of the lung and cause adverse health effects.

Particulate matter originates from natural and anthropogenic sources such as pollen production, fires, agricultural practices, combustion, transportation, and industry. Fugitive emissions, principally from both unpaved and paved roads are the principal direct emission source for PM10 (CIIT, 1997).

The respiratory tract is the portal of entry for airborne materials into the body as well as the prime target for the effects of inhaled PM. Particulate matter in the respiratory tract elicits a wide range of responses by a variety of mechanisms including the alteration of breathing frequency and depth. The respiratory tract may serve as a portal of entry for inhaled pollutants that cause disease in other organs or systems in the body.

Individuals with pre-existing respiratory disease such as chronic obstructive pulmonary disease and heart disease are especially vulnerable to a breakdown in normal function (such as increased airway resistance and bronchial obstruction) following respiratory tract injury from exposure to PM10.

A positive association with increased hospital admissions for respiratory-related illnesses has been reported. Decreased lung function and increased respiratory symptoms are associated with increased PM concentrations in community studies (CIIT, 1997).

Epidemiology studies point to several subpopulations as being at risk for PM exposure including children, individuals with respiratory disease (chronic obstructive pulmonary disease, acute bronchitis, asthma, pneumonia), cardiovascular disease, and the elderly.

4.0 QUANTITATIVE RISK ASSESSMENT METHODS

Standard EPA methodology was used for this assessment of potential exposure to deicing products (RAGS, 1989). This methodology is designed to identify health risks from chemical exposure of the general public. The assessment presented here is focused on a worst-case scenario of exposure. Very conservative default parameters are used in this type of assessment. Conservatism is built into this assessment due to the limitations of the available data.

A second tier of assessment was use to re-evaluated those chemicals with elevated risk when using the highly conservative parameters. This second tier re-defined the exposure assumptions.

Estimates of exposure to contaminants identified on air sample filters were made using standard intake equations (RAGS, 1989).   Both systemic toxicity and carcinogenicity are assessed for the inhalation pathway.

4.1 Assumptions and Limitations of Inhalation Risk Analysis

The quantitative assessment of inhalation risk assumed that all analytes detected on air sampling filters originated from the most recent and prior roadway application of deicing products. This assumption overestimates the total risk attributed to deicer applications because other sources of contamination likely contribute to the concentrations of analytes identified on the filters. As described in Section 2.0, it may not be appropriate to assume that the analytes identified on the filters correspond with trace substances found in deicing products. The risk assessment also assumes that people will be exposed to the concentrations measured in the air samples continuously, year round, for many years. This second assumption also overestimates potential risk since deicers are only applied for 6 months per year and airborne exposure is unlikely to take place 24-hours a day. Most citizens spend at least a portion of their day indoors and will not be subjected to the concentrations measured in the samples for 24-hours a day.

The data set is limited and therefore does not provide an accurate representation of what the average concentrations of contaminants in air might be. Samples were collected after deicers were applied, therefore concentrations measured in the samples may be higher than the yearly average. If correct, this difference will also contribute to a conservative assessment because the health-based comparison values used in the assessment are most appropriately applied to long-term average exposure.

Quantitative toxicity values are not available for all chemicals detected on the air filters. Therefore, not all chemicals detected were quantitatively evaluated in the risk assessment. Chromium concentrations were available as total chromium. For this assessment, total chromium was assumed to be the carcinogenic species, chromium VI.

Although both carcinogenic and systemic effects of lead have been documented, the EPA does not publish toxicity values for this compound.

Essential nutrient compounds such as iron, zinc, copper, selenium, molybdenum, and cobalt were not included in the risk assessment in accordance with EPA risk assessment methodology (EPA, 1994).

4.2 Systemic Toxicity

To evaluate systemic, i.e., noncancer, toxicity, a hypothetical child resident scenario is used in this risk assessment. In this scenario, a child is assumed to live in the area of exposure all year and is considered to be more sensitive to the chemical exposure than adults. For the child exposure scenario, the estimated intakes of each chemical contaminant is divided by chronic Reference Dose values to yield a hazard quotient (HQ). The HQ assumes that there is a safe level of exposure below which it is unlikely for even sensitive populations to experience adverse health effects (RAGS, 1989). A HQ that is less than or equal to 1 indicates the assumed long-term exposure level is unlikely to produce adverse health effects. If the HQ is greater than 1, there may be a concern for potential effects. The greater the HQ is above 1, the greater the potential level of concern. Risks associated with chemicals known to affect the same target organ or system are considered additive. A sum of hazard quotients targeting the same organ or system is referred to as a hazard index (HI). Hazard quotients or indices greater than 1 may indicate the need for a more refined risk assessment.

4.3 Carcinogenicity

To evaluate carcinogenicity, intakes were age-averaged over an assumed lifetime exposure. The estimated intakes are multiplied by cancer slope factors to estimate cancer risk. Cancer risk is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a carcinogenic chemical.

Not all known or potential carcinogens identified in this investigation as possible contaminants in deicing products have an adequate scientific basis for establishing a quantitative estimate of carcinogenic potency. For those that do, however, the estimated risks are considered and presented as additive. Estimation of individual or additive risk greater than 10^{-6} (i.e., a 1 in a million lifetime probability of an individual developing cancer) may indicate the need for a more refined risk assessment.

5.0 RESULT OF THE QUANTITATIVE RISK ASSESSMENT

For each municipality in this study (Aspen, Denver, and Pagosa Springs), ten PM10 filter samples were selected based on a collection date which corresponded to the application date of a deicing product. Table 2 lists the location, PM10 filter sample collection date, deicer application date, and type of deicer. Each filter was analyzed for a suite of chemicals, as listed in Table 3. The chemical analysis results for one Aspen PM10 filter were not used in the quantitative risk assessment because the magnesium chloride deicer applied prior to sample collection on the filter was not subject to the specifications for magnesium chloride deicers applied on later dates.

Tables 4-6 report the systemic health risk estimates associated with inhalation exposure by target organ. As shown in Table 4, both HQs and HIs are <1 for chemicals targeting the respiratory system. Hazard quotients for manganese and mercury, which target the central nervous system, exceeded 1, as shown in Table 5. In Table 6, some hazard quotients are >1 for barium, which targets the reproductive system.

Table 7 reports the cancer risk of inhalation contact. Several chemical-specific risks levels exceed 10^{-6}.

Table 2. Location, PM10 sample date, and date and type of deicer applied.

Site	PM10 filter date	Deicer Application Date	Deicer Type
Aspen	2/5/93	2/3/93[1] and 2/4/93[1]	Sand/salt
	1/22/94	1/21/94	Sand/salt
	1/23/94	1/23/94	Sand/salt
	3/3/94	3/1/94	Sand/salt
	3/8/94	3/6/94	Sand/salt
	3/27/96	3/26/96	Magnesium chloride[2]
	3/28/96	3/28/96	Magnesium chloride[2]
	3/25/97	3/25/97	Magnesium chloride[2]
	3/26/97	3/26/97	Magnesium chloride[2]
Denver	2/9/93	2/9/93[1]	Sand/salt
	2/18/93	2/15/93[1] and 2/16/93[1]	Sand/salt
	1/5/95	1/4/95[1]	Sand/salt
	2/18/93	2/15/93[1] and 2/16/93[1]	Sand/salt
	11/16/94	11/14/94[1]	Sand/salt
	1/28/97	1/28/97	Magnesium chloride[2]
	2/27/98	2/27/97	Magnesium chloride[2]
	2/4/98	2/4/98	Magnesium chloride[2]
	1/28/97	1/28/97	Magnesium chloride[2]
	2/27/97	2/27/97	Magnesium chloride[2]
Pagosa Springs	2/4/97	2/3/97	Sand/salt
	2/5/97	2/3/97	Sand/salt
	2/12/97	2/12/97	Sand/salt
	2/14/97	2/13/97	Sand/salt
	2/18/97	2/18/97	Sand/salt
	2/6/98	2/4/98	Magnesium chloride[2]
	2/18/98	2/16/98	Magnesium chloride[2]
	3/3/98	3/2/98	Magnesium chloride[2]
	3/5/98	3/4/98	Magnesium chloride[2]
	3/19/98	3/18/98	Magnesium chloride[2]

[1] No records are available indicating dates of sand/salt applications. Sand/salt applications were determined by snowfall records.
[2] Magnesium chloride deicer subject to current specifications.

Table 3. List of chemicals included in PM10 filter analysis.

Aluminum	Germanium	Potassium
Ammonia	Indium	Rubidium
Antimony	Iron	Selenium
Arsenic	Lanthanum	Silver
Barium	Lead	Sodium
Bromine	Lithium	Strontium
Cadmium	Magnesium	Sulfates
Calcium	Manganese	Sulfur
Chloride	Mercury	Tin
Chromium (total)	Molybdenum	Titanium
Cobalt	Nickel	Vanadium
Copper	Nitrates	Yttrium
Fluorine	Palladium	Zinc
Gallium	Phosphorous	Zirconium

Table 4. Inhalation hazard quotients for chemicals targeting the respiratory system.

Chemical	City	Application	Inhalation Hazard Quotient
Ammonia	Aspen	salt/sand	0.002
		$MgCl_2$ new specs	0.003
	Denver	salt/sand	0.028
		$MgCl_2$ new specs	0.027
	Pagosa Springs	salt/sand	0.004
		$MgCl_2$ new specs	0.005
Chromium VI	Aspen	salt/sand	0.167
		$MgCl_2$ new specs	0.127
	Denver	salt/sand	0.267
		$MgCl_2$ new specs	0.175
	Pagosa Springs	salt/sand	0.139
		$MgCl_2$ new specs	0.121

Table 5. Inhalation hazard quotients for chemicals targeting the central nervous system.

Chemical	**City**	**Application**	**Inhalation Hazard Quotient**
Manganese	Aspen	salt/sand	1.586
		$MgCl_2$ new specs	1.766
	Denver	salt/sand	1.580
		$MgCl_2$ new specs	1.466
	Pagosa Springs	salt/sand	1.895
		$MgCl_2$ new specs	1.289
Mercury	Aspen	salt/sand	0.031
		$MgCl_2$ new specs	0.063
	Denver	salt/sand	0.018
		$MgCl_2$ new specs	0.055
	Pagosa Springs	salt/sand	0.027
		$MgCl_2$ new specs	0.047

Table 6. Inhalation hazard quotients for chemicals targeting the reproductive system.

Chemical	**City**	**Application**	**Inhalation Hazard Quotient**
Barium	Aspen	salt/sand	0.752
		$MgCl_2$ new specs	2.410
	Denver	salt/sand	0.585
		$MgCl_2$ new specs	2.143
	Pagosa Springs	salt/sand	3.026
		$MgCl_2$ new specs	1.972

Table 7. Estimates of cancer risk for inhalation exposure to chemicals detected on PM10 filters.

Chemical	City	Application	Inhalation Risk
Arsenic	Aspen	salt/sand	$3.65 X 10^{-6}$
		$MgCl_2$ new specs	$2.45 X 10^{-6}$
	Denver	salt/sand	$1.01 X 10^{-5}$
		$MgCl_2$ new specs	$1.34 X 10^{-5}$
	Pagosa Springs	salt/sand	$8.36 X 10^{-6}$
		$MgCl_2$ new specs	$7.64 X 10^{-6}$
Cadmium	Aspen	salt/sand	$5.63 X 10^{-7}$
		$MgCl_2$ new specs	$3.77 X 10^{-6}$
	Denver	salt/sand	$3.05 X 10^{-7}$
		$MgCl_2$ new specs	$3.56 X 10^{-6}$
	Pagosa Springs	salt/sand	$2.03 X 10^{-6}$
		$MgCl_2$ new specs	$1.71 X 10^{-6}$
Chromium VI	Aspen	salt/sand	$4.90 X 10^{-5}$
		$MgCl_2$ new specs	$3.63 X 10^{-5}$
	Denver	salt/sand	$7.65 X 10^{-5}$
		$MgCl_2$ new specs	$5.00 X 10^{-5}$
	Pagosa Springs	salt/sand	$3.98 X 10^{-5}$
		$MgCl_2$ new specs	$3.47 X 10^{-5}$

The results shown in Table 8 indicate that barium and manganese exceeded an HQ of 1 and that arsenic, cadmium, and chromium exceeded a cancer risk of 10^{-6} for most sites. The quantitative risk was re-evaluated using more defined exposure assumptions. Exposure was assumed to be 8-hours per day rather than 24-hours per day, continuously. It was also assumed that deicers were applied 6-months per the year, rather than 365 days. Results are described in Table 9 and 10.

Table 8. Chemicals exceeding either the HQ or HI of 1 for systemic toxicity or the 10^{-6} risk level for carcinogens.

Systemic Toxicity	Carcinogenicity
Barium (Aspen, Denver, Pagosa Springs) Manganese (Aspen, Denver, Pagosa Springs)	Arsenic (Denver, Pagosa Springs) Cadmium (Aspen, Denver, Pagosa Springs) Chromium - (Aspen, Denver, Pagosa Springs)

Table 9. Inhalation hazard quotients for Manganese and Barium using refined exposure parameters.

Chemical	City	Application	Inhalation Hazard Quotient
Manganese	Aspen	salt/sand	0.272
		MgCl new specs	0.302
	Denver	salt/sand	0.338
		MgCl new specs	0.251
	Pagosa Springs	salt/sand	0.325
		MgCl new specs	0.221
Barium	Aspen	salt/sand	0.129
		MgCl new specs	0.413
	Denver	salt/sand	0.125
		MgCl new specs	0.367
	Pagosa Springs	salt/sand	0.518
		MgCl new specs	0.338

Table 10. Estimates of cancer risk for inhalation exposure to chemicals detected on PM10 filters using refined exposure parameters.

Chemical	City	Application	Inhalation Risk
Arsenic	Aspen	salt/sand	6.29×10^{-7}
		MgCl new specs	4.23×10^{-7}
	Denver	salt/sand	1.74×10^{-6}
		MgCl new specs	2.31×10^{-6}
	Pagosa Springs	salt/sand	1.44×10^{-6}
		MgCl new specs	1.32×10^{-6}
Cadmium	Aspen	salt/sand	9.63×10^{-8}
		MgCl new specs	6.45×10^{-7}
	Denver	salt/sand	5.22×10^{-8}
		MgCl new specs	6.09×10^{-7}
	Pagosa Springs	salt/sand	3.47×10^{-7}
		MgCl new specs	2.93×10^{-7}
Chromium VI	Aspen	salt/sand	8.15×10^{-6}
		MgCl new specs	6.21×10^{-6}
	Denver	salt/sand	1.31×10^{-5}
		MgCl new specs	8.55×10^{-6}
	Pagosa Springs	salt/sand	6.80×10^{-6}
		MgCl new specs	5.93×10^{-6}

6.0 CONCLUSIONS

Samples of magnesium chloride deicer solution obtained from Aspen and CDOT tanks could not be compared to the specification published by the northwestern states, Montana and Colorado or the manufacturer specifications used by the City and County of Denver. The laboratory analyzed the deicer samples by x-ray fluorescence (XRF), a qualitative screening protocol. To perform a qualitative comparison of the deicer solutions with the published specifications, an ion chromatography, or other appropriate protocol, should be used.

Qualitatively, magnesium chloride and sodium chloride are toxicologically similar. They both are eye, skin and respiratory irritants. There is no evidence that either compound is carcinogenic. Quantitative toxicity data does not exist for these two chemicals. Therefore, a quantitative comparative risk analysis can not be performed.

This assessment assumes that all chemicals detected on air filters originated from a temporally correlated application of a deicing product. The assessment also assumes that an exposed person will breath the contaminant concentration measured by the analysis of the air sample filters and that this exposure will take place continuously over a multi-year period.

The quantitative assessment also makes the assumption that chemical concentrations found on ambient air monitoring filters will be comparable to the chemical concentrations found at street level. Monitors are usually placed above street level, such as on building roofs.

The data set used in this assessment is limited and may not necessarily represent typical air quality conditions found at the cities of Pagosa Springs, Aspen, and Denver. The concentrations of metals found on the air monitoring filters did not necessarily correlate with the contaminants found in deicing product samples. Therefore, the data may not adequately represent the air contaminants found after applications of the specific deicing methods outlined in this report.

Not all chemicals detected have quantitative toxicity data. Therefore, only a limited number of chemicals are evaluated in the risk assessment. All chromium detected on filter samples was assumed to be chromium VI.

As listed in Table 8, the results of this risk screening exercise shows that arsenic, barium, cadmium, chromium and manganese exceeded the either the HQ or HI of 1 for systemic toxicity or the 10^{-6} risk level for carcinogens.

A re-evaluation of these chemicals using more defined exposure parameters shows that the HQs for barium and manganese were below 1 (see Table 9). Cancer risks still exceeded 10^{-6} for chromium and arsenic. However, neither of these constituents was detected in the deicer solution samples.

Based on the available data and the current assessment, no comparative risk statement can be made regarding magnesium chloride and sodium chloride deicers. This assessment does not show a clear difference in either deicing product's quantitative toxicity. Descriptive toxicity data available in the literature do not support a significant human hazard distinction between magnesium chloride and sodium chloride. Acute exposure to either compound at high concentration may produce irritation of the conjunctiva and respiratory mucous.

Although this assessment makes broad and conservative assumptions about ambient exposure to deicing products, it also has many limitations. A more precise quantitative assessment of risk associated with exposure to chemical deicers will require further analysis based on much higher quality and quantity of data.

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