New York State Integrated Pest Management Program | Cornell Cooperative Extension

Sodium Chloride Profile

Active Ingredient Eligible for Minimum Risk Pesticide Use

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Label Display Name: Sodium chloride

Active Components: Sodium and chlorine

CAS Registry #: 7647-14-5

U.S. EPA PC Code: 013905

CA DPR Chem Code: 721

Other Names: Common salt; Halite; Hydrochloric acid, sodium salt; Rock salt; Saline solution; Sea salt; Sal; chlorure de sodium (French); Natrium-chlorid (German); Cloreto de sódio (Spanish)

Other Codes: Caswell 754; EINECS: 231-598-3; CSID 5044; SMILES: [Na+].[Cl-]

Summary: Sodium chloride is a common food ingredient known as salt, and its use in registered products does not pose unreasonable risk. It has antimicrobial activity and has been used as a food preservative throughout human history. Sodium chloride is also used in a wide range of industrial, agricultural, medicinal, and public works applications. It is phytotoxic, which means it can be used as an herbicide, desiccant, and defoliant. Its pesticidal uses are many: antimicrobial, bactericide, fungicide; insecticide; herbicide, desiccant and defoliant; molluscicide.

Pesticidal Uses: Antimicrobial, bactericide, fungicide; insecticide; herbicide, desiccant and defoliant; molluscicide.

Formulations and Combinations: Frequently applied in saline solution of water. Various anti-caking agents are used, including silicon dioxide (sand) and sodium ferrocyanide (Yellow Prussiate of Soda). A common non-active ingredient used as a buffer.

Basic Manufacturers: Akzo; Cargill, China National Salt Co.; Morton; Mallinkrodt; Ruger; Heico; Tata

Safety Overview: As a commonly consumed food ingredient, the EPA concluded that registered products containing sodium chloride will not pose unreasonable risks or adverse effects to humans or the environment (US EPA 1993).

This document profiles an active ingredient currently eligible for exemption from pesticide registration when used in a Minimum Risk Pesticide in accordance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) section 25b. The profile was developed by the New York State Integrated Pest Management Program at Cornell University, for the New York State Department of Environmental Conservation. The authors are solely responsible for its content. The Overview Document contains more information on the scope of the profiles, the purpose of each section, and the methods used to prepare them. Mention of specific uses are for informational purposes only, and are not to be construed as recommendations. Brand name products are referred to for identification purposes only, and are not endorsements.

Background

The original 1996 list of active ingredients eligible for exemption from registration under 25(b) referred to "Sodium chloride (common salt)" [61 *Federal Register* 8876, 8879 (1996)]. The proposed clarification in 2012 omitted common salt (sodium chloride) [77 *Federal Register* 76979, 76991 (2012)], but the US EPA more recently stated that it did not intend to remove common salt from the exemption [80 *Federal Register* 80653, 80655 (2015)].

While the current regulation refers to sodium chloride [40 *Code of Federal Regulations* 152.25(f), Table 1 (2017)], sodium chloride and common salt are recognized as synonymous terms (Feldman 2011; Food Chemicals Codex Committee 2011; Royal Society of Chemistry 2015). This profile refers both to sodium chloride and to common salt, depending on the context.

Salt naturally occurs in great abundance, and is in solution in the oceans. Extensive mineral deposits are dominated by sodium chloride, particularly in the form of halite (Merck 2015). Salt is manufactured by mining, and by evaporation of salt water. One of the oldest and simplest methods uses solar evaporation of ocean water (Kurlansky 2002). Salt is conventionally mined by mechanical means, bringing dry salt deposits to the surface. Brine can also be pumped to the surface and evaporated (Feldman 2011).

The ocean's salinity is approximately 3.5%. Seawater and brine sources contain other salts as well, including calcium, magnesium and potassium chlorides, calcium, magnesium, potassium and sodium sulfates; and potassium iodide.

Salt is essential to nutrition. Sodium chloride is responsible for maintaining the extracellular fluids of most multicellular organisms (EMBL 2015). Its use since ancient times as a food preservative gives salt a long and well-documented history as a safe and effective antimicrobial (Kurlansky 2002). A considerable amount of sodium chloride is released into the environment as a highway deicer in areas where freezing occurs (Fay and Shi 2012).

Chemical and Physical Properties

The physical and chemical properties of sodium chloride appear in Table 1. There are many grades of salt, ranging from 95% to 99.99% sodium chloride (Feldman 2011). Technical grade salt is commonly 97% sodium chloride (Sigma-Aldrich 2014). Food grade sodium chloride is 99% pure, with specifications allowing it to be iodized and contain calcium, potassium, or sodium ferrocyanide (Food Chemicals Codex Committee 2011).

Table 1

Physical and Chemical Properties of Sodium Chloride

Property	Characteristic/Value	Source
Molecular Formula:	NaCl	(Merck 2015)
Molecular Weight:	58.44	(Merck 2015)
Percent Composition:	Cl 60.66%, Na 39.34%	(Merck 2015)
Physical state at 25°C/1 Atm.	Solid	(Merck 2015)
Color	White or colorless	(Merck 2015)
Taste and Odor	Salty	(US NLM 2016)
Density/Specific Gravity	2.17 g/cm^3 at 25°C	(US NLM 2016)
Melting point	804°C	(Merck 2015)
Boiling point	Volatilizes slightly above the melting point	(Merck 2015)
Solubility	1 g/2.8 ml water; 1 g/10 ml glycerol; slightly soluble in alcohol; almost insoluble in hydrochloric acid	(Merck 2015)
Vapor pressure	1 mm Hg at 865°C	(US NLM 2016)
pH	Neutral (6.7-7.3)	(Merck 2015)
Octonol/Water (K_{ow}) coefficient	Not found	
Viscosity	Saturated aqueous solution: 1.93 mPa-s	(US NLM 2016)
Miscibility	Not found	
Flammability	Non-combustible	(US NLM 2016)
Storage stability	Stable; incompatible with strong oxidizing agents	(Royal Society of Chemistry 2015)
Corrosion characteristics	Corrosive to base metals	(US NLM 2015)
Air half life	Stable	(Royal Society of Chemistry 2015)
Soil half life	71 hrs	(EPI 2012)
Water half life	29 hrs	(EPI 2012)
Persistence	653 hrs	(EPI 2012)

Human Health Information

While salt is an essential nutrient, it can also lead to adverse health effects in humans. Excessive salt intake is known as ‘acute hypernatremia’. Large quantities of orally ingested salt irritates the gastrointestinal tract (HSDB 2015), and the effects include swollen tongue, nausea, vomiting, diarrhea, abdominal cramps, and thirst. Neurologic effects include thirst, irritability, weakness, headache, muscle tremors, convulsions, and coma. In acute hypernatremia, cerebral edema, pulmonary edema and respiratory arrest may occur and result in death (HSDB 2015).

Sub-chronic effects include both hypertension and hypotension, and high salt diets have been linked to tachycardia, cardiac failure, and peripheral edema (HSDB 2015). The link between sodium chloride and other salt sources, and cardiovascular health is well established (LSRO 1979). Salt increases hypertension and high sodium diets put people at greater risks of heart attacks.

Acute Toxicity

The acute toxicity of sodium chloride appears in Table 2.

Table 2

Acute Toxicity of Sodium Chloride

Study	Results	Source
Acute oral toxicity	Rat: 3,000 mg/kg Mouse: 4,000 mg/kg	(HSDB 2015)
Acute dermal toxicity	Mouse subcutaneous: 3,000 mg/kg	(US NLM 2016)
Acute inhalation	Rat: > 42000mg/m^3	(US NLM 2016)
Acute eye irritation	Rabbit: Irritant causing hyperemia and increased corneal permeability	(HSDB 2015)
Acute dermal irritation	Not found	
Skin sensitization	Not found	

Sub-chronic Toxicity

The sub-chronic toxicity of sodium chloride appears in Table 3.

Table 3

Sub-chronic Toxicity of Sodium Chloride

Study	Results	Source
Repeated Dose 28-day Oral Toxicity Study in Rodents	Rat: Hypertension	(HSDB 2015)
90-day oral toxicity in rodents	Not found	
90-day oral toxicity in non-rodents	Not found	
90-day dermal toxicity	Not found	
90-day inhalation toxicity	Not found	
Reproduction/development toxicity screening test	Mice: Skeletal defects in mice injected with saline solution above 1,950 mg/kg	(HSDB 2015)
Combined repeated dose toxicity with reproduction/development toxicity screening test	Not found	
Prenatal developmental toxicity study	Not found	
Reproduction and fertility effects	Not found	

Chronic Toxicity

The chronic toxicity of sodium chloride appears in Table 4.

Table 4

Chronic Toxicity of Sodium Chloride

Study	Results	Source
Chronic toxicity	Not found	
Carcinogenicity	Negative	(US NLM 2016)
Combined chronic toxicity & carcinogenicity	Negative	(US NLM 2016)

Sodium chloride is a growth media ingredient used to grow the model organism, *Salmonella typhimurium* for chronic mutagenesis studies (Zeiger and Mortelmans 1999; Mortelmans and Zeiger 2000). As such, it is assumed to be negative in the Ames test, but no articles validating or refuting this implicit assumption were found. Sodium chloride was shown to be a mutagen of brewer's yeast (*Saccharomyces cerevisiae*) by base induction (Parker and Von Borstel 1987).

Neither salt or sodium chloride are identified as carcinogens by the International Agency for Research on Cancer (IARC 2014). They are not on the California Proposition 65 list of known carcinogens and do not appear on the Toxics Release Inventory (TRI) Basis of OSHA Carcinogens (US EPA 2015).

Human Health Incidents

Three human health incidents involving sodium chloride were reported to the National Pesticide Information Center (NPIC) between April 1, 1996 and March 30, 2016 (NPIC 2016). One involved sodium chloride as an active ingredient and the accident involved eye irritation. The other two involved other active ingredients in addition to sodium chloride. None of the incidents were in New York.

Environmental Effects Information

Effects on Non-Target Organisms

Sodium chloride has well-documented adverse effects on many freshwater aquatic organisms. Hundreds of studies relate how elevated salt levels in freshwater bodies affect dozens of model species. Results vary according to whether the water is still or moving, the biological oxygen demand, and other environmental conditions (HSDB 2015).

Similarly, the detrimental effects of sodium chloride on terrestrial and freshwater aquatic plants has also been extensively studied. In the case of terrestrial plants, most of the literature examines soil salinity increased by irrigation practices, production on saline soils, or the impacts from the runoff of salt applied to de-ice roads.

Selected effects of sodium chloride on non-target organisms are summarized in Table 5.

Table 5

Effects of Sodium Chloride on Non-target Organisms

Study	Results	Source
Avian Oral, Tier I	Not found	
Non-target plant studies	Common duckweed (*Lemna minor*) ErC_{100}: 250 mM Yellow lupin (*Lupinus luteus*) ErC_{100}: 400 mM	(Sikorski et al. 2013)
Non-target insect studies	Not found	
Aquatic vertebrates	Fathead minnow (*Pimephales promelas*) 96 hr LC_{50}: 6.57 g/L	(HSDB 2015)
Aquatic invertebrates	*Daphnia magna* 24 hr LC_{50}: 1,023 mg/L 24 hr EC_{50}: 2,184 mg/L	(Martins et al. 2007)

Concentrations of salt as low as 0.54% in drinking water have been observed to be fatal to day-old chicks (HSDB 2015). Birds are believed to be adversely affected by salt applied to de-ice roads. Bird kills associated with de-icing may be associated with the toxicity of the anti-caking agents, rather than the sodium chloride, but the salt attracts feeding behavior and possibly excessive consumption of salt (US US EPA 1971). Symptoms of excessive salt exposure in birds are polydipsia (abnormal thirst and heavy drinking), depression, excitement, hemoglobinemia, ataxia, and death (LaBonde 1995). Freshwater amphibians are also believed to be at risk. The model frog, *Rana breviceps* had a no observed effect concentration (NOEC) of 400 mg/kg (Feldman 2011). NPIC received no reports of animal incidents involving sodium chloride between April 1, 1996 and March 30, 2016 (NPIC 2016).

Environmental Fate, Ecological Exposure, and Environmental Expression

Sodium chloride is abundant in nature and readily goes into aqueous solution. Salt is essential for all life forms (Feldman 2011).

Environmental Incidents

Most environmental incidents involving salt are not pesticidal uses. The environmental impact of sodium chloride used as a de-icer in cold climates has been studied extensively, with the literature summarized in review articles (Ramakrishna and Viraraghavan 2005; Fay and Shi 2012). Salt released in the environment increases the salinity of fresh water, including still and moving surface waters as well as groundwater (Ramakrishna and Viraraghavan 2005). Increased sodium and chlorine content in the water can reduce the populations of fish, amphibians and invertebrates that are dependent on fresh water (Blasius and Merritt 2002). Blue-green algae populations can be stimulated by elevated salinity. Salt is believed to be a contributing factor for algal blooms that cause eutrophication (EPA 1971).

Salt released in the environment also causes changes in soil structure. Bulk density increases. The phytotoxicity of salt leads to dying vegetation, which in turn exposes bare soil. These factors combine to result in increased soil erosion where salt has been applied (Ramakrishna and Viraraghavan 2005; Fay and Shi 2012).

Three incidents involving sodium chloride that were neither human health nor animal related were reported to NPIC between April 1, 1996 and March 30, 2016 (NPIC 2016). Only one had detailed information in the database, and that incident involved 12 different pesticide products, most of which were registered pesticides.

Efficacy

Antimicrobial, Bactericidal and Fungicidal Activity

EPA reviewed sodium chloride's antimicrobial activity for products formulated with potassium peroxymonosulfate. The formulated product resulted in no growth of 10 bacteria as well as the virus responsible for Newcastle's disease—thereby allowing for public health efficacy claims on the label (Mitchell 1989). Additional claims were approved for control of *Aspergillus fumigatus* and the Porcine Reproductive and Respiratory Syndrome (PRRS) virus (Nieves 1994), methicillin resistant *Staphylococcus aureus* (MRSA), *Escherichia coli, E. faecalis,* Influenza A virus, Respiratory syncytial virus, and the norovirus (Blackburn 2005). The EPA also reviewed public health claims for sodium chloride to be used to treat swimming pools, specifically for the fecal bacteria *E. coli* and *E. faecium* (Montford 2006). The EPA found that the efficacy data was sufficient to support a disinfectant claim, but not adequate to support the more stringent claim as a sanitizer. The data indicated that the products effectively destroy bacteria in spas when bromine levels are maintained at 1.0 ppm. However, the data did not support efficacy claims when chlorine levels are maintained at 1.0 ppm or when ozone is used.

Salt's effective antimicrobial activity makes it one of the oldest and most widely used preservatives. Its use as a food preservative is prehistoric (Kurlansky 2002). Salt brines dehydrate bacterial cells, which in turn alters osmotic pressure and the disrupted cells die. Salting inhibits bacterial growth and reduces spoilage (Feldman 2011), explaining why salt is widely used in post-harvest handling and processing.

In addition to its own antimicrobial activity, salt can be combined with a wide range of other antimicrobial agents. A 3% solution of salt combined with 3% ethanol and the essential oil active constituents cinnamaldehyde, citral, citronellal, menthol and eugenol, was synergistically more effective in inhibiting growth of the fungi *Aspergillus oryzae*, *Aspergillus niger, Penicillium citrinum, Penicillium viridicatum* and *Aureobasidium pullulans* than any single ingredient (Kurita and Koike 1983). In some cases, the effective dose of the aliphatic aldehydes extracted from essential oils was decreased by a factor of two to four and increased the duration of growth inhibition by over 20 days.

An amphibian pathogen, the chytrid fungus (*Batrachochytrium dendrobatidis*), was effectively inhibited at concentrations of sodium chloride above 3,000 ppm, and increased the survival rate of Peron's tree frog (*Litoria peronii*) (Stockwell et al. 2012).

Herbicidal Activity

Salt may be the oldest herbicide. The use of salt to destroy vegetation is referenced in the Bible and in classical Greek and Roman writings (Smith and Secoy 1976). Salt can be used either as a selective herbicide or a soil sterilant. Its phytotoxic nature is based on osmotic stress that inhibits growth of shoots (Pardo 2010). Some plants are more tolerant of salt than others. Beets (*Beta vulgaris*) have a high tolerance for salt, therefore sodium chloride has been used as a selective herbicide on this crop to kill a wide range of weed seedlings (Pyenson 1951).

Salt tolerant turfgrasses can be effectively treated with sodium chloride to control susceptible weeds. In particular, seashore paspalum (*Paspalum virginatum*) can withstand levels of salt that would kill most plants. Sodium chloride applied at 488 kg/ha achieved over 90% control of the perennial weed sourgrass (*Paspalum conjugatum*) (Brosnan et al. 2009b). Goosegrass (*Eleucine indica*) also treated at 488 kg/ha had less effective results, with 0-19% control after three weeks. Successive treatments over 6-8 weeks achieved results comparable to the herbicide foramsulfuron, with over 50%, and in one case nearly 80% control. MSMA and metribuzin had slightly better control of goosegrass than sodium chloride, but also resulted in greater injury to seashore paspalum (Brosnan et al. 2009a). Smooth crabgrass (*Digitaria ischaemum*) was over 90% controlled by sodium chloride applied at a rate of 1,952 kg/ha (McCullough and L. Raymer 2011).

Common salt is reported to be an effective soil sterilant for eradicating the noxious perennials poison ivy (*Toxicodendron radicans*), poison sumac (*Toxicodendron vernix*) and barberry (*Berberis vulgaris*) (Pyenson 1951).

Plant Growth Regulator Activity

Sodium and chlorine are essential plant nutrients in trace amounts, but are seldom limiting in most soils. Sodium chloride can be used to defoliate organic cotton (Baker 1995). A review of the literature concluded that the receptors for producing the plant hormone abscisic acid are triggered in response to sodium chloride (Pardo 2010). At lower doses of sodium chloride, the plant stomata close to retain water, but undergo water stress at elevated concentrations of sodium.

When sodium chloride at 1% and 1.5% concentrations were used to thin organic Golden Delicious apples (*Malus domestica*) grown in Slovenia, russeted fruit occurred, but the amount of fruit set showed no significant difference between thinned and unthinned treatments (Stopar 2004).

Insecticidal Activity

Salt solutions have traditionally been used against ants and caterpillars (Smith and Secoy 1976). In addition, sodium chloride is a common inert ingredient in many insecticide formulations, where it shows synergistic effects, increases buffering and solubility, and acts as a diluent.

Molluscicidal Activity

Sodium chloride is recognized as a molluscicide (US EPA 1993; Milne 2004), yet its efficacy is anecdotal and application is relatively labor intensive. Salt may be applied as a slug and snail barrier around garden perimeters (US EPA 1993).

Standards and Regulations

EPA Requirements

When used with good agricultural or manufacturing practices, sodium chloride is exempt from the requirement of a tolerance as both an active and inert ingredient in pesticides [40 CFR 180.950(e)].

FDA Requirements

Sodium chloride is Generally Recognized As Safe (GRAS) as a food ingredient by the FDA [21 CFR 182.70]. The FDA permits sodium chloride to be sold as an over-the-counter drug as an ophthalmic hypertonic agent, therefore Generally Recognized As Safe and Effective (GRASE) for this purpose [21 CFR 349.16].

Other Regulatory Requirements

Non-synthetic (natural) sources of sodium chloride, such as evaporated seawater or mined salt, are allowed by the USDA's National Organic Program (NOP) [7 CFR 205].

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