

# Strategies to Mitigate Salt Runoff from Salt Storage and Salt Truck Maintenance Facilities

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**Abstract:** Mitigating salt runoff at salt storage and salt truck maintenance facilities has become a concern for many state departments of transportation (DOTs), since their storm water discharge is found to pollute the environment. The use of nonstructural and structural best management practices (BMPs) are required to minimize the generation of liquid waste containing salt and to minimize the potential hazard caused by salt runoff. The regulatory requirements mandate appropriate disposal of treated salt runoff, which has instigated the need to use wash water to make salt-brine for salt prewetting and anti-icing applications. This paper discusses a novel approach to collect and treat the liquid waste containing salt based on an approach similar to the wastewater management practices used in vehicle and equipment washing facilities. Collected wastewater will be first made to flow through an oil-grit separator to remove hydrocarbons and organic material, then through an underground sediment-sand filter to remove sediments. Sediments and oil-grit free wastewater will be stored in a fiberglass underground holding tank, until it is reused during the next winter storm. The salt-brine used for prewetting salts and for anti-icing is the eutectic solution with 23% salt, by weight. Salt solutions with low concentrations can be used as the base solution for making salt-brine, though it has to be intermittently stirred to prevent bad odor. The proposed measures may reap significant cost-savings, which otherwise would incur in treating wastewater prior to disposal.

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## Introduction

Storm runoff containing road salts used in deicing operations have become a source of contamination of surface and subsurface water bodies and water ways which provide clean water for human consumption. In certain localities high concentrations of ions have been found in plants and animals and have been linked to storm runoff containing road salts (USEPA 2002). Salt is found to be the most viable deicing material which keeps roads, highways, and pedestrian paths open during winter weather; its use accounted for \$289.5 million in 1998 (USGS 2002). However, the impact of salt runoff on the environment, and high corrosion rates in highway structures and vehicles have been identified as major issues of concern.

The proposed Phase II rules of the United States Environmental Protection Agency (USEPA), governed by the Clean Water Act [Section 402(p), December, 1999] regulates pollutants entering waterways from publicly owned and operated storm water systems. Many state departments of environmental protection

(DEPs) have taken steps to develop municipal storm-water management programs to seek compliance with the proposed regulations.

The adverse environmental implications arising from improper use of salt and the proposed regulatory requirements have made many state departments of transportation (DOTs) to take a proactive approach towards controlling storm water runoff containing salt. Many local government agencies are reviewing the techniques and material use at their local maintenance facilities to adopt favorable management practices and techniques that minimize salt use and hence salt runoff. The literature highlights the use of salt-brine for prewetting of deicing salts, anti-icing, and the use of Road Weather Information Systems (RWIS) in winter road maintenance.

Many road maintenance facilities with salt and sand storage have been recognized as point sources discharging untreated salt runoff to the environment. Road maintenance facilities become a major polluter if located in environmentally sensitive area. The National Pollutant Discharge Elimination System (NPDES 2000) requires unprotected salt storage facilities and those discharging untreated runoff to obtain a storm water multisector general permit for industrial activities. At state level many DEPs require state DOTs to report significant noncompliance and future corrective action. Many DOTs are working towards compliance by its highway maintenance facilities thereby seeking exemption from requiring a waste discharge license to operate.

A typical salt storage facility stores road salts, sand, sand-salt mixtures, and other solid chemicals used for de-icing, and salt-brine solutions used for prewetting and anti-icing applications. These materials are now required to be stored in closed enclosures to prevent discharge to the environment due to wind, moisture, and handling.

The Salt Institute (1997) has developed a comprehensive

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document highlighting best management practices (BMPs) for storage facilities. The machinery and equipment that are used to stockpile, mix, load/unload salt, and handle salt brine are washed periodically to reduce the corrosion hazard. The accumulated solid and liquid waste generated while washing needs to be treated, and reused or disposed. Many truck washing facilities owned by cities, townships, and counties are now in the process of implementing good management practices in line with the regulatory requirements to prevent or minimize the discharge of salt runoff.

This paper describes a novel approach to recycle and reuse wastewater containing salt-waste, generated at salt truck maintenance facilities and salt storage facilities.

## Literature Review

The effect due to excessive use of deicing chemicals during the winter season is taking a heavy toll on the environment. It has been reported that in regions with heavy and frequent use of deicing chemicals have discharged high concentrations of salt to surface soils, and surface and groundwater bodies. This has affected the bio-diversity of such regions, particularly the fresh water fish habitats (USEPA 2002).

Deicing chemicals do play an important role in maintaining safe transportation of goods and people across the nation (Jones and Sroka 1997), and the fact that humans have “engineered” the natural environment in meeting their social needs has always become a topic for political debate. It is also true that in the past, less emphasis was placed on optimal use of deicing chemicals, which would have addressed the environmental concerns.

The Clean Water Act (USEPA) recognizes the need to protect groundwater bodies, which supplies portable water to communities and hence requires the protection of groundwater recharging areas. These are more vulnerable to percolating chemicals since they remain as concentrated plumes. High concentrations of sodium ions have made water to taste different; and also found to increase the risk of heart and kidney disease (USEPA 2002).

Though steps have been taken to protect areas with high environmental sensitivity, directing storm runoff from highways containing deicing salts, to surface water bodies, is still unregulated. Though it is considered that instant mixing and dilution takes place, local government authorities are made responsible in controlling contamination through periodic water quality testing (USEPA 2002).

Due to increased ecological awareness, and understanding the impact of deicing chemicals that may have on society, economy and ecology, many local government authorities and state DOTs are stressing on the optimal use of such polluting chemicals. The direct and indirect costs associated with winter road maintenance are on the rise, mainly due to high levels of corrosion associated with deicing chemicals. The cost of snow maintenance can be 6–30 times the cost of deicing salts, with around 90% of cost associated with corrosion. When corrosion damage to bridges, highways and vehicles are factored in, the real cost per ton of salt could be much higher. The total annual national cost of salt-related damage is estimated at \$5.5 million (Hayes et al. 1996).

Anti-icing is an option where optimal use of chemicals is emphasized, while addressing ecological and socio-environmental concerns. It uses salt-brine solution (23.3% NaCl by weight) to wet the road surface prior to a snowstorm. This eutectic composition (see Fig. 1) lowers the freezing point of water to  $-21^{\circ}\text{C}$ , which in most instances sufficient to maintain enough moisture to

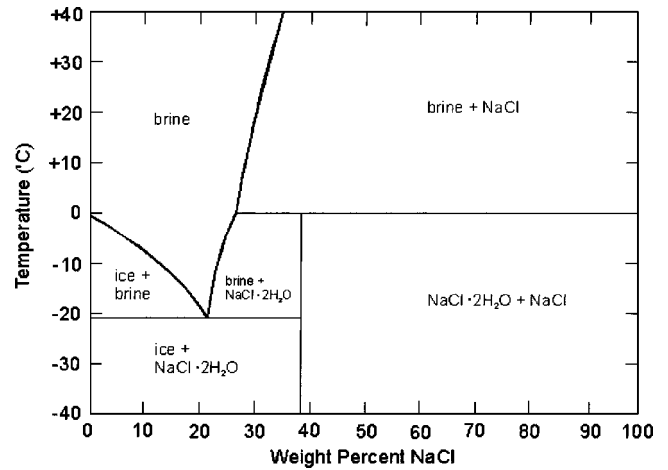


Fig. 1. Freezing temperatures of salt brine mixtures

have a fluid barrier between falling snow and the pavement surface.

Prewetted salts cling to the road with less rebound, 25–65% remaining on the roadway, causing less harm to roadside vegetation (TranSafety 1997). Many states use “zero velocity” applicators to reduce salt rebound during applications.

The moisture dissolves salt, releasing heat and thereby melting the ice and snow, as well as breaking the ice-road bond. The effectiveness of regular salt-brine reduces when the road temperatures are below  $-6^{\circ}\text{C}$  (MnDOT 1995). Alternate, yet expensive salt brines such as liquid calcium chloride ( $\text{CaCl}_2$ ) is found to be superior to regular salt brine since they could depress the freezing point of water well below  $-6^{\circ}\text{C}$  (Donahey and Burkheimer 1996).

Salt ( $\text{NaCl}$ ) is the cheapest and widely available deicing chemical, and perhaps would maintain its cost advantage for many years. Chlorides of calcium ( $\text{CaCl}_2$ ), magnesium ( $\text{MgCl}_2$ , also known as Freeze Guard), and regular salt are found to accelerate corrosion and hence are found less cost effective. The use of antiflaking agents and rust inhibitors to improve performance is found to be harmful to the environment (USEPA 2002). Other salt substitutes used in deicing include calcium magnesium acetate (CMA), potassium acetate (KAc), urea, natural brines, potassium chloride (KCl), and sodium formate. Calcium magnesium acetate and potassium acetate are found most benign to the environment since they contain weak biodegradable acids. Though CMA costs 25 times as much as regular salt, it is found more effective at subzero road temperatures (TRB 1992).

Salt prewetting during deicing is found to be effective and economical compared to the direct application of dry granular salt or salt-sand mixes. This also reduces the use of road salts significantly thus reducing harm to roadside vegetation and possible salt contamination.

In deicing, sand is used mainly as an abrasive, which generates traction on ice, under wet snow conditions. However, sand does not enhance melting of powdered snow or ice and hence it is found to be less effective than prewetted salt under urban heavy traffic situations with packed snow conditions. Sweeping sand residues from the road pavements increases the maintenance cost while they also tend to clog catch basins and sewers, necessitating expensive cleanup.

The optimal use of salt-brine as a freeze-point depressant, in deicing and anti-icing applications depends largely on timing of application. This requires the efficient use of RWIS, accurate

weather predictions, timely and efficient mobilization of machinery and manpower, experience, decision making, and coordination at operating levels.

The RWIS developed under the Strategic Highway Research Program and introduced in the 1980s has pavement sensors to monitor road temperatures, and meteorological sensors to measure wind speeds, wind direction, air temperatures, and precipitation. The information gathered from these sensors can be used in computer models to map road temperatures, which assist in identifying road segments and their respective treatment options.

Many state of the art techniques are experimented to minimize environmental damage caused by extensive application of road salts. An "anti-icing smart" permanent pavement coating is being developed at the Institute of Snow Research at Michigan Technological Univ. (Goodrich 2001). This coating is supposed to act as a sponge to retain liquid deicers for several days, to prevent the pavement from freezing.

The "Highway Maintenance Concept Vehicle" which is being developed at the Center for Transportation Research and Education (CTRE 2002), State of Iowa, uses truck mounted sensors to detect atmospheric and road condition prior to using the appropriate deicing application.

Many counties, cities, and townships have documented their success achieved in adopting anti-icing and deicing options that suit their local conditions, which had resulted in cost savings from less salt usage. However, winter maintenance requires washing of machinery and trucks to minimize corrosion, and to maintain salt storage facilities. Hence BMPs are needed to minimize salt runoff.

### **Best Management Practices to Mitigate Salt Runoff from Salt Storage and Salt Truck Washing Facilities**

Best management practices are adopted to make operations efficient and cost effective, while addressing environmental concerns. These are generally classified as nonstructural and structural BMPs. The nonstructural BMPs address good practices and control strategies to reduce waste generation and accumulation and to take precautionary measures against possible accidental spills or leaks resulting in salt runoff. The structural BMPs address treatment and safe disposal of salt runoff collected at the said facilities.

North Carolina Department of Transportation (NCDOT) is focusing on the equipment wash/maintenance facilities, and is planning to identify existing procedures and practices for equipment washing and also contacting other states to study practices followed by them. They are also planning to quantify pollutants of concern in equipment-wash wastewater by performing on site sample collection and identifying effective alternatives to equipment washing for NCDOT operations (Wu 2003).

#### ***Nonstructural Best Management Practices for Salt Storage Facilities***

The nonstructural BMPs for Salt Storage Facilities emphasize proper housekeeping to prevent salt runoff during storage and during operations.

#### **Roofed Salt Storage/Maintenance Facility**

Many state DOTs encourage enclosed storage facilities or to share such facilities with neighboring local government (Goodspeed et al. 1997). Many salt storage facilities in the United States lack

controls to curb salt runoff. MnDOT (1995) reported that 73% of its counties and 39% of its cities had enclosed or semienclosed storage facilities. Many facilities still use waterproof tarpaulins to cover salt storage.

Prefabricated sheltered structures are recommended to house storage of deicing products, the mixing facility and the truck loading facility (Davis 1994). This would require sufficient height of clearance for unloading and delivery of materials. Material handling in enclosed areas under dry conditions facilitates collecting sweepings for reuse (Salt Institute 1997).

During operations, wet salt residues and salt-water can be contained within, by constructing a perimeter curb around the facility. This could be periodically collected while allowing the salt wastewater to flow to a waste containment tank. It is important to separate moist salt from liquid salt waste since absorbed moisture evaporates at relative humidity values below 75% (Salt Institute 1997).

#### **Enclosed Conveyors**

Enclosed conveyors are found to take less time and effort during loading and hence are cost effective ("Enclosed conveyors improve salt storage" 1990). The well aerated enclosure maintains the salt in a dry granular form without forming large clumps ("Conveyors reduce salt storage problems" 1991). This is an important factor to minimize damage to grillwork on salt truck tops during subsequent loading. The system is made of noncorrosive materials, hence requires little or no maintenance; it being automated requires no labor input. The enclosure also prevents salt dust escaping during loading. Such enclosed conveyors are deployed in salt storage facilities in Schaumburg, Ill.; Nanuet, N.Y.; Lewisboro, N.Y.; and Holmdel, N.J. (Dwain 1998a, b).

#### **Proper Housekeeping**

Good housekeeping practices emphasize on being mindful by employees to protect themselves as well as the community at large (Salt Institute 1997). Maintaining salt storage under clean and dry conditions is considered important in reducing liquid-waste that requires treatment.

The NJDEP describes the registration and siting requirements for new storage areas. The owner or operator of a new storage facility shall register the storage area with NJDEP (NJDEP 1996, 2003). The site for a new storage facility cannot overlie sand or gravel aquifer, a source of water protection area, and has to be located more than 100 m from drinking water wells, excluding wells that serve only the storage area. Salt stockpiles should not be located adjacent to fresh surface water, in flood prone areas, aquifer recharge areas, and areas of steep slopes.

Having policies and procedures guiding operation and maintenance is important in proper functioning of a storage facility. These should emphasize reducing handling and reducing possible contamination.

#### ***Nonstructural Best Management Practices for Truck Washing Facilities***

Washing trucks after a major storm event is encouraged to protect them from corrosion. Truck washing facilities located in areas of high precipitation are recommended to be enclosed to reduce the amount of liquid waste. All washing facilities should have a perimeter curb to prevent runoff and wastewater should be collected to a sump for subsequent treatment. Caltrans (1998) provides a comprehensive list of nonstructural BMPs developed for storm

water management in vehicle and equipment washing facilities. Out of these, the relevant practices for a salt truck washing facility include:

1. regular inspection of washing areas for wash pads, sediments, sump, oil separators, etc. for cleaning;
2. training and instruction to employees and contractors using the area;
3. display of signs to indicate the usage instructions and discharge instructions;
4. it is recommended to discharge all water in recycling discharge or dead sump;
5. in case sump is not there, it is suggested to provide straw bales or gravel bags;
6. approved wash rack that is sloped to contain and drain wash water and constructed to prevent runoff and runoff should be used;
7. phosphate-free, biodegradable detergents should be used, when available; and
8. installation of oil water separators, rain sensors, or canopies when required.

#### Other Innovative Methods

These include vacuum cleaning of trucks to remove salt prior to washing and coating of trucks with a nonstick surface as a possibility for less washing or no washing.

### Structural Best Management Practices to Minimize Salt Runoff from Salt Storage Facilities and Truck Maintenance Facilities

The need for a salt wastewater collection system and a treatment facility for Salt Storage and Truck Maintenance Facilities is a concern of many state DOTs. Indiana Department of Transportation (INDOT 2003) identified the urgent need for a limited “pilot” implementation research project due to required environmental regulatory compliance. Salt spillage during unloading and loading of trucks at salt storage facilities and the wash water at truck/equipment washing facilities are released to storm sewers. Indiana Department of Transportation is currently investigating methods to evaluate the volumes and requirements for on-site collection of salt-laden wash water and runoff; to evaluate pretreatment requirements with these latter streams; and to evaluate and establish suitable usage practices and protocols associated with these brine solutions (Alleman 2002). Bertram and Wolf (2001) concluded that operators should be encouraged to implement and maintain site-specific structural controls and BMPs.

Direct discharge of storm runoff containing road salts through open drainage systems has been found to have a greater impact on down gradients from the highway. Granato et al. (1995), who compared the effectiveness of diverting highway storm runoff through a closed drainage system, a closed drainage system with snow-berm, and a full-snow-berm drainage system, reports that the latter is found to be most effective in removing chloride loads.

The regulatory requirements mandate road maintenance facilities to reuse treated salt wastewater rather than to discharge after diluting pollutants to required levels. This however, will require individual facilities to obtain a pollutant discharge license to operate. Road salt residues are found to contain a high level of heavy metals and anthropogenic constituents (Glenn and Sansalone 2002) which may require them to be reduced to acceptable levels before being discharged. This may require a costly treatment option. If the above is not made a requirement, discharging

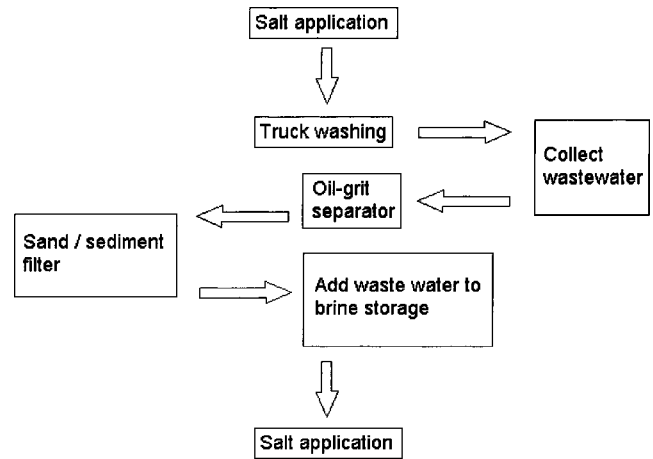


Fig. 2. Proposed approach

salt runoff using sanitary treatment lines may result in polluting downstream surface and groundwater bodies.

It is imperative that structural BMPs cannot be used in isolation, but have to be integrated with nonstructural BMPs in addressing both environmental concerns and regulatory requirements. The following structural BMPs can be used appropriately to mitigate salt runoff from salt storage and truck maintenance facilities.

#### Retention Ponds

Retention ponds are found to perform well in areas where evaporation exceeds precipitation. A lined pond, which collects only the salt contaminated runoff, would become an economical and viable solution. This requires a protective cover to prevent collection of rainwater. During dry weather, evaporation increases the salt concentration to a level where it could be used to make salt-brine. The waste residues after drying can be added to the salt pile.

A natural or constructed wetland can be considered as viable methods of discharging relatively clean runoff. A fore bay and a detention pond to remove pollutants and sediments and its low maintenance requirements make it a viable option for most parts of the United States. However, it being a source for mosquito breeding, low pollutant removal during the winter season, and having to comply with regulatory requirements (Hayes et al. 1996) makes this option less attractive.

### Proposed Method for Treating Salt Runoff

The method proposed requires directing salt-runoff through an oil-grit separator to remove hydrocarbons and organic material, and then through an underground sediment-sand filter to remove sediments (refer to Fig. 2). The cleaned water is then stored to prepare salt-brine to be used for salt prewetting and anti-icing.

#### Removal of Oil and Grit

Removal of oil and grit could be done using oil-water or oil-grit separators. Industrial type oil-water separators that are commonly available can be used to separate oil from the salt runoff.

The oil and grease traps that are commonly used in service stations and parking facilities can be used to direct the runoff to

the sediment filter via a subsurface sewer line. A typical oil-grit separators unit costs under \$1,500 and maintenance is typically \$300 per year. Oil-grit separators have performed well in drainage areas of less than 2 hectare with timely inspection and maintenance (Hayes et al. 1996).

### Removal of Sediments

Sand filters are commonly used to treat stormwater in large building complexes, access roads, and parking lots. They are successful in removing particulate matter and trace metals (Hayes et al. 1996). Such filters can be designed and installed below the paved surface. Large sand filters and self contained sand beds can treat stormwater to filter runoff from areas as large as 5 acres in size. Sand filters require little inspection and maintenance. However, filtration will retard with increased accumulation of sediments, and hence replacing sand is required. These can be installed in areas with space restrictions. A sand filter unit will cost under \$1,000 and maintenance is around \$100 per year. Frequency of maintenance depends on the quality of receiving water but is not expected to be less than once every year. Out of nearly 1,000 sand filters installed in Austin, Tex., only a fraction of them failed after being in operation for 10 years (Hayes et al. 1996).

### Holding Tank

The salt-wastewater free of sediments, oil, and grease is made to flow into an underground holding tank, which is kept until the next season or next winter storm. The tank is best made of fiberglass in order to prevent corrosion. If the salt concentration is less than 10%, use of mechanical stirrers will prevent bad odor.

Detergent free washing or the use of biodegradable detergents in truck washing facilities is encouraged. A typical high-pressure wash produces 95–130 litres of waste water per truck. A road maintenance facility with five trucks would generate 475–660 litres of waste water; hence, a 2275 litre fiberglass storage tank would be sufficient to collect treated salt wastewater for reuse.

The salt water has to be pumped to brine maker tanks, where more salt is added to bring the solution to 23% eutectic brine solution. The correct concentration can be monitored using a hydrometer or an electrical conductivity meter.

Increased use of salt-brine for anti-icing and prewetting of salt, thereby reducing the quantity of deicing chemicals, also reduces the total cost of winter maintenance. The salt-brine system that is used by an Iowa DOT facility has a 600 gallon stationary salt-brine maker, with 60 gallon truck mounted prewetting applicators. These are used to spray salt-brine to prewet dry salt, as it goes to the spinner. The cost of a brine maker is estimated at \$5,000 and an applicator at \$1,100. The estimated annual savings incurred in reduced salt usage was sufficient to pay back the cost of the system after 5 years (Donahey and Burkheimer 1996).

Removal of salt from wastewater to the required purification levels can be attained through sophisticated desalination processes. This, however, incurs high capital and maintenance costs, and hence can be compared as an expensive and only alternative to the proposed approach. The proposed approach to separate, store, and reuse salt-brine would serve as the best cost effective option to use salt wastewater from salt storage and salt truck washing facilities.

### Summary and Conclusions

Minimizing and controlling salt runoff from existing and new maintenance facilities is a nationwide goal set by USEPA and

state DEPs, and implemented by state DOTs. Salt storage and salt truck maintenance facilities generate wastewater containing excessive amounts of salt. Hence cost effective methods to reuse salt runoff from salt storage and salt truck washing facilities are required.

The nationwide attempt to reduce the use of deicing chemicals has forced many users to move towards anti-icing, prewetting of deicing chemicals, and making decisions based on local road weather conditions.

The reduced application of deicing chemicals in winter maintenance would reap cost savings achieved through a reduction in corrosion damage to vehicles and infrastructure such as bridges and culverts; a reduction in the cost of deicing chemicals; and by reducing the impact on the environment.

A novel way to reuse the runoff containing salt from salt storage and truck maintenance facilities is proposed. The oil, grit, and other sediments are removed from wastewater and stored in a holding tank until the next winter storm. Before the next winter storm salt water is pumped to brine maker tanks, where more salt is added to bring the solution to 23% eutectic brine solution. The salt-brine mixtures are used for anti-icing and prewetting of salt, thereby reducing the quantity of deicing chemicals, and also reducing the total cost of winter maintenance.

The proposed approach to separate salt wastewater generated at salt storage and salt truck washing facilities, and to reuse as salt-brine in anti-icing and prewetting of salts would serve as the best cost effective option available.

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