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The Use of Deicing Salt with Respect to Economic and Ecological Criteria

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ABSTRACT

The use of chemical deicing on roads with high volumes of traffic aims to rid the road of ice in order to decrease the risks of accidents. The risks of environmental damage caused by the use of deicing salt have been under discussion since the method was first used. Although the consumption of salt for deicing is fairly low, there will always be some critics of chemical deicing every winter.

An Austrian publication studying the effects of chemical deicing with respect to economic and ecological criteria was published in 1988. The study encompassed the effects on traffic safety, trafficability, corrosion and environmental influence on the use of deicing chemicals. The findings provided overwhelming evidence of the benefits of road salting by a margin of more than fourteen to one: the total annual benefits of road salting were 25,340 million Austrian shillings, while the annual costs of road salting were 1,711 million Austrian shillings.

Regarding the ecological cost in relation to the economic benefits of the use of deicing salt, our argument confirms the present policy. This means by using the lowest possible quantities of salt, the highest level of traffic security and trafficability can be maintained with the lowest level of environmental damage.

INTRODUCTION AND TERMS OF REFERENCE

For centuries, the snow cover on the network of roads was considered to be a benefit rather than an impediment to traffic, because sledges were an important means of overcoming distances. It was only when an improved infrastructure and high-capacity traffic systems laid the groundwork for economic advancement that an effective winter maintenance service became a necessity (Augustin et al., 1980).

Once this fact was recognized, salt started its triumphal progress as a deicing agent, preventing the breakdown of private and commercial traffic, including local public traffic, in winter and ensuring maximum efficiency at minimum cost. By using NaCl it became possible for the first time to clear roads completely during the winter months. However, after some years of extensive use of deicing salt, material damage was first discovered primarily on vehicles and traffic installations. In recent years, the soil and vegetation in the vicinity of roads were frequently found to be affected, and the damage was traced back to, *inter alia* the use of deicing salt. Today, the heated debate on the ecological hazards threatening our environment has exposed deicing salt to a rising tide of criticism.

It must therefore be our objective to find an optimum balance for the discrepancy between efficiency and ecology while focusing on the issue of traffic safety. This study aims to compare assessments of benefits and losses for the purpose of arriving at an objective macroeconomic evaluation of the use of deicing salt.

COST/EFFICIENCY COMPARISON

Need for winter maintenance

Roads that can be used on a year-round basis are a precondition to maintain the macroeconomic infrastructure. A country's economic performance depends to a considerable extent on low-cost transportation. It must be feasible to transport individuals and goods rapidly and safely and provide a variety of services at different locations.

Cost of using deicing agents

This section lists the costs connected either directly or indirectly with the use of deicing salt for the winter maintenance of roads.

Direct costs

In calculating direct costs, the collection of information is facilitated by the availability of precise data from the accounting departments of the road administrations.

An analysis of winter maintenance costs, using the classical breakdown of snow clearance, spreading of chippings, and salting varies in accordance with the division of the road network into motorways, highways and carriageways, and rural roads. At 81.2%, salt makes up a large share of the winter maintenance costs on motorways, as opposed to rural roads, where it is just 8.1% (Fig. 1).

In 1990, the direct costs for deicing salt usage for winter maintenance in Austria were: 90,000 × 1,700 = ATS 153,000,000 (tons of deicing salt × price/ton = cost of salt).

Indirect costs

Indirect costs are losses caused by the use of deicing salt. Contrary to the direct costs, they are difficult to quantify.

Vegetation: The impact of deicing salt is greatest on the flora in the immediate vicinity of the road. The green strips along the roads, particularly in the central divider, suffer the greatest exposure to deicing salt, in addition to numerous other harmful factors. In Germany experts have calculated that of the 2 million roadside trees, 20,000 or 1% must be expected to die annually due to the effect of deicing salt (Augustin et al., 1980). The replacement value including planting and nursing is set at DM 5,000 (ATS 35,000) per urban tree. In Austria, annual replacement costs are estimated at ATS 175 million.

Groundwater and potable water: Several studies performed in Austria and Germany on chloride rates in waterways in connection with deicing salt found no significant impairment or damage. Neither in Austria nor in Germany has there been any case of contamination of potable water by deicing salt, although it has been established that it might be caused in isolated instances by the general increase in the prevalence of chloride.

Road installations: Damage to concrete and reinforced concrete structures, prestressed concrete bridges and cement concrete surfacings is on the increase since deicing salt has been used for winter maintenance. Such damage also occurs naturally in the course of the freezing/thawing cycle, but is generally accelerated by the use of deicing agents.

Vehicles: In all available studies of quantifiable losses caused by the use of deicing salt for winter maintenance, corrosion damage of vehicles is rated relatively high compared to other losses. On average, the studies find costs of approx. DM 600–700 for

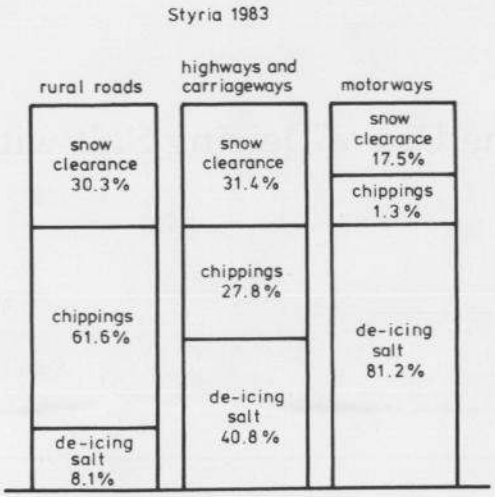

Fig. 1. Comparison of winter maintenance costs on rural roads, highways and carriageways, and motorways in Styria (Dirnböck, 1985).

about 6% of all vehicle types 4–6 years old, and some 12% of all vehicle types aged 6–8 years. A long-term test to determine the scope of corrosion of vehicles in Austria calculated that the additional winter corrosion makes up an average of 45% of overall corrosion (Dultinger, 1976). The Umweltbundesamt (Federal Environmental Office) in Berlin set the figure at 40–46% of overall corrosion in Germany. In Austria, total corrosion losses for vehicles caused by deicing salt are: 148,619 × 4,550 = ATS 676,216,450 (45% corrosion-damaged vehicles × average repair costs = total cost.

Intangible costs

This includes losses which, while not quantifiable, still provide valuable insights for an efficiency calculation within the scope of comparing costs and benefits (Sagasser, 1981):

- aesthetic impairment of the scenery,
- salt cover on shoes, shop floors,
- animals' paws exposed to salt.

Benefit of using deicing agents

In view of the fact that the increase in road traffic causes more than a thousand fatal accidents, tens of thousands of injuries and an aggregate economic damage reaching billions of Austrian shillings, urgent action is required to improve traffic safety. Arguments put forward in debates in favour of the use of deicing agents for winter maintenance usually involve traffic safety. The main benefit offered by deicing salt is that it ensures unimpaired access to the roads while maintaining traffic safety during the winter months.

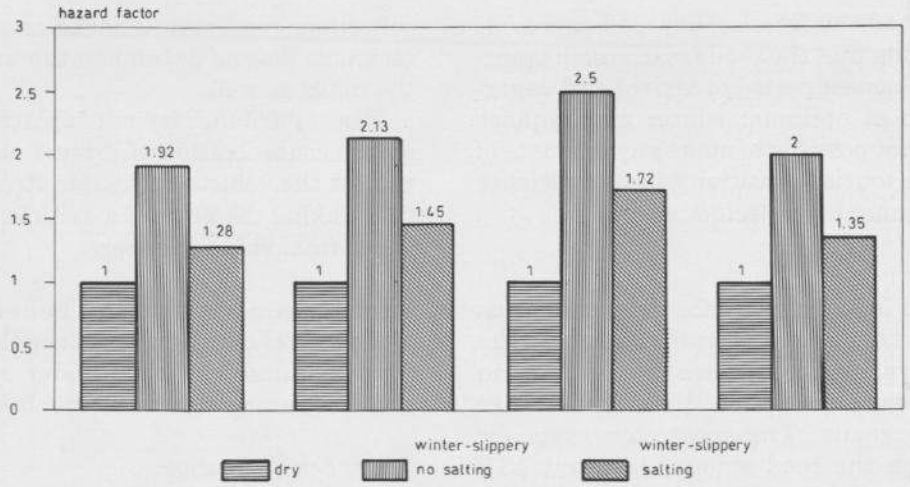

Fig. 2. Hazard factors for road surface conditions in built-up areas.

To represent the macroeconomic effects of using deicing salt, we must attempt to quantify them as a first step in the process of comparing costs and benefits.

Reduction of the accident rate

In the author's opinion, the only effective approach to this issue is to determine the hazard factor for a variety of road surface conditions. The Institute of Traffic Planning and Traffic System Design of the Technical University of Berlin investigated the consequences of not salting roads on traffic safety and traffic flow in Berlin in the winter of 1981/82. The hazard factor is determined from the mean vehicle distance and mean stopping distance for salted and unsalted roads. As illustrated in Fig. 2, the hazard factor for unsalted winter-slippery roads is between 1.92 and 2.5 in built-up areas (Heuber). Outside built-up areas, the hazard factor varies between 2.5 and 4.9.

Winter maintenance without deicing agents causes the hazard factor to increase by 132% outside built-up areas, and by 46.9% in built-up areas on days when the roads are slippery from ice.

The cost of accidents on freeze-prone days on roads where deicing agents were used was multiplied by the higher hazard factor. Results show that the general prohibition of deicing agents on the entire road network in Austria would raise accident costs by ATS 178,332,570 in built-up areas and by ATS 1,120,056,900 in non-built-up areas (Felber).

This comparison indicates most clearly that the non-use of deicing agents would result in a serious safety risk, particularly on inter-urban roads, and would generate higher accident and follow-up costs. Under the given premise, Austria can save about ATS 1,298 million annually from the reduction in the accident rate by the use of deicing agents.

Economic gain of time

The economic time value of traffic acceleration from the use of deicing salt is a derived value determined by the macroeconomic production process (Sagasser, 1981).

Commuter traffic: Preventing or eliminating road icing increases traffic safety and retains the performance and thus efficiency of the traffic flow. When calculating the national income at current prices in 1990 in terms of employees, on the basis of approx. 1800 working hours per year, we get an hourly rate of about ATS 254 for each gainfully employed person (Dolecal, 1991). At an assumed time loss of 30 minutes suffered by 2,381,764 daily commuters on the public roads on 50 working days at winter conditions and icy roads, the total time loss is 59,544,100 hours. When multiplying this value by an hourly rate of ATS 254 (1990 national income per employee), the fictive economic time gain from using deicing salt for winter maintenance is ATS 15,124 billion per year.

Education: With a student body amounting to 1,133 million in 1990/91, a delay of 30 minutes on 50 winter days with icy roads would cause the cancellation of innumerable lessons (Federal Ministry of Education).

Tourism

In recent years, winter tourism has experienced a boom in Austria. Private mobility is a major prerequisite for the individual usage of leisure times. A winter holiday with a vehicle of one's own has become an integral part of the lifestyle for much of the population. The non-use of deicing agents reduces

the capacity of roads on freezing days, an aggravating fact considering that the roads reach their capacity limits at the busiest period of arrival and departure traffic even at optimum winter maintenance conditions. It is not possible to make any estimate of benefits because tourist sensitivity in their leisure time behavior cannot be projected.

Goods transport

In addition to individual traffic, Austrian roads carry a major part of the freight traffic as well. Of the overall goods transported internally in Austria (412.6 million tons), 76.4% or 315.23 million are shipped on the roads. Transportation costs for freight carried on the road amount to about ATS 109.5 billion for some 365 million tons (internal and transit transport). Assuming that the transportation speed — and with it the transportation capacity — is reduced by 30% when no deicing agent is used on 75 winter maintenance days (Dedic), its use would provide for an aggregate gain of about ATS 6.75 billion.

Savings of fuel costs

In 1990, fuel sold at consumer prices totalled about ATS 42.213 billion (Federal Ministry of Economic Affairs). Assuming that the use of deicing agents on an average of 75 winter maintenance days per year generates fuel consumption savings of 25%, we have the following calculation: 42.213 billion × 75 winter maintenance days = 8.674 billion × 365 days; cost of fuel consumption.

The greater consumption would generate additional costs of about ATS 2.168 billion, and can thus be considered an aggregate gain from energy savings. Apart from higher fuel costs, increased fuel combustion would produce other harmful substances which in turn are an ecological hazard to the environment.

Increased wear and oil consumption have not been included in this calculation due to the lack of relevant data, but should nevertheless be noted.

Intangible benefits

Intangible benefits are advantages which are impossible or difficult to express or quantify in numbers.

Mobility/leisure time value: Individual private mobility would be reduced significantly if no deicing agent were used on winter maintenance days.

Maintenance vehicles: On icy, unsalted or ungritted roads, emergency services whose proper functioning depends on high mobility will have problems in meeting their purpose. Each life that can be saved by the timely arrival of an emergency service is a major gain which cannot be expressed in numbers, particularly for their families. Apart from emergency services, utility vehicles such as garbage collection, road maintenance or repair vehicles for technical defects depend on the unobstructed use of the roads as well.

Ease of driving: Icy roads place greater demands on the concentration of drivers as much as icy ruts subject the vehicle to greater strain. Ice can extend the braking distance of a vehicle by up to 15 times the normal value (Heuber).

Comparison of costs and benefits

The use of deicing salt to keep the roads from icing over in winter has come under increased criticism since its damaging side-effects became known.

Costs/benefits ratios

A comparison of annual costs and benefits shows a cost/benefit ratio of 1:14.8. Brenner and Moshman found a cost/benefit ratio of 1:18.1 when evaluating all pros and cons of road salting in their 1976 U.S. study within the TISA report. In Germany, Sagasser in 1982 based his assessments partly on the TISA report and adapted its values to German conditions. This method produced a cost/benefit ratio of 1:3.27.

The author wishes to emphasize that the above values are cautious estimates and that practical values are much higher.

Considering the three results, we find a clear dominance of the financially evaluated benefits over evaluated costs, in spite of the divergent ratios. The methodology of evaluating losses is simpler because detailed studies are available in some fields and some of the costs can be quantified directly.

TABLE 1

Comparison of costs and benefits of using de-icing salt in Austria in 1990

Benefits	Million ATS	Costs	Million ATS
Reduction of accident	1,298	Direct cost of deicing agents	153
Economic time gain:		Indirect costs:	
Commuter traffic	15,124	Trees	175
Education		Green strips	17
Tourism		Ground and potable water	20
Goods traffic	6,750	Road installations	670
Savings on Fuel	2,168	Vehicle corrosion	676
Intangible benefits:		Intangible costs:	
Mobility		Scenery	
Utility vehicles		Pet care	
Ease of driving		Aesthetic loss	
Total	25,340		1,711

Evaluating the benefits is much more difficult, as is defining and identifying benefits of prevailing practices in the winter maintenance service.

With regard to evaluating benefits it should be added that the values determined are applicable for all deicing agents which are economically and ecologically acceptable and which produce the desired effect.

SUMMARY AND ANALYSIS

The use of deicing salt as an economical deicing agent

Today, the use of deicing salt for winter maintenance is subject to the need to ensure unobstructed use of roads while maintaining a high degree of traffic safety on the one hand, and the public expectation of measures to protect the environment on the other.

When corrosion damage and ecological impacts first became known, critics raised their voices and pleaded for a limited use of deicing salt combined with a search for alternative options.

The development of new technologies for road salting reduced the average quantity spread at each run from 40–50 to 5–15 g per m^2 of road surface.

Preventive salting, methods to measure the residual salt, the installation of ice warning signals and improved application techniques for moist and mixed salt spreading have cut the quantities actually used for salting.

A compromise to balance ecological and economic considerations

An analysis of the 1:14.8 cost/benefit ratio illustrates most clearly the effect that the refusal to use deicing agents can have on the national economy. Winter maintenance must be carried out with an ecological bias, yet without generating any economic disadvantages.

The working group on winter maintenance established by the Research Society for Traffic and Road Systems recommends the following measures:

– Priority gradings for road salting should be reviewed in accordance with actual traffic requirements;

– Salt quantities should be limited to 10–15 g per square meter and run;

– Salt quantities should not significantly exceed 1 kg per square meter per winter;

– Preventive salting should be used when the ambient temperature drops to 0°C or lower while the relative humidity is at least 75% and the road surface temperature is less than 0°C;

– The use of sodium chloride is economically sensible when the road surface is dry and has a maximum low temperature of about –6°C while the relative humidity is at least 75%;

– The use of calcium chloride is economical at temperatures down to about –20°C and a relative humidity of at least 40%;

– Repeat runs should take into account residues and should not apply more than the difference to the reference quantity;

– Moist salt should be spread to avoid spreading losses in the wake of the vehicle or from cross-winds;

– Accuracy of the salt dosing equipment should be checked at regular intervals.

The following protective measures are also recommended to alleviate economic and ecological losses (Augustin, 1980):

– Prevent salt penetration into the soil by removing or draining off the salty snow;

– Construct new road installations from air-entrained concrete, and coat and seal existing components made of concrete or reinforced concrete;

– Plant green strips along the roads with salt-resistant greenery;

– Use abrasives for gritting sidewalks in urban areas where trees are planted;

– Irrigate, fertilize and break up salty soil;

– Anti-corrosion manufacturing techniques in the automotive industry, use of galvanized sheet metal, more washing of older cars.

When the above measures are observed in practice, it is possible to achieve a compromise in the use of deicing salt that makes sense both economically and ecologically.

All the facts point towards the assumption that safety on icy winter roads can be ensured only when deicing salt continues to be used. Yet we should give due regard to the following principle to provide adequate protection for an endangered environment: "Maximum safety with a minimum of salt" (Giesa).

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