

Traffic Accidents on Slippery Roads

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1. ABSTRACT

Police registrations from 65 accidents on slippery roads in normally Danish winters have been studied. The study showed:

- 1 accident per 100 km when using brine spread with nozzles
- 2 accidents per 100 km when using pre wetted salt
- 3 accidents per 100 km when using kombi spreaders

The results of accidents in normally Danish winter seasons are remarkable alike the amount of salt used in praxis in the winter 2011/2012.

- 2.7 ton NaCl/km when using brine spread with nozzles
- 5 ton NaCl/km when using pre wetted salt.
- 5.7 ton NaCl/km when using kombi spreaders

The explanation is that spreading of brine with nozzles is precision spreading, while spreading of salt with rotation plate are very imprecise; you can measure 80% residual salt when using brine and only 40% when using pre wetted salt. Of course the result would be worse if dry (solid) salt were used on dry roads.

A winter route in Denmark is normally 50 km, but when using driver navigation and GPS controlled spreading of brine with nozzles 110 km is possible and cheaper.

KEYWORDS: TRAFFIC ACCIDENT / BRINE /ICE CONTROL / SPREADERS / SPREADING / HIGHWAYS / DENMARK

2. INTRODUCTION

2.1. Traffic Accidents

Police registration of traffic accidents in Denmark has taken place in many years. The challenge is to know so much about the accidents that you know how to prevent accidents. Formerly 1 of every 6 accidents on highways was registered by the police; today the rate has fallen to approximately 1 out of 10 accidents.

Sigurdsson reported 2001 that 5–10 % of all accidents on highways in Denmark are with slippery roads [1]. Denmark has only a little amount of snow and have used anti-icing (preventive salting) on highways since 1980, but temperature oscillating near the freezing point causes risk of slippery roads (thin ice). 5–10 % is a little amount, but it represents in Denmark 10 to 20 traffic deaths annually.

In Swedish The Winter Model [2] try to explain something about the accidents with slippery roads. From figure 1 we find:

- if 1 % of the traffic is on thin ice, 25 % of the accidents are on thin ice,
- if 20 % of the traffic is on thin ice, 40 % of the accidents are on thin ice

In other words: "If you cannot totally avoid thin ice, it hardly shows in the accident figures that you try!"

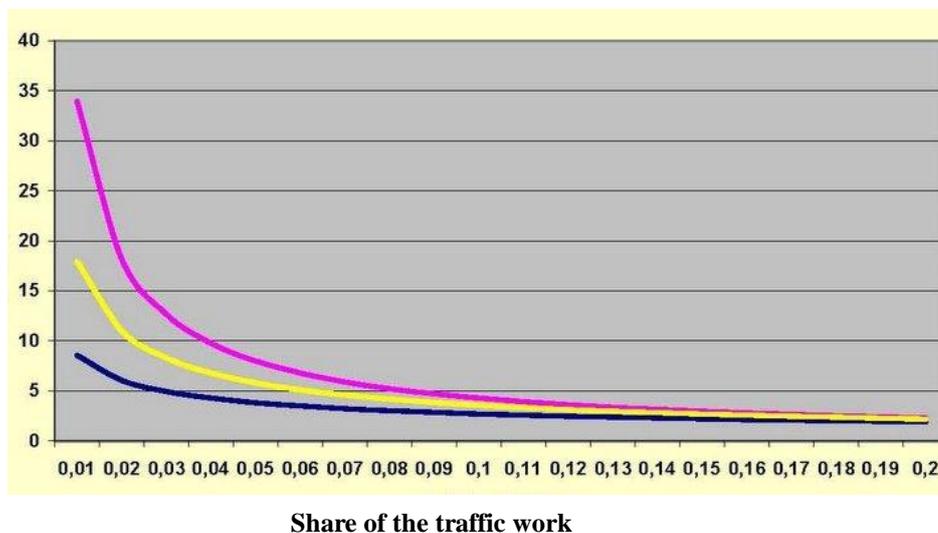


Figure 1. Accident quota relative to dry road in Sweden. Applies to both hard accidents and to all police reported accidents. Blue line: Packed snow. Yellow line: Loose snow. Magenta line: Thin ice. Figure from the Swedish Winter Model (figure 4) [2].

2.2. Anti-icing (preventive salting)

The objective of anti-icing is never having slippery roads, especially with thin ice. It should be easy, because only a little amount of salt (often only 1 gram salt/m²) is needed, Haavasoja 2012 [3] og Alex Klein-Paste [10].

Yet the police register slippery roads, often without snow. Often the road master may say: "It is not correct, we have spread salt on this road only an hour before the accident took place". Or a politician may say: "The police was wrong. I drove in the opposite direction on that road, a few minutes after the accident had taken place and I tried to brake, and can for sure say, there was not slippery road!"... All 3 observations may be right at the same time!



Figure 2. Marts 6. 2010, motorway near Herning in Denmark. Heavy snow (5mm) the day before. Cold -10 to -15 C° in the night and day temperature up to +3 C°.

2.3. Imprecise spreading of salt!

Our problem is spreading of salt with rotation plate. Spreading with rotating plate are very imprecise, Bolet and Fønnesbech 2010 [4]. Often spreading is not balanced and we do not know when or why a problem occurs. It means that the driver of the salt spreading machine cannot avoid that salt is placed in only one of the lanes. The problem gets worse because on a black, wet road, you cannot with your eyes see whether the road surface is icy or just wet.

Figure 2 gives an example of the problem on a snowy road. The picture shows a motorway in Denmark. In Denmark we drive in the right-hand side.

If the salting has been uniform and there was an equal amount of salt in both lanes, the lane in the right-hand side would clean up first. But on the picture there is snow in this lane and almost no snow in the left-hand lane where there normally is only a little traffic!

Three measurement examples from three different measurements of spreading salt explain how it can happen; see Figure 3, Figure 4 and Figure 5.

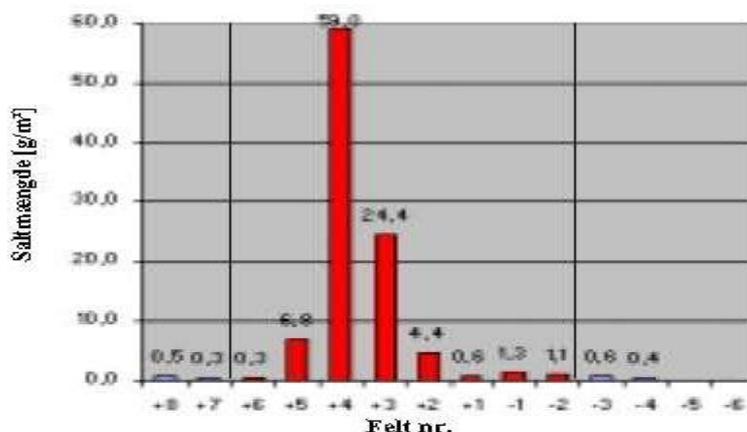


Figure 3. Sobo20 measurements in the year 2000 from Århus airport [5]. In the spreading test the rotating plate spreader try to spread dry salt 8 meter asymmetrical with 30 km/hour. Nearly all salt ends up in left lane. “Felt nr.” corresponds to distance in metres from centreline of the test-lane considered. “Saltmængde” is amount of salt found by measurements.

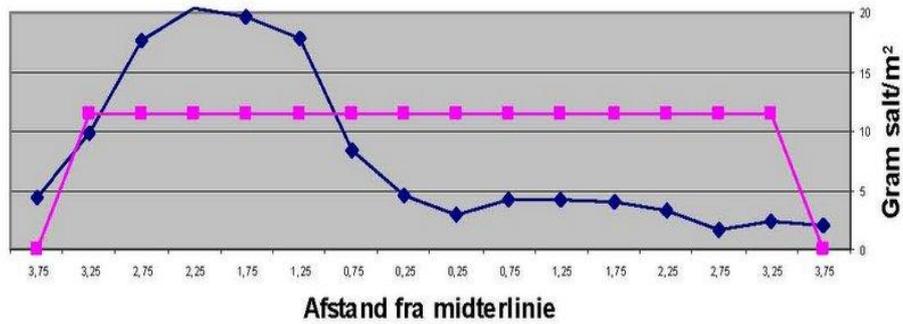


Figure 4. Sobo20 measurements in the year 2004 [6] on a wet highway 3 hours after the rotating plate spreader try to spread pre wetted salt 7 meter asymmetrical with 60 km/hour. Most of the salt is found in left lane. “Afstand fra midterlinie” is distance in meters from middle of the road.

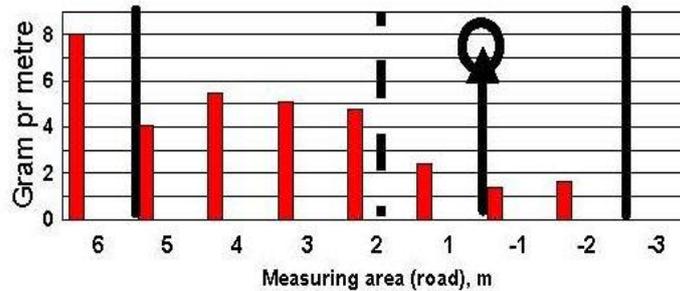


Figure 5. Laboratory measurements in the year 2008 [7] inside a hall after the rotating plate spreader try to spread dry salt 7 meter asymmetrical with 15 km/hour. Only a little amount of salt in the right lane.



Figure 6. Municipalities and The Road Directory on Funen in accidents study.

3. TRAFFIC ACCIDENTS WITH SLIPPERY ROADS

3.1. Study area

The study of traffic accidents at slippery roads involves roads within a distance of 50 km from the municipality Middelfart, Figure 6 in the winters 2007/2012.

The roads in the study are all 2 lane highways (not motorways). Traffic works differs on the roads, but totally not very much.

Accidents considered in the following are: Accidents where the police in the rapport write the road was “slippery, snow” or “Slippery, otherwise”.

3.2. Total accidents with slippery roads

Totally in the study there were 202 accidents with slippery roads and 1140 km roads. It means that for approximately 30 km road there was 1 accident with slippery road every year.

In mild winters 2007 / 2008, 2008 / 2009 and 2011 / 2012, there was totally 65 accidents. It means that for approximately 50 km highway there was 1 accident every mild winter.

In snow winters 2009 / 2010 and 2010 / 2011 there was totally 137 accidents with slippery roads. It means that for approximately 15 km highway there was 1 accident with slippery road every snow winter.

The great difference between snow winter and mild winter, 3 : 1, means that if we want to know something about benefits in using different winter strategies, we have to separate in mild winters and snow winters.

All studied routes use anti icing (preventive salting). The difference is the use of spreading machines.

- Brine with nozzles: Pure 24% NaCl brine spread with nozzles.
- Pre wetted salt spreader: Salt spread with rotating plate, normally as pre wetted (70% dry salt and 30% brine), but on snow often dry salt.
- Kombi salt spreader: Various combination spreaders, which can spread pure brine, pre wetted or dry salt with rotating plate and combination of all. Some spreaders can have nozzles, too.

3.3. Accidents in mild winters

The accidents registred in mild winters are summarized in Table 1. The overall result is:

- Brine with nozzles 1 accident every 100 km in mild winters
- Pre wetted 2 accident every 100 km in mild winters
- Kombi 3 accident every 100 km in mild winters

Table 1. Number of accidents registred and km of roads treated during mild winters by 8 road authorities with A: nozzle-spread brine, B: pre-wetted salt and C: with combi saltspreaders.

Mild winters, Brine with nozzles

Road board	2007/2008		2008/2009		2011/2012	
	Accidents	km road	Accidents	km road	Accidents	km road
1						
2	0	39	0	39	2	105
3						
4						
5	1	161	2	161		
6						
7						
8						
total	5			505		

Approximatly 1 accident every 100 km

Mild winters, pre wetted saltspreader

Road board	2007/2008		2008/2009		2011/2012	
	Accidents	km road	Accidents	km road	Accidents	km road
1	1	26	1	26	0	26
2						
3	2	100	2	100	1	100
4	4	207	9	207	2	207
5						
6	1	219	2	219	7	219
7	2	41	0	41	2	41
8	1	107	3	107	2	107
total	42			2100		

Approximatly 2 accident every 100 km

Mild winters, combi saltspreader

Road board	2007/2008		2008/2009		2011/2012	
	Accidents	km road	Accidents	km road	Accidents	km road
1						
2	1	51	3	51		
3						
4						
5					4	161
6						
7	3	96	4	96	3	96
8						
total	18			551		

Approximatly 3 accident every 100 km

3.4. Accidents in snow winters

The accidents registered in snow winters are summarized in table 2. The overall result is in all cases 1 accident per approximately 15 km.

Table 2. Number of accidents registered and km of roads treated during snow winters by 8 road authorities with A: nozzle-spread brine, B: pre-wetted salt and C: with combi saltspreaders.

Snow winters, Brine with nozzles

Road board	2009/2010		2010/2011	
	Accidents	km road	Accidents	km road
1				
2	2	39	3	39
3				
4				
5				
6				
7				
8				
Total	5	accidents	78	km roads

Approximatly 1 accident every 15 km

Snow winters, pre wetted saltspreader

Road board	2009/2010		2010/2011	
	Accidents	km road	Accidents	km road
1	0	26	2	26
2				
3	7	100	8	100
4	23	207	20	207
5				
6	9	219	9	219
7	2	41	4	41
8	1	107	9	107
Total	94	accidents	1400	km roads

Approximatly 1 accident every 15 km

Snow winters, combi saltspreader

Road board	2009/2010		2010/2011	
	Accidents	km road	Accidents	km road
1				
2	3	51	3	51
3				
4				
5	7	161	13	161
6				
7	5	96	7	96
8				
Total	38	accidents	616	km roads

Approximatly 1 accident every 15 km

3.5. Brine with nozzles contra kombi salt spreader

100 km road: 3 police reported accidents with slippery road every mild winter when using a kombi salt spreader strategy and only 1 when using brine spread with nozzles! Can this be correct? Yes it is!

Look at the two Road boards, number 2 (Middelfart municipality) and number 5 (Nordfyns municipality). They are neighbour municipalities in the Northwest of Funen. Middelfart used mostly kombi salt spreader in 2007/2009, where Nordfyn used brine spread with nozzles. In 2011/2012 it was the other way around: Nordfyn used kombi salt spreader and Middelfart used brine spread with nozzles.

Take another look at the accidents, Table 3.

Table 3. Length of treated roads and accidents in mild winters in the two municipalities Middelfart and Nordfyn.

	Brine with nozzles		Kombi salt spreader	
	km road	Accidents	Km road	Accidents
Middelfart				
2007/2009	78	0	102	4
2011/2012	105	2	0	0
Nordfyn				
2007/2009	322	3	0	0
2011/2012	0	0	161	4
Total	505	5	263	8
Accidents per 100 km		1		3

4. CONSUMPTION, A COMPARISON

4.1. Salt

The use of different spreaders are studied in the winter 2011/2012. The routes which are studied cover a larger area than the routes which is included in the study of traffic accidents, as some municipalities have not data in a form that make comparison possible. Totally 43 winter routes were studied. The winter was nearly without snow.

- 1 route used only brine spread with nozzles, route length 105 km and 67 operations,
- 7 routes used kombi spreaders, average route length 64 km and 65 operations
- 36 routes used pre wetted salt spreaders, average route length 44 km and 70 operations

The main results for the study are in figure 7, figure 8 and figure 9.

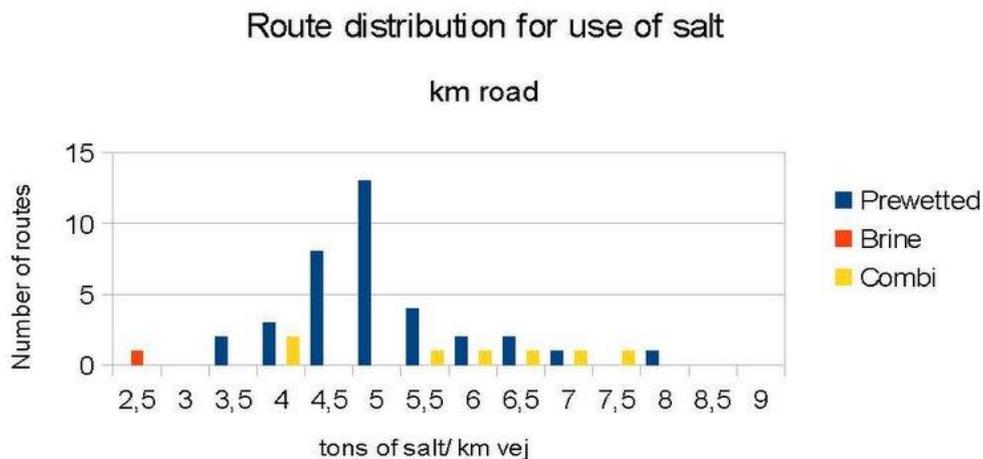


Figure 7. Use of tons of salt/km road. The diagram for pre wetted spreaders have a statistically normal distribution. It means that km roads with this data can be used for comparison. Brine used only half the amount of salt compared to other strategies, but perhaps it's more surprising that pre wetted used less salt then kombi! The results for brine are likely what was observed in the County of Funen in the winters 2005/2006 <http://www.aiban.dk/Lessenvironmentalimpact.html>

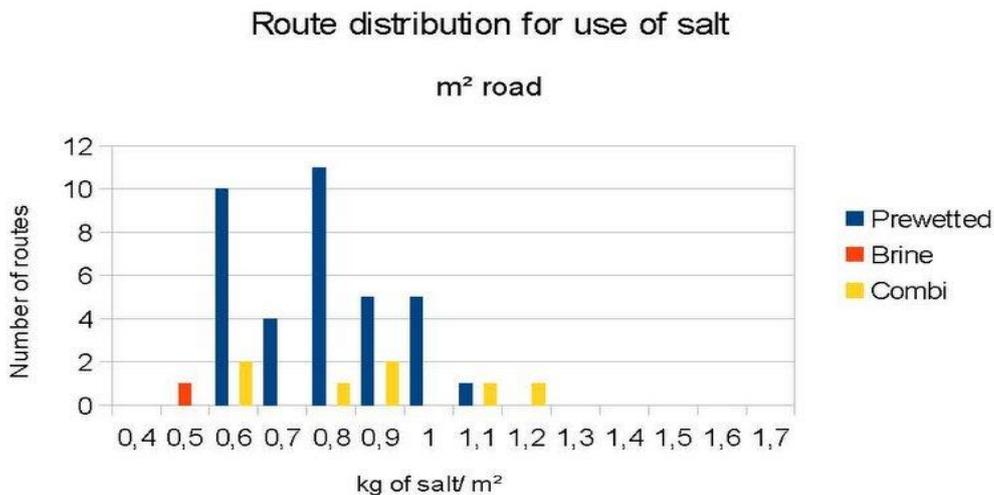


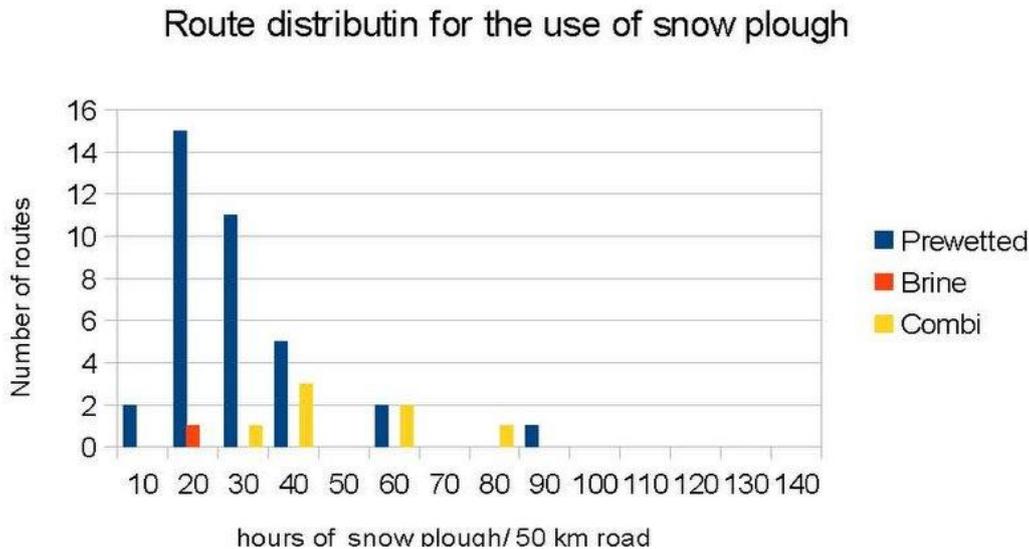
Figure 8. Use of kg of salt/m² road. The diagram for pre wetted have not a statistically normal distribution. It means that m² roads with this data is not good for comparison.

4.2. Snow ploughing

Additionally Figur 9 shows the use of snow ploughs in the winter 2011/2012

The findings that kombi salt spreaders have many accidents and use most salt and most snow plough hours, too, can explain why users of combined salt spreaders often experience getting reports of icy roads or snow, although it was supposed to be tackled.

This result agrees with the information in Bolet and Fønnesbech [4] where exactly kombi salt spreaders turns out to be most inaccurate.



Figur 9. Use of hours of snow plough/50 km road. The diagram for pre wetted have nearly a statistically normal distribution. It means that km roads with this data can be used for comparison. Only a little snow this winter, but again surprising that pre wetted used less snowplough hours compared to kombi.

5. RESIDUAL SALT.

When using Sobo20 we can measure how much salt there is on the road. Compared to the knowledge of how much salt we have tried to spread, we know how many % of the salt we can recover.

Two studies on the road between Middelfart and Nørre Aaby [8] [9] show:

- 80% residual salt when using liquid only (brine spread with nozzles)
- 40% residual salt when using pre wetted salt.

The results were on a wet road 2-4 hours after spreading salt and with ADT = 9.500.

6. ECONOMY

More factors make nozzle-spread brine cheaper than pre wetted and kombi spreaders. The equipment for spreading brine with nozzles is simple. Only pumps, control valves and nozzles is moving and exposed to abrasion. The spreading can be carried out with normal truck velocity and with precisely spreading of the salt to the road.

In praxis the brine route in Middelfart municipality in the last 2 winters covered more than 100 km salting road and the truck drove nearly 180 km in each passage (3½ hour). Normally 2 trucks and 2 spreaders would have been necessary, Jørgen Lie [11].

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