

EXPERIENCE WITH BRINE APPLICATION IN CITIES

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ABSTRACT

Latest researches point out, that even with pre-wetted salt at 30 percent brine quotient, the potential of salt savings with pre-wetted technology is not fully tapped. Thus, new spreaders have been developed, allowing higher brine share and/or application of only brine via spray nozzles.

In the past few winters, the City of Vienna tested several different brine treatment approaches in different types of areas and a wide range of vehicles.

The comparison of salt consumption between vehicles with brine and standard spreaders (pre-wetted, 30% brine share) show a huge potential for salt savings.

Nevertheless, the use of brine only has its limits at low temperatures. The used spreaders however, are able to spread pre-wetted salt and brine separately. Therefore also heavy snowfalls, very low temperatures or sudden temperature drops do not require the change of vehicle or spreader. Well trained and experienced drivers are very important to bring the new spreading methods to a success.

With the increasing use of brine spreaders, the associated brine infrastructure has to be adapted accordingly. Brine application with spreaders also capable of pre-wetted spreading combine the advantages of both technologies and has been a success.

1. BASIC INFORMATION ABOUT WINTER MAINTENANCE IN VIENNA

Within the Vienna City Administration the Municipal Department 48 - Waste Management, Street Cleaning and Vehicle Fleet – is responsible for winter maintenance on public roads except highways and pavements with no adjoining owner or the City of Vienna as adjoining owner. The division street cleaning and winter maintenance is the leading operational division in the Municipal Department 48 (MA 48) supported by other divisions.

The division Street Cleaning and Winter Maintenance is organised in 13 cleaning districts with 12 day cleaning districts and one additional cleaning district for night hours based in the inner city of Vienna. Each cleaning district is led by one cleaning district manager and has at least one maintenance depot. Distributed in the city area there are 13 winter maintenance depots with 43 de-icing silos and 17 brine mixing plants.

The road network in Vienna is around 2,800 km or 6,000 lane km long with a total paved surface area of around 23 million m². The winter maintenance interval and service time depend on priority of the road, topographic conditions and requirements of public transport. Winter maintenance routes for ploughing and salting are planned concerning the mentioned parameters as well as traffic organisation and are adapted continuously.

With the development of new spreading machines which can apply pre-wetted salt as well as brine and various studies about usage of brine in Austria, Germany and Switzerland the MA 48 aims for an increased use of brine. In the winter season 2017/2018 combined spreading machines capable of pre-wetted salting using a spreading dish and brine application using a spreading bar mounted 6 trucks and 16 medium size vehicles (9t) were in use. Additionally 6 brine trailers for small tractors and 55 small tractors with brine tank were used for winter maintenance on bicycle lanes. Figure 1 gives an overview of the distribution of these vehicles in Vienna. In total up to 350 winter maintenance vehicles are in use during heavy winter weather.

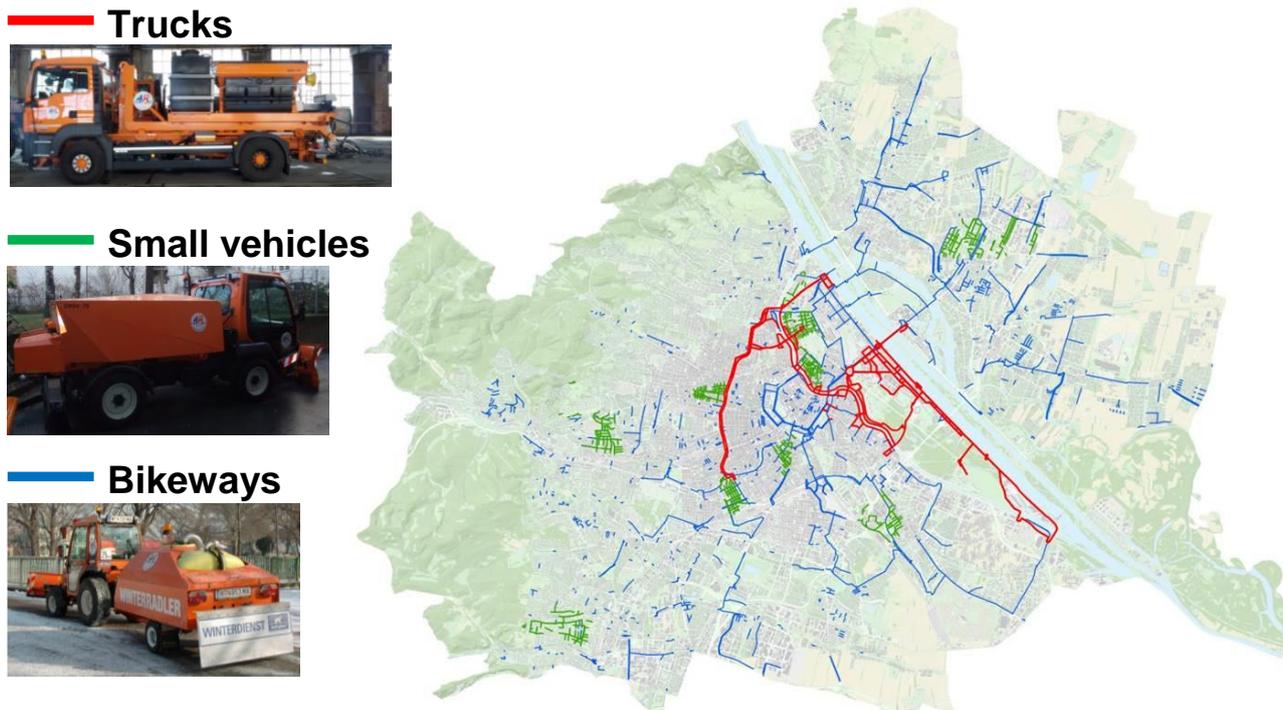


Figure 1: Brine spreaders used in the winter 2016/17 in Vienna

2. BRINE APPLICATION WITH TRUCKS

In winter 2013/2014, two spreading machines with both spreading dish and spreading bar were tested in Vienna. Previous tests with brine spreaders were not successful as it turned out you need to change spreader and/or truck if the weather situation changes. Even with roll-on and roll-off spreaders, the time needed for a change was too long as one need to consider the time for driving from or to the maintenance depot. Thus the use of brine spreaders was limited, and pre-wetted salt spreaders were used instead.



Figure 2: Combined spreader for brine and pre-wetted salt (Type 1)

The first models (Type 1) were mounted on a 2-axle-truck, with lower salt but higher brine capacity compared to pre-wetted spreaders (see table 1). The range of these spreaders is around 50 km using 20 g/m² brine. The handling of the new spreader was similar to usual spreaders with the exception the driver could choose pre-wetted salt dosage and brine dosage separately. A guideline for salt or brine usage and quantity depending on weather and road condition has been developed, based upon various studies [1].

Due to the exceptional mild winter 2013/2014, with only 2cm snow in Vienna, practical experience with lower temperature and higher amounts of snow were missing. Even so, both spreaders broke and could not be used properly. Over the next seasons practical experience was very good but low salt/brine loading capacity and fragile construction are weak points of type 1.

The combination of brine spreading bar and spreading dish however worked and feedback from drivers as well as salt consumption showed the profits of a system like this. With this background new spreaders (Type 2) have been developed and are now in use. The new spreaders have a higher loading capacity (see Table 1) and a new constructed spreading bar. In the winter season 2017/2018 a total of 21 trucks using combined spreaders are in use at the MA 48.

Tabelle 1: Facts of a typical combined spreader used in the City of Vienna

	Type 1	Type 2
Brine capacity	2.800l	5.000l
Salt capacity	2,1 m ³	5 m ³
Range at 3m spreading width	~ 50 km	~90 km
Duration of refilling brine/salt	~ 15 minutes	~ 20-25 minutes

3. BRINE APPLICATION WITH SMALL TRUCKS (8-10 TONS)

3.1. Trucks for smaller roads

The MA 48 uses trucks on the lower priority road network with an overall weight of 8 tons to 9.5 tons. 16 of these small trucks are equipped with combined spreaders with a load capacity of 1,400 litres brine and 0.8m³ salt. Due to very narrow roads the driving speed is slow and the length of a typical winter maintenance route is low compared to regular trucks. Thus, the capacity is sufficient for the smaller vehicles.

The spreading bar is, in driving direction, mounted in front of the spreading dish and hidden behind a rubber belt (see figure 3). The rubber belt combined with the low mounting point of the spreading bar guarantee good conditions for brine spreading in urban areas. Spreading often very close to bicyclists and pedestrians make this construction detail necessary.



Figure 3: combined spreader for brine and pre-wetted salt on a small truck

A short list of facts to the spreaders can be found in table 2. Mild winters in the past few years made it possible to use brine only most of the time. With the given capacity, the range is around 20 km, which is enough for the small trucks.

The time to reload brine is around 12 minutes for a full brine tank, which is acceptable. Reloading time is an issue if a lot of vehicles use the same winter maintenance depot. Problems can be found if the diameter of internal distribution hoses is very small. Even if the main brine reload clutch is big enough the whole system has to be configured for fast reloading.

Table 2: Facts about the combined spreaders for small trucks

Brine capacity	1.400l
Salt capacity	0,8 m ³
Range at 3m spreading width	~ 23 km
Duration of refilling brine/salt	~ 12 minutes

3.2. Functionality of the combined spreader

Brine is applied using a spreading bar consisting of two or three pipes covering the whole vehicle width. Spreading nozzles are mounted on the bars which use different pressure to adjust the set dosage at different vehicle speeds (see figure 4). The distribution of brine is

very continuously without gaps over the whole width and length. Together with brine application using the spreading bar, salt can be applied using the spreading dish. This is used if temperatures are low and brine would not be sufficient. The current low temperature limit is -4°C but a future decrease of this limit seems feasible.



Figure 4: left: spreading dish and spraying bar with nozzles; right: application of brine and salt

Using side nozzles, the driver can expand the spreading width (1.5m on each side) if necessary. The side nozzles can be switched on and off from the control panel separately. The variability of the system has been proofed in practical operations and is popular within the drivers.

Problems have been located at very low speeds or in start/stop traffic where the pressure in the brine system was not high enough for the spreading nozzles. After an update from the producer, the problem has been solved and the brine distribution is continuously also at very low speeds. Part of the update was the additional pipe with nozzles for different pressure zones (see figure 5).

Drivers check the proper performance using visual control at the beginning of their route. If nozzles are blocked it could be seen after a few meters of spreading. Against first misgivings the nozzles did not make trouble. They are cleaned using warm water if the spreader is not in use for a longer period.



Figure 5: Side view of a multiple-row spreading bar

3.3. Evaluation of de-icing agent usage

Depending on weather conditions, combined spreaders apply brine using a spreading bar or additional salt by a spreading dish. For a better interpretation of the presented numbers, it has to be mentioned, that the past few winters in Vienna have been rather dry and warm. When comparing salt usage, salt that was used in the brine mixing plants was also considered. Brine concentration in all brine mixing plants in Vienna is around 20%.

Comparing the salt usage per kilometre of 5 combined spreaders with 5 pre-wetted spreaders gives an overview of possibilities in reducing salt usage in operational use. With trained drives and under good conditions salt savings of around 50% are feasible (see Figure 6). The spreaders in this comparison have been uses on routes next to each other so impact of micro climate could be reduced to a minimum.

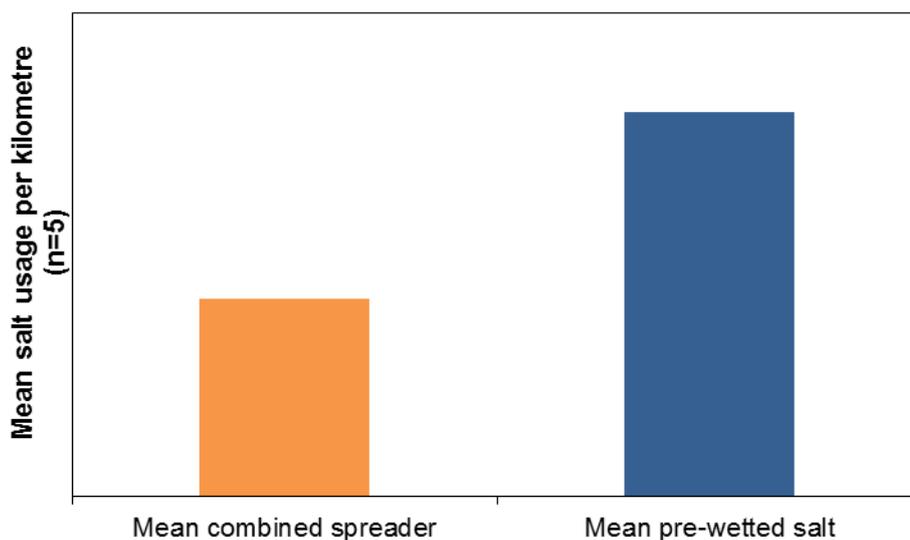


Figure 6: Mean salt usage per km of a combined spreader and a pre-wetted salt spreader

Too keep winter maintenance standards high, constant quality checks have been conducted by drivers and supervisory staff. The quality comparison between combined spreaders and pre-wetted spreaders showed that the brine spreaders are equal or slightly better. Figure 7 shows the results of the analysis with only one rating combined spreaders worse, while the majority (15 ratings) says the quality is equal and 11 ratings approve the usage of brine a significant better quality.

Once again, it should be mentioned, quality and salt usage have been analysed during a very dry winter which puts brine usage in favour. Later, comparisons for single heavy snowfall events show that the difference in salt usage is smaller for these events. Over a whole winter season with many preventive treatments and a lot of hoarfrost scenarios there are still huge salt savings possible with combined spreaders.

Drivers mentioned the good and fast thawing reaction of combined spreaders but liked the gapless distribution of a spreading bar even more. Especially on roads with very little traffic and on bicycle lanes or pedestrian areas where cars do not help with the salt distribution brine applied trough a spreading bar has an advantage.

Combined spreader vs. pre-wetted salt

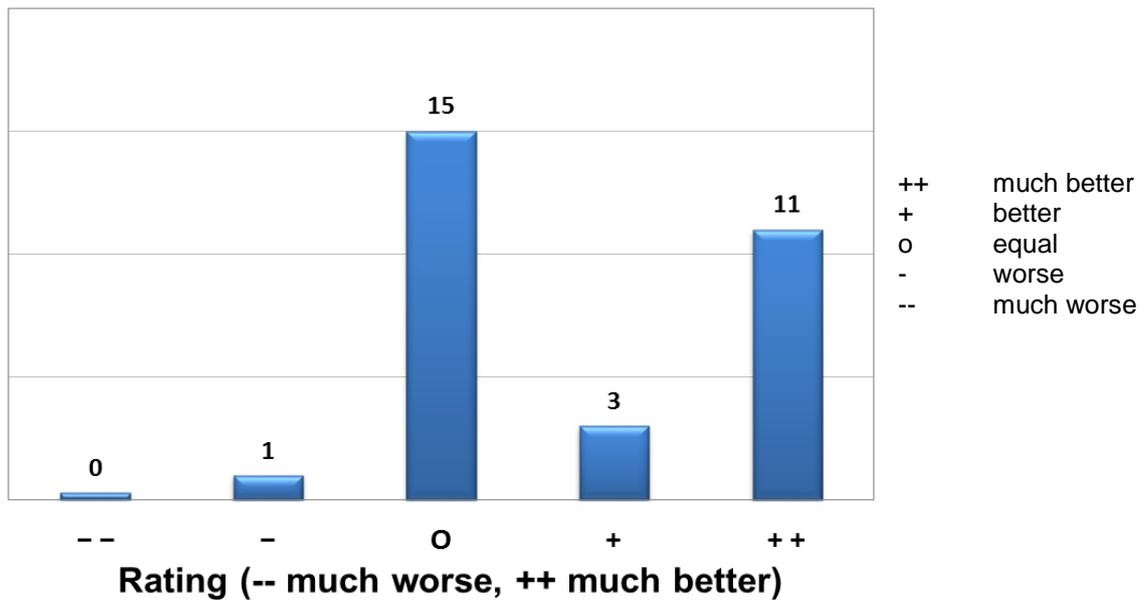


Figure 7: Rating of spreading quality and effect of combined spreaders compared to pre-wetted spreading (from -- combined spreader much worse than pre-wetted, to ++ combined spreader much better)

A deeper analysis of the salt usage data reveals another very important detail of the introduction of a new technology. Figure 8 shows the salt usage per kilometre of combined spreaders compared to pre-wetted spreaders with remarkable differences specific salt usage reaching from 1:1 to 1:7. Since technology, road priority and climate were comparable the driver has to play an important role. Thus, quality and content of training courses and instruction manuals need to be very good in order to benefit from the new technology.

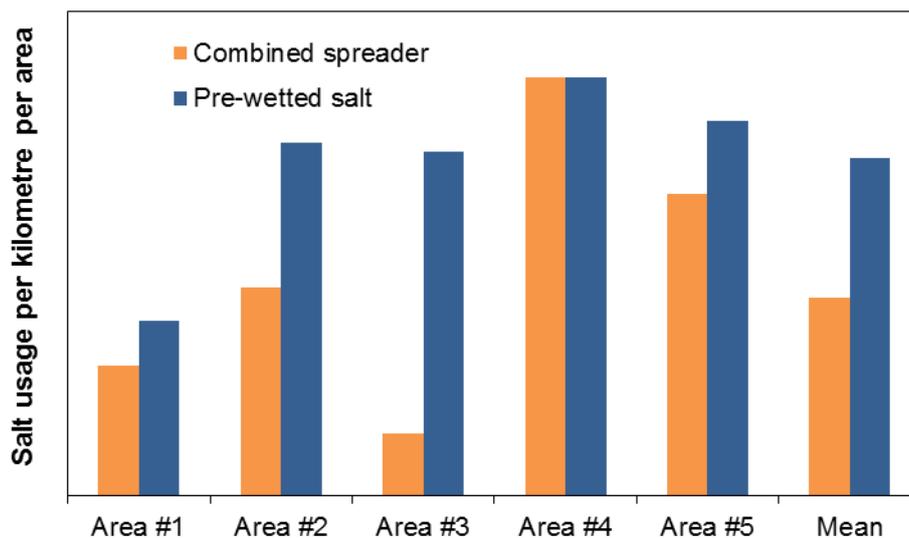


Figure 8: Salt used per kilometre for combined spreaders and pre-wetted spreaders in 5 comparable areas

Good experience could be made with a step-by step-introduction, beginning with a few interested drivers. They made good use of the new technology and word of the new spreaders gets around, which makes it easy to find other drivers who want to use this technique as well.

4. BRINE APPLICATION ON BICYCLE LANES

4.1. Winter maintenance on bicycle lanes in Vienna

The City of Vienna aims for an increase of the number of bicyclists not only in summer, but also during winter. Thus, a new concept of winter maintenance on bikeways and bicycle lanes has been developed since 2011. A new category of winter maintenance routes has been created that service a winter main bikeway network of around 280 km. This network is of high importance for commuter traffic and has a higher priority compared to other bicycle lanes. The remaining bicycle lanes and bicycle lanes with a length of over 900 km are serviced together with the road network.

On bikeways, brine (sodium chloride, 20% concentration) is used as de-icing agent, no grit or sand is used. The advantages of brine are higher traffic safety for bicyclists compared to grit and the better dosage and distribution. Also, brine sticks better to the surface and is not carried out to the edges of bikeways. Together with new small tractors 13 semi mobile brine mixing plants ensure that the necessary resources are available.



Figure 9: Brine trailer on a bikeway next to Riesenrad

4.2. Semi mobile brine mixing plants

One of the drawbacks when using only brine is the lower range due to the limited weight capacity. Also the top speed of small tractors is rather slow, which means it takes a huge amount of time to get to the next winter maintenance depot and refill the brine tanks. Therefore the distance between servicing area and brine station has to be kept as small as possible. The solution to this problem was the installation of semi mobile brine mixing plants in existing accommodations with break room, kitchen and changing room for employees if the servicing area of a tractor is too far away from the next regular depot. Each brine mixing plant can produce 1,200l of brine at once which is only used by the tractors servicing bikeways or bicycle lanes.



Figure 10: Semi-mobile brine mixing plant

4.3. Results of the approach

Over all, the results of brine application using a spreading bar are very satisfying as the distribution is very continuous even without the help of cars. With very low temperatures the thawing capacity of brine decreases. To compensate the physical limitations of salt, a very high quality of ploughing is necessary.

The best way to take an objective look at the results are questioners where public opinion to is asked. Asked if the quality of winter maintenance on bikeways and bicycle lanes has been improved to the last winter 60% answered “yes” and only 5% said “no” (see Figure 11). The public response to a system with a main network and the use of brine is positive and future bikeways in new build areas in Vienna will be integrated into this system.

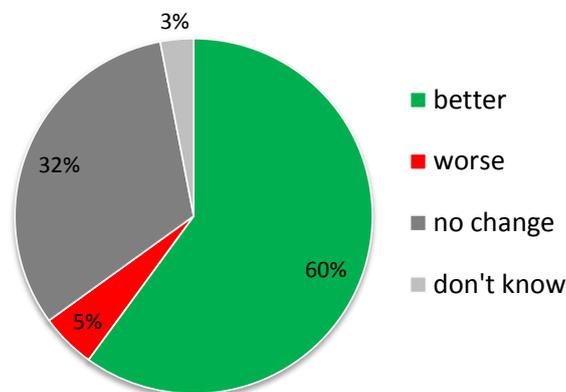


Figure 11: Survey results for the question: „Do you think the winter maintenance of bikeways and bicycle lanes has been improved in the past years?”

5. CONCLUSIONS

The use of brine instead of, or in combination with, pre-wetted salt has been a success in the past few winter seasons. One advantage of a spreading bar is the continuous brine distribution, especially on surfaces with no car traffic. For cities with a lot of urban areas like bikeways and pedestrian areas, the system is more suitable than pre-wetted salting.

Combined spreaders make salt savings of up to 50% feasible under beneficial weather conditions. Winter seasons with a lot of hoarfrost, temperatures around 0°C and little amounts of snow allow higher savings than colder winters with more snowfall. In Vienna, many winter maintenance operations happen at temperatures around 0°C where brine has the biggest potential.

The effectiveness of brine has been compared to pre-wetted salt with a benefit for brine.

Analysis of salt usage shows that the training of drivers is very important to profit from possible salt savings. Additionally, drivers and employees have to be trained, so they can explain the new technology when citizens ask why liquid is sprayed out at temperature below freezing point.

With the increase of brine usage not only the vehicles, but also the infrastructure at the winter maintenance depots needs to be checked, if the necessary brine capacities are available.

REFERENCES

1. Hoffmann, M.; Nutz, P.; Blab, R. (2012); Optimization of pre-wetted salting (Original: "Optimierung der Feuchtsalzstreuung"); Research report published by the Federal Ministry for Transport, Innovation and Technology; Vienna;