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CO_2 Footprint: Comparison Between Rock Salt, Sea Salt and Vacuum Salt

Track: Salt, Safety and Environment

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Sustainability, green economy and life cycle assessment are topics that are increasingly discussed and are getting more in the focus of public interest. A systematic analysis of life cycle assessment (LCA) of different salt types (rock salt, vacuum salt and sea salt) was compared within the European Union. The LCA analysis starts with the raw material extraction and ends with transportation of the salt to customers. The packaging aspect was excluded for the purposes of this analysis.

The LCA assessment indicates that, compared to the other salt types, sea salt has the smallest environmental impact (concerning energy consumption and CO_2-emission) at a production level. However, the advantage for sea salt is almost completely lost, when transportation is included with the analysis. The primary driver behind this result is the location of the resources in question, where sea salt may only be produced in warm coastal areas, and unfortunately many of these products need to be transported long distances to get them to customers. Concerning transportation, rock salt and vacuum salt can have significantly lower impacts on the environment than sea salt.

Holistically, looking at the complete supply chain, the environmental impact of a salt product is an issue that needs to be evaluated on a case-by-case basis, yet both sea salt and rock salt can be considered as equivalent when the complete life cycle is taken into account. With respect to vacuum salt, the energy consumption of vacuum salt is already so high, that the positive effect of distribution does not significantly affect the results.

1. Introduction

Salt is a commodity and is used in over 14,000 applications. In some cases, only a very special type of salt can be used, for example, pharmaceutical applications demand high purity and special packaging requirements.

But in the vast majority of applications (for example, in the food or feed industry), there is no need for a special product and the user can decide whether to use a rock salt, sea salt or vacuum salt. That´s why more and more users take both the product quality and economic factors, in addition the sustainability aspect into account. As is generally known, the European Commission has set a target of reducing CO_2-emisions by 80% by 2050, as compared to 1990 emission levels. Therefore, European industry has to change not only the production but also the purchasing process towards a more sustainable thinking.

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First indications of a re-thinking are seen in the winter maintenance business. In cold winter climates, a good winter maintenance practice ensures the security of walkways, streets and motorways, and assures that national economies run continuously. Given the high economic and social importance, winter maintenance is provided mainly by public authorities. With the stated CO_2-reduction targets in some European countries, public authorities are obliged to consider sustainability in addition to pricing within their tenders.

2. Discussion

For a holistic point of view, it is necessary to take not only the production itself, but also the transportation into consideration (cradle-to-gate). This study will compare the CO_2-emissions for the production of 1/t of rock salt, vacuum salt and sea salt. The transportation of the finished products to fictional customers will be done by trucks, ships and trains. The packaging aspect was excluded for the purposes of this analysis.

2.1 Salt Production

The following figure shows the simplified production schemes of the various types:

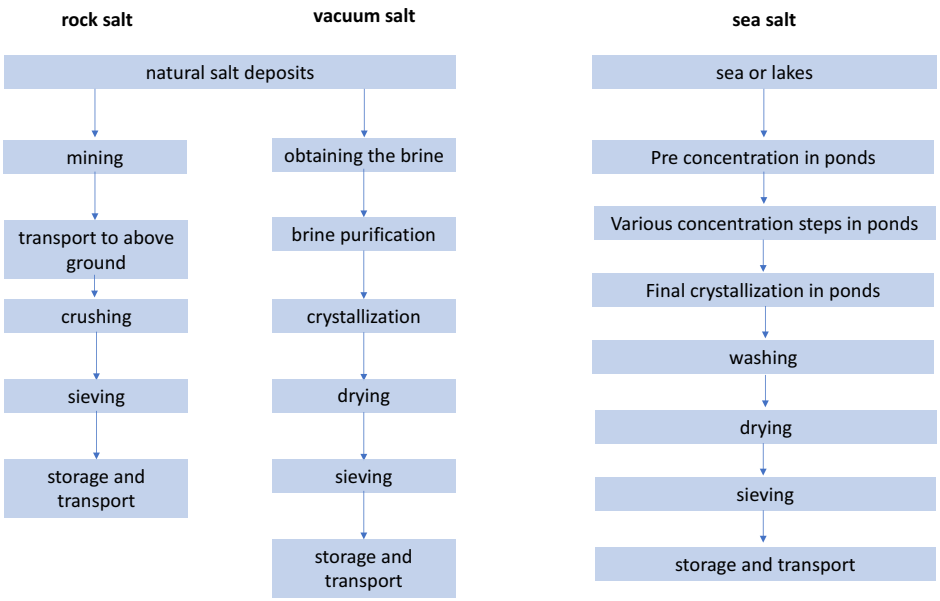

Figure 1: Production schemes of rock salt, sea salt and vacuum salt

2.1.2 Rock Salt

Rock salt production starts with mining activities in underground or open pit mines. The extracted crude salt is transported to production plants for further processing, to be crushed and sieved into the different particle size distributions. After conditioning with anti-caking agent, the final product is stored as bulk material or packed products until the transport to the customer.

2.1.3 Vacuum Salt

The first step in the vacuum salt production is obtaining the brine by dissolving crude salt in water or through solution mining. During the solution mining process, water is pumped into natural salt deposits. Afterwards the brine is pumped above ground. As vacuum salt is a product with a very high purity, the crude brine needs to be purified by precipitation of all by minerals like Ca and Mg. The purified brine passes the crystallization process to obtain the crystallized salt. For a better usage, the salt is mechanically and thermally dried and sieved. The final steps correspond to the rock salt process.

2.1.4 Sea salt

Sea salt plants are typically located near seas or salt lakes in warm weather areas. It starts with pumping the saline water to a pre-concentration pond. Afterwards, the brine runs through various concentration steps until it reaches the final crystallization pond. The evaporation of the water is done by solar energy. The crystallized salt is harvested and washed to remove potential impurities. After a mechanical and thermal drying process, the product is conditioned and stored for further usage.

3. Data

The data for the rock salt production is an average of the 2014 production at plants Werk Bernburg, Werk Grasleben and Werk Borth of esco – european salt company GmbH & Co.KG. For vacuum salt, the average of the plants Werk Bernburg and Werk Borth is used. The sea salt values are from a plant in Brazil with an annual production capacity of 0,5 Mio t, which is similar in size to production plants around the Mediterranean Sea. For calculation of the CO_2-emission sourcing from electricity the German energy mix (2014: 26,2 % renewable, 25,4 % lignite, 17,8 % coal, 15,8 % nuclear Power, 9,5 % natural gas, 5,8 % mineral oil and others) [1] was used.

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Table 1 Comparison of the different salt parameters:

	Primary energy consumption [MJ/t salt]	CO_2-Emission [kg/t salt]
Rock Salt	93	12
Sea Salt	35	3
Vacuum Salt	803	93

Table 1: CO_2- and energy parameters for salt

In Table 2 the values for the different transportation types are listed, which were published from the German Umweltbundesamt [2]:

	energy consumption [MJ/ton kilometers]	CO_2-Emission [kg/ton kilometers]
Trucks	1,4	0,09
Freight train	0,3	0,03
Oversea vessels	0,1	0,01
Inland vessels	0,4	0,03

Table 2: CO_2- and energy parameters for different transports

Following scenarios were considered for a transport to Copenhagen or Berlin:

	Route	Transport vehicle	Distance [km]
Scenario 1 (sea salt)	Aigues-Mortes – Copenhagen	Oversea vessel	4700
Scenario 2 (rock salt)	Bernburg – Wissmar Wissmar Copenhagen	Freight train Inland vessel	300 240
Scenario 3 (vacuum salt)	Bernburg – Wissmar Wissmar Copenhagen	Freight train Inland vessel	300 240
Scenario 4 (sea salt)	Aigues-Mortes – Hamburg Hamburg – Berlin	Oversea vessel Freight train	4400 290
Scenario 5 (rock salt)	Rheinberg – Berlin	Trucks	560

Table 3: Calculated distances from production plant to customer

4. Results

Regarding the production process, sea salt products have the least impact on the environment, as production uses mainly renewable energy. Most of the greenhouse gas emissions are from the Harvesters during the short harvest period. Rock salt is the second best alternative. The intensive mining activities of using explosives and afterwards transporting the crude rock salt with excavators and trucks to the secondary production process, leads to an approximately 4 times higher CO_2-emission compared to sea salt. Vacuum salt has the highest impact, as a large amount of water needs to be evaporated, for which mainly electrical energy is used.

But the picture changes if transportation is included in the discussion. As previously mentioned, sea salts are produced in coastal areas. To get the product to customers, it needs to be transported long distances. Regarding the scenarios mentioned above the CO_2-emissions for the transports are the following:

	Route	Transport vehicle	CO_2-emission [kg/ton kilometers]	total CO_2-emission [kg/ton kilometers]
Scenario 1 (sea salt)	Aigues-Mortes – Copenhagen	Oversea vessel	47	47
Scenario 2 (rock salt)	Bernburg – Wissmar Wissmar Copenhagen	Freight train Inland vessel	9 7,2	16,2
Scenario 3 (vacuum salt)	Bernburg – Wissmar Wissmar Copenhagen	Freight train Inland vessel	9 7,2	16,2
Scenario 4 (sea salt)	Aigues-Mortes – Hamburg Hamburg - Berlin	Oversea vessel Freight train	44 8,7	52,7
Scenario 5 (rock salt)	Rheinberg – Berlin	Trucks	560	50,4

Table 4: CO_2-emissions for each transport vehicle

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That results in a total cradle-to-gate CO_2-emission of:

	CO_2-emission production [kg/ton]	CO_2-emission transport [kg/ton kilometers]	combined CO_2-emission [kg/t salt]
Scenario 1 (sea salt)	3	47	50
Scenario 2 (rock salt)	12	16,2	28,2
Scenario 3 (vacuum salt)	93	16,2	109,2
Scenario 4 (sea salt)	3	52,7	55,7
Scenario 5 (rock salt)	12	50,4	62,4

Table 5: Product specific CO2-emission including transport

The farther away a customer is from a sea salt plant, the more environmentally unfriendly sea salt becomes. From a holistic point of view, rock salt and sea salt can be seen as equivalent, but it is an issue that needs to be evaluated on a case-by-case basis and can´t be generalized.

However vacuum salt already has such a high greenhouse gas emission during the production process, that even a plant in a very short distance and thus a positive effect from a logistic point of view does not affect the results significantly.

5. Summary

As sustainability becomes more and more a topic for the European industry, it is always necessary to include all parameters, besides just the economic facts. If product quality is not the main issue, customers can also consider, for example energy consumption or greenhouse gas emissions in their evaluation, but it must be done holistically, as this study has shown that transportation can have a higher impact on CO_2-emission than the production of the product would. In conclusion, sea salt and rock salt can be considered as equivalent, but this must be evaluated on a case-by-case basis.

6. References

[1] BDEW Bundesverband der Energie- und Wasserwirtschaft e.V.: https://www.bdew.de/internet.nsf/id/energiemix-de

[2] Umweltbundesamt: https://www.umweltbundesamt.de/daten/verkehr/endenergieverbrauch-energieeffizienz-des-verkehrs#textpart-3