SUSTAINABILITY ASSESSMENT OF TRADITIONAL SOLAR SALT

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ABSTRACT

Concern regarding the sustainability of human activities is increasing and becoming a key factor in the development and growth of economies. The business environment will also have to incorporate sustainability ideas at its three levels: economic, environmental and social. Firms who are first to understand and adopt them in their value chain will have a strong competitive advantage. For this matter it is essential that each company is able to analyse and adapt their production processes.

In this paper we aim to assess the sustainability of the production process of traditional solar salt in an integrated perspective. In order to do this, a research consortium was established between Necton, S.A. (a traditional solar salt producer), and Instituto Superior Técnico. The full production cycle was analysed using mainly two methods: life cycle assessment (LCA) and the ecological footprint (EF). Using LCA we estimate the environmental impacts attributable to the whole life cycle of a product, like its impact on climate change. The LCA was performed using software SimaPro by Pré Consultants (Goedkoop, 1998; Goedkoop and Spriensma, 2000). With the EF we estimate the productive land a population, a district or even a product, requires to produce the resources it consumes and to absorb part of the waste generated (Wackernagel & Rees, 1996). This is a suitable tool for comparative purposes.

Our results show that solar salt production is, *per se*, a sustainable activity, especially due to its low fossil energy requirements. Given the alternative process, which requires non-solar water evaporation, that is a huge advantage. Traditional salt production also yields a by-product which is salt flower, a gourmet product with high eco-efficiency.

The ultimate aim of this analysis is to support the development of an environmental norm for traditional salt production. This norm provides standards for the calculation of environmental impacts for any company. We believe that the creation of common sustainable standards in this industry will enhance its competitiveness towards other production processes, since it empowers companies with a tool to compare and maximize their own environmental performance. Ultimately, that will contribute to the preservation and protection of the activity, as well as of the ecosystems that it sustains.

KEYWORDS: sustainability, salt, life-cycle assessment, ecological footprint.

1. INTRODUCTION

The pathway towards the European Union's (EU) strategic goal, of becoming "the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion" [1], is being drawn. Both the EU Sustainable Development Strategy (EU SDS) [2] and the Renewed EU SDS (REU SDS) [3] set the guidelines to achieve this goal. One of the REU SDS key objectives is environmental protection. In this document the need of a sustainable consumption and production is highlighted, since all human activities should respect the planet's natural limits. As a result, in July 2008, EU published an Action Plan to promote sustainable consumption and production policies [4]. The core of the Action Plan is a framework that aims at improving the overall environmental performance of products throughout their life-cycle, promoting and stimulating the demand of better products and production technologies and helping consumers to make better choices through a more coherent and simplified labelling [4].

The fulfilment of this Action Plan requires detailed knowledge about products' life cycle, not only to achieve better natural resources and energy use performances but also to transmit it to the consumer. One of the most used methods to study both direct and indirect environmental effects of products and services throughout their life cycle is Life Cycle Assessment (LCA). This method was strongly stimulated by the Communication on Integrated Product Policy [5] of the European Commission. LCA is also referred to as "cradle-to-grave analysis", since it describes and quantifies the impacts of the whole production chain of a product, from the production of its inputs to its final destiny [6]. LCA analysis categorizes impacts in environmental themes, according to their emissions. Since most times there are trade-offs between themes, some method of aggregation is usually needed to weigh different environmental scores. Two commonly used methods are Ecoindicator 95 [7] and Ecoindicator 99 [8]. Project EIPRO – Environmental Impact of Products [9] used LCA to determine the product groups with greatest impacts and concluded that those groups are food and drink, housing and private transport.

The Ecological Footprint (EF) is a very powerful tool to communicate human's demand on Nature. This concept was developed by Wackernagel and Rees in 1996 [10]. The main concern behind it is that we must not forget that the "humansphere" is enclosed within the ecosphere. In order to live sustainably we must guarantee that the rate at which we use nature's services is lower than the rate at which nature can renew itself. The EF attempts to compare these two rates by measuring how much of the services provided by nature an individual, population or activity requires to produce the renewable resources (crops, forest products and animal products) it consumes and to absorb the waste it generates [10] [11]. EF calculation is been mainly used to assess the human pressure within a geographic region, and few work has been done on products [12] [13] [14] [15].

In the vast array of existing products, food is one of the most essential ones. Humanity's food system is a very dominant force affecting Earth's ecosystems. The EIPRO project showed that of all human activities the food sector is the one with greatest environmental impacts [9], using about 40% of Earth's biologically productive area [16]. Future's sustainability is directly dependent on the sustainability of the food system.

Salt was not considered in the EIPRO study. Interestingly, environmental impacts of the salt production process were never studied, although its processes of productions are very well described [17]. Salt's largest resource in the world is the ocean, with approximately 41 quadrillion tons of salt [17]. It is essential in the maintenance of the osmotic equilibrium necessary to all life forms and its use as a food preservative dates back to ancient times. Nowadays its importance is not restricted to the food sector. Salt's main consumer is the chemical industry, where it plays a major role as feedstock for an infinity of productive processes.

In this paper we aim to assess the sustainability of the production process of traditional food graded solar salt (from now on referred as TSS) in an integrated perspective. The full production cycle was analysed using two methods: life cycle assessment (LCA) and ecological footprint (EF); that will be describe in the following sections. Ultimately, this study will set the ground for an Environmental Standard for traditional salt production.

2. METHOD

The goal of this paper is to determine the environmental impacts of traditional salt production. In order to do so, the first step is to define the salt production methods we wish to study, and then the impact assessment methods we will apply.

2.1. Characterization of the production of Traditional Solar Salt (TSS)

Necton S.A, the partner in this study, is a salt production company from Olhão, a city in the Algarve region of Portugal. Necton produces salt using the traditional method that consists on the use of solar energy for water evaporation. This is a relatively slow process in which a co-product is also produced, named "flor de sal" (FS) (salt flower). While TSS is formed by precipitation at the bottom of saltworks, FS consists on salt crystals formed on top of saltwork waters. FS is a gourmet product with a high market value.

Our characterization of the TSS and FS production processes was obtained from Necton. TSS and FS production processes can be schematized as follows (Figure 1). The process is common up to the harvesting stage. Therefore, for common operations, two impact allocation methods were used: mass allocation and economic value allocation. The mass allocation method considers that impacts of common stages are proportional to the quantity of each product. The economic value allocation method considers that impacts are proportional to the total revenue obtained by the production of each product.

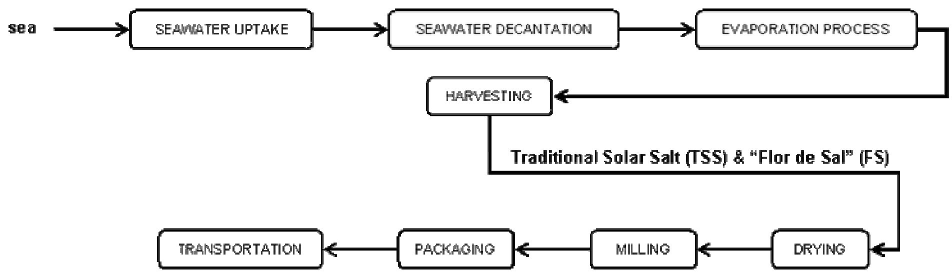

Figure 1. Flux scheme for TSS and FS production. After harvesting, TSS and FS follow separated pathways

Using this method, and according to Necton's data, each productive hectare will produce around 50 t of TSS and 4 t of FS. Depending on weather conditions, TSS production may change between years by 30 to 40%, and FS production may change by around 50%. This is the productivity implied in our calculations.

Since this system relies on solar energy it is typical of warm and dry countries. We wished to compare this production method with a traditional production method from a cold country. Therefore, we considered natural gas (NG) as the evaporating fuel, to produce the so called "flake salt". Since we did not have a case study for NG salt we used a simplified method to obtain the main differences from TSS. We considered the energy required to evaporate saline water and the natural gas's heating power. We assumed a 70% energy efficiency for the evaporator and obtained a consumption of 0.22 m^3 of natural gas for each kilogram of NG salt produced. We assumed that the NG production process was equal to TSS production, plus the NG consumption, and minus the internal transportation at the saltworks. This is because the extensive nature of TSS and FS production implies transportation between sites, and NG salt is produced indoors. Note that, since we do not have data on the productivity of the NG salt process, we assumed it to be the same as for TSS.

2.2. Information sources and data used

The information and data on the production process of TSS and FS was gathered through direct inquiries to the responsible personnel at Necton. All inputs were considered, as well as machinery, instruments and hours of labour.

SimaPro is the software we chose to determine environmental impacts, as we will show in the next sub-section. Therefore, information needed for the LCA calculations is contained in SimaPro's databases.

For the EF we used the LCA results as a data source. We also used the conversion factors for global hectares according to Calculation Methodology for the National Footprint Accounts 2008 Edition [18].

As for transportation requirements, we chose Necton's location (Olhão) as the basepoint and countries representative of the most important salt markets as the final destinations. Those countries were Belgium, as a central European county, the USA, as a transatlantic salt importer, and Russia, as a rapidly growing player in the salt market. Since we needed to choose one particular point to determine the destiny we selected the capital of each country. Distances and final destinations considered are shown in Table 1.

For the comparison between TSS and NG salt we also needed a scenario for transportation distances. We assumed that the NG process occurs in England, since it is a typical system for colder countries. We also consider the same locations for transportation, as shown in Table 1.

Table 1. Distances considered for TSS, FS and NG transportation to major salt markets; TSS – traditional solar salt; FS – "flor de sal"; NG – natural gas

Country	Capital	Inland distance (km)		Sea distance (km)	
		TSS/FS	NG	TSS/FS	NG
Belgium	Brussels	2 214	409	0	0
USA	Washington	663	578	5 460	5 699
Russia	Moscow	995	924	3 899	2 359

2.3. Environmental impact assessment methods

2.3.1 Life Cycle Assessment (LCA)

According to ISO 14040, every LCA study must contemplate four stages, namely goal and scope definition, inventory analysis, impact assessment and interpretation.

Goal and scope definition is the stage where the question to answer during the study is formulated. In this case, we wish to determine the direct and indirect environmental impacts of TSS and FS production. Our functional unit is a five kilograms package of traditionally produced salt. We also aim to compare TSS and FS, which are produced with solar evaporation, with an alternative consisting on the evaporation using natural gas. The functional unit is five kilograms of salt at a local store, which means that we internalize the environmental damages from packaging and transportation.

Regarding the impact assessment stage, the LCA and the EF were the two selected methods to reflect the environmental damage caused in each scenario. For the LCA study we used software SimaPro 7.0, developed by the National Reuse of Waste Research Programme and Pré Consultants of the Netherlands. SimaPro is widely used in assessing environmental performance. It consists of an inventory of inputs and outputs from several processes and production of materials. It also calculates emission inventories, aggregates them into environmental themes, and then aggregates those themes in a single score for environmental impact.

We calculate two types of environmental indicators: single theme, and aggregated. Single theme indicators are obtained from the inventory step in SimaPro. Aggregated indicators are the EF and two other methods also present in SimaPro, namely Ecoindicator 95 and Ecoindicator 99. These two methods use weight factors for each environmental theme, or damage type, and convert different types of impacts into a single impact score. In that aspect they are similar to the EF.

Interpretation naturally takes place at the end of the process and consists of an explanation of the results obtained. We study mainly six aspects:

1. Is it TSS or FS that is responsible for a higher environmental impact?
2. Does the choice of the allocation method change the results?
3. Which are the processes that contribute the most for the total impact of TSS and FS?
4. Which are the most important environmental impacts (themes) in salt production?
5. What is the transportation weight regarding environmental impacts in the final salt product?
6. If salt is produced using natural gas do impacts decrease or increase?

Regarding the validation stage, we compared analogous results from LCA and EF. We also compared our results with other studies, and tried to frame salt production in the scope of the EIPRO study for other products in the agro-food sector.
Some results from the LCA study were used in the EF calculation, such as the results from the Ecoindicator 95 theme greenhouse gases (GHG) emissions, measured as the emissions of CO_2eq. We also used results at the inventory level for land occupation throughout the life cycle. There are many land occupation categories in SimaPro but we aggregated them into four: (1) arable and cropland, (2) built up land, consisting on construction, dump, industrial and mineral sites, traffic and urban zones; (3) forest and shrub land; and (4) water areas. This coupling of land occupation types intends to obtain equivalent categories to those considered by [10].

2.3.2 Ecological Footprint (EF)
Our use of the EF concept follows [15]. We calculate EF for a given product *i* as a sum of three terms, namely direct land occupation (E_i^d), indirect land occupation (E_i^{in}) and the area of productive land required to offset GHG emissions (C_i), also known as the carbon footprint:

$$EF_i = E_i^d + E_i^{in} + C_i \,.$$

EF is measured in global hectares (gha). Global hectares are hectares with world--average productivity for all productive land and water areas in a given year. The terms in the sum must be converted to the same unit. In order to calculate each of these terms, we obtained conversion factors in the literature. The equivalence factors for direct and indirect land occupation were obtained in the literature [18]. The conversion factor for the carbon footprint is 0.556 t CO_2eq/gha [10].
Both the indirect land occupation and the GHG emissions are obtained from LCA results with SimaPro. Data for direct land occupation is available for TSS and FS, but not for NG. However, we may assume that direct land occupation would not be significant, since the NG process occurs mainly indoors. In the case of TSS and FS, we only consider the area of crystallizers for calculations (as built-up land). Other zones, like the reservoirs and evaporators are ecologically very productive areas. They support the food chain of the marine ecosystem, and therefore their use cannot be considered an impact.

3. RESULTS AND DISCUSSION

3.1. LCA of sea salt production by solar evaporation

3.1.1 Impact allocation between Traditional Solar Salt (TSS) and "Flor de Sal" (FS)
The total environmental impact of TSS is lower than FS's impact, for most of the 20 environmental themes analysed. Table 2 shows results for Ecoindicator 95's environmental themes. This happens because, for approximately the same inputs and operations, much more TSS is produced than FS. Impacts are, therefore, more diluted for the total quantity produced. The allocation of the impacts of the pre-production stage was made using two different methods: mass allocation and economic value allocation.
Results show that, if we consider economic value, FS environmental impact increases, while TSS impact decreases. The reason for this is related with the fact that the quantities of TSS produced are much higher than FS quantities (mass allocation), but its economic value is much lower. The relative importance of the impacts associated with the pre--production stage is, thus, higher for FS.

Table 2. LCA results for the most important themes and Ecoindicators 95 and 99 for Necton's salt production scenario; funcional unit: 5 kg; TSS – traditional solar salt; FS – "flor de sal"

	Impact category	Unit	TSS		FS	
			Mass allocation	Economic value allocation	Mass allocation	Economic value allocation
Eco-indicator 95	greenhouse	kg CO_2	2.23E-01	2.01E-01	2.53E-01	3.22E-01
	ozone layer	kg CFC_{11}	8.18E-08	7.98E-08	3.27E-08	3.90E-08
	acidification	kg SO_2	2.51E-03	2.28E-03	2.54E-03	3.25E-03
	eutrophication	kg PO_4	1.72E-04	1.55E-04	1.95E-04	2.48E-04
	heavy metals	kg Pb	1.87E-06	1.53E-06	1.69E-06	2.75E-06
	carcinogens	kg B(a)P	9.13E-09	6.25E-09	8.01E-09	1.70E-08
	winter smog	kg SPM	1.69E-03	1.53E-03	1.57E-03	2.06E-03
	summer smog	kg C_2H_4	2.87E-04	2.78E-04	2.55E-04	2.84E-04
	pesticides	kg act.subst	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	energy resources	MJ LHV	8.44E+00	8.07E+00	8.55E+00	9.71E+00
	solid waste	kg	9.26E-03	9.26E-03	9.42E-03	9.42E-03
	Total	**Pt**	**5.14E-04**	**5.00E-04**	**5.39E-04**	**5.82E-04**

3.1.2 Environmental analysis of TSS and FS production stages

The stage of both TSS and FS production processes with the highest contribution to the total impact is the packaging stage, with over 76% of total impact in Ecoindicator 95 for TSS and about 68% of the total impact in Ecoindicator 95 for FS.

The environmental themes (impact categories) which contribute more to the total impacts of the mentioned stages are the same for TSS and FS and consist of acidification, heavy metals, winter smog and greenhouse gas (GHG) emissions. Regarding acidification, winter smog and GHG emissions, the impacts are related to substances emitted during electricity production, which is the most relevant input for the packaging stages of TSS and FS production processes, respectively. Packaging materials also contribute with about half of the impact in the packaging stage. The high impact in the heavy metals theme is a striking effect for which we obtained no explanation. If we consider the entire life cycles of TSS and FS, the environmental themes that contribute more to the total impact of both are still the same.

3.1.3 Transportation impacts

To assess the environmental performance of a product it is necessary to consider the whole value chain until it reaches final consumer. In our case study, transportation to final consumer accounts for the most part of the total impact (Table 3), and it is more expressive in FS. Table 3 also shows that, even though Brussels is closer to the production site (Olhão), transportation to Washington and Moscow has lower impacts. This happens because road transportation has much higher impacts than sea transportation. These results are true for both Ecoindicators, and also for all the environmental themes analysed.

3.2. Comparing solar evaporation with natural gas use

We compared the traditional solar salt production process with another process using natural gas (NG). We did not consider FS in this section, since it is not a co-product of the production process with NG, and therefore it is not directly comparable. The analysis we performed also considered transportation impacts.

Results show that the production stage using NG is responsible for higher impacts than TSS in almost all themes. This is a direct consequence of the increased energy resources needed, since solar energy is substituted with NG. When transportation is considered, for all the analyzed themes, results are very sensitive to distances and mode of transportation. For example, even though the NG production has higher impacts than TSS, if TSS has to be transported far enough, as for example to Brussels (Table 4), NG is the best environmental option. However, when transportation distances are similar or in cases where sea transportation dominates (Table 4), TSS is the best environmental option.

Table 3. LCA results per theme for the transportation of TSS and FS to major export countries; functional unit: 5 kg; TSS – traditional solar salt; FS – "flor de sal"

Impact category	Unit	Transportation		
		Brussels	Washington	Moscow
Ecoindicator 95	**Pt**	**0.035**	**0.011**	**0.016**
% total TSS impact	%	98.6	95.8	97.0
% total FS impact	%	98.3	95.2	96.6
Ecoindicator 99	**Pt**	**0.473**	**0.177**	**0.238**
% total TSS impact	%	94.5	86.4	89.5
% total FS impact	%	91.7	80.4	84.7

3.3. EF results

3.3.1 Comparing solar evaporation with natural gas use

There are three terms in the calculation of the EF indicator: direct land occupation, indirect land occupation, and carbon emissions. We started by calculating the direct land occupation, which is equal to the area of crystallizers in TSS and FS production. In an average year, this area is, according to Necton's experience, about 1 m^2 for TSS and 12.5 m^2 for FS. We also assumed that crystallizers are, regarding their biocapacity, similar to build-up land. Therefore, in terms of global area they represent 2.64 m^2 for TSS and 33 m^2 for FS.

We also calculated the indirect land use indicator for TSS and FS. This indicator reveals that land occupation is very different for each of them, even though production impacts are similar (Table 5). The choice of the allocation method will once again influence FS results more than TSS's results.

We then calculated the carbon footprint for TSS, FS and NG. The carbon footprint consists on the equivalent area required for the sequestration of GHG emissions. As we have showed before (Table 4), results depend on the distance of transportation. We used the same countries as before.

Results show that, for large road transportation distances, TSS has almost the same footprint as NG. For example, TSS and NG have similar results for production and transportation to Brussels (Table 6). Therefore, that seems to be the cut-off point. For distances closer to England, NG has the lowest carbon footprint. For distances closer to the TSS production site, or when sea transportation dominates, TSS has the lower carbon footprint. Results also show that the carbon footprint is much higher than the indirect area footprint. For TSS and NG, the carbon footprint is also higher than the direct area footprint. Therefore, the contribution to the final EF indicator will be mostly made by GHG emissions.

Table 4. Comparison of LCA results for TSS and NG salt per theme, with transportation from the production site to Brussels, Washington and Moscow; functional unit: 5 kg; TSS – traditional solar salt; FS – "flor de sal"; NG – natural gas

	Impact category	Unit	Brussels		Washington		Moscow	
			TSS	NG	TSS	NG	TSS	NG
			Mass		Mass		Mass	
Eco-indicator 95	greenhouse	kg CO_2	4.22E+00	4.16E+00	1.69E+00	4.77E+00	2.21E+00	5.22E+00
	ozone layer	kg CFC_{11}	7.99E-07	5.70E-07	3.38E-07	6.70E-07	4.34E-07	7.56E-07
	acidification	kg SO_2	2.95E-02	1.07E-02	1.69E-02	1.95E-02	1.91E-02	1.98E-02
	eutrophication	kg PO_4	4.62E-03	1.30E-03	2.04E-03	2.21E-03	2.55E-03	2.58E-03
	heavy metals	kg Pb	3.20E-04	6.57E-05	9.80E-05	9.12E-05	1.45E-04	1.40E-04
	carcinogens	kg B(a)P	1.71E-07	2.82E-07	1.34E-07	3.76E-07	1.36E-07	3.54E-07
	winter smog	kg SPM	1.17E-02	5.33E-03	8.53E-03	1.02E-02	8.92E-03	9.40E-03
	summer smog	kg C_2H_4	5.51E-03	1.94E-03	1.97E-03	2.48E-03	2.72E-03	3.22E-03
	pesticides	kg act.subst	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	energy resources	MJ LHV	7.60E+01	7.89E+01	3.30E+01	8.90E+01	4.19E+01	9.67E+01
	solid waste	kg	9.26E-03	9.25E-03	9.26E-03	9.25E-03	9.26E-03	9.25E-03
	Total	**Pt**	**0.035**	**0.009**	**0.012**	**0.013**	**0.017**	**0.017**

Table 5. Area footprint calculations for TSS and FS salt; functional unit: 5 kg; TSS – traditional solar salt; FS – "flor de sal".

Land use category	Unit	Equivalence factor (gha/ha)	TSS		FS	
			Mass	E. value	Mass	E. value
Arable & crop	ha.a	2.64	1.18E-09	1.05E-09	2.13E-09	2.56E-09
Construction, dump, industrial, mineral, traffic & urban	ha.a	2.64	1.31E-07	1.11E-08	5.11E-08	2.33E-07
Forest & shrub	ha.a	1.33	7.98E-05	7.51E-05	2.70E-05	4.17E-05
Water	ha.a	0.4	8.41E-09	3.41E-09	2.18E-08	3.74E-08
Total	**m^2.a**	**-**	**0.80**	**0.75**	**0.27**	**0.42**

Table 6. Carbon footprint calculations for TSS and NG salt, with transportation from the production site to Brussels, Washington and Mocow; functional unit: 5 kg; TSS – traditional solar salt; FS – "flor de sal" ; NG – natural gas.

Impact category	Unit	Brussels			Washington			Moscow		
		TSS		Maldon	TSS		Maldon	TSS		Maldon
		Mass	Econ.		Mass	Econ.		Mass	Econ.	
GHG emissions	kg CO2	4.22	4.24	4.16	1.69	1.71	4.77	2.21	2.23	5.22
Land area	m2a	75.9	76.3	74.9	30.4	30.8	85.7	39.8	40.1	93.9

3.3.2 Comparing LCA and EF results

The EF indicator is calculated as the sum of direct land occupation, indirect land occupation, and carbon footprint. Since the EF is an aggregated indicator, as the Ecoindicators are, we may compare their final results regarding the impacts of TSS and NG. Results for the EF are similar to those found for the GHG emissions theme in the Ecoindicators. This happens because, as noted before, the EF result is approximately the same as the carbon footprint, which was calculated according to results from the GHG theme. As a consequence, results for the Ecoindicators are different than those of the EF. Ecoindicator 95 never yields the same results as the EF, since the EF is very sensible, for example, to natural gas use (and consequent GHG emissions). This is taken into account by the Ecoindicator 95 in the GHG theme, but since the energy resources category is not included in the final aggregated result, the effect is diluted in other categories. The Ecoindicator 99, however, has both a climate change category and a fossil fuel use category, and so its results are similar to those of the EF.

4. CONCLUSIONS

In this paper we determined the total environmental impacts of TSS and FS production and transportation. Since TSS is produced using solar energy for evaporation, we compared it with an option, namely the use of NG in that process. The methods we used were LCA and the EF indicator.

Regarding LCA analysis, packaging is the stage of TSS and FS production's life cycles with highest impacts. The impact of packaging is mostly due to electricity use and packaging materials. Transportation, however, has a much higher impact than production. Its contribute to the total impact is always around 90%. The most significant environmental themes are acidification, heavy metals, winter smog and GHG emissions.

FS is a product with high eco-efficiency, which means that its impacts are low compared to its market value. Therefore, FS contributes to the sustainability of the traditional salt production. Only solar evaporation produces FS as a co-product. Regarding the comparison with NG salt, we found that transportation is again the dominant effect. Even though TSS production has a lower environmental impact, if distances travelled by road are big enough, then NG may become the better environmental option. For smaller road transportation distances, and in cases where sea transportation is dominant, the production effect makes the difference, and TSS is the best environmental option.

The EF indicator is calculated as the sum of direct land occupation, indirect land occupation, and carbon footprint. Therefore, the EF aggregates two types of impacts: occupation of land and GHG emissions. In that aspect, the EF is comparable with Ecoindicators 95 and 99, which also aggregate impacts of many different themes. The EF has the advantage, over the Ecoindicators, of having biophysical conversion factors to the aggregated unit, which is the global hectare. The Ecoindicators, on the other hand, are based on a subjective assessment of impact relevance. However, our results show that if we only take into account the EF, we may find significantly different conclusions than if we consider all the themes in the Ecoindicators. The EF is, at best, a carbon footprint indicator, since carbon emissions weigh much more than any other land occupation impact. The Ecoindicators, by weighing other themes, provide a complete assessment of a product's environmental impact. They can be, however, misleading, as for example due to the relevance put upon heavy metal emissions.

We conclude that the EF indicator has the potential to depict the environmental score of a given product or activity, but it requires significant upgrades to incorporate other environmental categories in its calculation. As it is right now, the EF is mainly a carbon footprint indicator.

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