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## **INCORPORATION OF LIFE CYCLE MANAGEMENT IN PRODUCING DICALCIUM PHOSPHATE: A BRAZILIAN EXPERIENCE**

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### **ABSTRACT**

An organization within the Brazilian fertilizer sector is proposing to search for alternatives towards environmental performance improvement for the dicalcium phosphate's production process. This analysis comprised an LCA within an approach of cradle-to-gate, for obtaining 1 ton of the product. The main environmental impacts were associated with the extraction of sulfur - a resource fully acquired via importation - and its logistics. So it was decided to follow using the Life Cycle Management in the decision-making process related to the selection of suppliers of sulfur, performing an analysis based on Eco-efficiency, relating the costs of obtaining and shipping sulfur with the environmental impacts associated, allowing suppliers classification from an economic and environmental criterion.

### **INTRODUCTION**

Dicalcium phosphate ( $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ , DF) is used in the composition of dog food, mineral salts, and other products and other products spread with the livestock sector. Nevertheless, its manufacture is not absent from causing impacts on its surroundings. This occurs not only by way of the inexorable consumption of phosphate rock – a natural resource considered by many as the strategic reserve of a nation – but also because of the demand for water, sulfur, additives, energy, other processing agents. Also negatively affect the environment the liquid effluents, gaseous emissions, solid residues, land transformation and vegetation suppression originating from the mining activities.

Features like these have motivated an important organization within the fertilizer industry in Brazil to assess the environmental performance of the technological route practiced by it in the manufacture of DF. The organization expects with this effort, not only to reduce costs related to the process, but also to present itself in the market as a proactive company in terms of environmental sustainability. In terms of working method for the study was structured in three phases.

Phase 1 comprises conducting a LCA to identify opportunities of environmental performance improvement. This diagnosis makes it possible that in Phase 2 be structured specific scenarios in which problem previously identified can be evaluated in more detail in terms of its causes and consequences.

Phase 3 of the project performs an analysis in which economic and environmental variables are reconciled to provide subsidies for management decision-making of the executive team of the company.

To be carried out Phase 1 of the method for production of 1.0 ton DF were identified different potential sources for the implementation of improvement actions. Among these stood out the impacts associated with the obtaining and transport of sulfur, an essential asset to the production of dicalcium phosphate. This article describes and discusses in more detail this case.

### **PHASE 1: LCA FOR DICALCIUM PHOSPHATE**

LCA for DF was carried out to comply with the patterns defined in ISO standards 14040:2006 and 14044:2006. The goal of the study consisted in identify environmental impacts occurred along its production. In this frame, a methodological approach of cradle-to-gate used. Regarding to Scope Definition it was established as Reference Flow: “*to produce 1 ton DF*”. the product system under analysis considered the elementary processes of phosphate rock treatment – which are made up of the washing, crushing and classification operations –; obtaining the phosphate concentrate; the importing of sulfur;  $H_2SO_4$  and  $H_3PO_4$  productions; the extraction of limestone (calcium carbonate) and the production of dicalcium phosphate. In addition, the unit processes of industrial water and effluents treatments, the production of electricity by cogeneration and the electricity acquired from the Brazilian grid were included.

The application of cut-off criteria followed the guidelines given in NBR ISO 14044 (2006). Stood by exclusion limit 1.0% of cumulative contributions. Resource consumption and waste generation from DF manufacture were modeled by primary data. The same occurred with transports and the industrial utilities production. Other product systems – the production and transport of sulfur and of electrical energy acquired from the grid – were modeled by using secondary exhaustively adapted for the process conditions (Althus et. al. 2009).

Temporal Dimension comprised a continuous historical series of twelve months along 2011. Geographical Dimension selected the State of Sao Paulo because this is the region in which the DF manufacturing unit is installed. For the specific case of sulfur, the productive regions within countries from which importation occurs, were identified, namely: Germany, Canada, United Arab Emirates, the United States, Italy, Qatar and Russia.

Technology Coverage considered the average technology practiced by the organization at the time of data collection. Energy content was applied as the allocation criteria between vapor and  $H_2SO_4$ . In whatever other situation mass criteria was employed. Life Cycle Impact Assessment (LCIA) was carry out by the method ReCiPe – midpoint (H) v 1.07. Only impact categories of interest for analysis were taking into account. Thus, no longer were considered Urban Land Occupation, Marine Eutrophication and Ecotoxicity, Ionization Radiation, Metal Depletion and Natural Land Transformation (Goedkoop, et al. 2012).

This LCA allowed for the identification of the  $H_3PO_4$  and electricity cogeneration processes as the stages with the greatest impact in obtaining of 1.0 ton DF. Together with the electricity acquired from the concessionaire, such unit processes figured as major contributors in twelve of the thirteen categories analyzed.

However, must to be highlighted common influence upon both processes for the production of H<sub>2</sub>SO<sub>4</sub>. In this context, the importation of sulfur – whose logistic reformulation could be carried out, taking into account the environmental variable as a benchmark – would become the target of potential improvement actions, as well as the losses of SO<sub>x</sub> to the atmosphere.

If such effects were to be damped down, one could then think of increasing cogeneration already in operation at the unit, to levels that would allow for no longer having dependence on energy supplied by the Brazilian grid. Such non-compatibility must occur, only and merely, after taking care of the rationalization of the raw materials of the process itself.

## PHASE 2: LCA FOR DICALCIUM PHOSPHATE

In Phase 2 the diagnosis made in the previous step was taken in order to investigated in more detail the problems identified. Three scenarios of analysis were defined: Scenario A: *Sulfur import*, Scenario B: *Phosphoric acid production* and Scenario C: *Rationalization of energy consumption*.

The team responsible for the evaluation of scenario A made a survey of parameters associated with origin and logistics sulfur acquired by the company. Table 1 present these data.

Table 1: Logistical information about the supply of sulfur

Country	Extraction technology	Local of extraction	Modal transportation Facility-Port	Port of departure	Modal transportation Port-Port	Port of arrival
Russia	Natural gas sweetening	Astrakhan	Barge + Rail	Kavkas, Kerch, Ust Luga	Transoceanic	Santos-SP
Germany	Petroleum refining	Brake	Rail	Brake	Transoceanic	Santos-SP
United Arab Emirates	Natural gas sweetening	Abu Dhabi	Road by truck	Ruwaiss	Transoceanic	Santos-SP
Canada	Natural gas sweetening	Edmonton + Calgary	Rail	Vancouver	Transoceanic	Santos-SP
Italy	Petroleum refining	Genoa	Road by truck	Genoa	Transoceanic	Santos-SP
United States of America	Petroleum refining	Texas City + Beaumont	Rail	Beaumont + Long Beach	Transoceanic	Santos-SP
Qatar	Natural gas sweetening	Ras Laffan	Road by truck	Ras Laffan	Transoceanic	Santos-SP

This information allowed the construction of individual models of product systems for the sulfur acquired at each location. Apart from the transoceanic displacement, also terrestrial distances were identified in accordance with each specific modal of transport.

After being completed this intermediate step LCIA method ReCiPe – endpoint (H) v 1.07 with normalization model World H / H was applied to each of the situations. Once again, there were considered only the impact categories selected for the Phase 1. The application of the method led to development of single scores for each transport logistics and obtaining of sulfur.

Table 2: Environmental Performance and Unitary Costs of production and transport of sulfur

Country	Unitary Cost (C) (US\$/ton)	Environmental Performance (E) (Pt)	$F = (C * E) ^ 0.5$
Russia	227	107	155.85
Germany	227	94.2	146.23
United Arab Emirates	228	102	152.50
Canada	227	103	152.91
Italy	227	92.4	144.83
United States of America	217	102	148.77
Qatar	228	100	151.00

Parallel to that the team in charge of analyzing collected data on the costs associated with these operations. The result of this survey and the application of the recipe - Endpoint as single score for each scenario under study appear in Table 2.

### PHASE 3: ENVIRONMENTAL – ECONOMIC PERFORMANCE: JOINT ANALYSIS

The F factor represents the geometrical means between E and C. Considering this indicator the sulfur provided by Russia presents the worst environmental-economic performance among the alternatives under analysis (155.85). At the other end of a possible ranking of suppliers are located respectively products imported from Italy and Germany. The derivative shows German environmental performance but slightly higher than its counterpart (1.9%). Another aspect that should be highlighted is the profile similarity between sulfur imported from North America, with that originating from the Middle East. Considering that the transoceanic distances are greater from Asia, the product originating at that location was able to compensate for this deficiency with lower impacts on terrestrial and displacements in the extraction process.

### CONCLUSIONS

LCA technique supported the decision-making process for selection of suppliers of sulfur answered adequately the expectations of the company. From this approach, it was possible to assess the environmental performance of discretized way of alternatives. Income generated from this analysis can then be appropriately harmonized with economic indicator.

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