InLCA-LCM03 CONFERENCE
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Environmental Performance Comparison of Wet and Thermal Routes for Phosphate Fertilizer Production using LCI A Brazilian experience.

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SCENERY

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Industrial production of phosphate fertilizers

Apatite $Ca_{10}(PO_4)_6F_2$ – main mineral PR's

Two routes

Thermal: thermal treatment of a mixture apatite + serpentine

↓

Fused magnesium phosphate - FMP

Wet: reaction apatite + sulfuric acid

→ **Single superphosphate - SSP**

→ **Phosphoric acid** → **Triple superphosphate - TSP**

→ **Ammonium phosphates**

SCENERY

Environmental features of both routes

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Thermal – energy intensive process

Wet (sulfuric)

- **consumption of natural resource sulfur** (for sulfuric acid production)
- **generation of phosphogypsum (solid residue):**
  - **= contamination of underground water**
  - **= intensive land use**

GOAL AND SCOPE DEFINITION OBJECTIVES

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- **To compare environmental performance of both routes**
  - **to subsidize fertilizer industry policies**
  - **to identify environmental opportunities**

- **LCI – cradle to gate**
  - **use step: Agricultural Engineering School USP**

GOAL AND SCOPE DEFINITION
FUNCTIONAL UNIT

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Functional unit: supply 41.66 kg of P_2O_5

REFERENCE FLOW

TSP – 45 % P_2O_5
FMP – 20% P_2O_5

Reference flow:
93 kg TSP
208 kg FMP

GOAL AND SCOPE DEFINITION
PRODUCT SYSTEM - TSP

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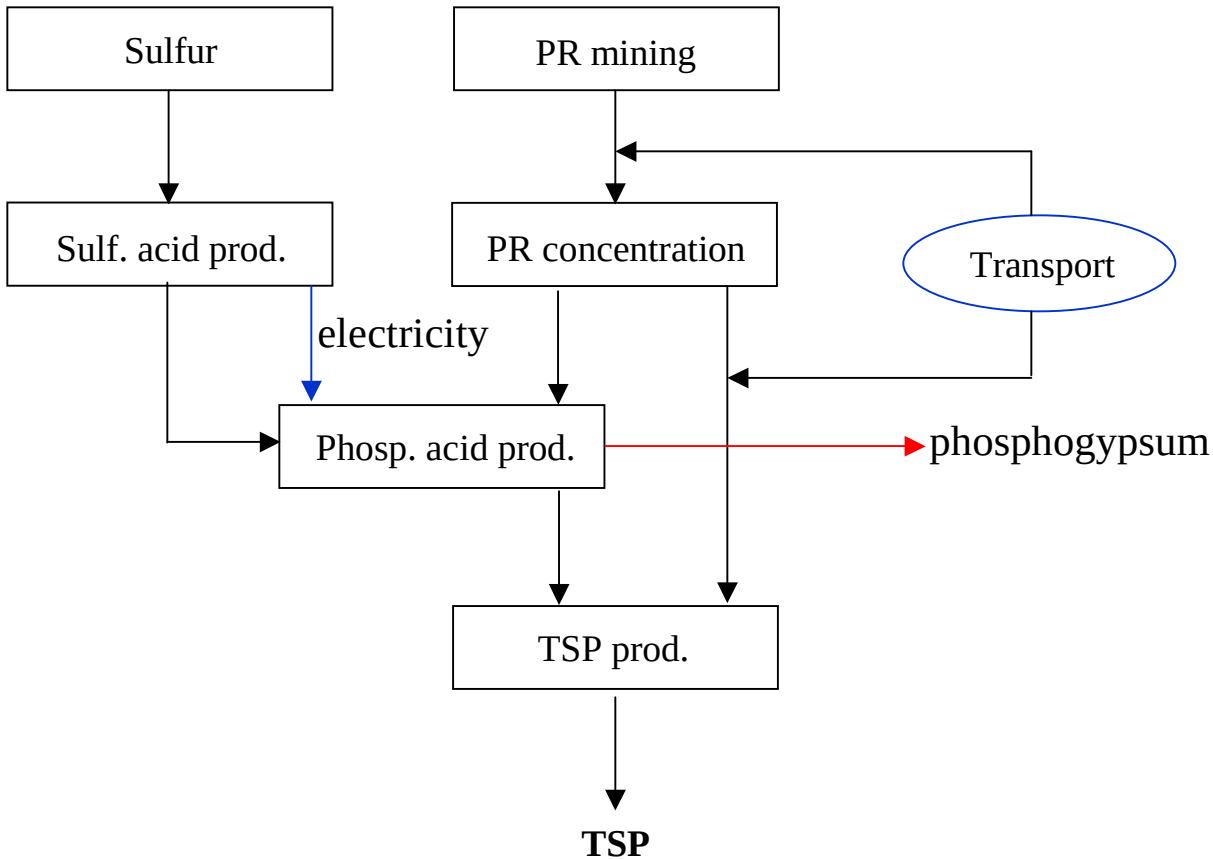

GOAL AND SCOPE DEFINITION
PRODUCT SYSTEM - FMP

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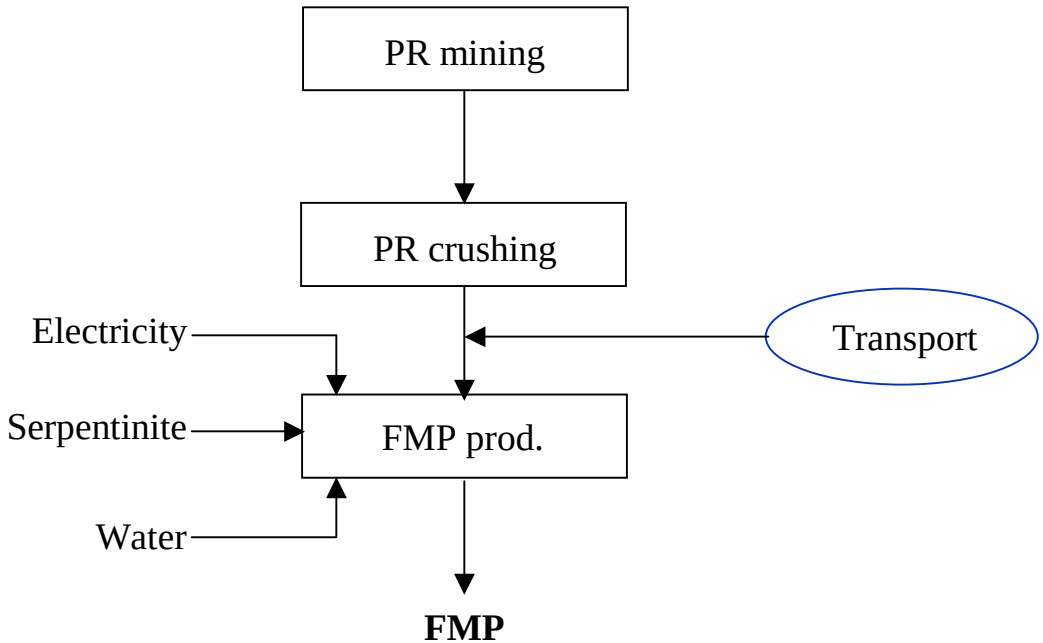

GOAL AND SCOPE DEFINITION
IMPACT CATEGORIES

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- Global warming (GW)
- Ozone layer depletion (OD)
- Human toxicity (HT)
- Water ecotoxicity (WE)
- Acidification (Ac)
- Eutrophication(Eu)

INVENTORY ANALYSIS
DATA COLECTION

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- **Mining (both systems); phosphate concentration (TSP); crushing (FMP) -** Silva & Kulay (2003): Int. J LCA 8 (4) 209-214 (2003)

- **Sulfuric acid, phosphoric acid and TSP – two Brazilian plants**

- **FMP – the only Brazilian plant**

- **Electricicy – TEAM database** (Ecobilan Group, 1998)
  89% hydroelec.; 8% thermoelec.; 1% nuclear; 2% other

- **Transport – truck: capacity 28 ton; 0.45 l/km**

INVENTORY ANALYSIS

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Consolidated inventory for FMP and TSP systems (units/FU)

Aspect	Unit	TSP	FMP
Inputs			
Phosphate ore	kg	922	167
Serpentine ore	kg	-	108
Elemental sulfur	kg	30.7	-
Water	kg	2,150	4,210
Electricity	MJ	44.5	951
Outputs – Atmospheric emissions			
Carbonic gas	kg	46.4	160
Arsenium	kg	7.26×10^{-6}	7.03×10^{-6}
PAH	kg	1.97×10^{-6}	1.60×10^{-6}
Benzene	kg	2.42×10^{-4}	1.24×10^{-4}
Sulfur dioxide	kg	0.273	0.149

INVENTORY ANALYSIS

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Consolidated inventory for FMP and TSP systems (units/FU) (cont.)

Aspect	Unit	TSP	FMP
Outputs – Liquid effluents			
Phosphates	kg	0.176	0.114
Chloride	kg	0.0498	0.176
Sulphate	kg	9.84×10^{-3}	0.0134
Barium	kg	2.63×10^{-4}	7.65×10^{-4}
Vanadium	kg	6.05×10^{-6}	4.78×10^{-6}
PAH	kg	1.97×10^{-6}	1.60×10^{-6}
BOD	kg	0.0235	4.64×10^{-5}
Outputs – Solid wastes			
Phosphates	kg	0.803	2.37×10^{-6}
Sulfur	kg	0.697	4.54×10^{-5}
Aluminum	kg	0.150	7.56×10^{-5}

IMPACT ASSESSMENT

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- **CML 2 baseline 2000 method –** CML – Centre of Environmental Science. *Life Cycle Assessment. An operational guide to ISO Standards*, version 2.02. Leiden University, The Netherlands. 2001.

- **SimaPro 5, version 5.1.0.21 –** Pre Consultants, Amersfoort, The Netherlands.

IMPACT ASSESSMENT

Environmental profiles: TSP and FMP systems

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Impact categories	**Unit**	**TSP**	**FMP**
Global Warming (GW)	kg CO_2 eq.	160	46
Ozone Layer Depletion (OD)	kg CFC11 eq.	9.87×10^{-6}	7.03×10^{-6}
Human Toxicity (HT)	kg 1,4DB eq.	11.1	6.2
Water Ecotoxicity (WE)	kg 1,4DB eq.	0.93	0.31
Acidification (Ac)	kg SO_2 eq.	0.20	0.33
Eutrophication (Eu)	kg PO_4^{-3} eq.	0.12	0.98

COMMENTS

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- **Global Warming:**
  - **FMP -** (160 kg CO_2 eq.) – **mainly 8% thermoelectricity**
  - **TSP -** (46 kg CO_2 eq.) – **mainly transport**

- **Human Toxicity:**
  - **FMP -** (11.1 kg 1,4DB eq.) – **Niquel, Arsenium and Vanadium emissions (electricity generation and ore transport)**
  - **TSP -** (6.2 kg 1,4DB eq.) – **Arsenium, benzene and PAH emissions (ore transport)**

COMMENTS

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- **Acidification:**
  - **FMP -** (0.195 kg SO_2 eq.) – **mainly 8% thermoelectricity**
  - **TSP -** (0.332 kg SO_2 eq.) – **mainly sulfuric acid production**

- **Eutrophication:**
  - **FMP -** (0.12 kg PO_4^{-3} eq.) – **phosphate in effluents of FMP manufacture step**
  - **TSP -** (0.98 kg PO_4^{-3} eq.) – **mainly phosphate in phosphogypsum**

CONCLUSIONS

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- **FMP - high electricity use:**
  - ⇨**non renewable resources consumption**
  - ⇨**global warming**
  - ⇨**acidification**

- **TSP – phosphogypsum:**
  - ⇨**soil use for disposal**
  - ⇨**eutrophication**
    - **long distance transport (Brazilian conditions)**
  - ⇨**GW; OD, HT**

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