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Grupo de Prevenção da Poluição
Escola Politécnica - USP

Contribution to the Brazilian Database: Offset paper LCA

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Presentation Contents

1. The pulp & paper sector in Brazil

- Number of companies: **220**
- Location: **16 States (450 municipalities)**
- Planted area: **1.7 million hectares**
  - Eucalyptus: **75%**
  - Pinus: **24%**
  - Other: **1%**
- Native forests preserved by the sector: **2.6 million hectares**

- Direct employees: **110 thousand**
- Exports: **US$ 3.4 billion**
- World Ranking
  - **7th** Pulp
  - **1st** Hardwood market pulp
  - **11th** Paper
- Trade balance: **US$ 2.5 billion**
- Share in the GDP: **1.2%**

World Consumption of Paper – 2005

Country	(kg/inhabitants/year)
United States	312.0
Japan	246.6
Germany	235.9
Canada	222.5
United Kingdom	209.8
France	182.7
Mexico	57.8
Argentina	49.5
China	41.6
Brazil	39.5
Russia	34.4
World Average	56.3

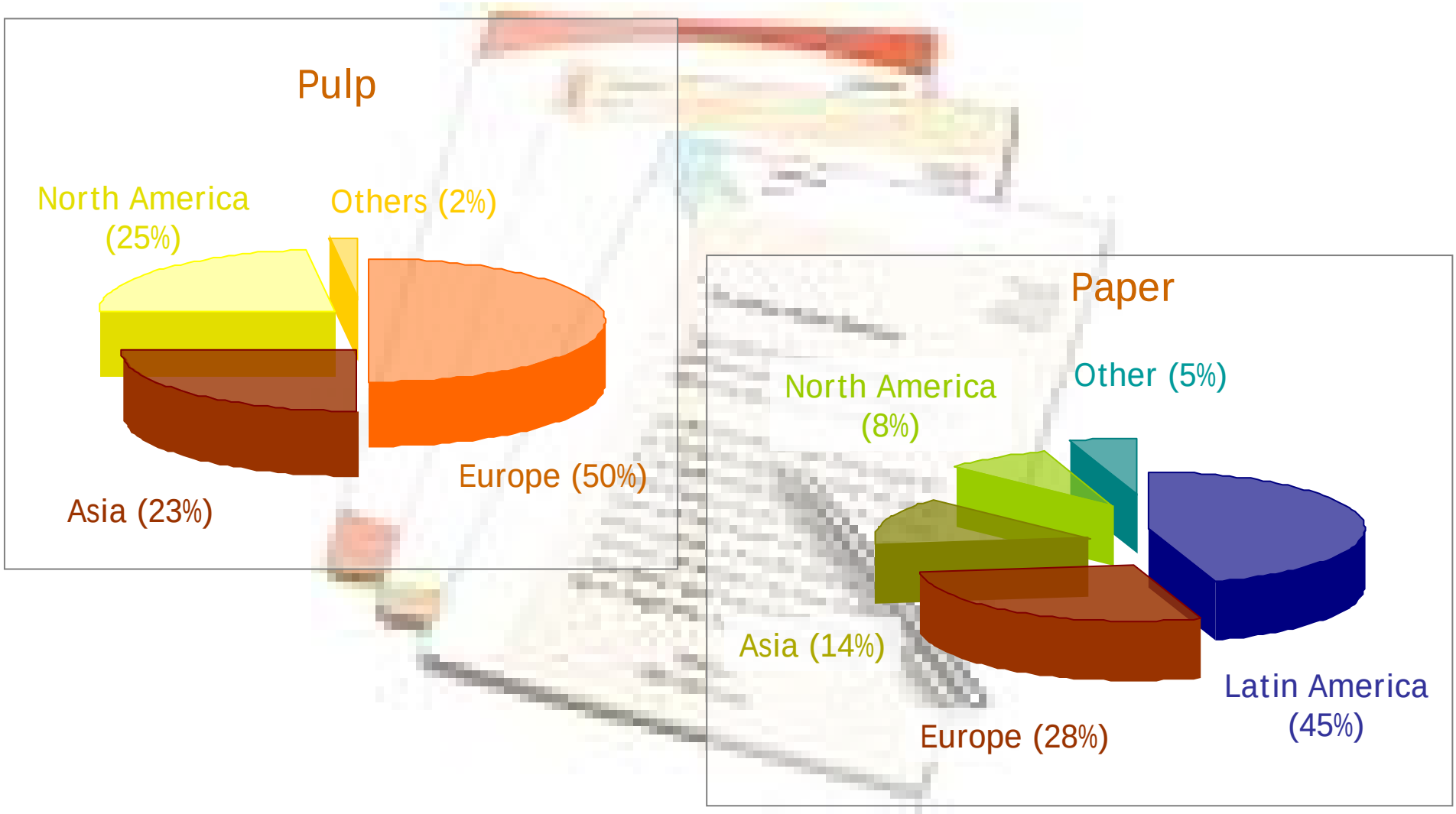
Source: PPI (2006)

Main Pulp and Paper Producers (2005) – in 1000 tons

Paper		Pulp	
1. USA	83,401	1. USA	53,585
2. China	49,500	2. Canada	26,406
3. Japan	30,889	3. China	14,180
4. Canada	20,461	4. Finland	12,619
5. Germany	20,392	5. Sweden	12,106
6. Finland	14,036	6. Japan	10,720
7. Sweden	11,589	7. Brazil	10,352
8. Korea	10,511		
9. France	10,249		
10. Italy	9,665		
11. Brazil	8,597		

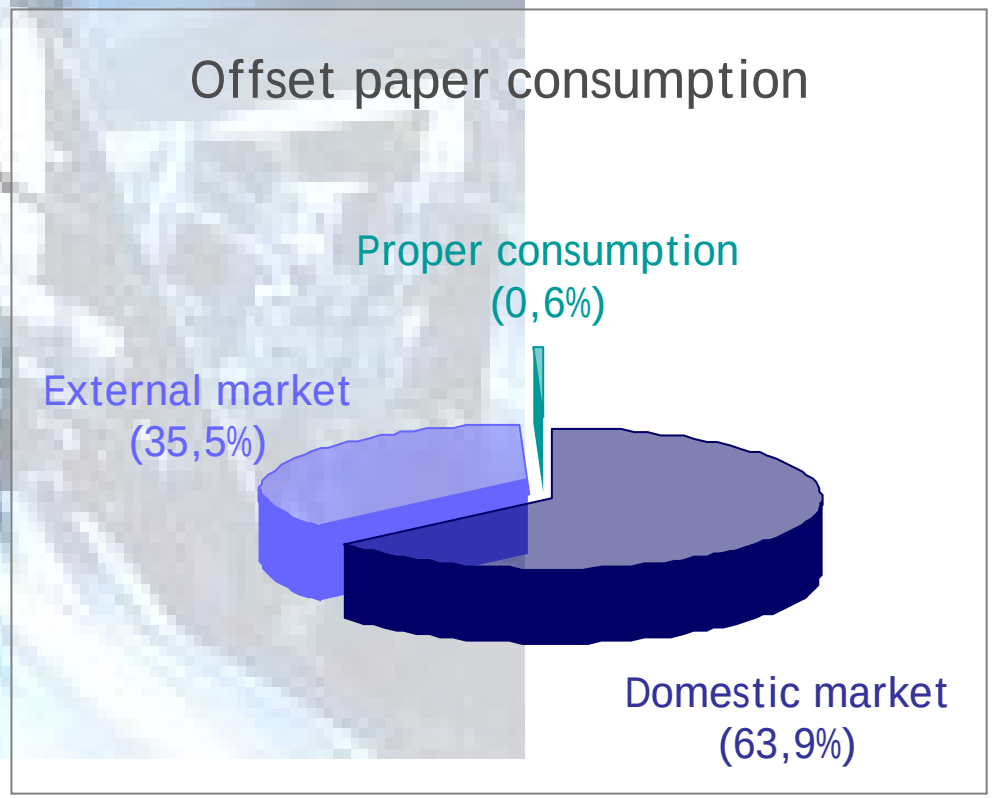
Source: PPI (2006)

Export Destination



2. Offset paper Profile

- Number of companies: **11**
- Location: **5 States**
- Production (2005): **1,568,890 ton**
- Share in the Brazilian production of paper: **21%**
- National ranking: **2nd**



Main Producers

Bahia	226,917 ton (14.4%)
Bahia Sul Celulose S.A.	226,917

São Paulo	1,252,142 ton (79.8%)
International Paper do Brasil Ltda	398,995
Votorantim Celulose e Papel S.A.	365,673
Suzano Papel e Celulose	274,598
Ripasa S.A. Celulose e Papel	188,482
Cia Santista de Papel	24,394

3. Offset paper: Brazilian Database

3.1 Methodological Requirements

Objective - carry through the Life Cycle Inventory (LCI) of the offset paper in order to contribute to the Brazilian Database for LCA studies

Reference Flow – 1 ton of 75 g/cm^2 uncoated woodfree, and no calender bleached offset paper

Scope – cradle to gate approach

Methodological Framework – NBR ISO 14040 series

3.2 Product System Modeling

Technical Premises

- **Fibrous raw-material:** *Eucalyptus grandis*

  - about 64% of the Brazilian planted forest corresponds to eucalyptus;
  - little more than 26% of this production consist of *Eucalyptus grandis*

- **Model of productive installation: integrated pulp-paper plants**

  - more than 90% of the offset paper production occur in integrated plants
  - technology of pulp extraction – Chemical Pulp (96% as Kraft Process)

- **Production Capacity: 5 companies**

  - the production of such company in last the 5 years corresponded to 92.7% of the total amount of offset paper in the country

Boundaries Refining

- **Exclusion Criteria: exclusion of Unit Processes and environmental loads**
  - quantitative: contribution below 5.0% were excluded from the product system;
  - environmental relevance.

Considered Subsystems

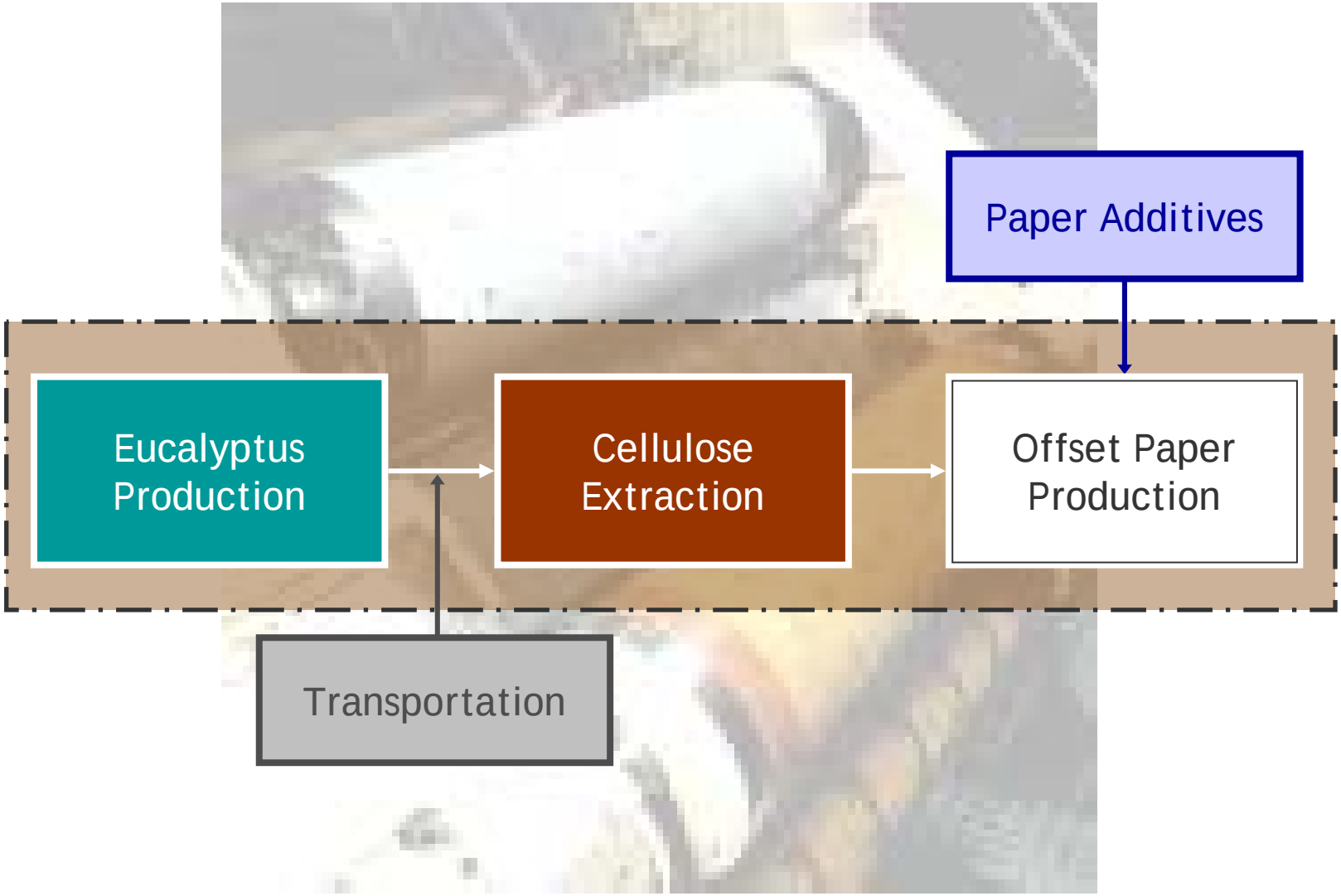
- wood production
- pulp extraction
- washing, delignification and bleaching
- chemical recovery
- paper production
- effluent treatment

Chemical production:
sodium chlorate; chlorine dioxide;
calcium carbonate; hydrogen peroxide
sulphuric acid

Excluded Subsystems

Production of:
- fossil fuels
- herbicides and formicides
- fertilizers
- construction and maintenance of capital goods

Product System: offset paper



3.3 Material Balance of the fibrous raw materials

~ 30 trees
12% barks
35% wet

3216 kg
Eucalyptus

1821kg
OD wood

911kg
Brown pulp

862kg
Pre-O_2 pulp

818kg
Bleached pulp

1000kg
Offset paper

Offset paper

Component	(%)
Bleached Cellulose	76.10
Starch	0.74
Additive	0.37
coating starch	0.47
PCC	18.30
Water	4.00

3.4 Specific Premises

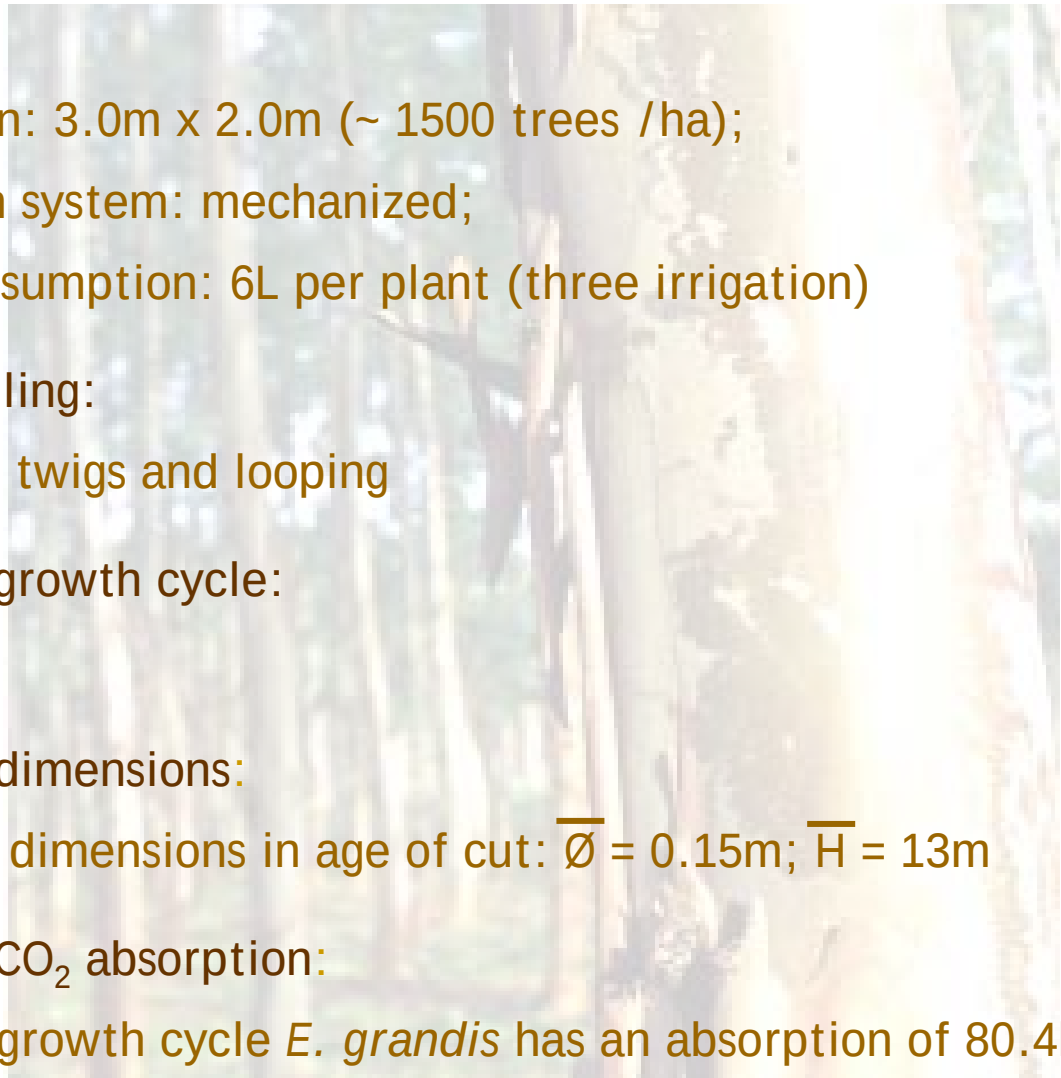
Eucalyptus Production

- seedling production:
  - vegetative propagation (clone seedlings);
- preparation of the ground:
  - minimum culture: use of heavy machines just in specific cases;
  - ground revolution;
  - no roots, rinds, barks and leaves burnt
- Formicides and herbicides:
  - sulphluramide and glophosates – 2.0 kg/ha/year
- Fertilizers consumption:

essential nutrients	kg/ha
N	150
P	80
K	180

micronutrients	kg/ha
B	3.0
Zn	2.0
Cu	1.0

Eucalyptus Production



- Plantation:
  - occupation: 3.0m x 2.0m (~ 1500 trees /ha);
  - plantation system: mechanized;
  - water consumption: 6L per plant (three irrigation)
- Forest handling:
  - pruning of twigs and looping
- Eucalyptus growth cycle:
  - 7 years
- Eucalyptus dimensions:
  - *E. grandis* dimensions in age of cut: $\overline{Ø}$ = 0.15m; $\overline{H}$ = 13m
- Eucalyptus CO_2 absorption:
  - along the growth cycle *E. grandis* has an absorption of 80.4kg CO_2/ton

Cellulose Extraction

- Wood treatment:
  - wood barking – contact mechanism;
  - barks – energy production in power boiler;
  - naps dimension range: 2.0 < Ø (m) < 2.5;
  - average chips dimension: 2.0cm x 2.0 cm x 4.0cm
- Wood digesting:
  - white liquor: NaOH + Na_2S (sulfidity: 25%);
  - pulp extraction yield: 49-52% wt;
  - process technology: continuous;
  - operational conditions: 4hs at 170°C and 14kgf/cm^2
- Depuration:
  - removing of wood nodes and sticks – energy production

Cellulose Extraction

- Pulp washing and O_2 pre-bleaching:
  - clean condensate from black liquor evaporation unit;
  - barks – energy production in power boiler;
  - O_2 consumption in pre-leaching: 22kg/ton of pre-bleached pulp
  - delignification pH = 10-10.5 (additional consumption of NaOH)
- Pulp bleaching:
  - technology: Elementary chlorine free (ECF);
  - bleaching sequence: $D_1 - E_{P1+O} - D_2 - P_2$

Code	substance	consumption (kg/ton of bleached pulp)
D	chlorine dioxide	10.70
E	alkaline extraction with soda	7.50
P	hydrogen peroxide	7.80
O	oxygen	5.00

Cellulose Extraction

- Black liquor evaporation:
  - suspended solids (ss) concentration from 12-15% (digestion and washing processes) until 77-80% (recovery boiler inlet);
  - evaporation unit economy: 5.5-7.2 kg water/kg steam
- Recovery boiler:
  - concentrated black liquor: ~ 2,200 kJ/kg ss;
  - oxi-reduction reaction: production of Na_2CO_3;
  - steam production: ~ 3.0 ton steam (420°C; 40 kgf/cm^2) per ton ss
- Cauterizing and Calcination:
  - obtaining of NaOH: 110-130 g/L;
  - production of slime: 40-50% ss $CaCO_3$ + generation of dregs and grits
  - $CaCO_3$ calcination with natural gas to produce CaO and CO_2 (atmosphere)

Paper Production

- Unit processes:

  - mass preparation, refining, depuration, paper leave obtaining, drying, coating and convention;

- Additives consumption:

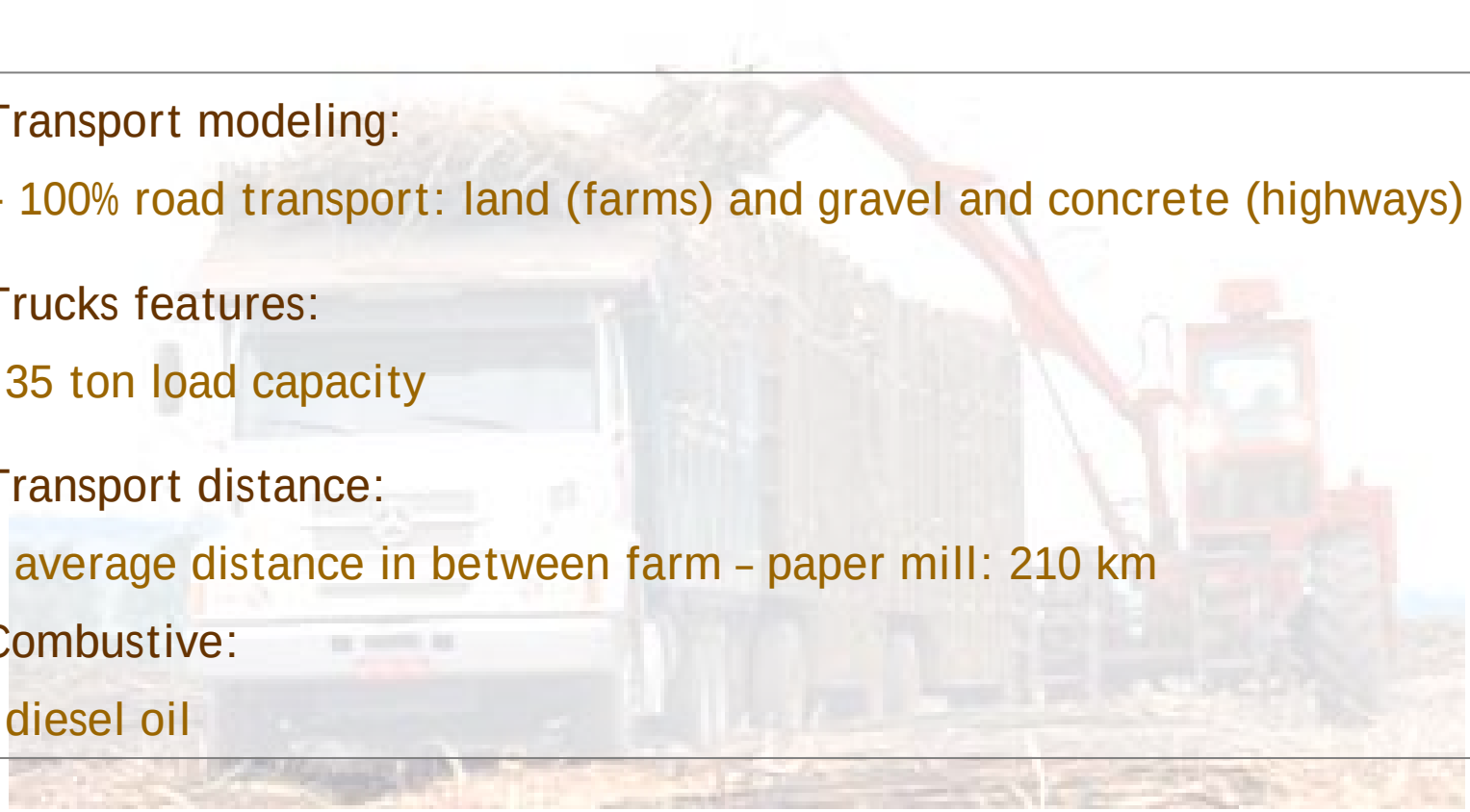
additive	consumption (kg/ton offset paper)
bleached pulp	818.40
starch	8.00
coating stark	5.00
PCC ($CaCO_3$ precipitated)	196.80
water	8,000-25,000
steam	6.0-8.0
other additives	4.00
white pulp scrap	88.00

- Effluents:

- features: 600 < Suspended solids (mg/L) < 1200 and 350 < DBO_5 mg/L < 600

Transportation

- Transport modeling:
  - 100% road transport: land (farms) and gravel and concrete (highways)
- Trucks features:
  - 35 ton load capacity
- Transport distance:
  - average distance in between farm – paper mill: 210 km
- Combustive:
  - diesel oil



3.5 Data Collection

- Primary data
  - Questionnaire distribution;
  - completeness: ~ 50%

- Secondary data
  - literature;
  - experts consultation;
  - material and energetic balances;
  - databases

3.6 Results

INLETS	
MATERIAL RESOURCES	
Eucalyptus grandis (kg ODMT)	3,22E+03
$CaCO_3$ precipitated (kg) (in 7 years)	1,97E+02
fertilizers (as NPK) (kg)	2,87E+01
diesel (kg)	1,68E+02
oxygen liquid (kg)	2,33E+01
hydrogen peroxide (kg)	6,39E+00
ENERGETIC RESOUCES	
Electricity (MW)	1,15E+00
petroleum (kg)	8,19E+00
OUTLETS	
ATMOSPHERIC EMISSIONS	
CO_2 (kg)	6,40E+02
SOx (kg)	4,37E+02
TRS (kg)	2,34E+00
LIQUID EFFLUENTS	
AOX (kg)	1,70E-01
COD (kg)	5,50E+00
DBO_5 (kg)	2,31E+00
SOLID WASTE	
Landfield (kg)	1,29E+02
OTHER ENVIRONMENTAL LOADS	
CO_2 absorption (kg)	2,59E+02
Land use (ha)	2,00E-02

Total amount of measured environmental loads: 147

4. Conclusion and Limitations

The study makes conclude that:

- Carbon dioxide:
  - CO_2 absorbed along growth period of *Eucalyptus grandis* corresponds to 41% of the total emission of this pollutant during the offset production

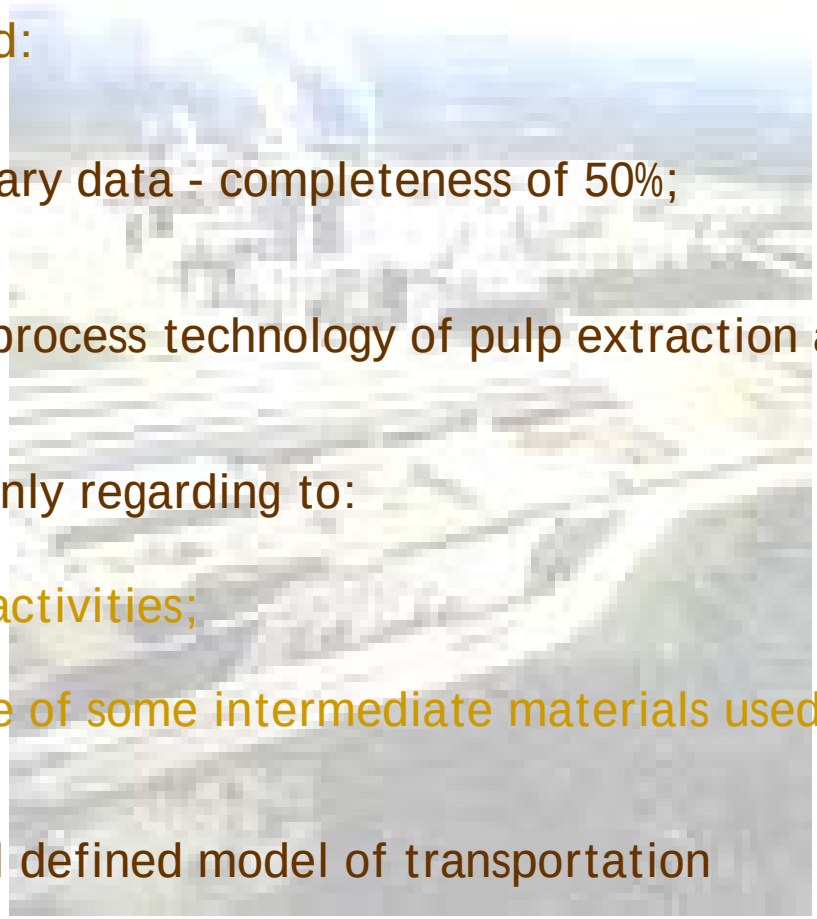
- TRS:
  - even with an emission of 2.34 kg /ton offset TRS continue being the most significant source of atmospheric problems atmospheric to the integrated pulp and paper companies

- Water consumption:
  - circuit closing procedures made the average water consumption ranges in between 7.5 and 12 m^3 per offset ton in the investigated companies

- Energetic balance:
  - the amount of electric energy generated by black liquor burn in recovery boiler corresponds to 34.7% of the energetic demand of 1.0 ton offset

4. Conclusion and Limitations

Regarding to limitation and obstacles observed during the study development, must be highlighted:



- low level of primary data - completeness of 50%;
- high diversity in process technology of pulp extraction and paper production
- data quality, mainly regarding to:
  - agricultural activities;
  - The life cycle of some intermediate materials used in offset production;
- absence of a well defined model of transportation

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Tanks for your attention!!

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