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Environmental science and technology research institute

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Public research institute (EPST)

- **9 centres** + 2 branches (Strasbourg and Martinique)
- Workforce of **1400** including **500 scientists**, **200** doctorate and **40** post-doctorate students
- **110 M€** budget including **79 M€** Core Budget and **31 M€** contracts (2010)

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Competences

Land, water and environmental technologies
Fields directly related to the **needs of Society**

Scientific and technical support for **public policy** in the form of research, science advice, models and operational tools

An **engineering** approach that includes **multi-disciplinary components**

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Organisation

3 departments

- **Water**
  Resources, environments, uses and risks
- **Environmental technologies**
  Networks, water treatment, waste
- **Land**
  Territorial development, biodiversity, risks and vulnerabilities

12 research themes

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International partnerships (out of Europe)

Canada : Laval University, INRS, University of British Columbia, Mc Gill Univ., Ministry of Natural Resources,IRDA

US : USGS, MIT, UC Berkeley, UC Davis USDA-ARS

Brazil : Sao Paulo University, Brasilia University, EMBRAPA, National Water Agency (ANA)

Mediterranean area :
IAV Hassan II Marocco,
INRGREF Tunisia

South Africa :
Cape Town University, IWMI

Australia :
ANU, CSIRO, USYD, UTS, UNSW, Univ. of Western Australia, Monash Univ., Newcastle Univ.

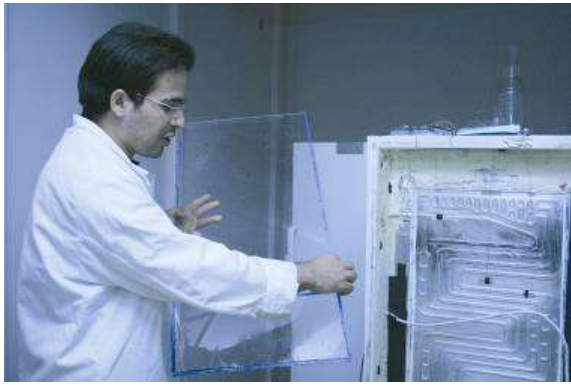
New Zealand :
NIWA, Landcare Research

Cemagref organisation

Environmental technologies

Networks, water treatment, waste

- Technologies for sustainable agricultural systems
- Technologies for clean, energy-efficient processes
- Water and waste technologies and processes
- Integration, modelling and environmental evaluation



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A set of technological platforms

1.5 T Agro&Process MRI in Rennes

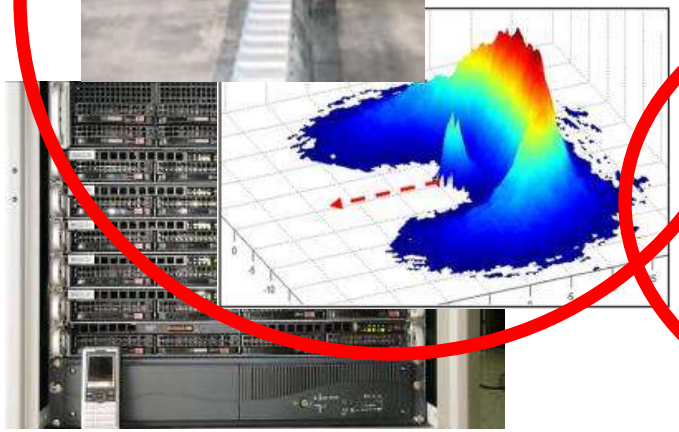
Low-speed aeraulic platform in Rennes

Test facility for irrigation systems in Aix

Tractor test track and truck equipped with dynamometric apparatus in Antony

Test facility for manure spreading in Clermont

Remote sensing in Montpellier



L'Esturial in Bordeaux

Computer cluster in Clermont-Ferrand

Reduction of pesticide pollutions in Montpellier

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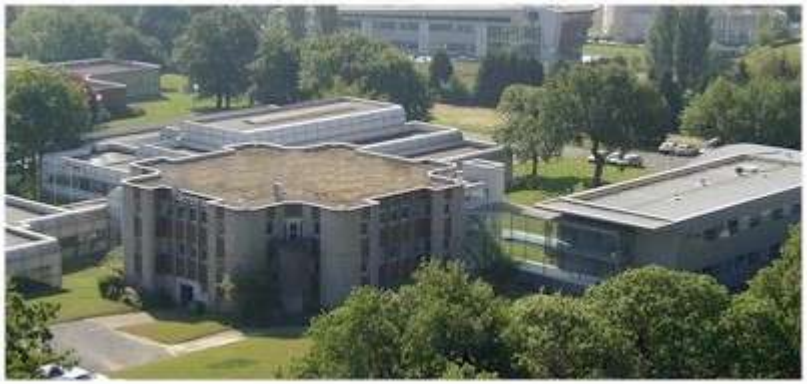
Cemagref in Rennes



- 60 permanent staffs
- 20 PhD students
- 2 research units
  - Food product quality
  - Environmental management and biological treatment of wastes (GERE)

Cemagref and livestock effluents

Wind tunnel

In line or single analysis N_2O, NH_3, CO_2, CH_4

plastic tent + sucking

In situ measurement of green house gas emission

In situ measurement of treatment plants performances

Pilot experiments

Biological pilot treatment plant used for studying nitrogen removal.

Equipment to measure ammonia emissions in controlled conditions

Pilot experiments

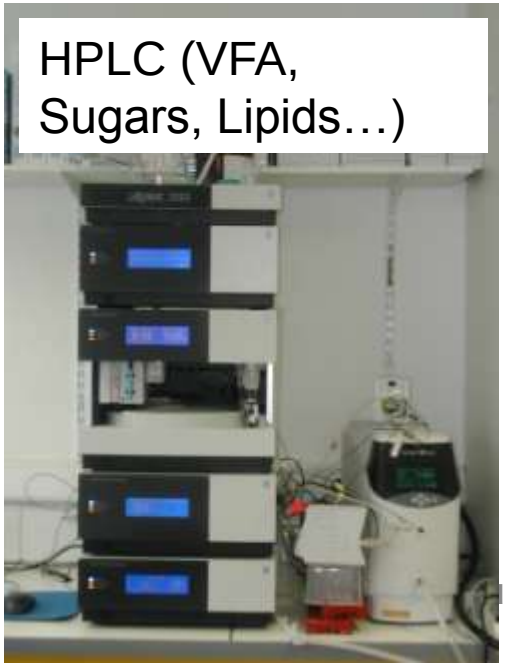
Combined anaerobic digestion +aerobic nitrogen removal

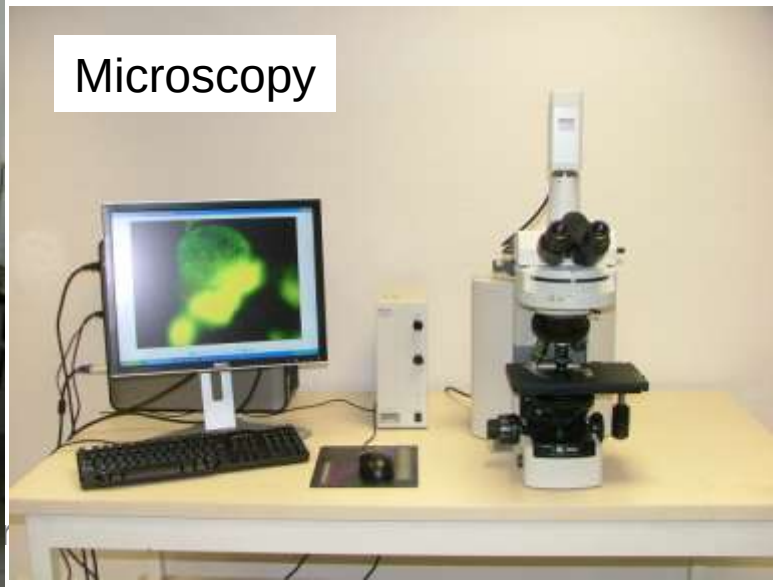
Laboratory test to assess methanogenic potential from animal wastes

1- Pressure is measured to calculate the biogas amount

2- Headspace is analysed for CO_2/CH_4 ratio

Some others lab equipments….





European perspectives on technical and economical approaches to phosphorus recycling

Marie-Line Daumer

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Sciences, eaux & territoires

Plan

Context

- Why recycling P is important ?
- What is the problem in Europe ?

Phosphorus in animal manure

- Sources of animal P
- P from Cattle manure
- P from Poultry manure
- P from Pig manure

Phosphorus Recycling from liquid effluents

- Current techniques
- Developing techniques

Conclusions

Context : Why recycling P is important ?

Phosphorus is a limited Resources

- **Available for the next 100 – 400 years depending on the technical and economical criteria for the extraction.**

Phosphorus is contributing to surface water eutrophication

Photo :
http://eauxpluviales.wordpress.com/2008/02/10/introduction/

<u>Environmental impact</u>
Wildlife (fauna and flora) disturbances

<u>Economical consequences :</u>

- Drinkable water (less authorized resources and more expensive to purify)
- Leisure use compromised
- Fish farming impossible

Context : What is the problem in Europe?

Livestock concentration

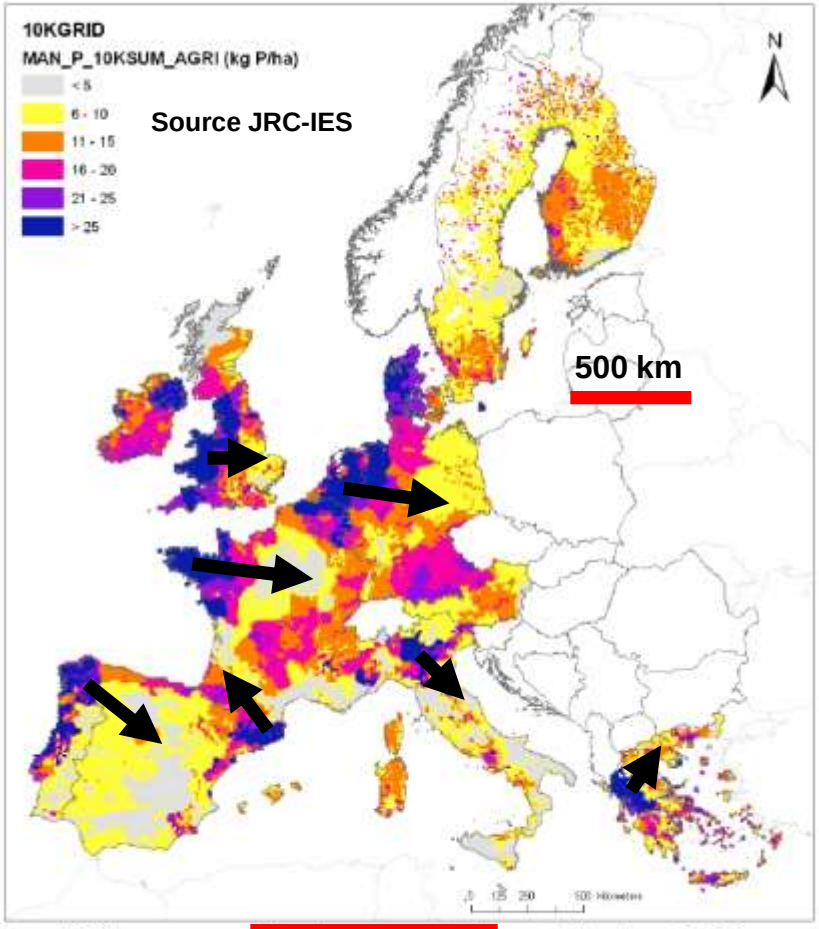

Figure 4.27 European map of phosphorus manure input per agricultural area in EU15, average on 10 km² area. (In Sweden and Finland the white colour indicates the absence of agricultural land within the 10 km² area).

Solution = Transfer ?

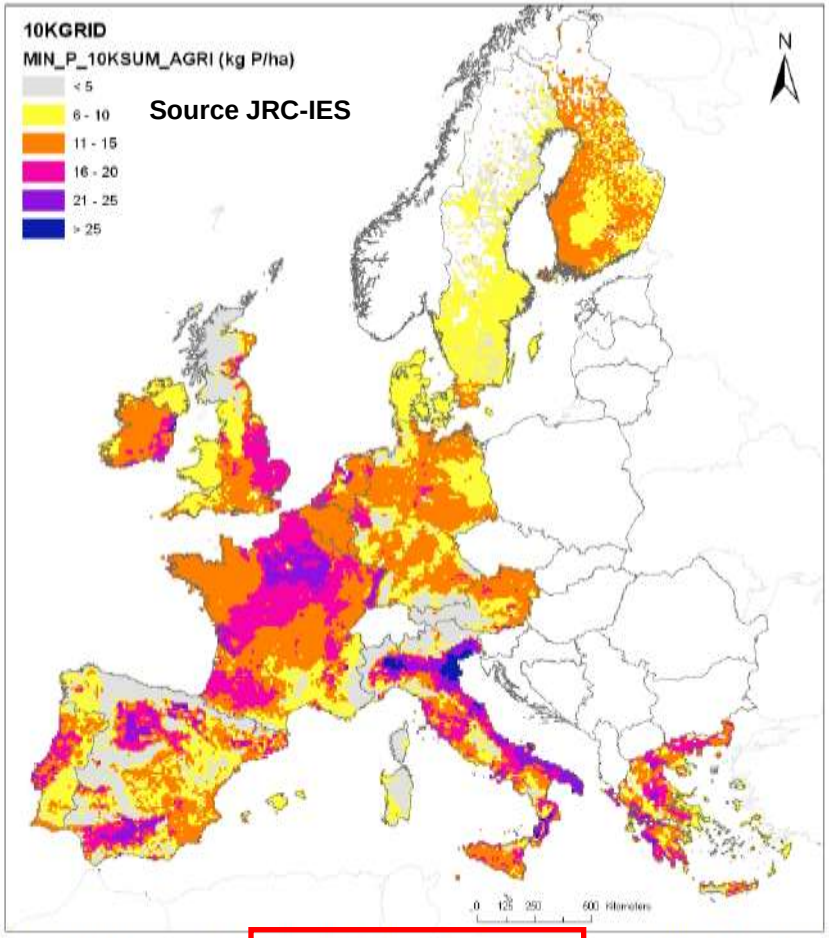

Figure 4.19 European map of phosphorus mineral fertiliser input per agricultural area in EU15, average on 10 km² area. (In Sweden and Finland the white colour indicates the absence of agricultural land within the 10 km² area).

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Phosphorus in animal manure : sources

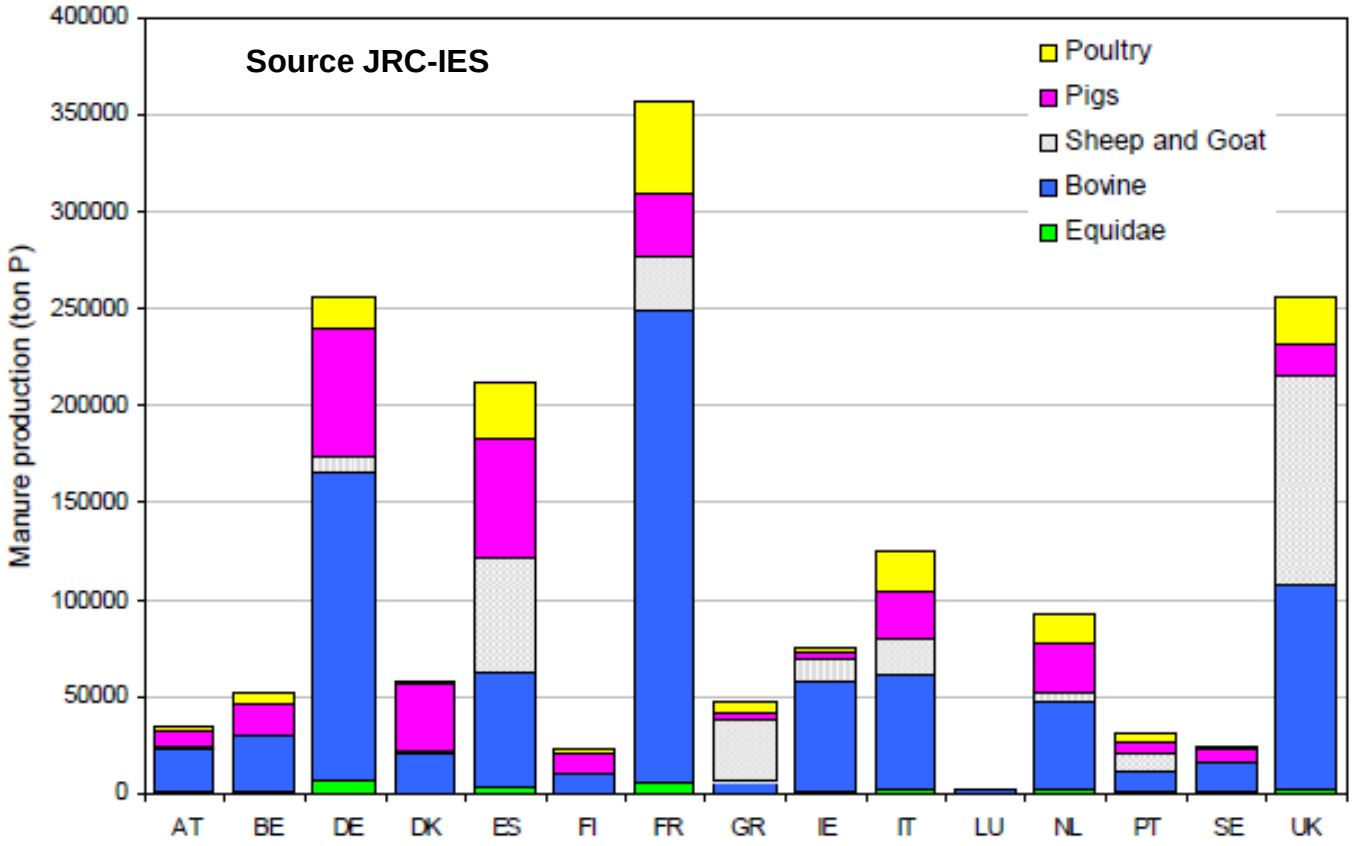
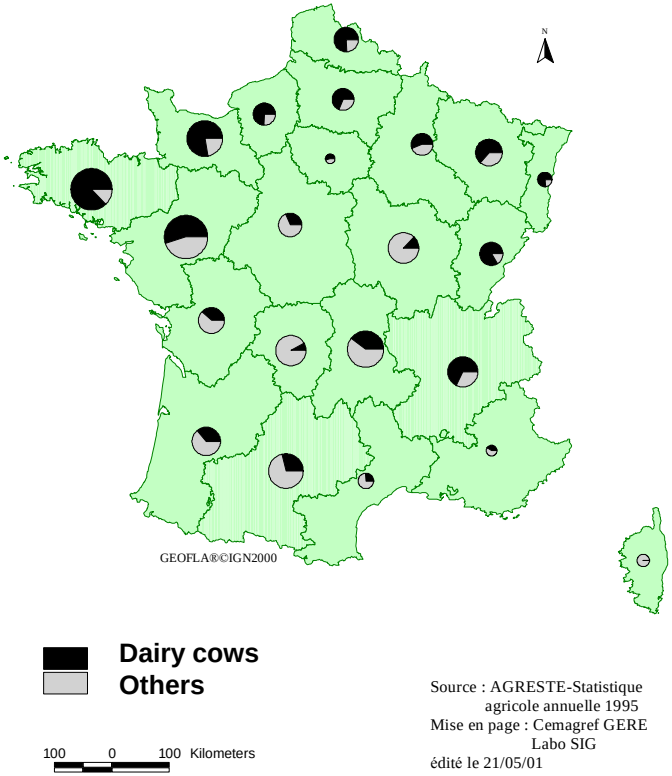


Figure 4.4 Estimated phosphorus manure production (ton P) distributed for different animal types for EU15 countries.

Most of the phosphorus is from bovine and other grazing animals

Phosphorus in animal manure : Cattle

Example for France (comparable to UK)



Bovine and grazing animals are spread over all the territory :

- **Manure is already used locally**

Grazing is still significant, bovine farms have usually enough land :

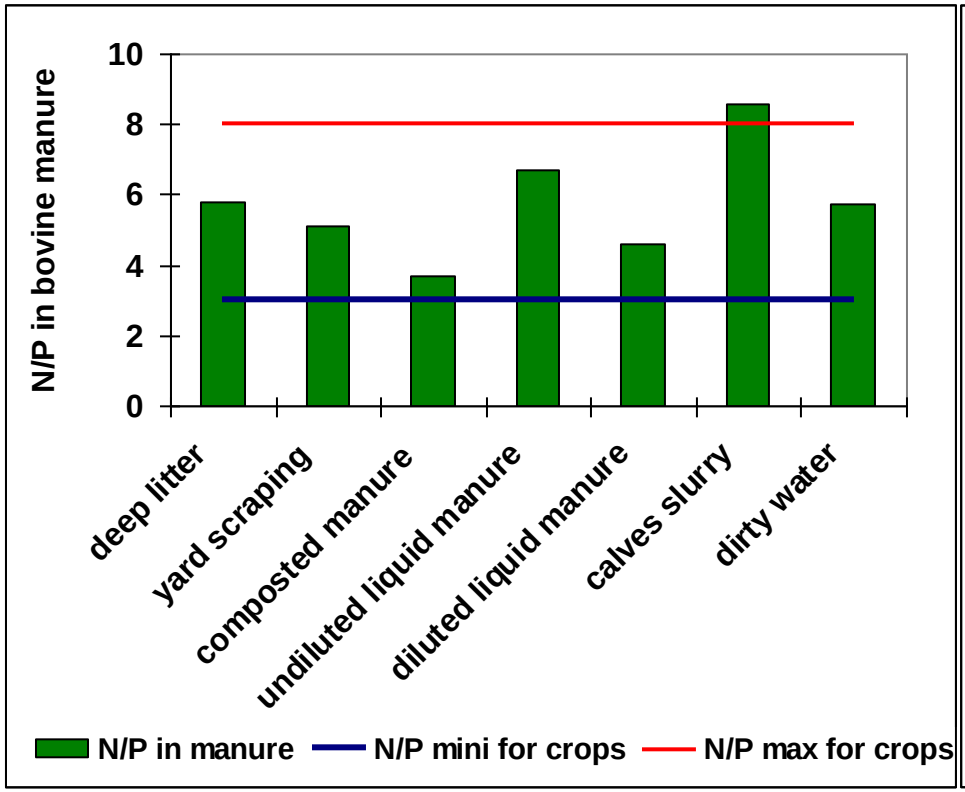
- **No or low surplus at the farm level**

Excepted in Netherlands

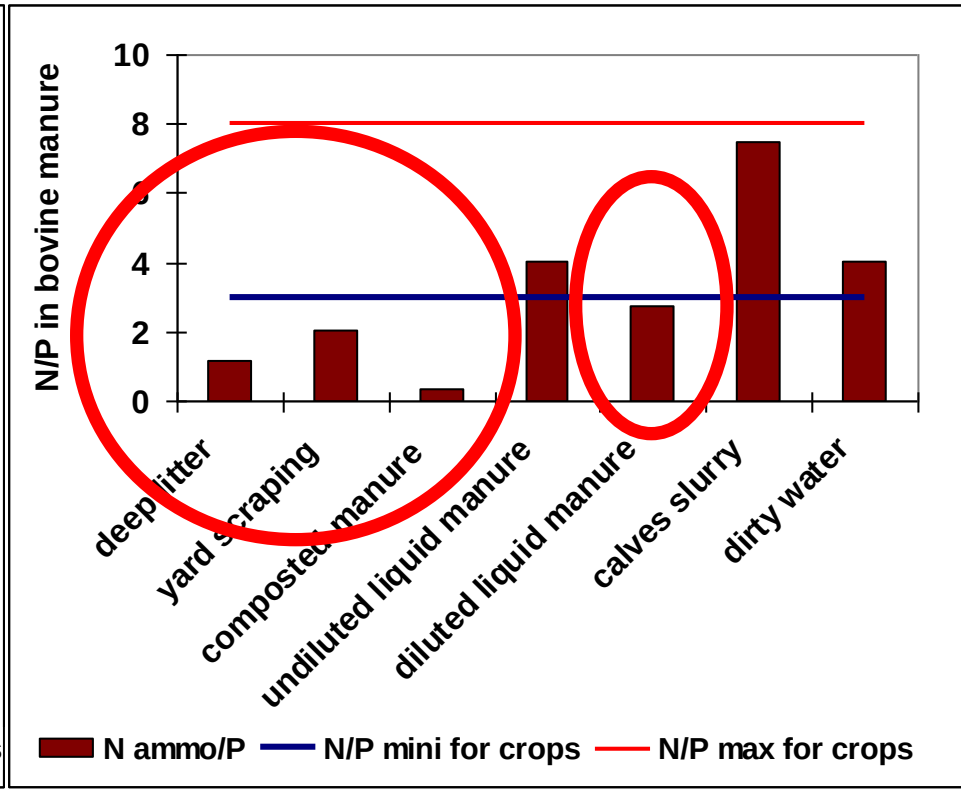
In the current context P from cattle manure is not an issue excepted in some cases
But it can become if bands are increasing without increasing the surfaces.

Phosphorus in animal manure : Cattle

Long term effect (NTK/P)



Short term effect (Namm./P)



Bovine manures are quite well balanced
Considering long term effect
(mineralization of organic nitrogen)

<u>P surplus in solid manures</u>

No surplus at farm level:

•Complementary mineral N

P surplus at farm level

n of the manure

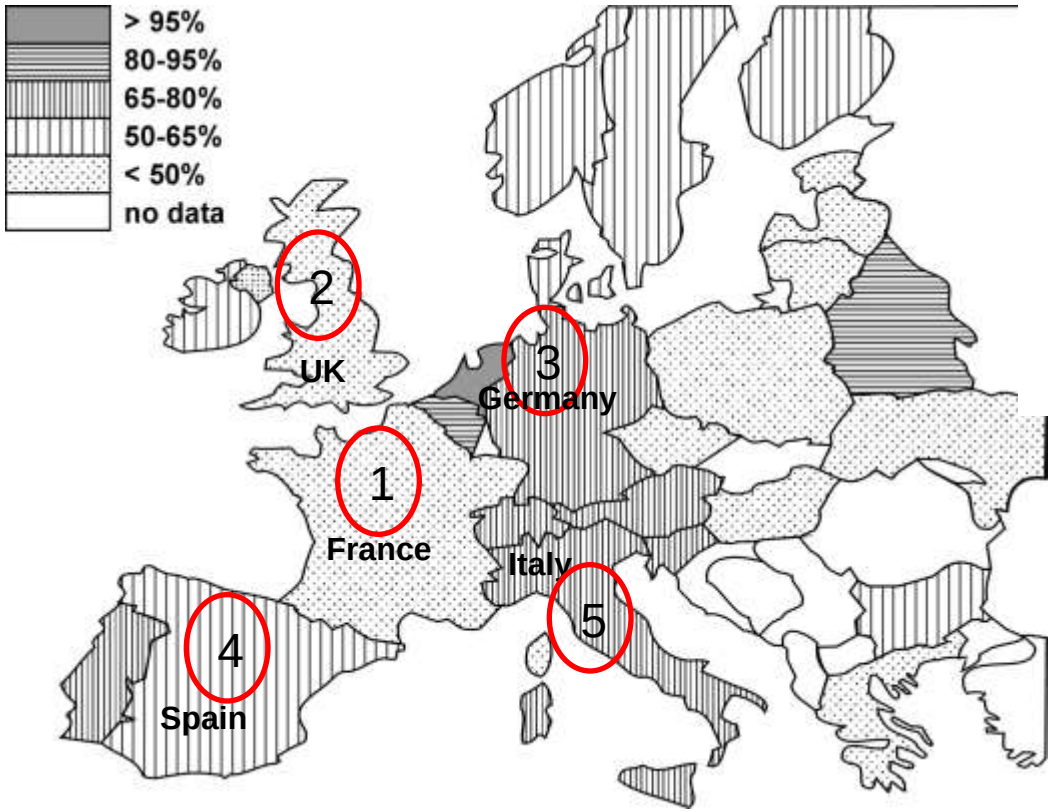
<u>P surplus in liquid manures</u>

•Recycling by extraction

Phosphorus in animal manure : cattle

P recycling by extraction will depend on the country

The proportion of manure from housed cattle produced as liquid on a country by country basis (Burton and Turner, 2003).



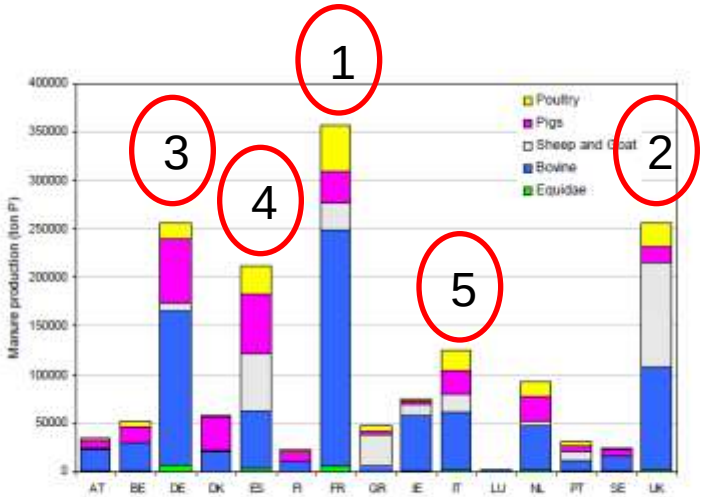


Figure 4.4 Estimated phosphorus manure production (ton P) distributed for different animal types for EU15 countries.

Liquid manure → **Extraction**

Solid manure → **Exportation**

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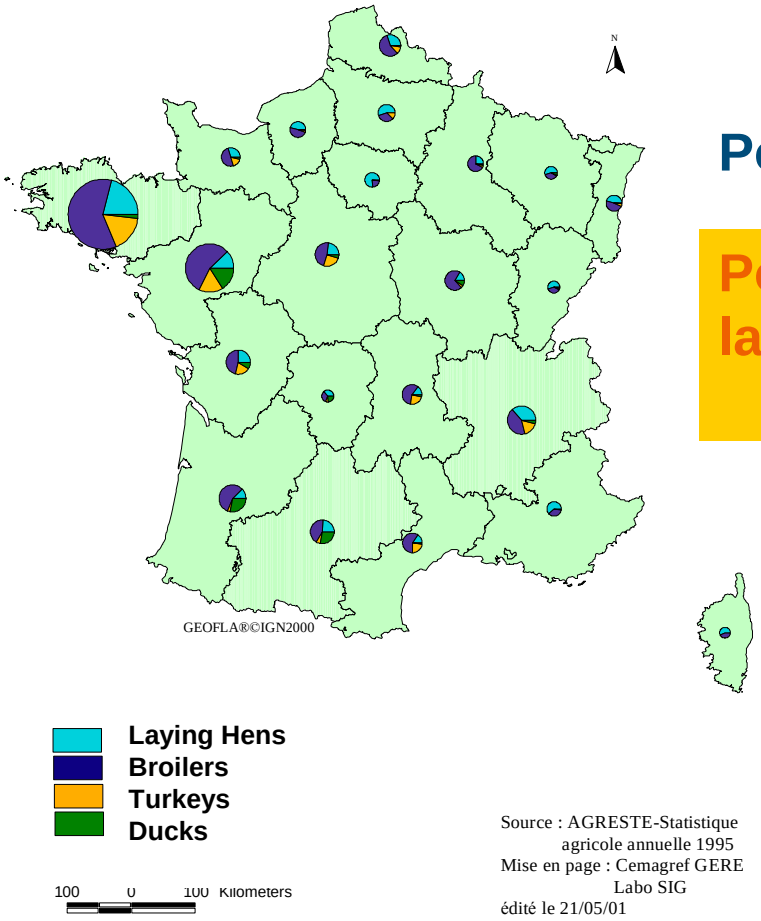
Phosphorus in animal manure : poultry

Example for France
(comparable to other countries)



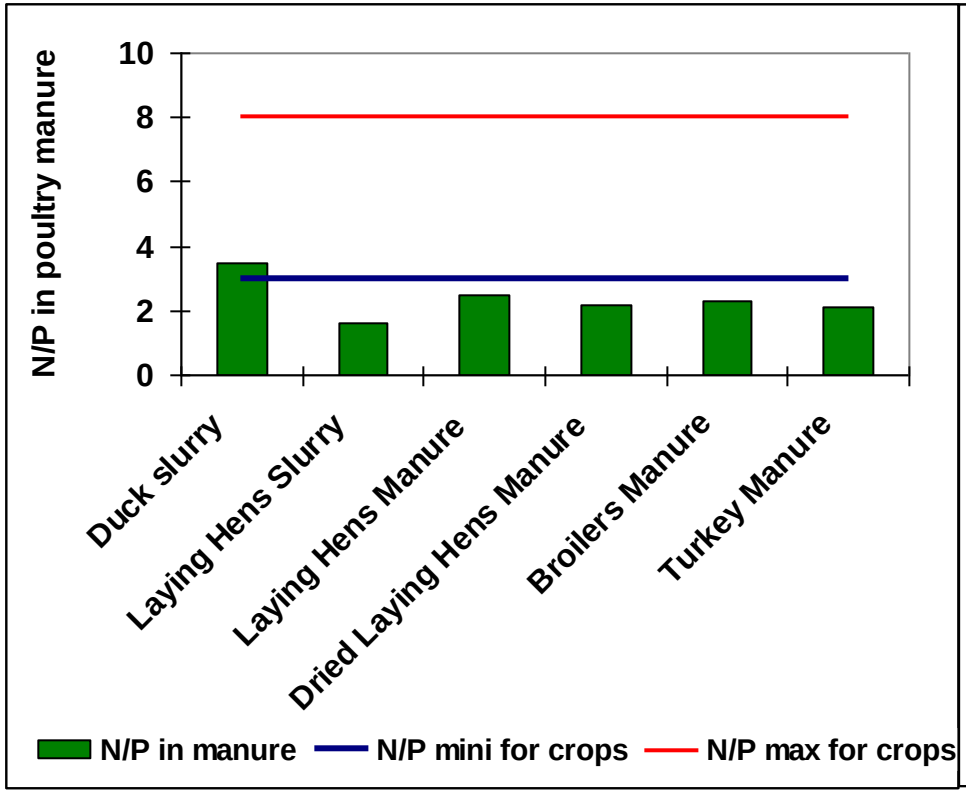
Poultry are in defined areas

Poultry farms have usually not enough land :

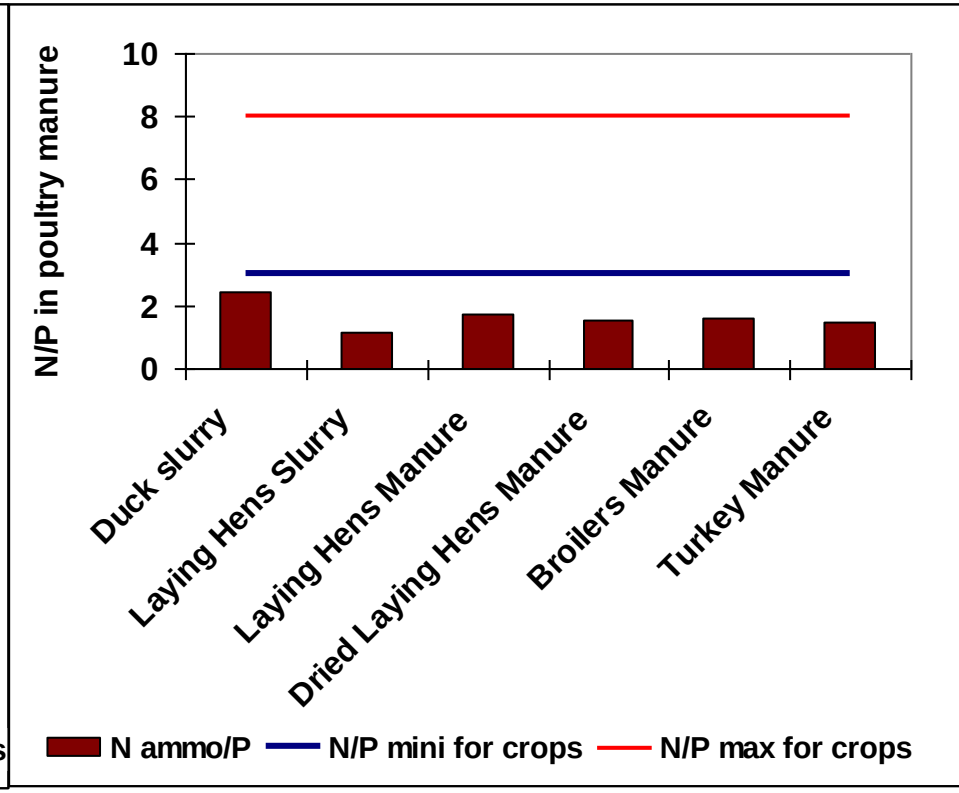
- **High surplus at the farm level**

Phosphorus in animal manure : poultry

Long term effect (NTK/P)



Short term effect (Namm./P)



<u>Poultry manures are not balanced</u>

<u>P surplus in liquid manures</u>

- Recycling by extraction (see below)

<u>P surplus in solid manures</u>

- High dry matter content
- Low bedding material
- Heat available

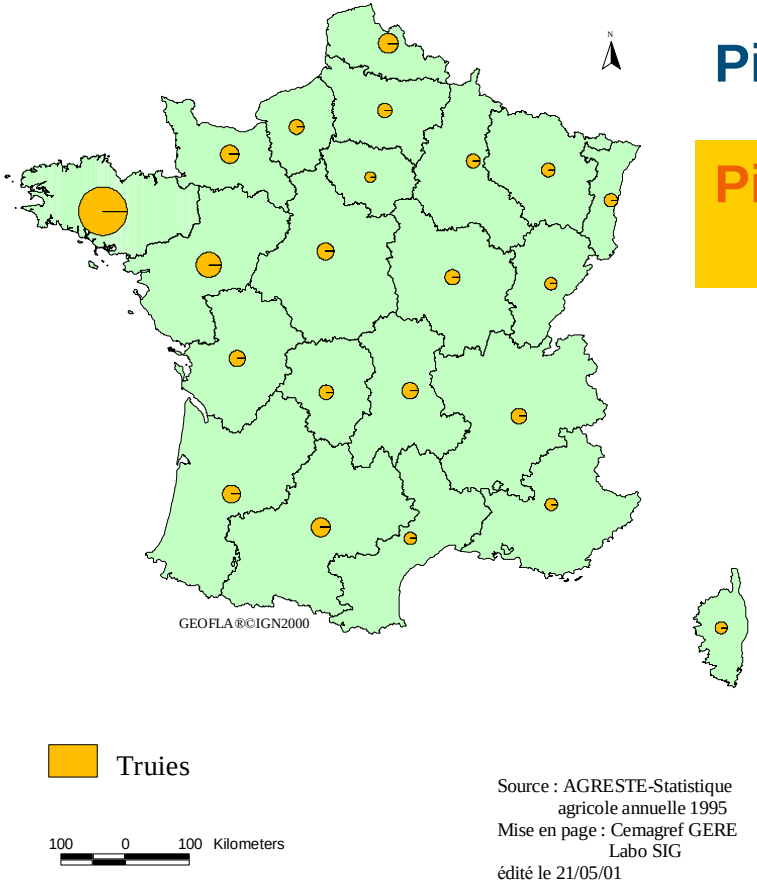
→ **Easy to dry and to export**

Phosphorus in animal manure : poultry

- **Other solution developed for solids**
  - **Combustion (in UK mainly): 3 units**
  - **The biggest one :**
    - ***400.000 ton dry solid poultry manure***
    - ***800-850° C***
    - ***Electricity produced 38.5 MW***
    - ***Supported with subsidies from a governmental program on non-fossil fuel electricity generation.***
    - ***Ashes used as K and P fertilizer***

Phosphorus in animal manure : pigs

Example for France
(comparable to other countries)

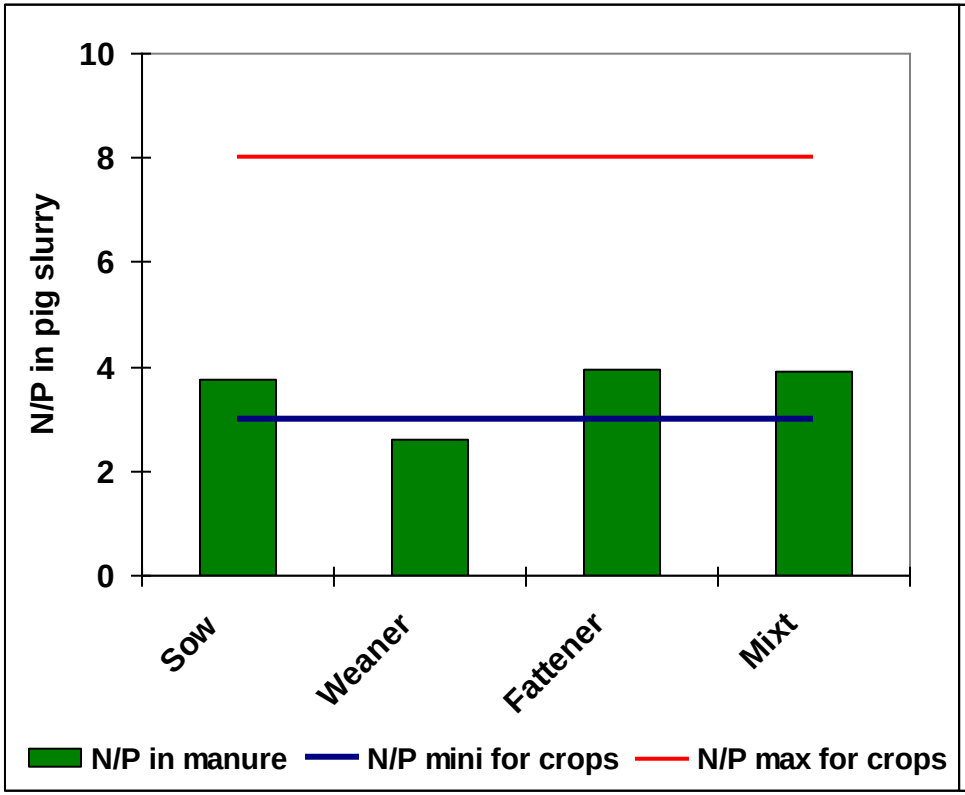


Pigs are in defined areas

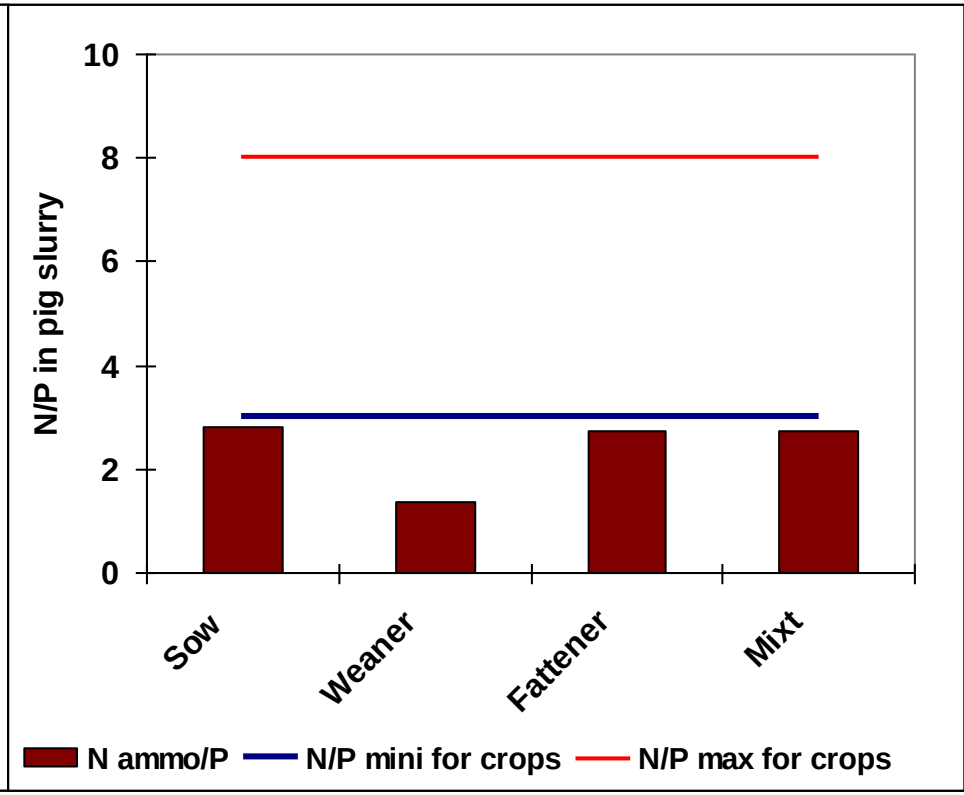
Pigs farms have usually not enough land :
➢High surplus at the farm level

Phosphorus in animal manure : pigs

Long term effect (NTK/P)



Short term effect (Namm./P)



<u>Pigs slurries are not balanced</u>

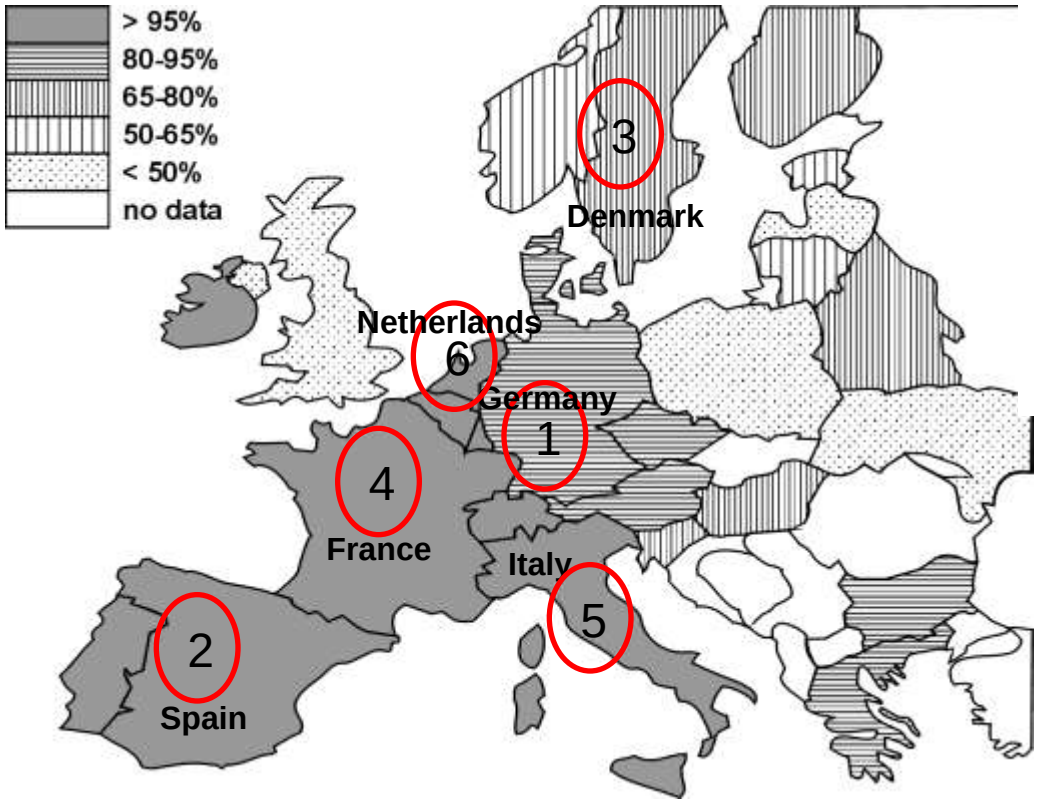
<u>P surplus in liquid (slurries)</u>

•Recycling (see below)

Phosphorus in animal manure : pigs

Main pig farmers are producing slurries (liquid manure)

The proportion of manure from housed pigs produced as liquid on a country by country basis (Burton and Turner, 2003).



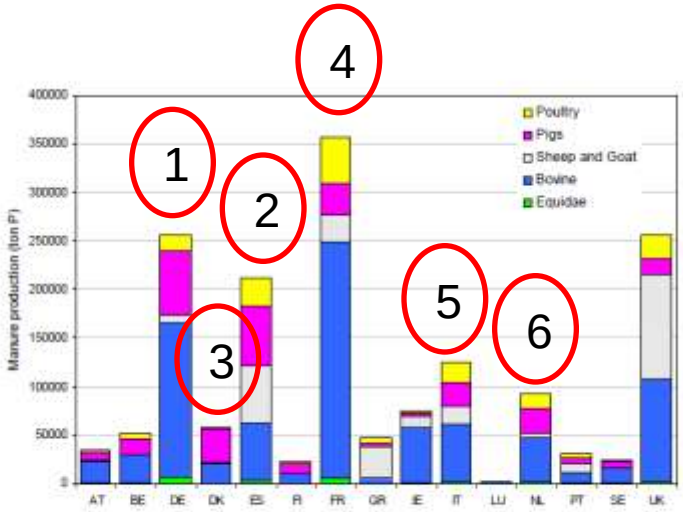


Figure 4.4 Estimated phosphorus manure production (ton P) distributed for different animal types for EU15 countries.

Liquid manure

Extraction

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Phosphorus in animal manure : conclusion

- **Most of P from animal is coming from cattle in Europe but**
  - **Cattle are spread over all the territory**
  - **In cattle farms, P surplus are low. Solids are in concern.**
    - **Local application complemented by mineral N fertilization when required.**
    - **Exportation of solid manure on short distances because of volume (bedding material) and dry matter**

- **Less than 10% of P is coming from poultry in Europe but**
  - **Poultry are produced in specific areas**
  - **In poultry farms, P surplus are high, solids are in concern**
    - **Exportation after drying is developed –medium distances- high dry matter, low bedding materials**
    - **Exportation of ashes after combustion (ashes used as mineral fertilizer, UK mainly)**

- **Less than 10% of P is coming from pigs in Europe but**
  - **Pigs are produced in specific areas**
  - **In pigs farms, P surplus are high, liquids are in concern**
    - **Exportation after mechanical separation is developed –short distances- (low dry matter)**

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P recycling from liquid manure: current techniques

History

Raw slurry

N : 3-4 kg.m^{-3}

P : 1 kg.m^{-3}

Nitrate directive

1991

43-57 kg P/ha

Low surplus

140-340 kg P/ha

High surplus

N and P have to be removed in the same ratio!

Recycling P from liquid manure: current techniques

- **P in liquid manure is as small and dense particles (calcium P or magnesium P) → Mechanical separation**
  - **Developed at a large scale only for pig slurry and mainly in France, Belgium and Spain**

Centrifuge decanter

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Recycling P from liquid manure: current techniques

Performances of separation devices

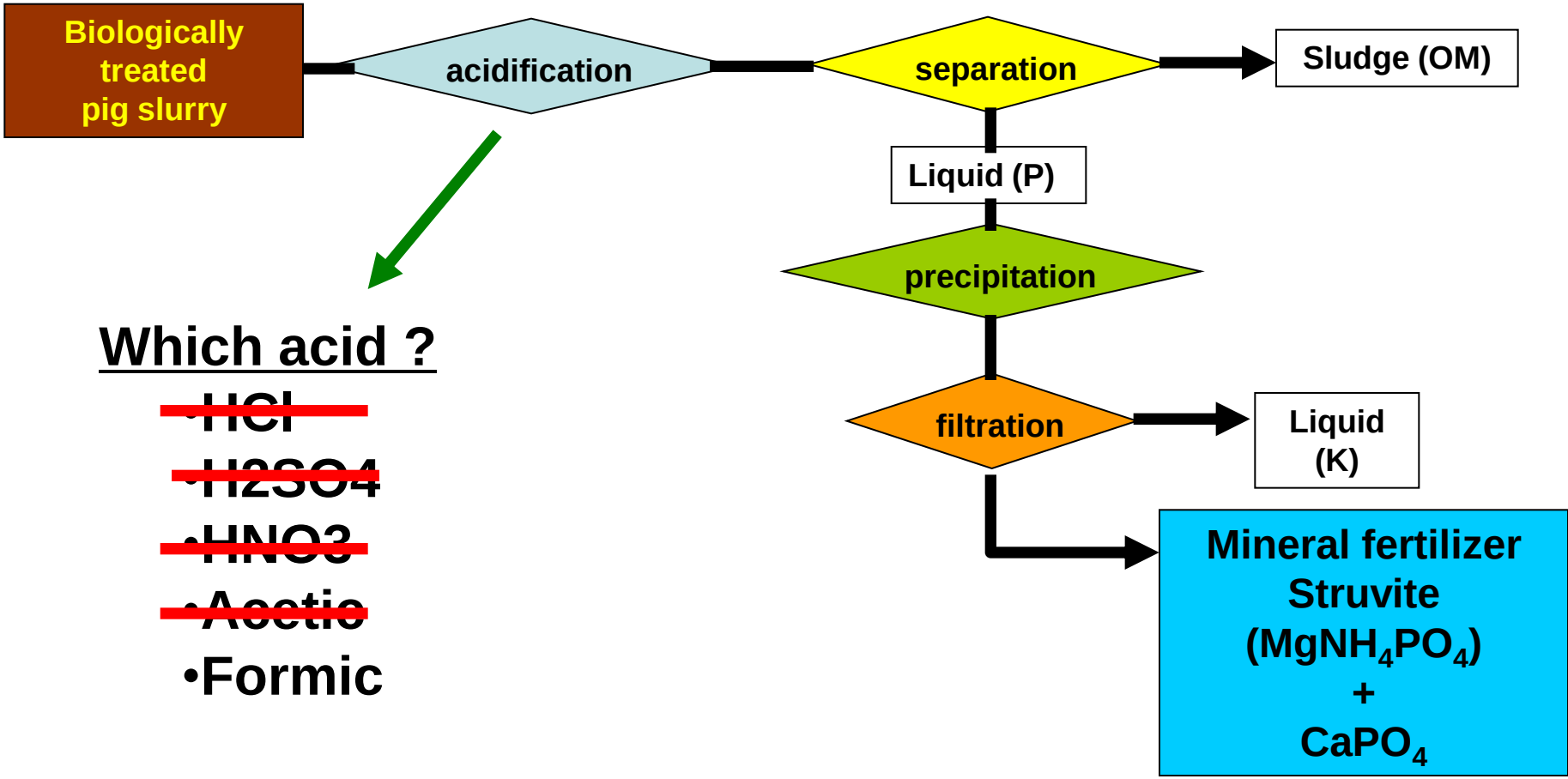
Press-auger

Recycling P from liquid manure: current techniques

- **Limits of mechanical separation**
  - Post-treatment of solid required
  - Product outlet (short distances- 20km)
  - Competition with other organic fertilizers (composts from household wastes)

- **Other techniques**
  - Developed only at pilot scale
  - Too sophisticated to be manage at farm level in European context
  - Too expensive

Recycling P from liquid manure: Perspectives

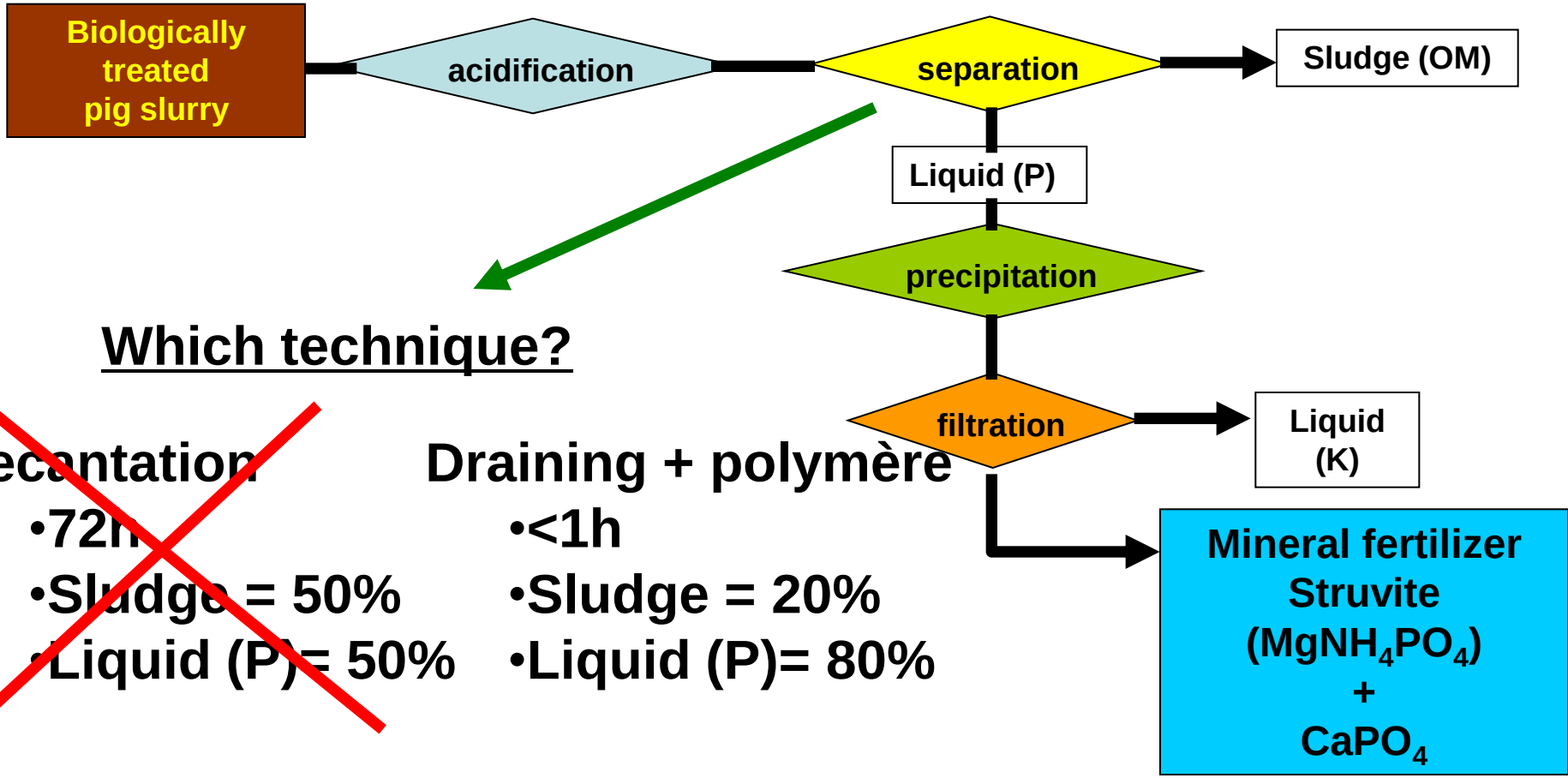


Which acid ?

- ~~HCl~~
- ~~H2SO4~~
- ~~HNO3~~
- ~~Acetic~~
- Formic

Technical approach 1

Recycling P from liquid manure: Perspectives



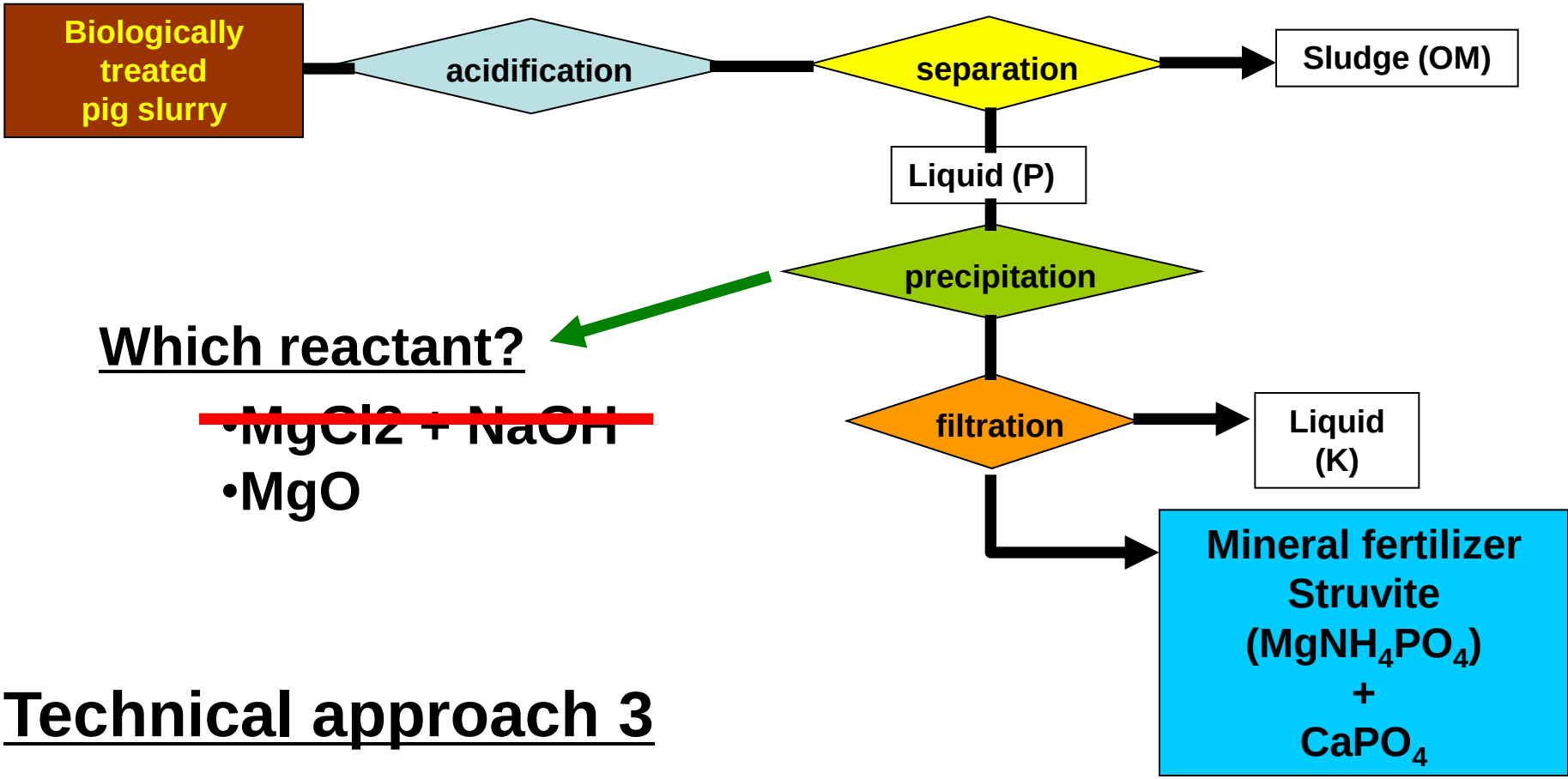
Which technique?

~~**Decantation**~~
- ~~**72h**~~
- ~~**Sludge = 50%**~~
- ~~**Liquid (P)= 50%**~~

Draining + polymère
- **<1h**
- **Sludge = 20%**
- **Liquid (P)= 80%**

Technical approach 2

Recycling P from liquid manure: Perspectives



Which reactant?

- ~~$MgCl_2$ + NaOH~~
- MgO

Technical approach 3

Recycling P from liquid manure: Perspectives

- **Mineral fertiliser quality**

	g/kg	
TS	838±1	
P	96±2	26%(P2O5)
NTK	4±1	<1%
Ca	142±26	24%(CaO)
Mg	70±10	14%(MgO)
K	50±4	7%(K2O)
Na	17±1	

- Normalized NPK (N-P2O5-K2O): 0-26-7 +24% of CaO +14% of MgO,.
- In compliance French standard NF U42-001/A8 class II (> 18% of P2O5+K2O).
- Close to the limits for class III products (fertilizers supplying calcium and magnesium).
- The neutralizing value of the products was not analysed in the present study.

Recycling P from liquid manure: Perspectives

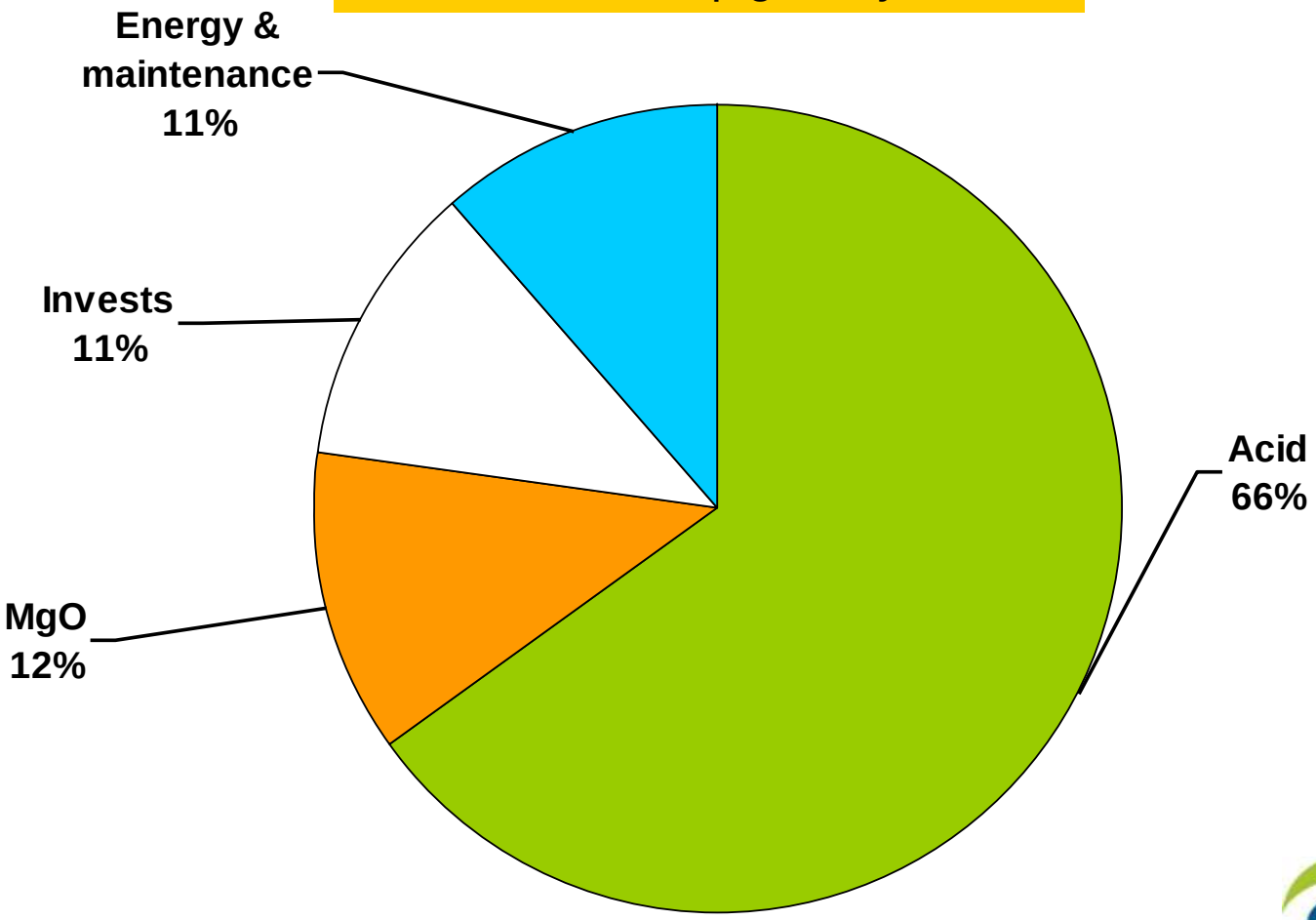
Economical approach

	Amount (kg/m 3)			
	Formic	Acetic		
Acid	8	20		
MgO	1	2		
Invest				
En.& Maint.				
Total				

Recycling P from liquid manure: Perspectives

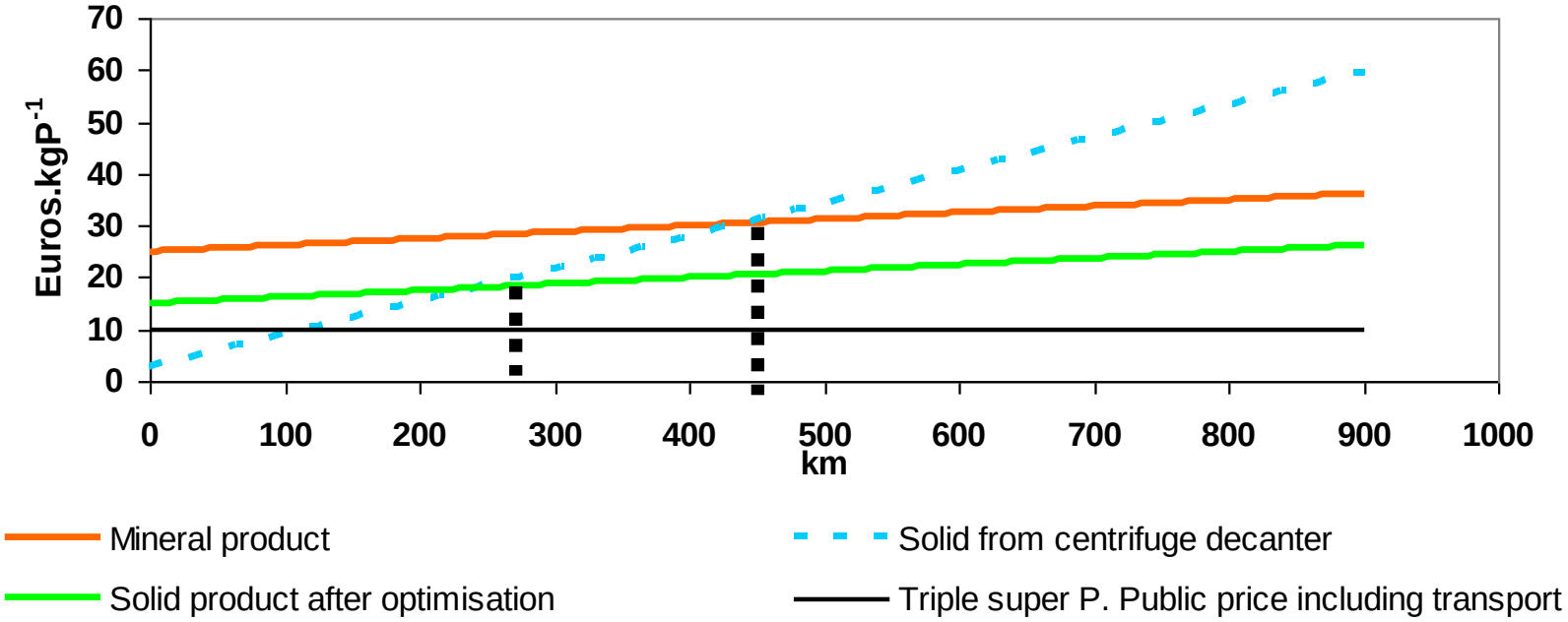
Economical approach

Total 12.3€/m^3 of pig slurry treated



Conclusions

- **Treatment point of view :**
  - cost >Centrifugation (2€/m ^{3}) but …
  - No further composting required
  - Product that can be sold
- **Fertilizing point of view *(first approxim.)*:**



Conclusions

- **Fertilizer point of view :**
  - Recycled P : 15€/kgP
  - Mineral P: 10 €/kgP (public price including transport)
  - In ten years?
  - Higher agronomic efficiency than current mineral P?
- **Ingoing works :**
  - Optimization
  - Full scale pilot for pig slurry and agro-food indutries effluents (dissolution not required)
  - Assessment of fertilizer value
  - Environmental assessment of the process

Thank you for your attention

More questions?

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www.cemagref.fr