Recycling of plant nutrients, especially phosphorus

Overview and preliminary results of the German Funding Programme

Univ.-Prof. Dr.-Ing. Johannes Pinnekamp
Dr.-Ing. David Montag
Dipl.-Ing. Wibke Everding
Institute of Environmental Engineering

7. FONA-FORUM
2.-4. November 2010

Contents

- Background
- R&D Initiative
- Project Overview
- Accompanying Project „PHOBE“
- „PASCH“-Project
- Conclusions

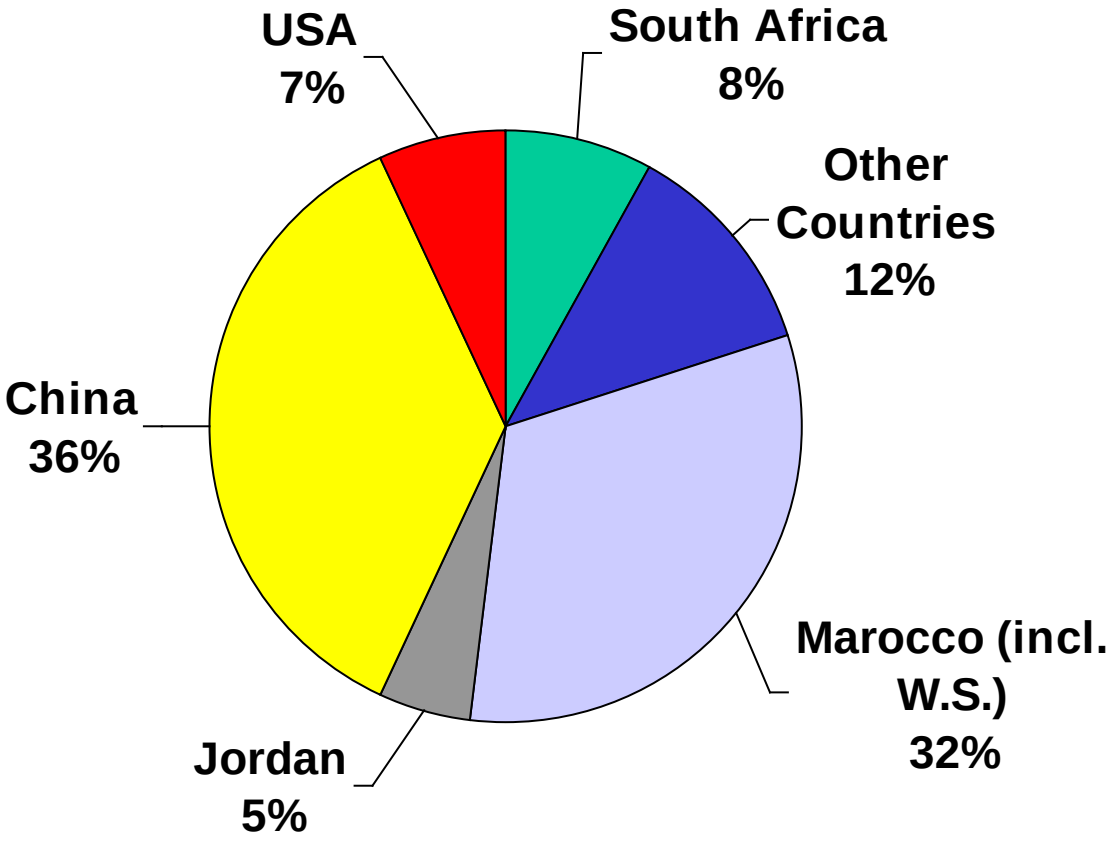
Contents

- Background
- R&D Initiative
- Project Overview
- Accompanying Project „PHOBE“
- „PASCH“-Project
- Conclusions

Background

- Approx. 30% of sewage sludge is utilised in agriculture to the purpose of plant fertilisation
- Not only nutrients but also heavy metals and other harmful substances spread onto the soil
- In Germany: discussion about the future of agricultural sludge utilisation; trend is incineration of sludge for total pollutant removal
- Without sludge usage in agriculture, nutrients have to be substituted by mineral phosphate fertilisers, phosphates can not be substituted
- Phosphate rock reserves (the “source” of phosphate fertilisers) are finite and non-renewable; those containing few contaminants are considerably exhausted (last for < 100 years).
- In terms of protecting the phosphate resource it’s especially important to evaluate possibilities to recover this nutrient from secondary raw materials, for example at wwtp’s

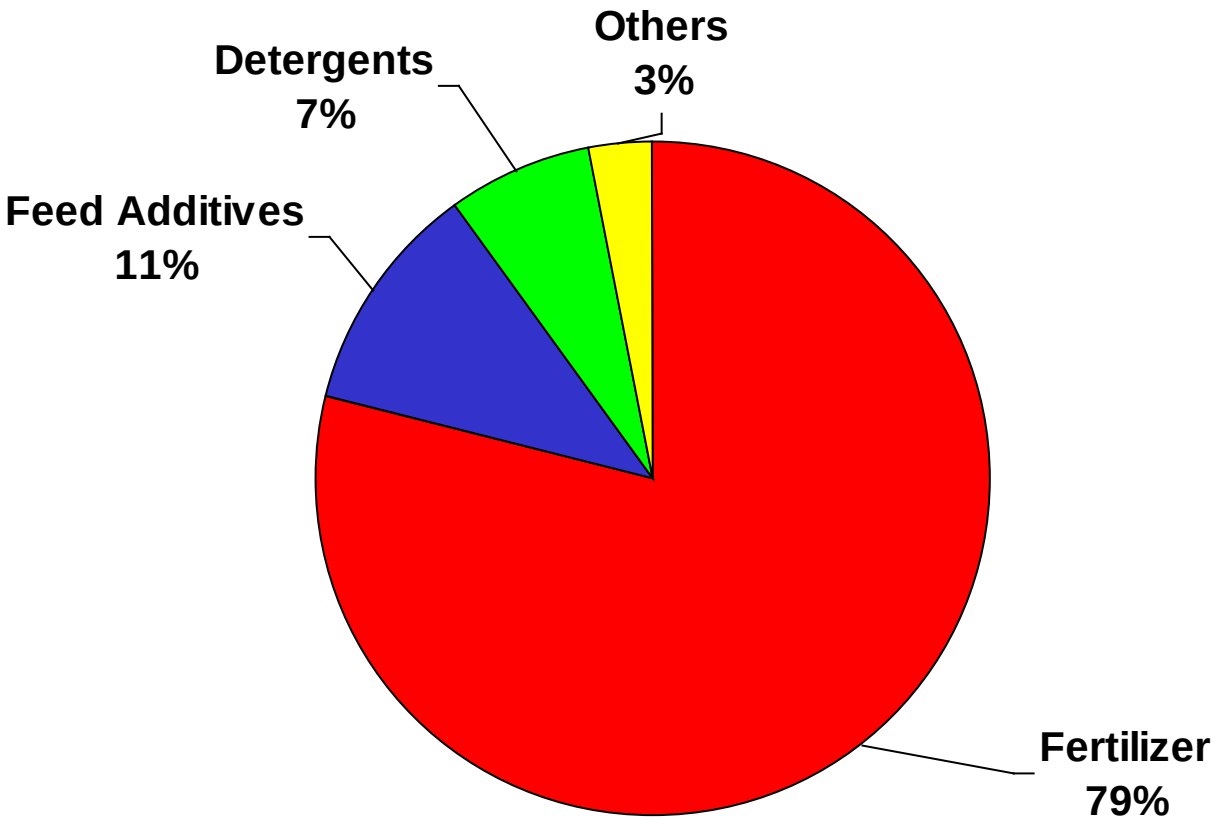
Global Distribution of Phosphate Reserves



➡ Static Lifetime of Reserves 90 – 120 years

data: USGS (2008)

Phosphorus Use in Western Europe



There are no substitutes for phosphorus in agriculture!

data: JOHNSTON und STEEN (2000)

Phosphorus Load at Wastewater Treatment Plants

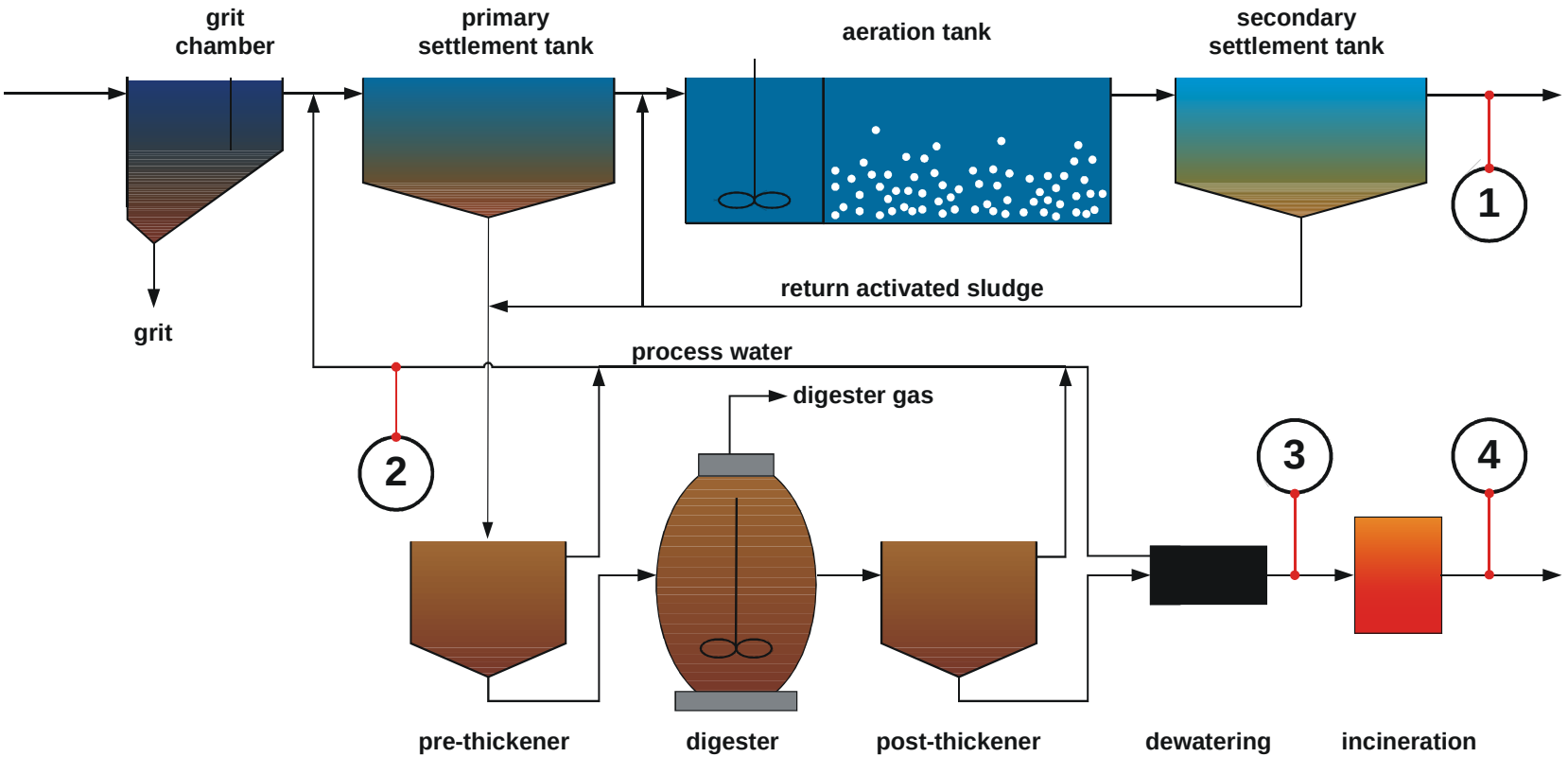
Phosphorus load at municipal WWTPs in Germany

- domestic wastewater: 54,750 t P/a [2.0 g P/(Inh.·d)]
- industrial wastewater: 18,250 t P/a
- Σ 73,000 t P/a

- Phosphorus removal (transfer into sludge) to prevent algal blooms in receiving waters (→ eutrophication)
- agricultural sewage sludge utilisation in Germany under consideration because of heavy metals, trace pollutants, endocrine disruptors, … (future: incineration)

- **solution: phosphate recovery from wastewater or sewage sludge with separation of nutrients and pollutants**

Integration and Add-on of Phosphorus Recycling



1 **effluent**

2 **sludge liquor**

3 **digested sludge**

4 **sewage sludge ash**

➡ differences in: potential of recovery, technology, costs, etc.

RWTH AACHEN UNIVERSITY ISA

Contents

- Background
- R&D Initiative
- Project Overview
- Accompanying Project „PHOBE“
- „PASCH“-Project
- Conclusions

German National Research & Development Initiative

- "Recycling management of plant nutrients, especially phosphorus"
- launched 2005

Federal Ministry for Education and Research

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

- Panel of Experts

Coordination

- Project Management Agency Forschungszentrum Karlsruhe, Water Technology and Waste Management Division (KIT)
- German Federal Environment Agency (UBA)
- runtime: 2006 - 2011

Status of BMU projects

- 19 sketches for demonstration plants
- Meat and bones, manure, wastewater, sewage sludge
- Panel of experts voted positive for approx. half of the ideas
- Up to now none of the projects has been finalized

Contents

- Background
- R&D Initiative
- Project Overview
- Accompanying Project „PHOBE“
- „PASCH“-Project
- Conclusions

BMBF Research Funding Program – projects I

Technical cooperative projects (1/2)

➡PASCH: Recovery of plant nutrients, especially phosphorus from sewage sludge ash

- RWTH Aachen University
- Aachen University of Applied Sciences,
- ATEMIS GmbH

acid leaching, liquid-liquid-extraction, precipitation, bioleaching

➡PHOXNAN: Optimised phosphorus recycling from wastewater sludge by the combination of low pressure wet oxidation and nanofiltration

- Bayer Technology Services
- RWTH Aachen University

oxidation, nanofiltration, crystallization

➡PROPHOS: Phosphorus recovery from wastewater, sewage sludge and incineration ash

- Darmstadt University of Technology
- University of Karlsruhe
- Gottfried Wilhelm Leibnitz University Hannover

elution, adsorption, crystallization

BMBF Research Funding Program – projects II

Technical cooperative projects (2/2)

➡RECYPHOS: Phosphorus recycling – Substainability contribution to decentral wastewater treatment

- TU Dresden
- BTU Cottbus
- Bergmann Waste Water Engineering

Adsorption, desorption, precipitation

➡PHOSIEDI: Phosphorus Recovery using Ion-Exchange and Electrodialysis

- University of Karlsruhe

ion-exchange, elektrodialysis

BMBF Research Funding Program – projects III

Accompanying projects

➡PhoBe: Recycling of Phosphorus – Ecological and Economic Evaluation of Different Processes and Development of a Strategical Recycling Concept for Germany

- RWTH Aachen University
- Fraunhofer Institutes IME and ISI
- Justus-Liebig-University Giessen
- Institute for Energy and Environmental Research Heidelberg GmbH

➡Phosphorus recycling – Characterisation of the effect of recycled phosphate fertiliser by field and pot experiments

- Georg-August-University Göttingen

www.phosphorrecycling.de

BMBF/BMU Funding Programme

"Recycling management of plant nutrients, especially phosphorus"

Mainmenu

- Home
- Funding Programme
- Objective
- BMBF-Projects
  - PhoBe
  - Göttingen
  - PASCH
  - Phoxnan
  - ProPhos
  - RECYPHOS
  - PHOSIEDI
- BMU-Projects
- Dates
- Publications
- About us

Username

Password

Home ◆ BMBF-Projects

BMBF-Projects

Seven projects are promoted in the funding programme "Recycling management of plant nutrients, especially phosphorus" by the German Federal Ministry of Education and Research (BMBF) and are coordinated by the Project Management Agency Forschungszentrum Karlsruhe, Water Technology and Waste Management Division (PTKA-WTE). The seven research and development projects are composed of two accompanying and five technical projects.

Both accompanying projects work in close collaboration to permit a comparability of the achieved results.

Accompanying projects:

Accompanying project **PhoBe**: Recycling of Phosphorus - Ecological and Economic Evaluation of Different Processes and Development of a Strategical Recycling Concept for Germany

„Phosphorus recycling - Characterisation of the effect of recycled phosphate fertilisers by field and pot experiments" of the Department of Agricultural Crop Sciences, Georg-August-University **Göttingen**

Technical projects:

Cooperative project **PASCH**: Recovery of plant nutrients, especially phosphorus from ash of sewage sludge as well as meat- and bone meal

Cooperative project **PHOXNAN**: Optimised phosphorus recycling from waste water sludges by the combination of low pressure wet oxidation and nanofiltration

Cooperative project **PROPHOS**: Phosphorus recovery from wastewater, sewage sludge and sewage sludge ashes

Cooperative project **RECYPHOS**: Phosphorus recycling - Sustainability contribution at the decentral wastewater treatment

Project **PHOSIEDI**: Phosphorus Recovery using Ion-Exchange and Electrodialysis"

Contents

- Background
- R&D Initiative
- Project Overview
- Accompanying Project „PHOBE“
- „PASCH“-Project
- Conclusions

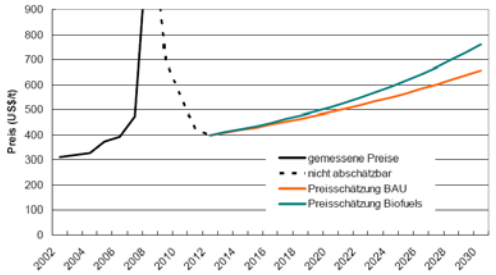
PhoBe I

Analysis of the medium and long-term global price development of phosphate (Fh-ISI)

➡Two scenarios with 1 and 2% increase of the phosphate consumption

➡Price development of phosphoric acid from 2007 to 2030 :

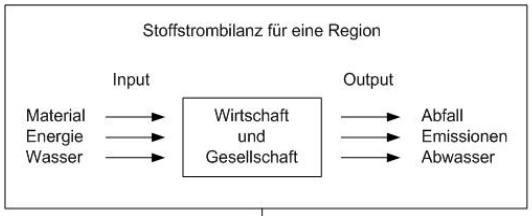
- ➔ scenario 1%: from 400 to 660 US$/t
- ➔ scenario 2%: from 400 to 760 US$/t



Identification and balancing of material flows in Germany, which are capable for phosphorus recovery (ISA RWTH Aachen)

➡stock flow which can be used in Germany for phosphorus recycling:

- ➔Waste water from industry and households
- ➔Sewage sludge
- ➔Manure



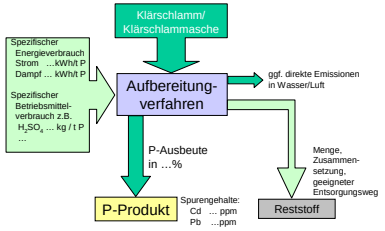
PhoBe II

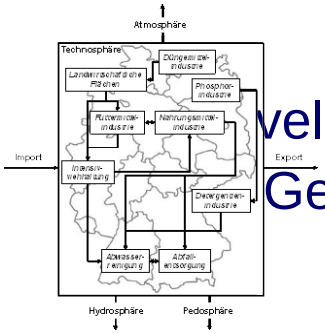
Analysis of the fertilising effect and detection of possible harmful environmental impacts of the products generated in the funding programme (Fh-IME, ILR Gießen)

- ➡struvite meets the limit values of DüMV
- ➡No significance in yield between TSP and struvite
- ➡struvite fertilise better than CaP (from ash) and ashes

Cost estimation and life cycle assessment of the processes developed within the funding programme (ISA RWTH Aachen, Ifeu Heidelberg)

- ➡Specific costs: 2 – 13 €/kg P





velopment of a phosphorus recovery concept
Germany (ISA RWTH Aachen)

PhoBe III

Identification of processes which can give additional impulses to the medium-term technology development (Fh-ISI)

- Survey of experts:
  - P recovery will be introduced and economical till 2030 in industrial countries
  - Prerequisite: Recovered Phosphorus should be “clean” and available for plants

Estimation of a future commercialisation of phosphorus recovery technologies in Germany and by German business (Fh-ISI)

Brochure and Workshop September 14th 2011, Berlin

Contents

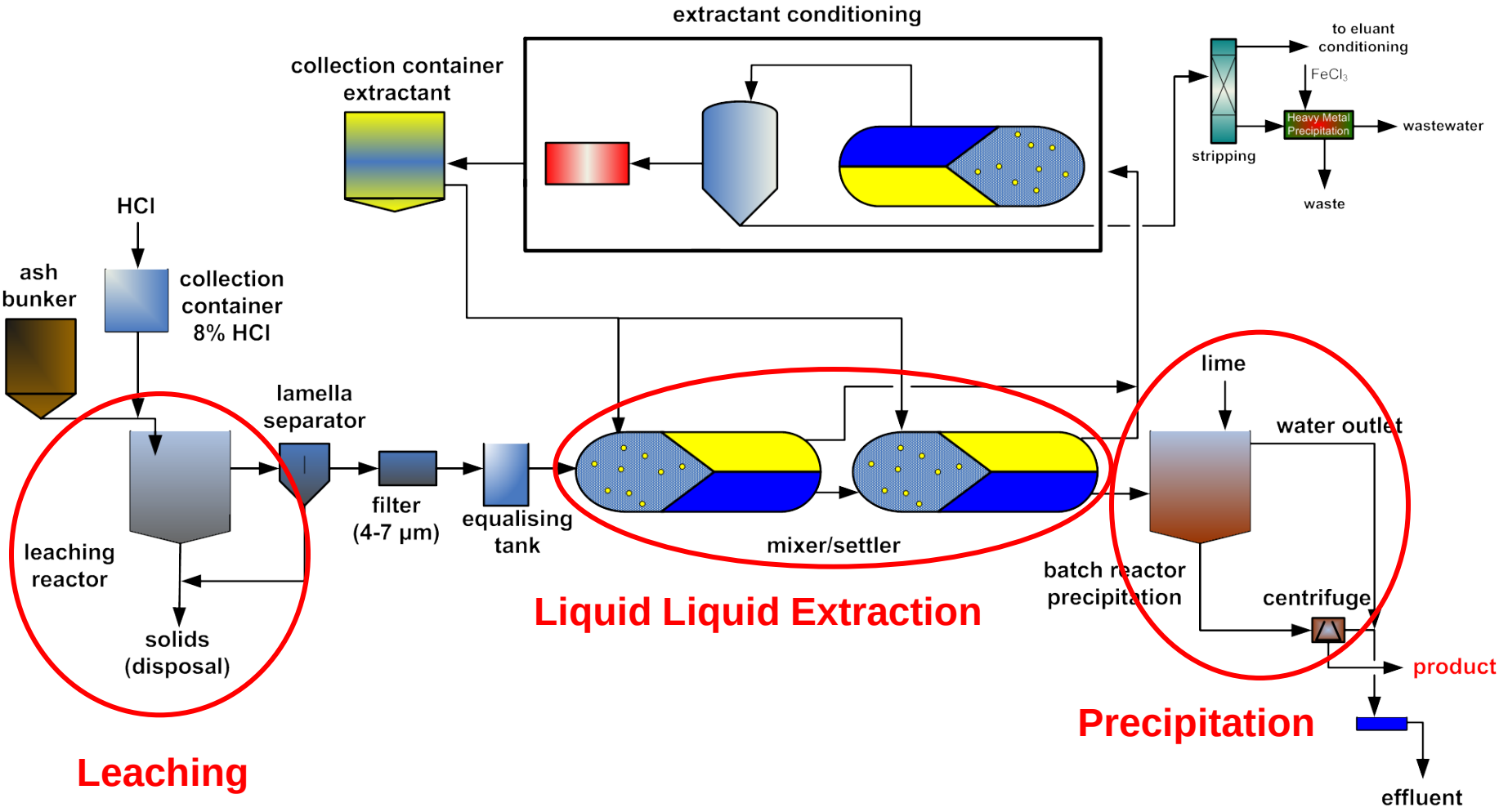
- Background
- R&D Initiative
- Project Overview
- Accompanying Project „PHOBE“
- „PASCH“-Project
- Conclusions

PASH Process - Phosphorus recovery from Ash

- Highest potential of P recovery: 90%
- Potential in Germany : 16,000 tons P/a (seperate incineration capacity)
- Recovery not possible directly but P release from the ash necessary
- Investigations in laboratory and pilot scale

- Project Management
  - Institute for Environmental Engineering of RWTH Aachen University
- Project Partners
  - RWTH Aachen University
    - Coking, Briquetting and Thermal Waste
    - Hygiene and Environmental Health
    - Thermal Process Engineering
    - Waste Management
  - **Aachen University of Applied Sciences**
    - Applied Polymer Sciences
  - **ATEMIS Consulting Engineers, Aachen**

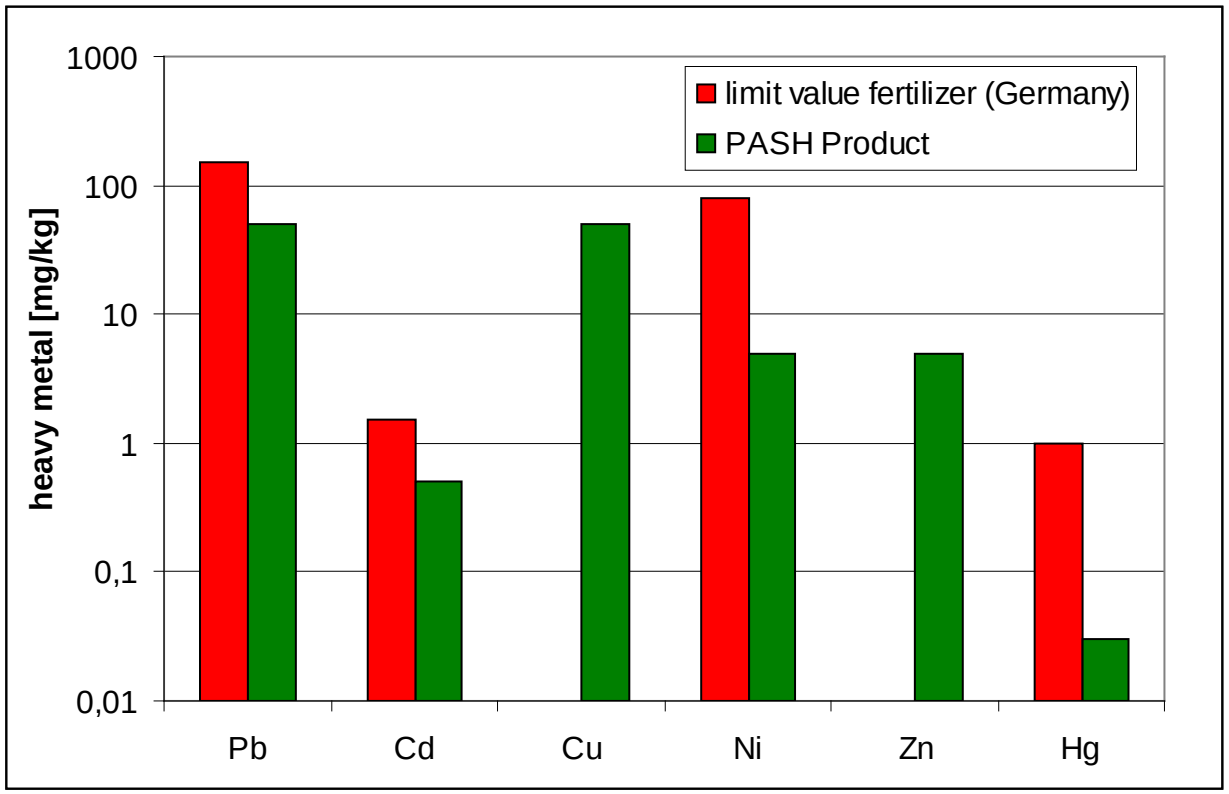
PASH – Flow Sheet (simplified)



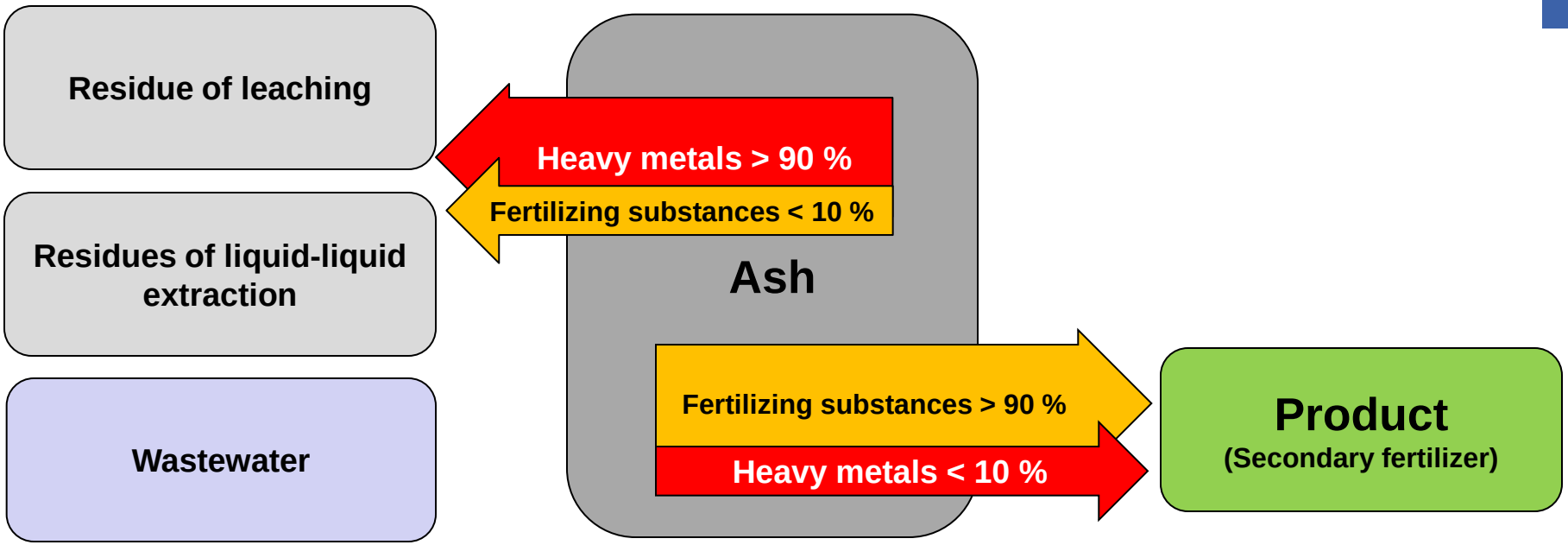
PASH – Product Quality

➔ Heavy Metal Content:

3 – 30% of limit value



PASH – ecological aspects



- Compared to the origin substance (sewage sludge ash) the PASH process residues are not increased in quantity and hazardousness.
- The environmental risk potential of the PASH fertiliser is lower than TSP (30%; reference $PNEC_{soil}$).
- The environmental effects of the PASH process are lower in comparison to the fabrication of superphosphates (incl. mining, enrichment/purification, production).

LFA RWTH Aachen

Contents

- Background
- R&D Initiative
- Project Overview
- Accompanying Project „PHOBE“
- „PASCH“-Project
- Conclusions

Conclusion and Future Prospects

- Phosphorus is a scarce resource
- Phosphorus demand in industrialised countries is stagnating but in developing countries increasing with constant rise in population and economic growth (especially India, China)
- No phosphate deposits in Europe → totally dependend on imports
- Important phosphorus source: Wastewater/Sewage Sludge

Conclusion and Future Prospects

- Products meet the requirements of the phosphate industry and agriculture
  - separation of pollutants and nutrients
  - products proofed a good plant availability
- Due to low prices for primary phosphate products (fertilisers) a recycling seems to need subsidisation. Economic advantage of primary fertilisers results from lower environmental standards in mining countries (amongst others).
- Phosphate Recovery has to become part of sustainable sludge management in the future. Several technologies are ready for industrial scale implementation.

Thanks to …

FKZ 02WA0793, 02WA0794, 02WA0795
FKZ 02WA0805, 02WA0806, 02WA0807, 02WA0808

Thank you for your attention!