



Requirements for recycled P from the perspective of fertiliser industry

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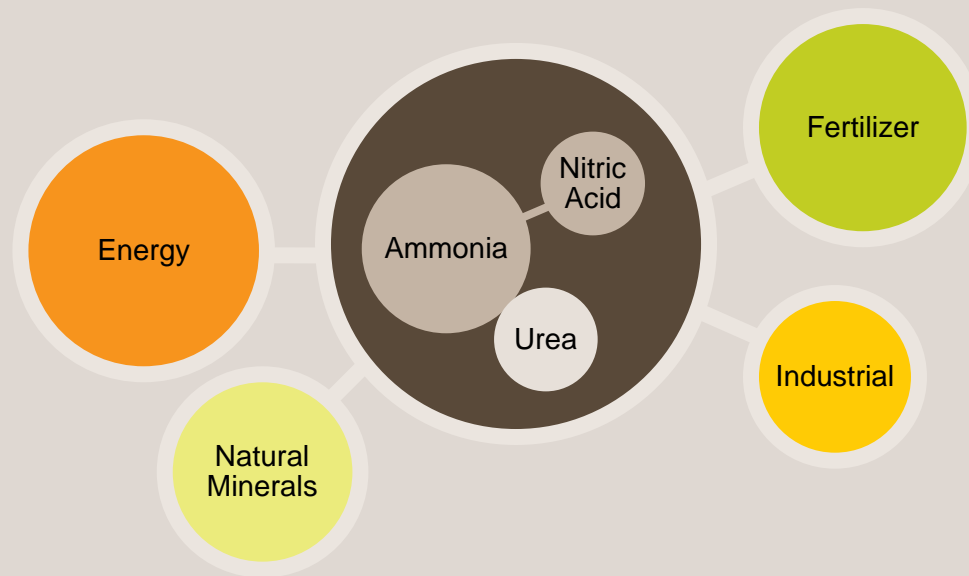
PRESENTATION OVERVIEW

- Yara International ASA - a major fertiliser producer in Europe and globally
- Fertiliser products - various combinations of main and micro nutrients
- Fertiliser production - regulations and other commitments set to the manufacturers
- Phosphorus - raw materials to day and in future
- Recycled phosphorus - alternative to rock phosphate?
- Various options to use Recycled P as fertiliser or fertiliser raw material
- Conclusions



Yara International ASA - What we do

- Yara is a leading chemical company that converts energy, natural minerals and nitrogen from the air into products for farmers and industrial customers.



Yara International ASA - business structure



Downstream



Industrial



Upstream



What is a fertiliser?

- Fertilisers are used to supplement the plant nutrients available from soil and thus maintain the soil fertility.
- Manufactured fertilisers contain at least 5 % of one or more of the three primary nutrients (N, P, K)
- In the market there are straight fertilisers and/or multinutrient fertilisers
- In addition to the three primary (or main) nutrients fertilisers may contain secondary nutrients (Ca, Mg, S) and micronutrients (Mn, B, Zn, Fe etc.)
- The physical form of a fertilisers must ensure good and efficient application and spreading on the soil.



Yara provides optimum main and micro nutrient combinations for the needs of various crops under various soil and climate conditions



Foliars



Fertigation



Dry/Soil Application



FERTILISER MANUFACTURING - a strictly regulated business within EU

- Product regulations are given either in EU directive 2003/2003 and/or in national fertiliser ordinances of each member state
- In legislation, fertiliser products are categorized according to main nutrient content, such as NPK-, NP-, NK-, N-, P-, and K-fertilisers
- Legal regulations set targets for minimum amount of each nutrient, solubility limits for the nutrient components and occasionally control even the allowed raw materials
- If the products are according to EU-regulations, they have the EC-fertiliser status and they can be freely transported and delivered within EU member states
- However, in each member states there are still many national fertiliser grades in use. They are controlled by national ordinances.
- **ANY NEW FERTILISER GRADE MUST FULFILL DEMANDS SET BY THESE REGULATIONS**



Manufacturers other commitments

- **Product Stewardship Program**
 - to ensure that fertilisers and their raw material and intermediate products are processed, manufactured, handled, stored, distributed and used in a proper way with regard to health, environment and safety.
- **Sustainability in European Farming**
 - full support to integrated farming systems as appropriate in different regions in Europe
 - covers good soil management, sound cultivation practices, crop health, biodiversity issues, reduction of negative environmental effects and the profitability of the farm.
- **Agricultural best management practices (BMPs)**
 - right product, right rate, right time, right place
 - BMPs are site-specific and crop-specific and in each case the practices should help to ensure that fertiliser uptake and removal by target crops is optimized and fertiliser loss to the environment is minimized.



Phosphorus:

The main raw material to day is phosphate ore either from igneous or sedimentary origin



Siilinjärvi, Finland - the only exploitable apatite mine in Western Europe (igneous origin), Production 850 000 tons/a ($P_2O_5 = 36\%$)

The main commercial phosphate deposits globally are in the United States, Russia, Morocco and China



Can we substitute phosphate ore with recycled phosphates and how to do it?

- When speaking about recycled phosphates, I refer to MBM, sewage sludge and other ashes, manure etc.
- Three different options:
 1. The use of recycled material as a fertiliser as such
 - straight P-fertiliser with low content of any other nutrients
 2. The use of recycled phosphates as raw material in present fertiliser manufacturing processes
 3. To design and develop a totally new production concept for fertilisers based on recycled materials



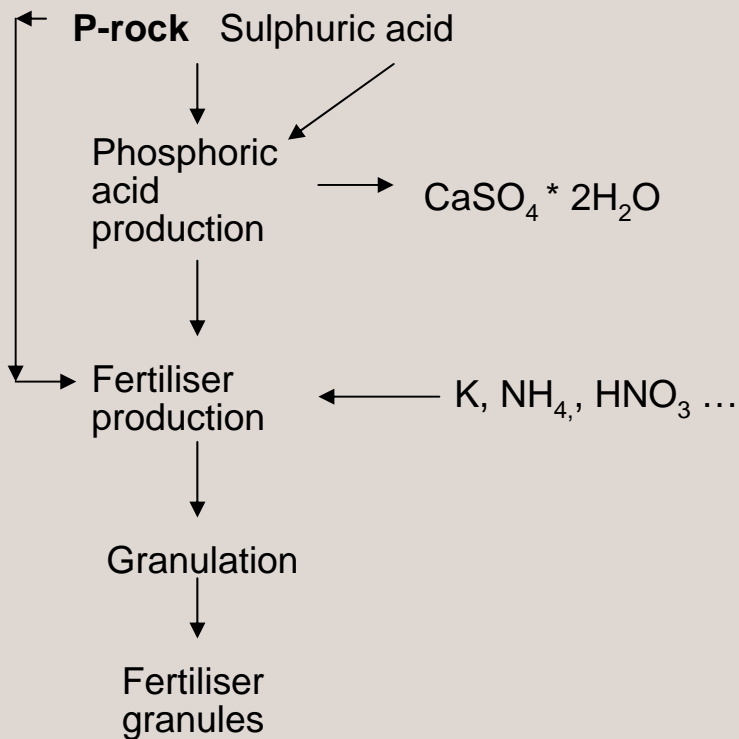
1. The use of recycled material as a fertiliser as such without extra chemical processing

- Nutrient content - optimum for which soil, which crop etc.?
- How stable chemical quality between various lots?
- Physical form - powder, granules, briquettes ... etc.
- Transportation and spreading quality? - Dustiness, humidity resistance...?
- Nutrient availability to plants - P and other nutrient solubilities?
- Nutrient content and solubility vs. specific crop and soil needs?
- Stable low enough impurity level (Cd, Hg, toxics)

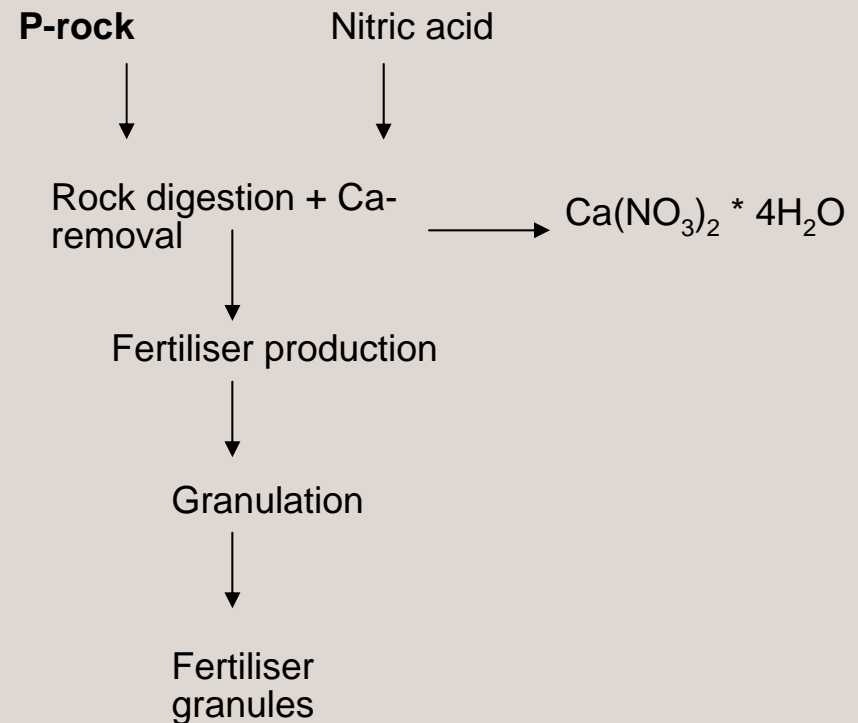


2. The use of recycled phosphates as raw material in present fertiliser processes

- **Mixed acid process:**



- **Nitrophosphate process:**



Criteria for phosphatic raw materials in fertiliser industry to day

- *Total phosphorus content* (usually 15-20 % P)
- *Impurity level*
 - elements such as Ca, Fe, Al, Mg, F, Cl, Si define how well P-minerals suit the production process (**scaling, corrosion, unexpected side reactions**)
 - Heavy metals and radioactive elements affect the purity level of final end products (**security in food chain, safety in production, avoidance of soil contamination**)
 - esp. Cd-content is widely discussed and regulated in relation to P-fertilisers (Special limits for instance in Finland, Austria, Sweden)
- *Constant availability and stable quality of various raw material lots* (**production process stability, stable product quality**)
- *Reactivity in production process* (**right product composition, right nutrient solubilities and suitable physical quality in final products**)
- *If recycled phosphates are used instead of rock phosphate as raw material in current production processes, all these criteria must be fulfilled.*



Phosphate ore vs Recycled phosphates (mainly ashes) as raw material in present fertiliser process

Phosphate rock

- Chemically mainly $\text{Ca}_3(\text{PO}_4)_2$
- Stable quality and available in big amounts
- High total P-content
- Sometimes high Cd-content
- Sometimes problems with radioactive elements
- Well suitable for reaction conditions in current processes

Recycled phosphate

- Fe-, Al-, Mg-, Ca-phosphates, struvites etc.
- Various lots with different compositions from many different sources
- Total P-content depends on origin and treatment process
- Sometimes high heavy metal content
- Fear of unexpected impurities (organics, pathogens, hygiene problems)
- Dusting problem in transportation, storage and feeding to process



Quality demands for recycled phosphates when used in fertiliser manufacturing

- Purity and hygienity demand (in transportation and production)
- High enough P- content
- Safety demands in production plants, storage and transportation (dust or organics content)
- Demand on sustainable logistics
- Stable quality in terms of the content of impurity elements, organics, dry matter etc.
- Processing characteristics



3. Design and development of totally new products from recycled materials – questions to be answered

- Target crop and soil? Customer segment? Crop farming, gardening etc.?
- Nutrient content of final product? P, NP, PK or NPK?
- Agronomical effectiveness and P solubility demands in the final product?
- Physical form? Granules, powder?
- Logistics?
- Wet chemical processing and/or granulation or compaction of dry materials?
- EC-fertiliser or product for local markets?
- Compliance with present fertiliser regulations or need to apply for new type definitions?
- The production concept and product must be acceptable to public and food consumers



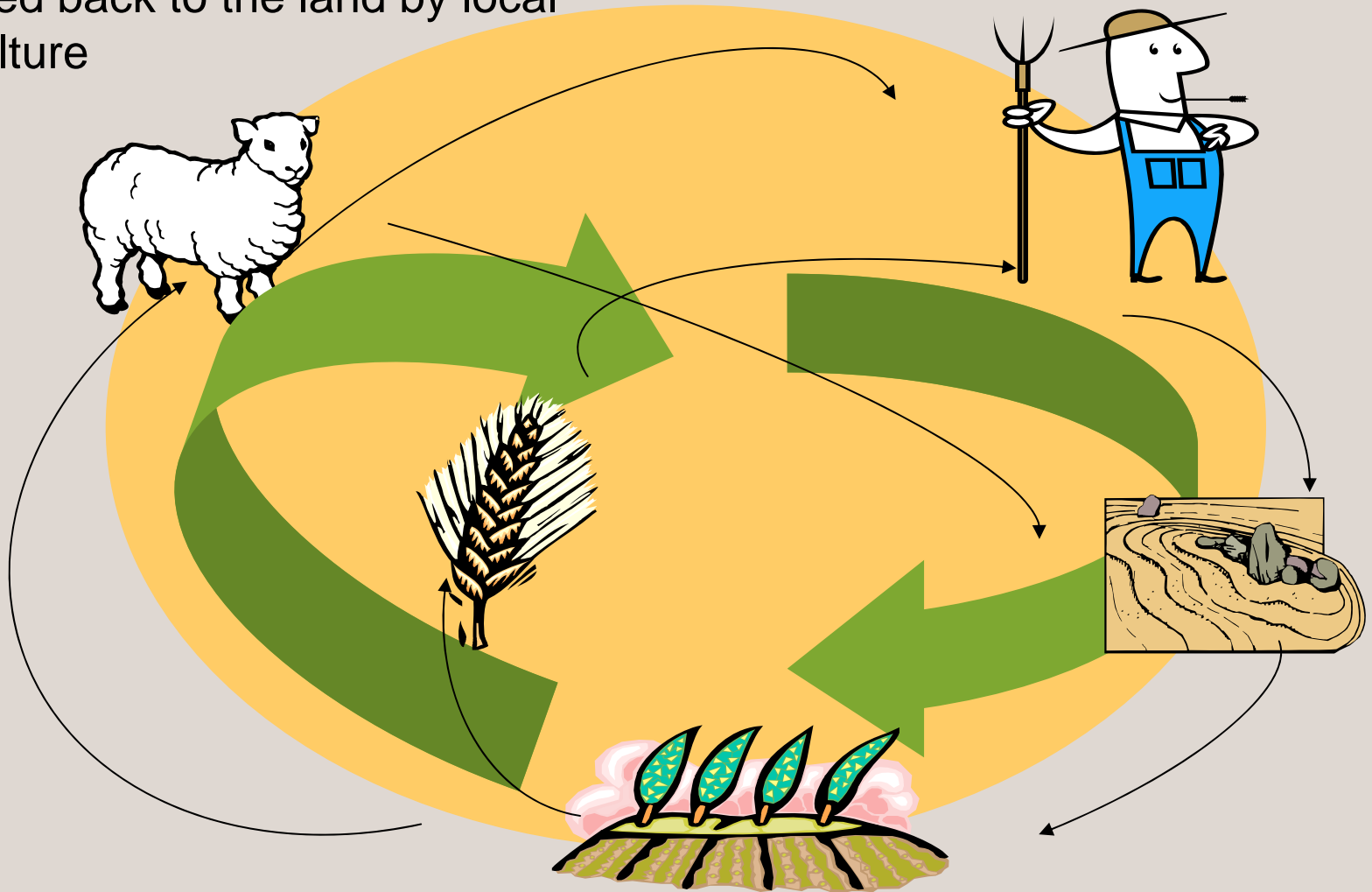
CONCLUSIONS

- Recycled material as P raw material in present manufacturing processes
 - main problems: logistics, quality instability
 - not probable and expected solution
- Recycled material as fertiliser as such
 - usually only one nutrient available
 - nutrients plant availability low
 - physical quality not optimum for spreading
- Production process design based on certain recycled material
 - most probable solution in my opinion
 - focus on final product quality (physical & chemical)
 - market evaluation needed

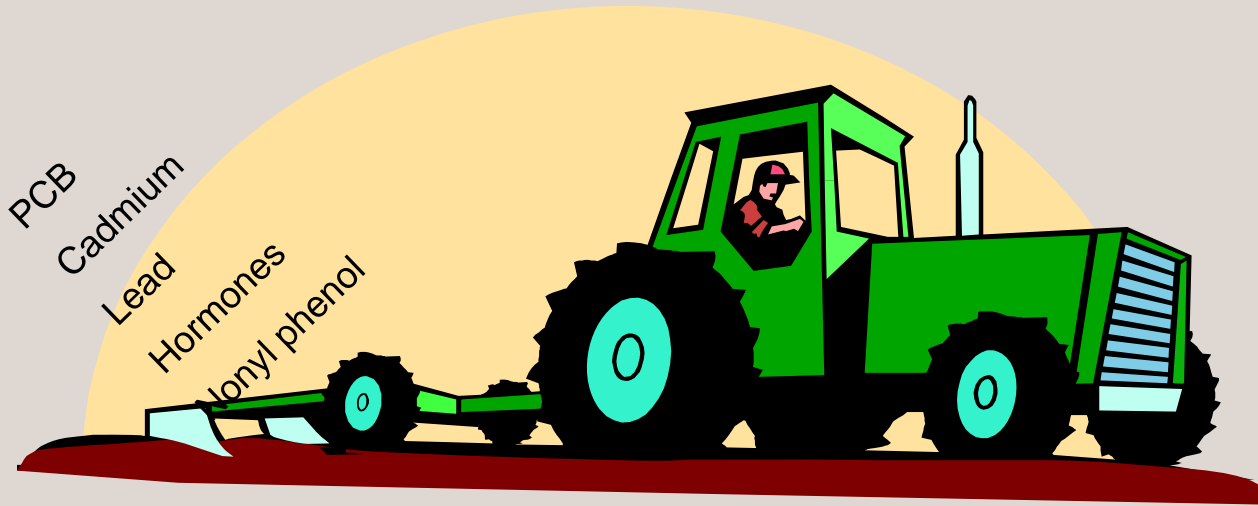


Traditional P-cycle:

in the past phosphorus was recycled back to the land by local agriculture



"Sludge horror show"



Thank You for Your Attention



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