Wrocław
University
of Science
and Technology

Bio-based fertilizers: a practical approach towards circular economy

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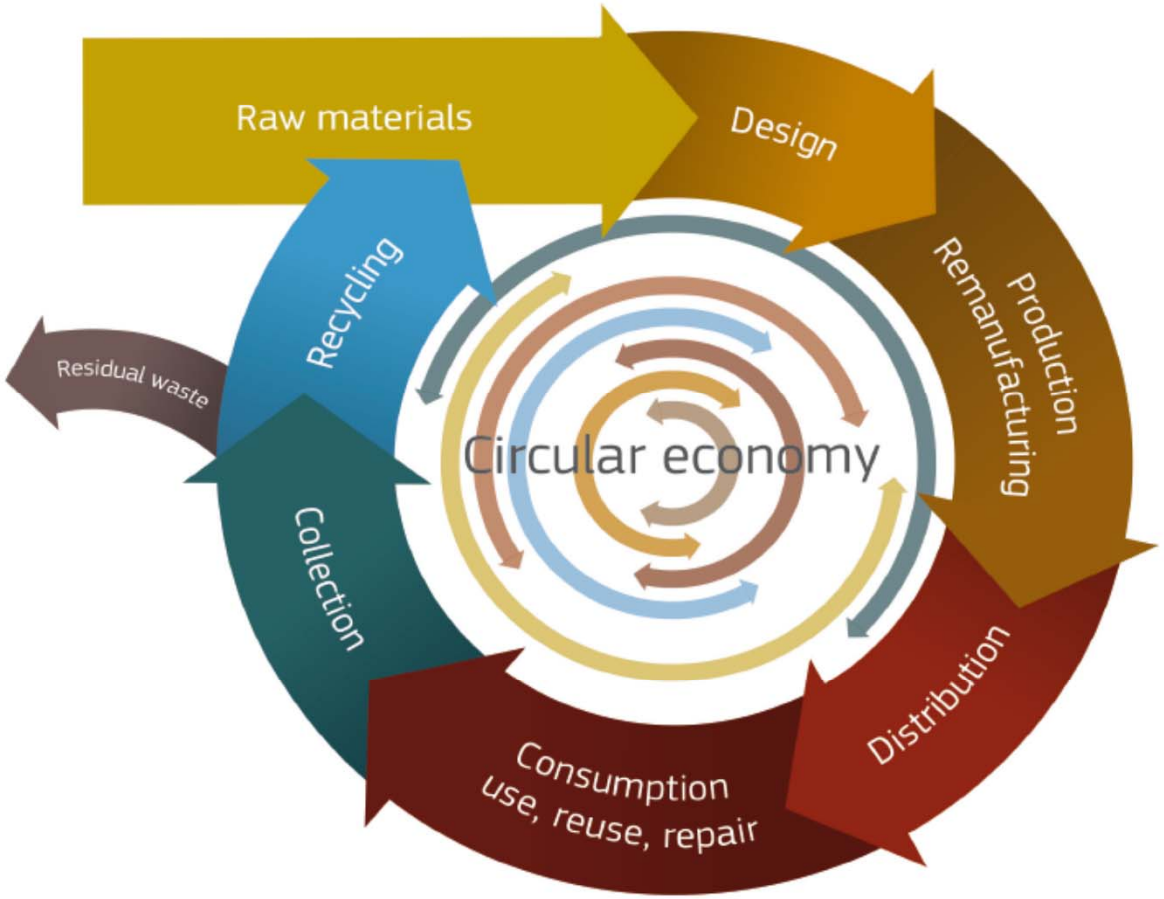
From a linear economy

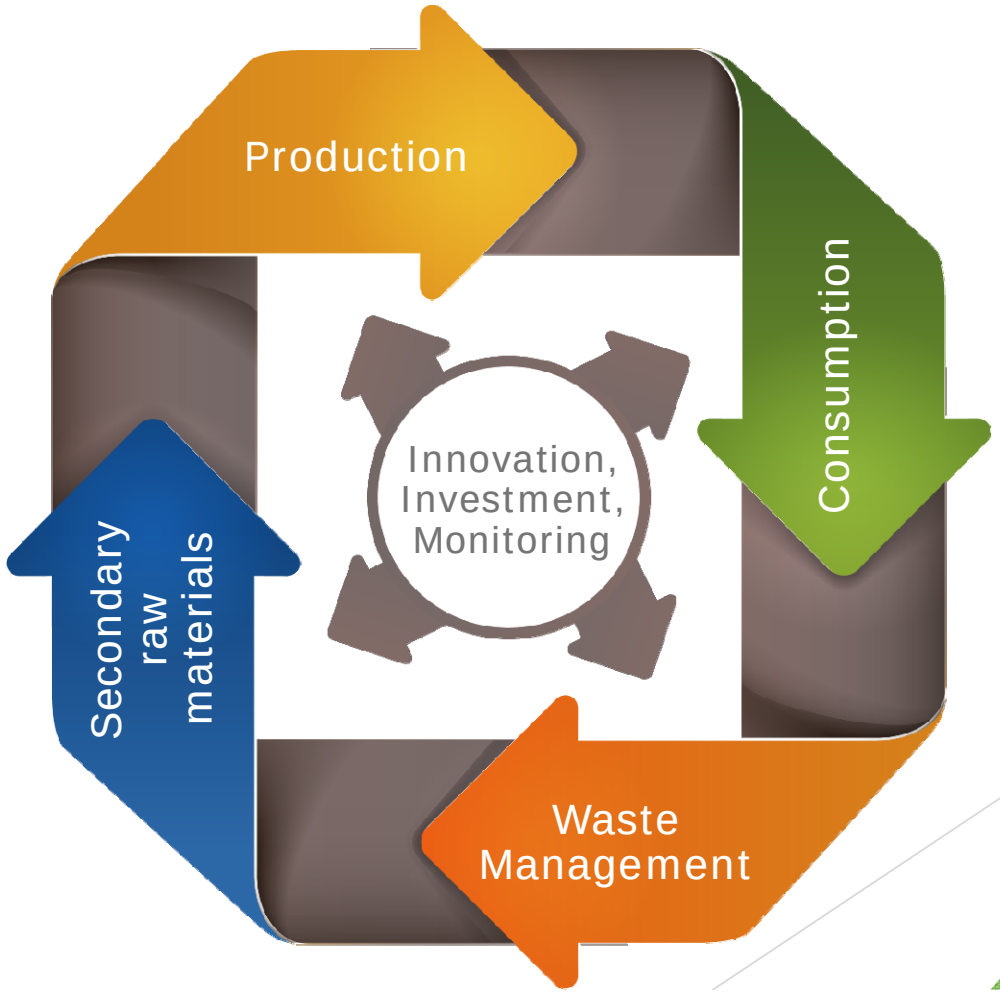
To a circular economy



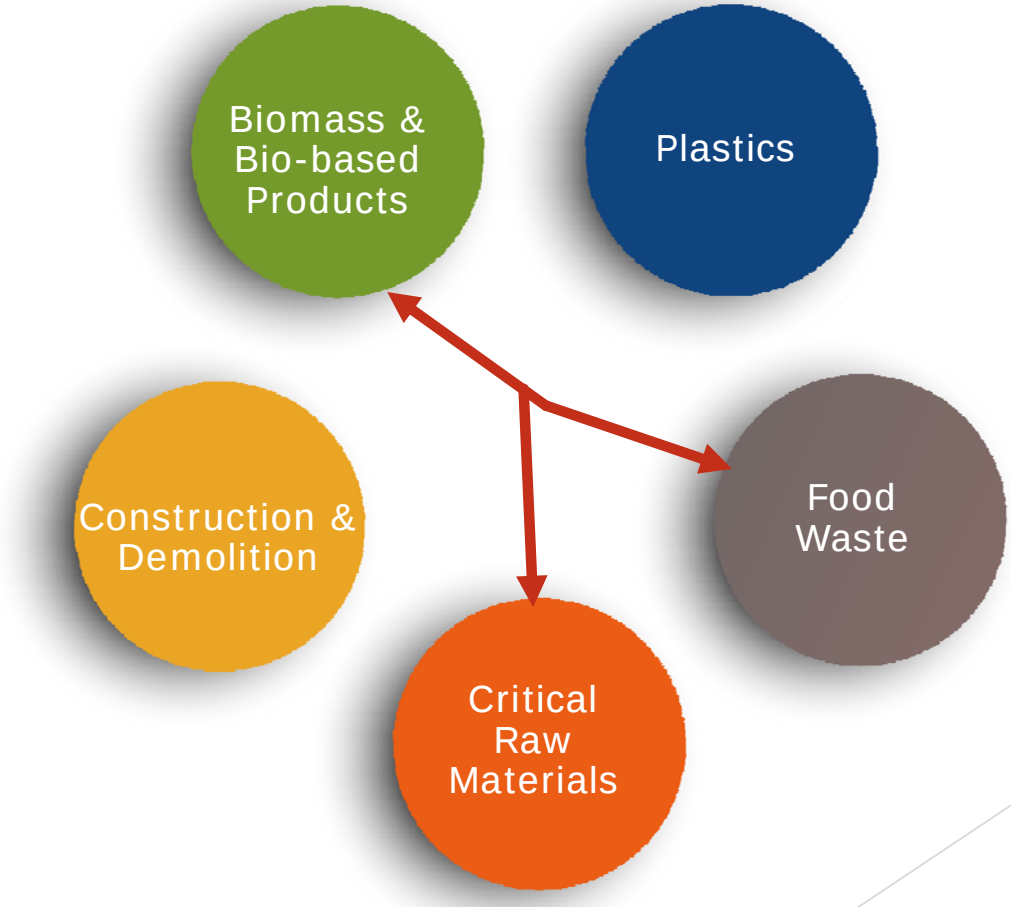
The Circular Economy Package Adopted by the Commission on 2nd December 2015:

- Action Plan
- Communication
- List of Follow-up Initiatives (Annex)
- Legislative proposal on waste

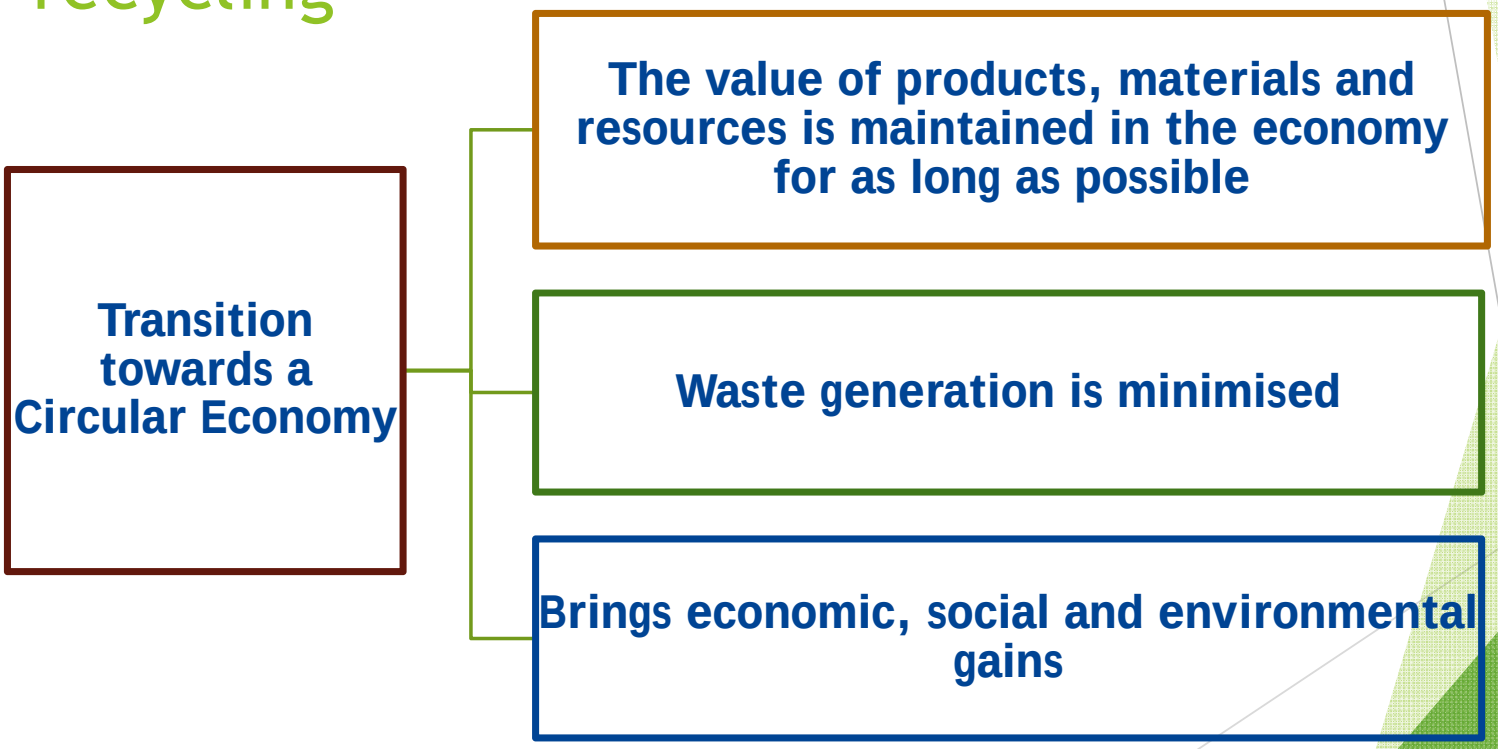
Key action areas



Priority sectors



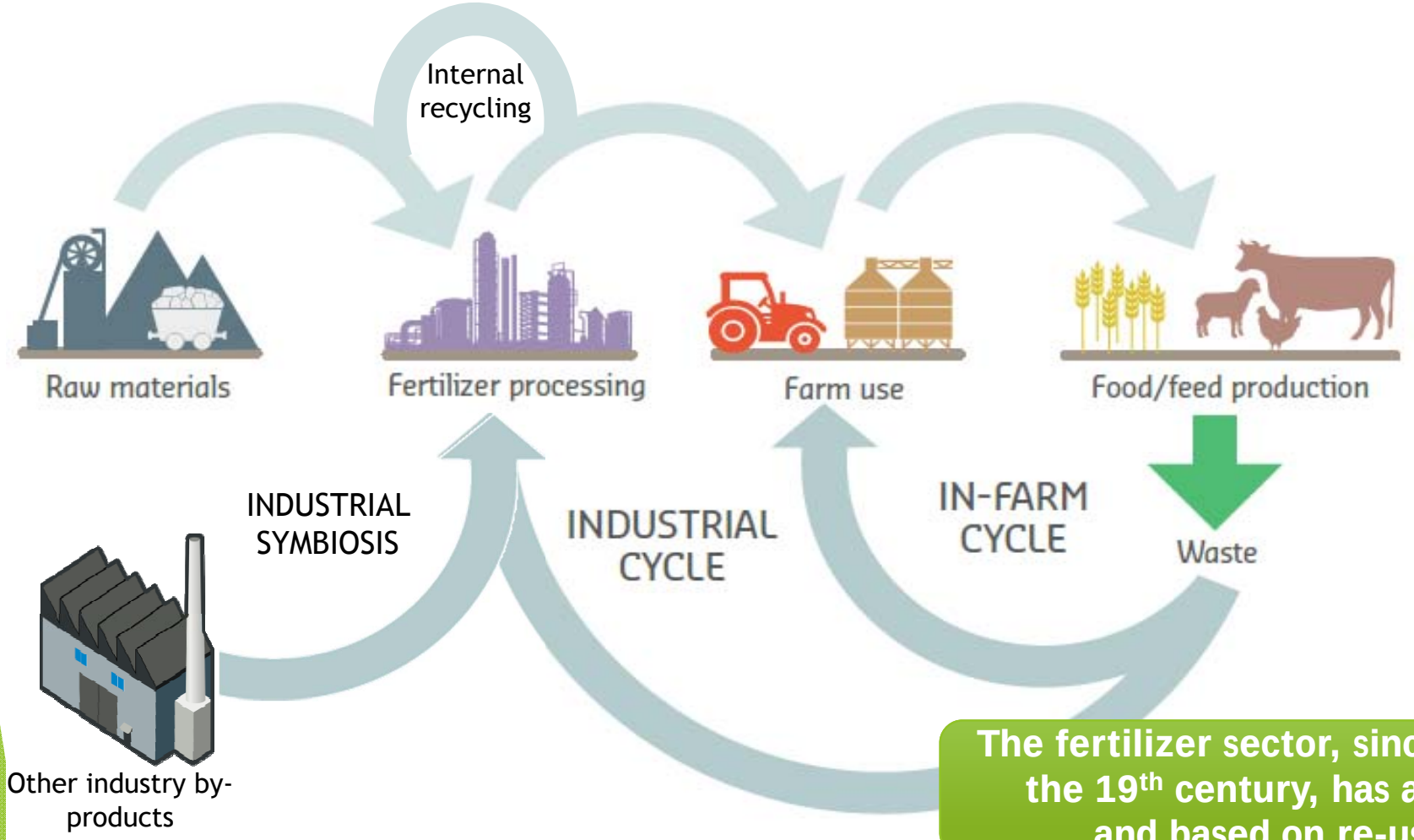
Circular Economy—”closing the loop” of product life cycles through greater recycling



Why? From a Global Perspective…

- 9 billion people by 2030 is estimated – a challenge is to meet demand for goods. Feeding the larger, better-fed, longer-living human population
- IFA predicts that food requirements by 2050 will be 50 to 80% greater than they are now
- All Will fertilizer Growth track population Growth?
- Global solid wastes is estimated to increase from 1.3 to 2.2 billion tons by 2025.
- The exponential growth in nutrient use is overwhelming the absorptive capacity of natural nutrient cycles
- Waste and the growing leakage of nutrients into the environment are more important challenges of nutrients management and a more urgent threat to food sustainability/security than resource finiteness.
- SOLUTION: Changes in nutrient use efficiency—many contributing technologies

Circular economy and fertilizer sector



The fertilizer sector, since its very beginning in the 19th century, has always been circular and based on re-use and recycling

Nutrients recovery in fertilizer industry

Recycling of nutrients, especially phosphates, from waste streams into high quality mineral fertilizers.

Examples:

- Ashes from wood, meat & bone meal, manure
- Struvite from wastewater ($NH_4MgPO_4*6\ H_2O$)
- Calcium phosphate and ammonium sulphate from manure

P is finite resource

Finity,
Increasing demand,
Quality

Almost no P rock in Europe

Geopolitical dependency

N is energy demanding

Large impact on food production

N & P cause environmental problems

Water &
air quality

Since 2014 Rock Phosphate identified as one of 14 “scarce” raw materials: very limited sources in EU and “geopolitical complicated” suppliers

Closing the P cycle &
other nutrients

What can be done?

1. Removing barriers in **legislation** that prevent the creation of a market

2. Raising **awareness**, sharing successful examples of phosphorus recycling

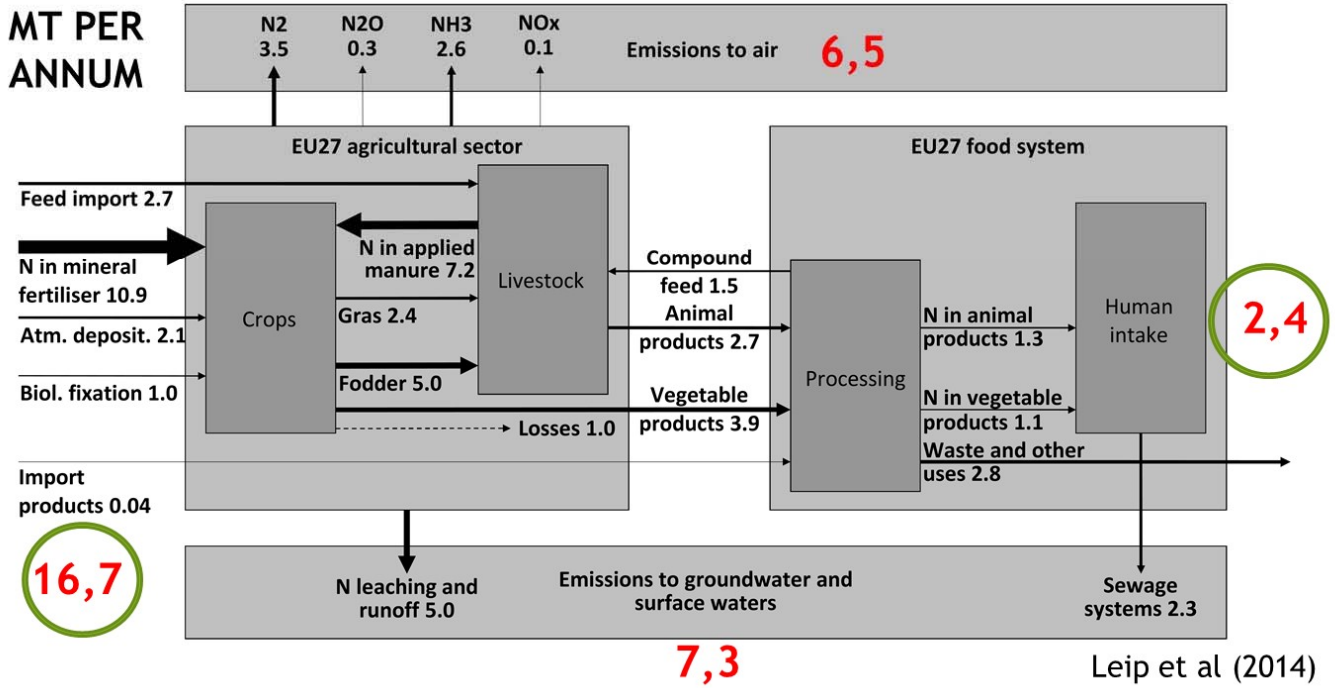
3. Facilitating set-up of **concrete project** and **business cases**

Nutrients leakage

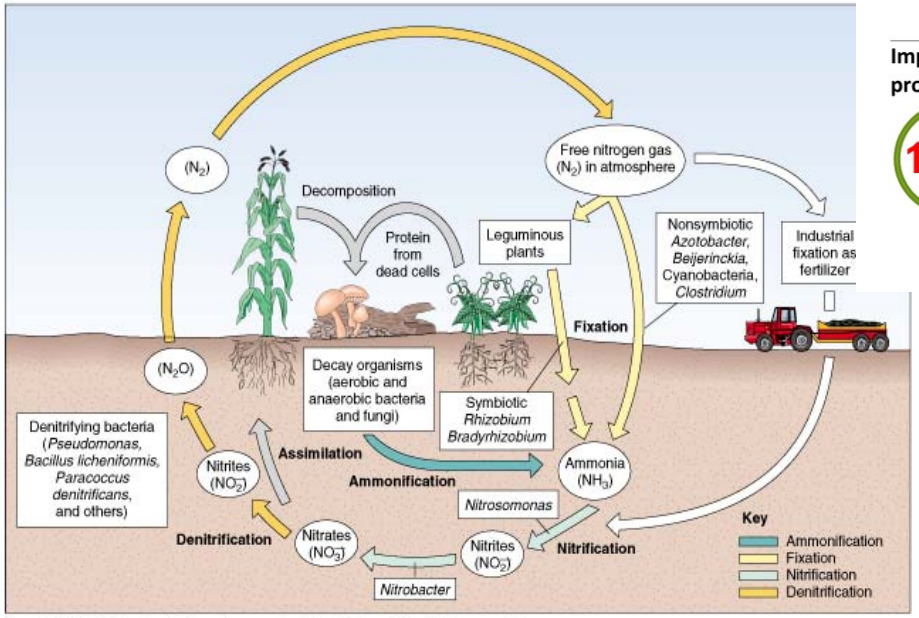
- **Low efficiency and high leakage in 4 sectors:**
  - **Fertilising crops with manure and mineral fertilisers**
  - **Feeding livestock and managing their waste**
  - **Processing food and feeding humans**
  - **Managing human waste**
- **Signs of this over-extended system:**
  - **Eutrophication of waters (N and P) - Damage to terrestrial and aquatic/marine biodiversity**
  - **Pollution of air – nitrogen oxides, particulates, ammonia; Greenhouse gases – nitrous oxide and methane**

NITROGEN FLOWS FOR THE EU27

ONLY 14% OF INPUT N REACHES HUMAN CONSUMPTION



Leip et al (2014)



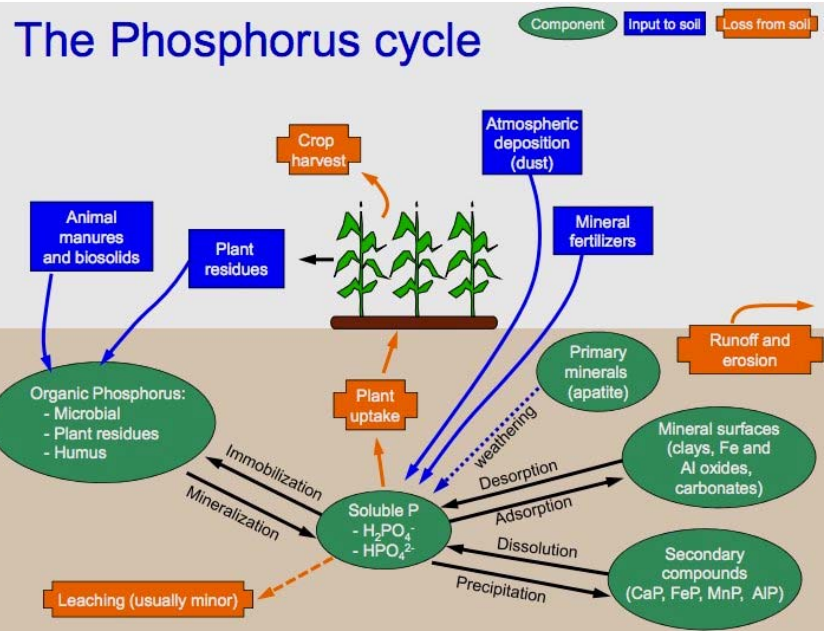
Slide 13

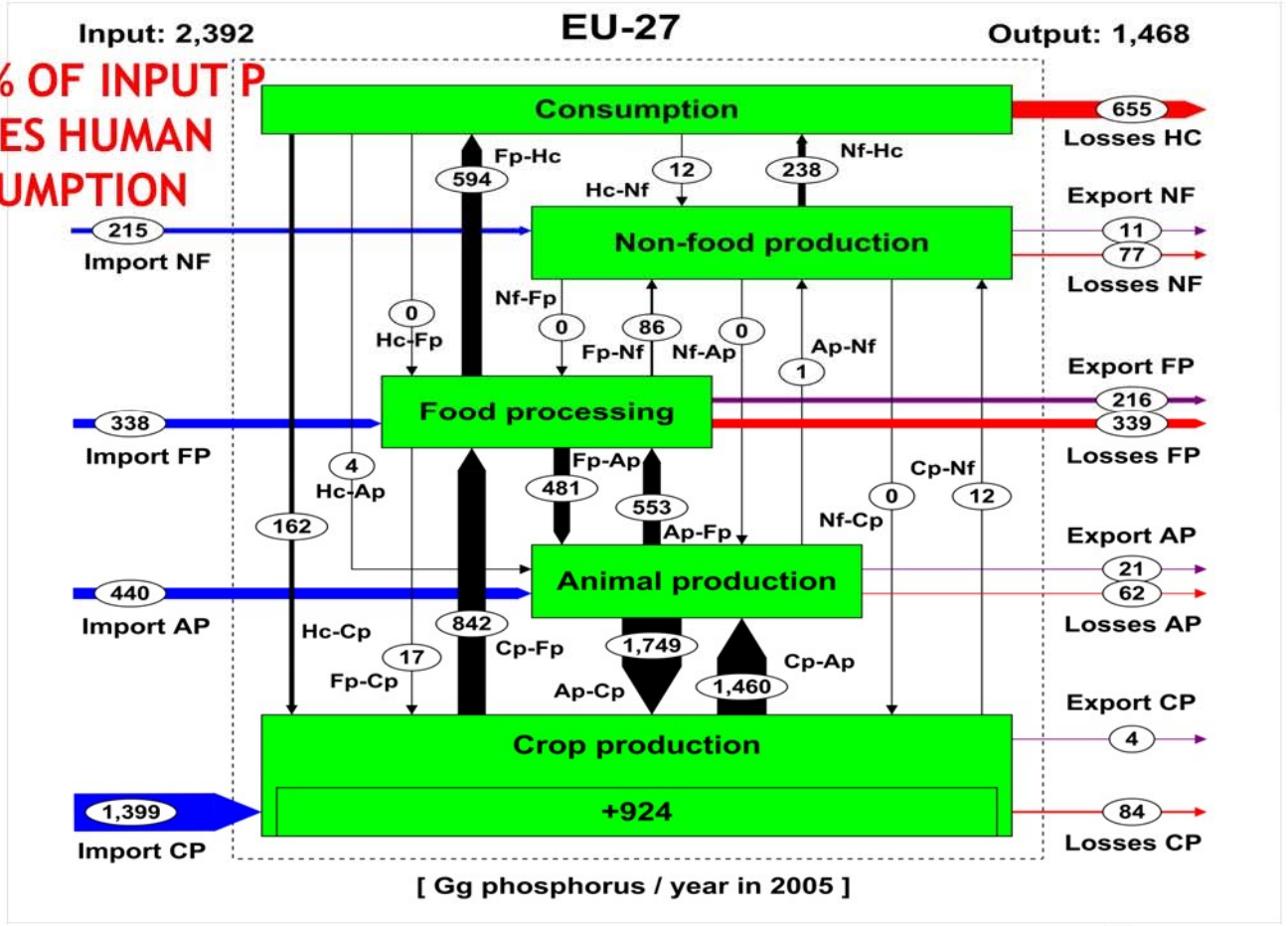
AB1 I must clarify how we calculate the 20 %If we look at human uptake compared to total input into the system it looks like 14 percent 2.4 over 16.74.

Allan Buckwell; 20/3/2016

PHOSPHORUS FLOWS IN THE EU27

ONLY 30% OF INPUT P REACHES HUMAN CONSUMPTION



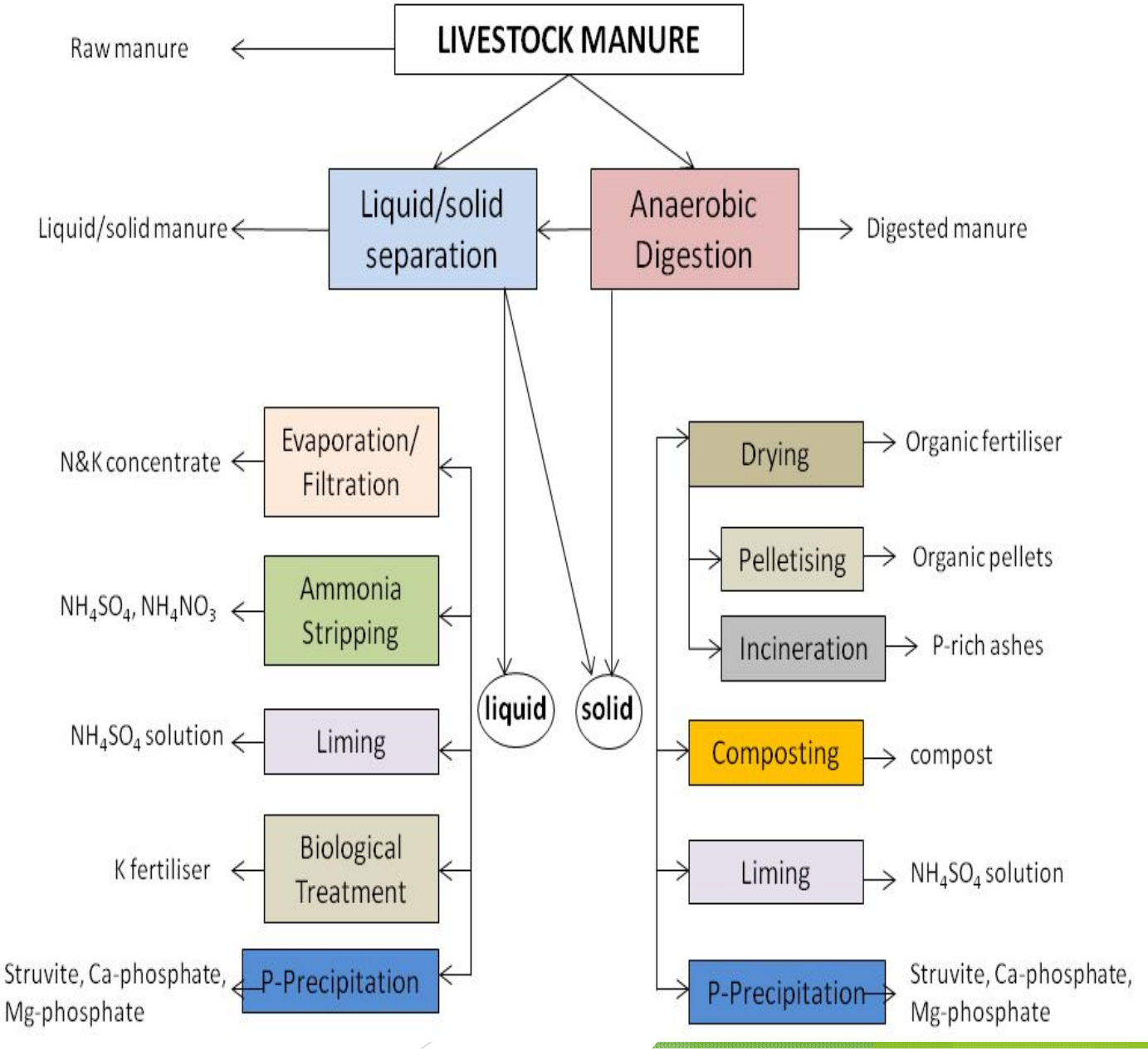


van Dijk et al. 2016

1) MANURE

Challenges:

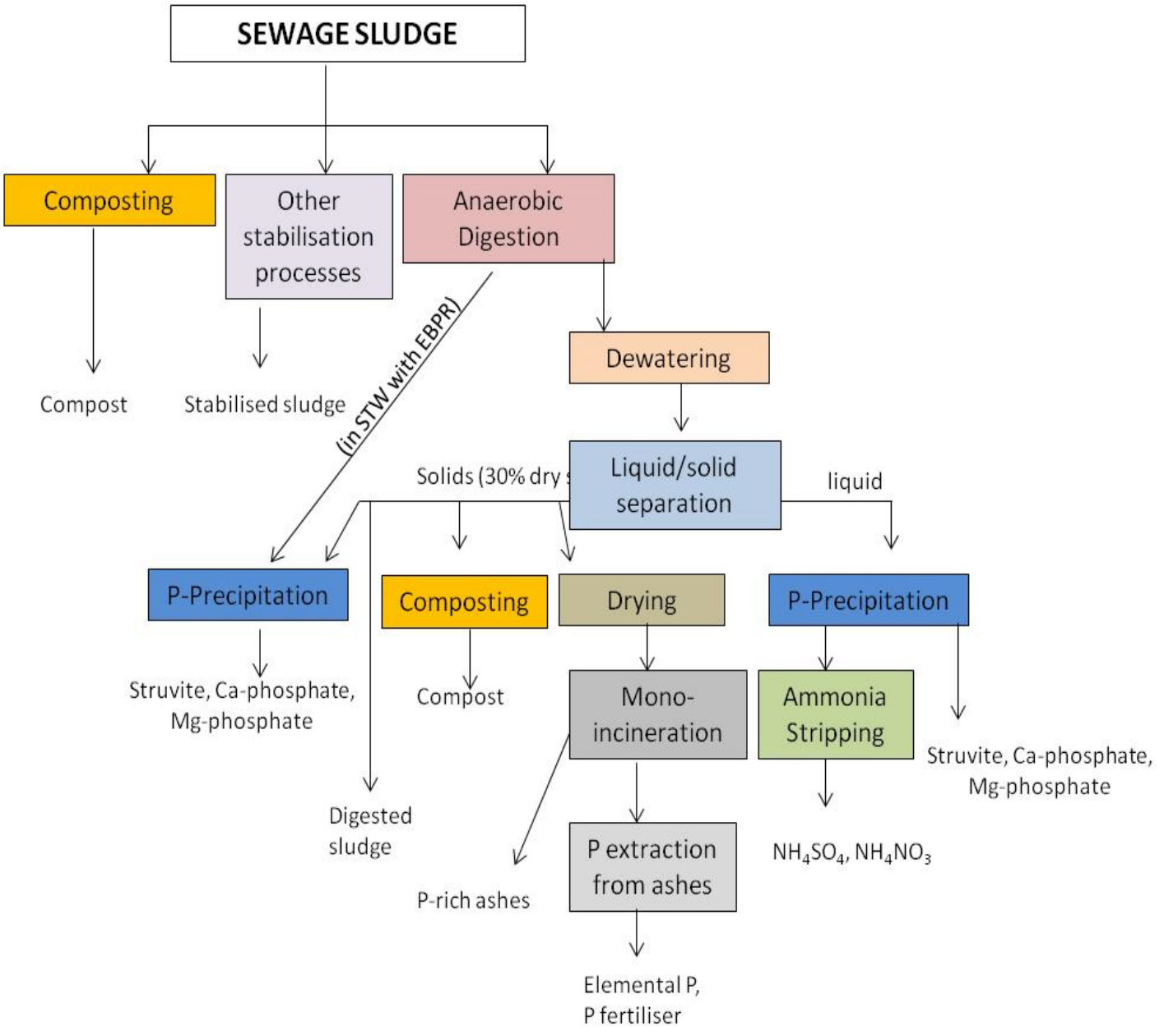
- **efficiency and nutrient recovery:**
- **Improve handling, storage**
- **Process manure to more concentrated product**



2) SEWAGE SLUDGE

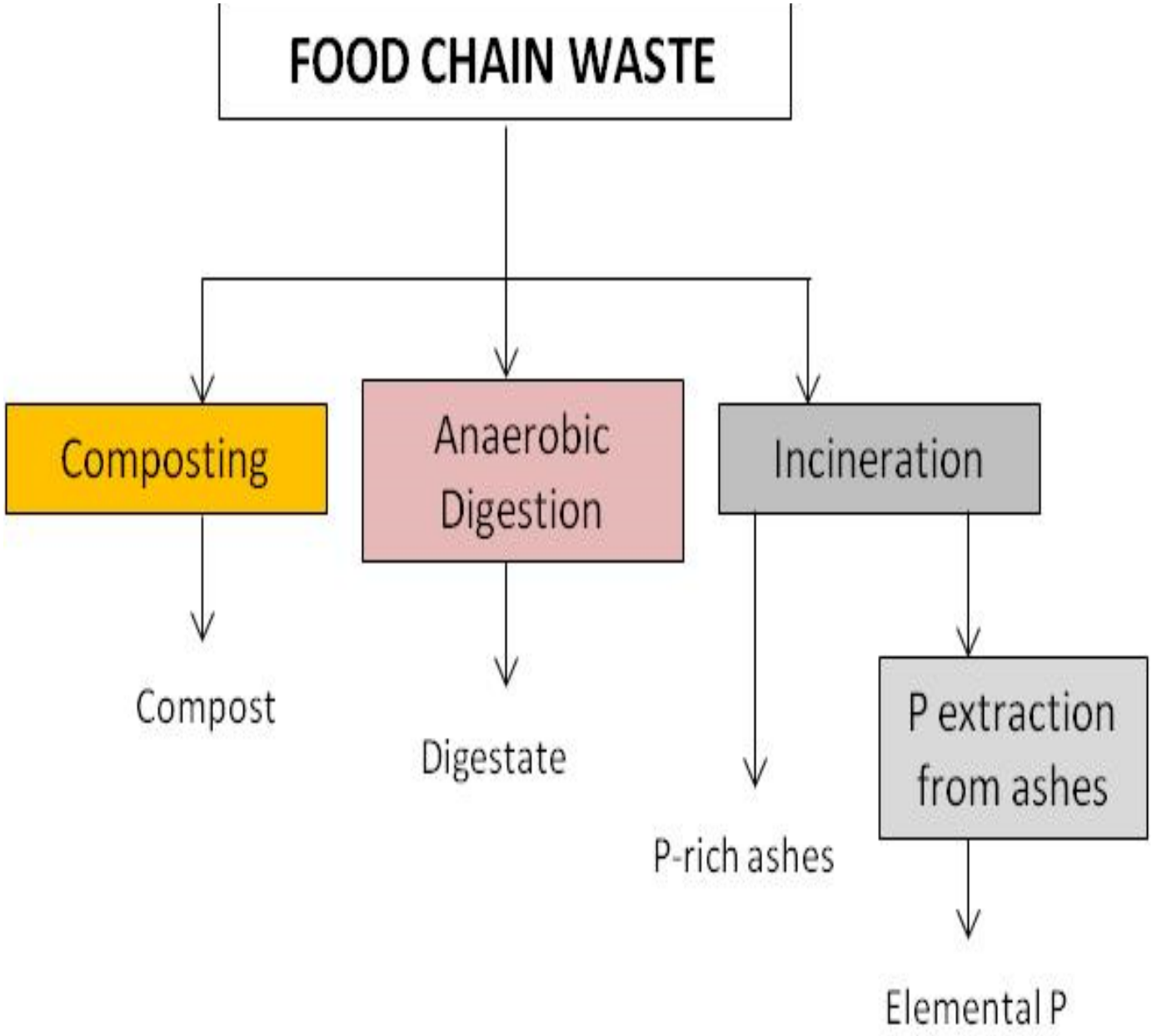
Challenges:

- **Increase recovery.**
- **Specification of nutrient content**
- **Concerns about soil, plant and human health**



3) FOOD WASTE

- **Less information is available.**
- **Definitions of waste vary among member states.**
- **biodegradable/organic waste**
  - **compost**
  - **digestate**
- **slaughterhouse waste**
  - **Most incinerated**



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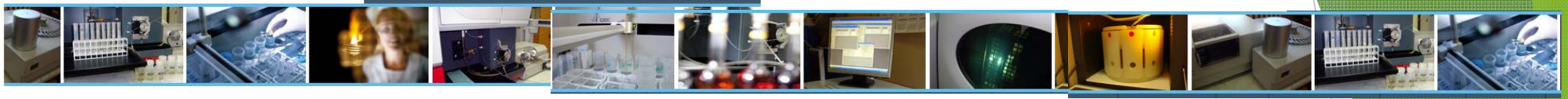

Fertilizer technologies for circular economy elaborated by team from WUST:

PCA Polskie Centrum Akredytacji BADANIA

Wrocław University of Science and Technology

- Accredited Laboratory for ISO 17025 (ILAC MRA)
  - Fertilizer macro- and micronutrients, toxic elements; ICP-OES, ICP-MS, Kjeldahl N
- Experience in elaboration of technologies of bio-based fertilizers and bio-plant protection products (plant growth biostimulants, bio-fertilizers)
- Working in full R&D cycle: from the concept, through lab tests, scale-up (large-laboratory, quarter technical) ending with evaluation of applicative properties of product (in vitro and in vivo (germination tests, pot trials, field experiments)
- Ending with technological offer for industry

4 new groups of fertilisers from bio-based streams were proposed:

1. Biomass-Based Micronutrient Fertilisers (BBMF),
2. Protein Hydrolysate-Based Fertilisers (PHBF; e.g., feathers),
3. Animal Feces-Based Fertilisers (AFBF; e.g., animal waste, sewage sludge, biochar),
4. Slaughter By-Products-Based Fertilisers (SBBF; e.g., feathers, bones).

Table 1.3: Macro-element content (%) in selected bio-based products[1]

Renewable fertiliser sources	N	P_2O_5	K_2O	S	MgO	CaO
Poultry feathers	15.5	0.32	0.24	2.32	0.22	0.4
Bones – poultry	7.15	18.72	0.16	0.153	0.85	34.1
Swine bone meals	6.06	16.82	0.25	0.84	0.49	28.5
Farmyard manure	0.52	0.22	0.58	0.078	0.13	0.024
Poultry manure	1.94	1.44	0.93	0.055	0.92	0.015
Swine manure	0.33	0.039	0.54	0.081	0.012	0.031
Cattle manure	0.42	0.049	0.39	0.063	0.013	0.028
Oak ash	0.01	4.9	8.94	0.32	0.59	34.8
Urban biowaste	2.88	0.57	1.00	0.19	0.17	1.58

1) Biomass-Based Micronutrient Fertilisers (BBMF)

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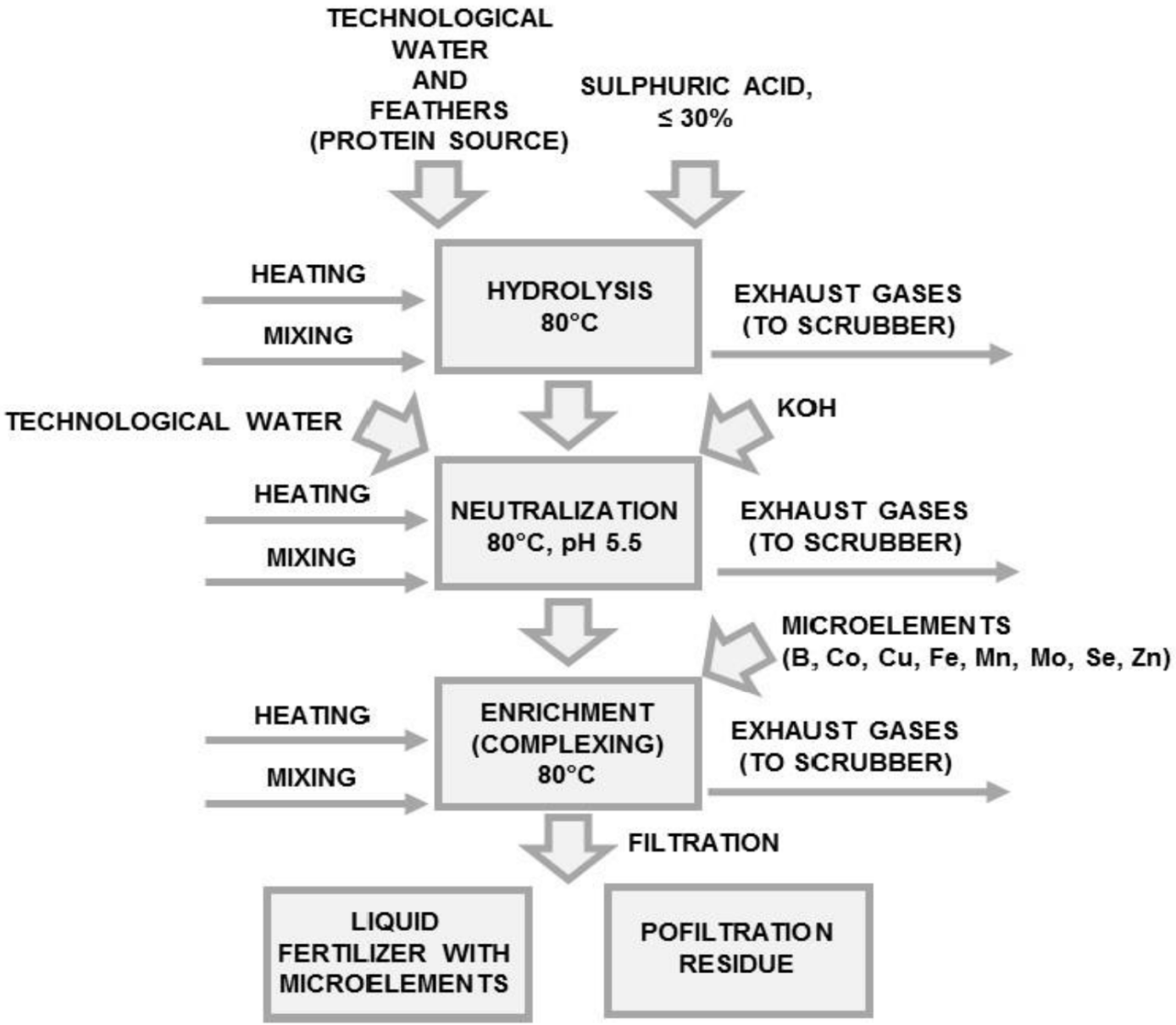
- *Formula* – biomass enriched with fertilizer microelements in the biosorption process. Different types of the biomass can be enriched with microelement ions via biosorption process, for example: biochar, spent mushroom substrate, post-extraction residues (supercritical fluid extraction with carbon dioxide; SFE-CO2) from berries seeds, post-extraction residues (SFE-CO2) from biomass of micro- and macroalgae.
- *Results*
- Field experiments on **corn** with the use of enriched with Zn, Mn and Cu ions biomass of **spent mushroom substrate** (SMS) and **post-extraction residues from** *Spirulina* **sp.** (SP). The highest yield was obtained for enriched SP tested at a dose 100% - 7.8 t/ha.

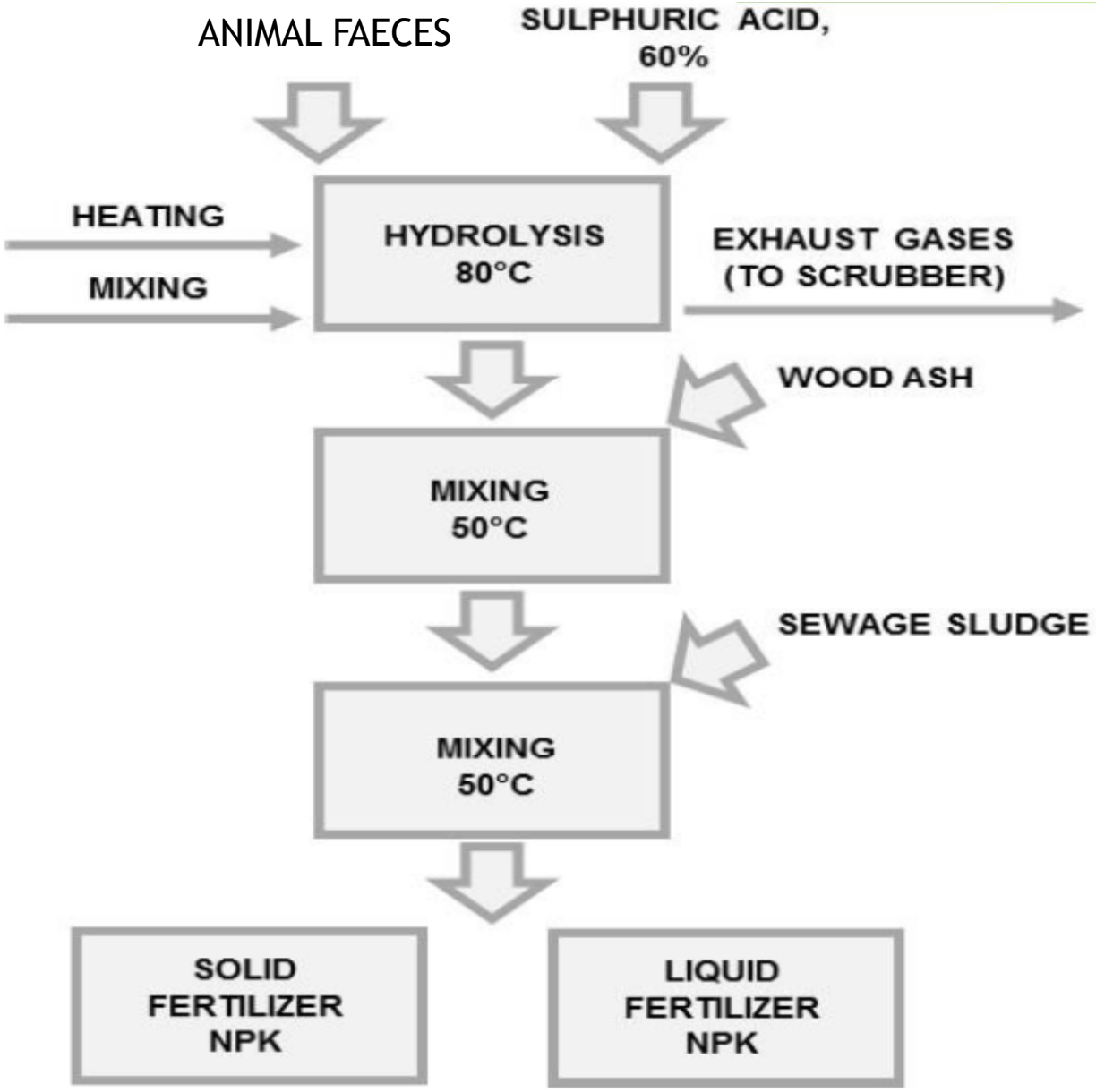
2) Protein Hydrolysate-Based Fertilisers (PHBF; e.g., feathers),



2) Protein Hydrolysate-Based Fertilisers (PHBF)

- *Formula* – protein hydrolysates enriched with micronutrient ions obtained from feathers as a source of protein
- *Results*
- Field experiments on **winter wheat** and **tomatoes** with the use of two products obtained by hydrolysis of feathers: AminoPrim and AminoHort containing amino acids, respectively 15 and 20% and microelements, respectively 0.27 and 2.1%. Yield and content of micronutrients was significantly higher than in control groups.

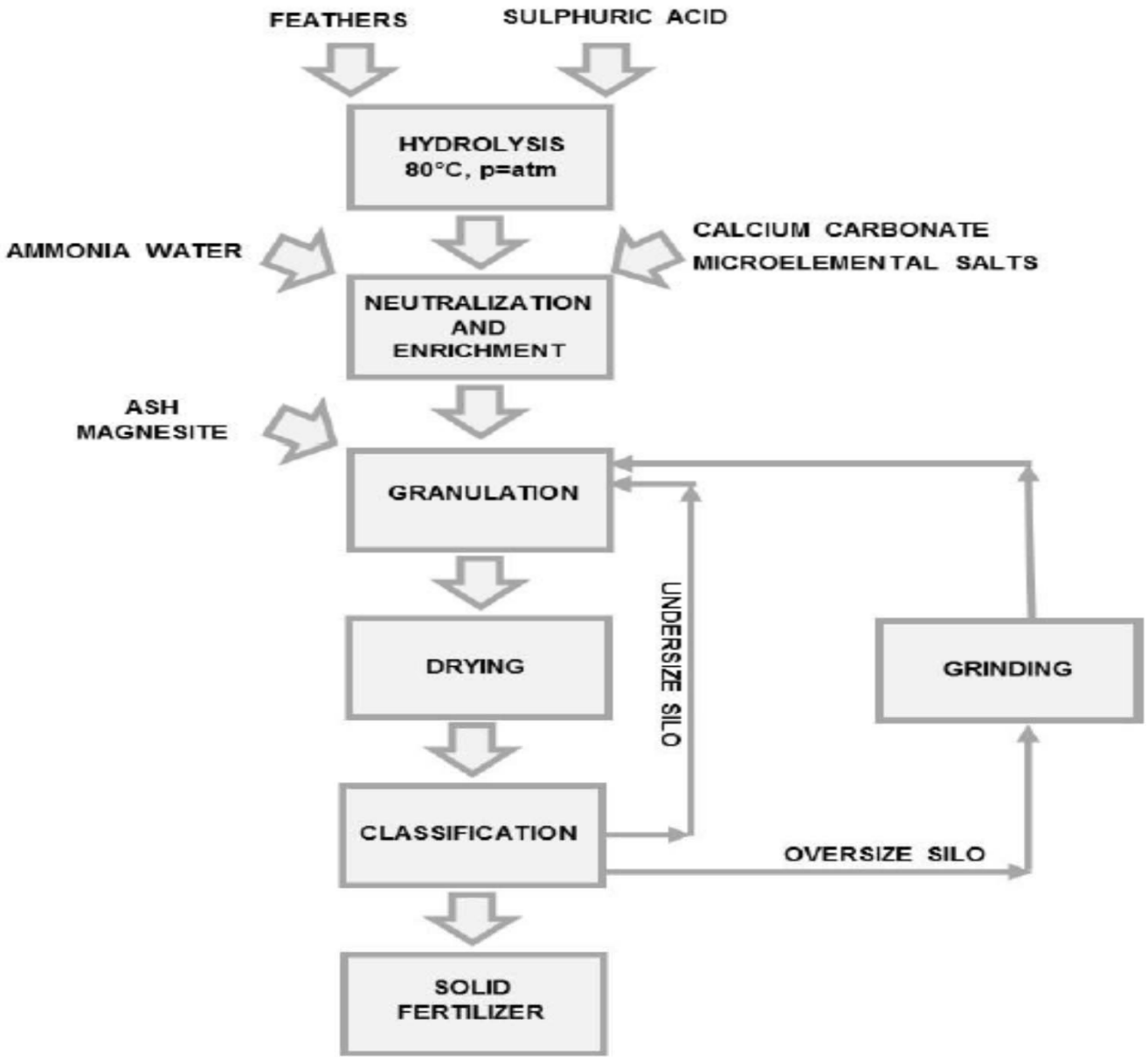
3) Animal Faeces –-Based Fertilisers (AFBF)



3) Animal Faeces -Based Fertilisers (AFBF)

- *Formula – hydrolysate of animal waste with wood ash and sewage sludge*
- *Results*
- Field experiments on were performed on rapeseed, where obtained solid and liquid fertilizers were applied in two doses – 100 and 200%. In 200% dose of NPK solid fertilizer obtained yield was 10% higher than in control groups.

4) Slaughter By-Products-Based Fertilisers (SBBF)



4) Slaughter By-Products-Based Fertilisers (SBBF)

- *Formula*
- ▫ Solid fertilizer I – feathers, sulphuric acid, ammonia water, calcium carbonate, ash, magnesite
- ▫ Solid fertilizer II – feathers, sulphuric acid, ammonia water, calcium carbonate, zinc sulphate, manganese sulphate, copper sulphate, ash, magnesite
- *Results*
- The field experiments were performed on lupine and mustard. The content of macro- and microelements in the cultivated plants was 2-10% higher than in control groups.
- The production of above-mentioned fertilisers will be supported with an on-line system including database on bio-feedstock (e.g., accessibility of the biomass, chemical composition) and fertiliser composer covering the demand of given plant species for different nutrients, considering local climate and soils compositions. Bio-based fertilisers can be manufactured at a pilot scale and their utilitarian properties will be examined.

THINGS TO DO TO IMPLEMENT THE IDEA OF CIRCULAR ECONOMY:

1. **Readiness of technologies**
2. **Legislation, pollutants, registration REACH**
3. **Organization of bio-wastes collection system to assure availability of secondary raw materials**
4. **Market Stimulants Direct Subsidies**
   - **Fiscal Reliefs**
5. **Penalties**
   - **Surpluses fertiliser taxes**
   - **Landfill and Incineration prohibitions/Gate Fees**
   - **Tax on nutrients leakage**
   - **Tax on using non-renewable raw materials**

Only then circular economy would become a fact, not only theory…

This project is financed in the framework of grant entitled: “Cultivated plants and natural products as a source of biologically active substances assign to the production of cosmetic and pharmaceutical products as well as diet supplements” (No. BIOSTRATEG2/298205/9/NCBR/2016) attributed by the National Center for Research and Development.