Nutrient Recovery and Reuse (NRR) in European agriculture.

A review of the issues, opportunities, and actions.

RISE Foundation

21st March 2016 Brussels

We all love nutrients!

- 20 Century miracle: feeding the larger, better-fed, longer-living human population
- **But**
- The exponential growth in nutrient use is overwhelming the absorptive capacity of natural nutrient cycles
- Nutrient use has relatively 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
- Four signs of this over-extended system:
  - Eutrophication of waters (N & P)
  - Pollution of air – nitrogen oxides, particulates, ammonia
  - Greenhouse gases – nitrous oxide and methane
  - Damage to terrestrial and aquatic/marine biodiversity

Origins of this report: five goals and concerns for nutrients

FOOD PRODUCTION

FARM VIABILITY

REDUCTION AND RECYCLING OF FOOD CHAIN WASTE

POLLUTION OF WATER, AIR, SOIL AND IMPACT ON THE CLIMATE

DEPENDENCE ON FINITE, INSECURE, NON-RENEWABLE RESOURCES

Objectives of RISE NRR study

- To improve understanding of the issues and interactions involved in two nutrient flows in EU food production, Nitrogen - N, and Phosphorus – P and assess the relative importance of five goals and concerns about these flows. And to try and answer 3 questions:
  - What is the potential scale for enhanced recovery and reuse of N and P in the EU?
  - What are the challenges in doing it?
  - What actions are required to stimulate a wider adoption of nutrient recovery and reuse in Europe?

Critical qualitative conclusions

1. Resource finiteness, and thus rising prices, is not the key challenge this century.
2. Security/reliability of EU supply of P and natural gas may be
3. The more important challenges are waste and the growing leakage of nutrients into the environment.
4. These environmental impacts of current nutrient flows are a more urgent threat to food sustainability/security than finite resources.

Nutrient Recovery and Reuse can:

1. Contribute to all four of these aspects
2. Stimulate innovation and contribute to jobs and growth.

Potential benefits of NRR

- Every tonne of recovered and reused N & P potentially contributes:
  - Less waste and less water, air and atmospheric pollution as N & P are captured from waste streams and leakages.
  - Less depletion of finite reserves of P, and less GHG emitting natural gas
  - Reduction in the pollution associated with P mining and N manufacture.
  - Diversification of nutrient supply, improving system resilience

Quantifying the nutrient flows and challenges

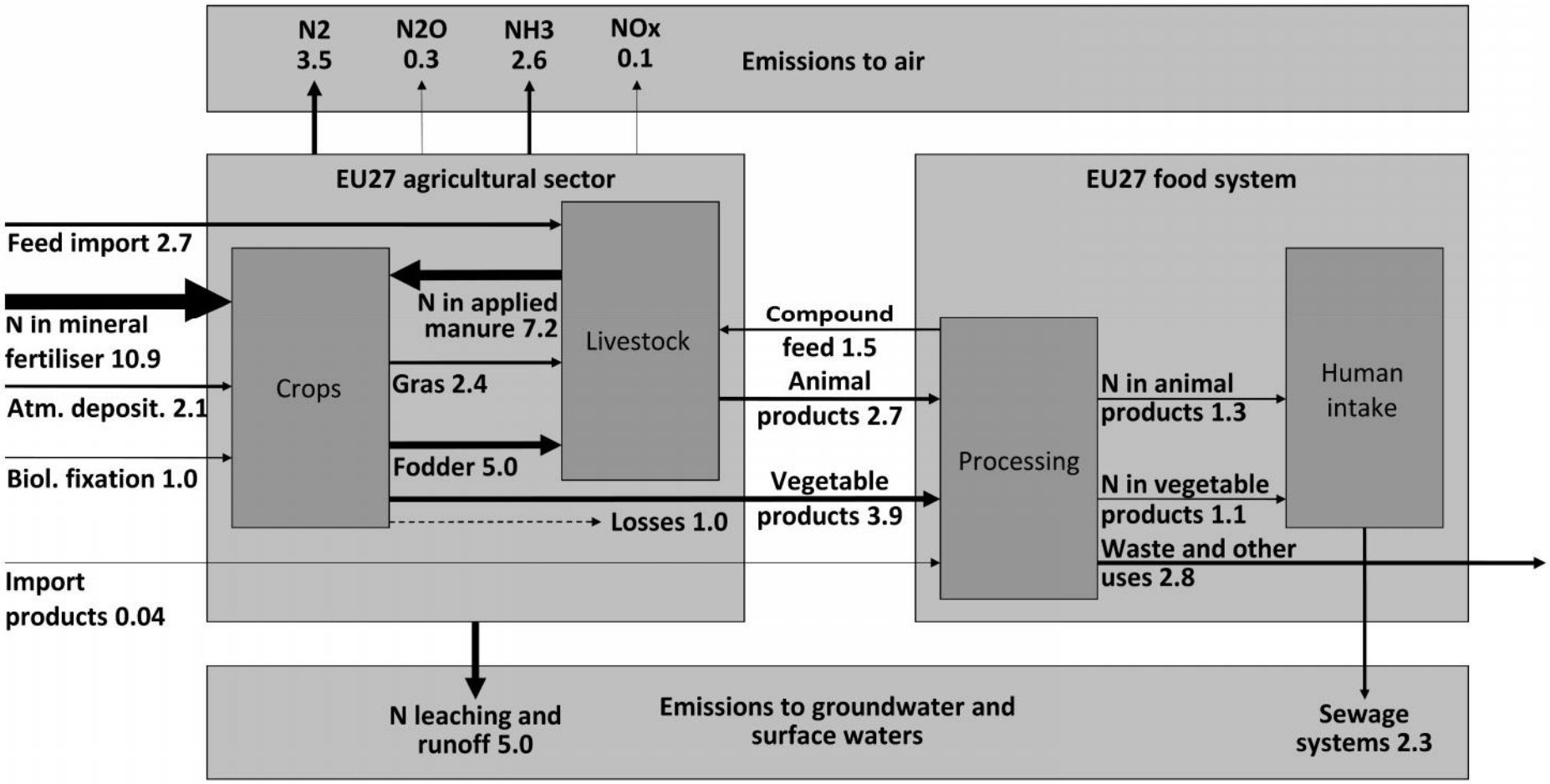
- Detailed studies using annual balanced flow methods accounting for all flows into and from agricultural activities through the food chain and in some cases wider non-food industrial flows:
  - **N** – the European Nitrogen Assessment, Sutton *et al* (2011), Leip *et al* (2014), Westhoek *et al* (2015)
  - **P** – see van Dijk *et al* (2016), Cordell (2009, 2010)
- Data assembled for EU27, for particular years around 2000-2005.
- There are no time series data on detailed flows, only some components, low precision on some emission factors.
- More experimentation and debate required on treatment of food chain and international trade.

Nitrogen flows for the EU27, Mt per annum

Total input 16.74 Mt

Only 14% of input N reaches human consumption

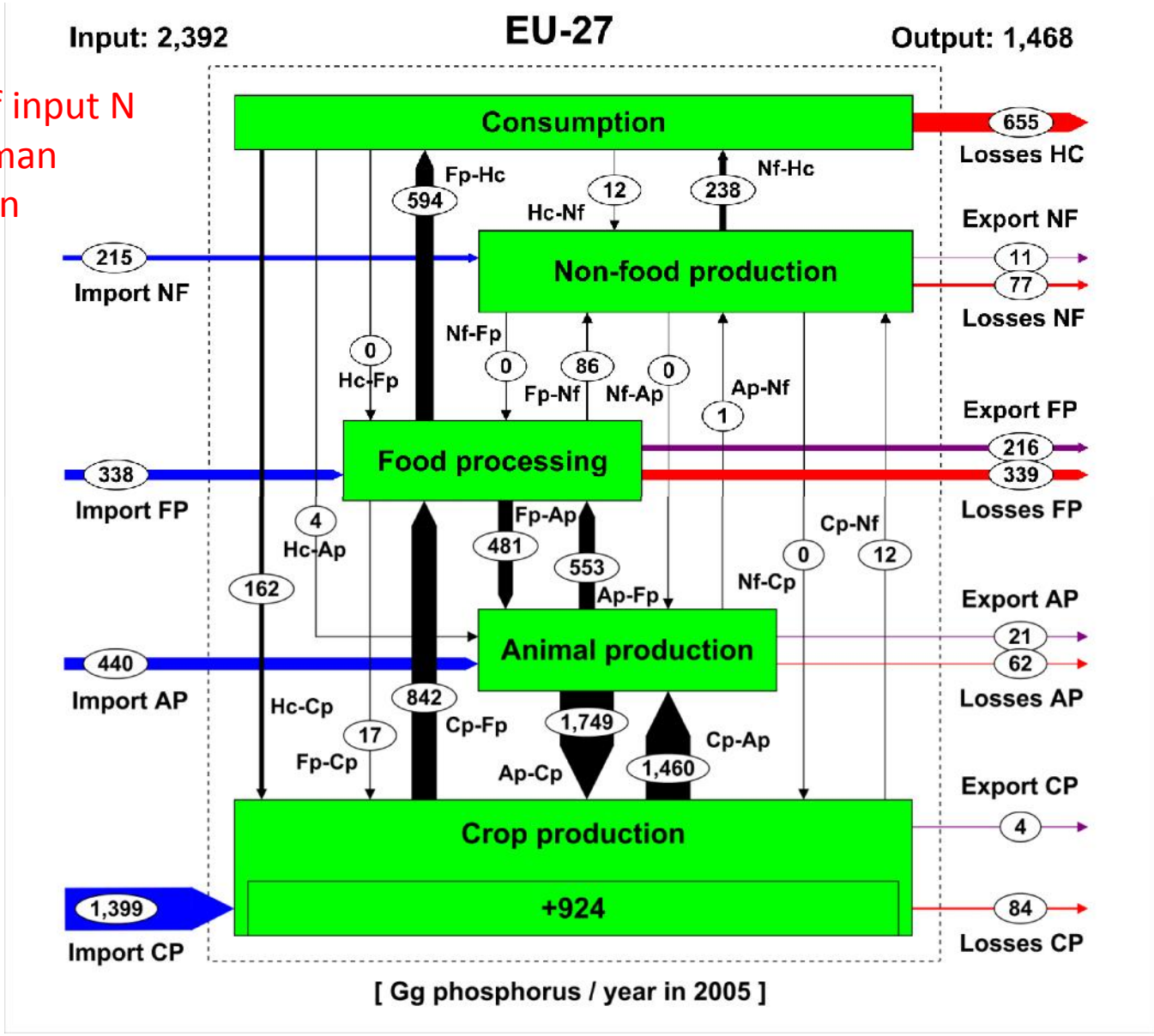
Total human Uptake 2.4 Mt



Leip et al (2014)

Phosphorus flows in the EU27

Only 30% of input N reaches human consumption



van Dijk et al. 2016

Role of nutrient recovery and reuse

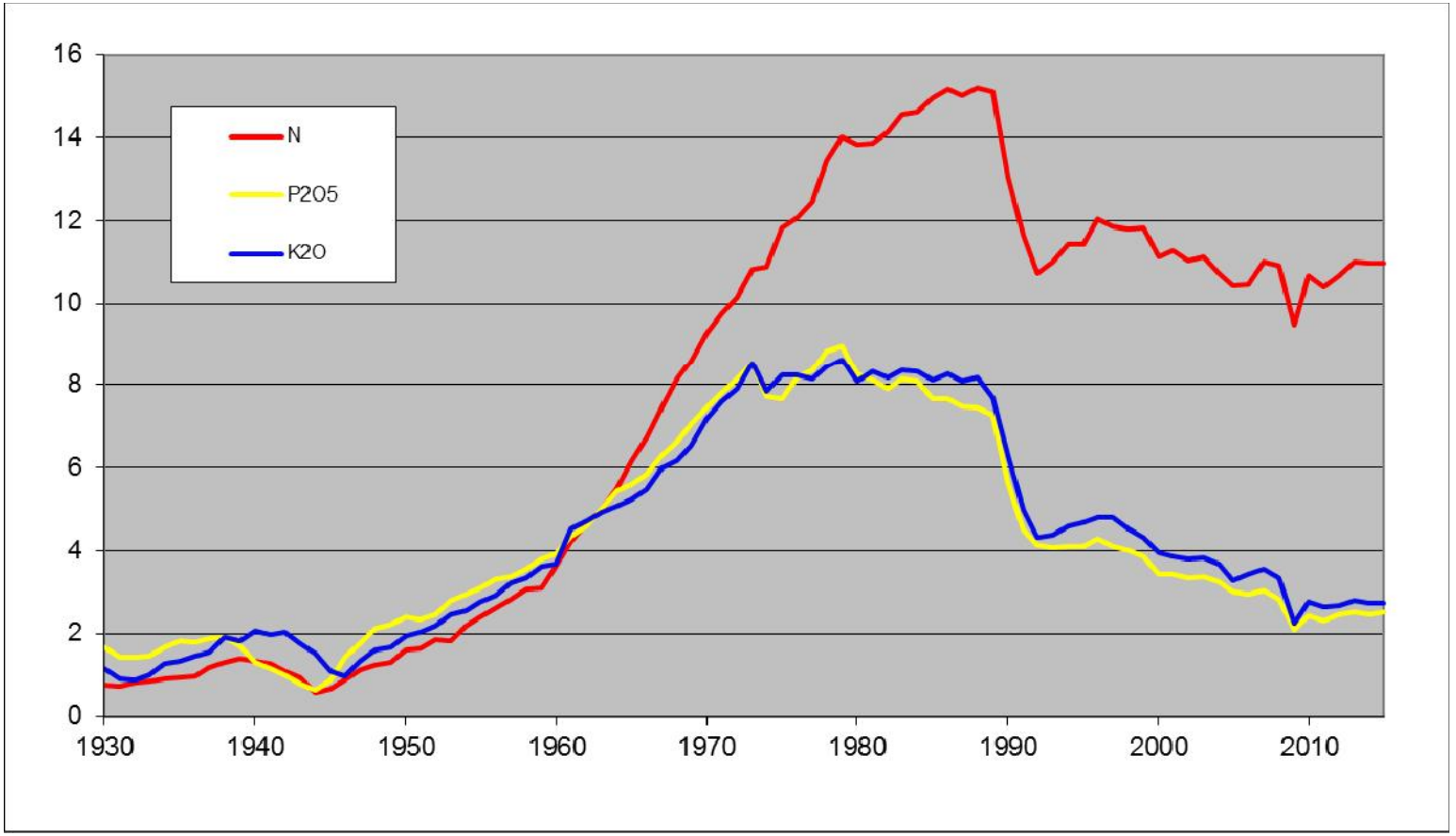
- Nutrient recovery does not address all the disruptive environmental effects of nutrient flows, but can be an important contribution to nutrient stewardship
- It involves three parallel tasks:
  - Increasing the amount of recovered nutrients
  - Increasing the fertiliser equivalent value of recovered nutrient
  - Creating recovered products that are safe, easy to store, handle and use cost-effectively by farmers

Office [2]1 Not sure we want to indicate that we don't consider the second and third bullet points (i.e. the ones not in red)
Microsoft Office User; 17/03/2016

Summary of the scope for EU nutrient recovery and reuse

- We identified the three largest substrate flows for NRR to be:
  - Animal manure
  - Waste water and sewage sludge
  - Food chain waste (e.g. slaughterhouse waste)
- Potentially recoverable annual flows from these three streams together are estimated to be:
  - 12 Mt of N of which 60% is currently recovered
  - 2.5 Mt of P of which 75% is currently recovered
- Therefore the prime target for additional NRR is:
  - 2 to 5 Mt of N, ≡ 18 to 46% of the 11 Mt mineral N used
  - 0.6 Mt of P, ≡ 43% of the 1.4 Mt of mineral P used

Nutrient use – mineral fertilisers, 1930 -2015



Fertilizers Europe

Livestock manure

- ~1400 Mt of manure/yr EU-27 (pigs, cattle and poultry; Foged et al. 2011)
  - <10% is processed (separated, anaerobic treatment, additives) yielding 0.55 Mt N and 0.14 Mt P
- Manure already provides 53% of the phosphorus and 43% of the nitrogen in EU-27 agriculture: **7.1 Mt N and 1.5 Mt P** (Sutton et al. 2011, Van Dijk et al. 2015). It represents 70% of all recovered N and P.
- Challenges are to increase efficiency and nutrient recovery:
  - Improve handling, storage and application of manure:
  - Process manure to more concentrated product
  - Scale and location of livestock production?

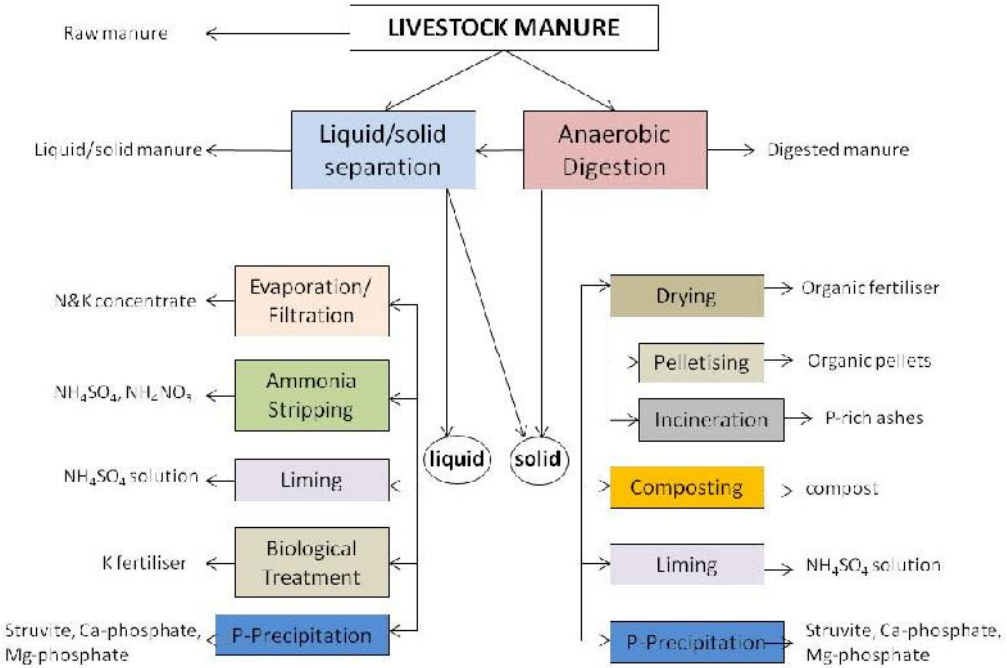
Waste water and sewage sludge

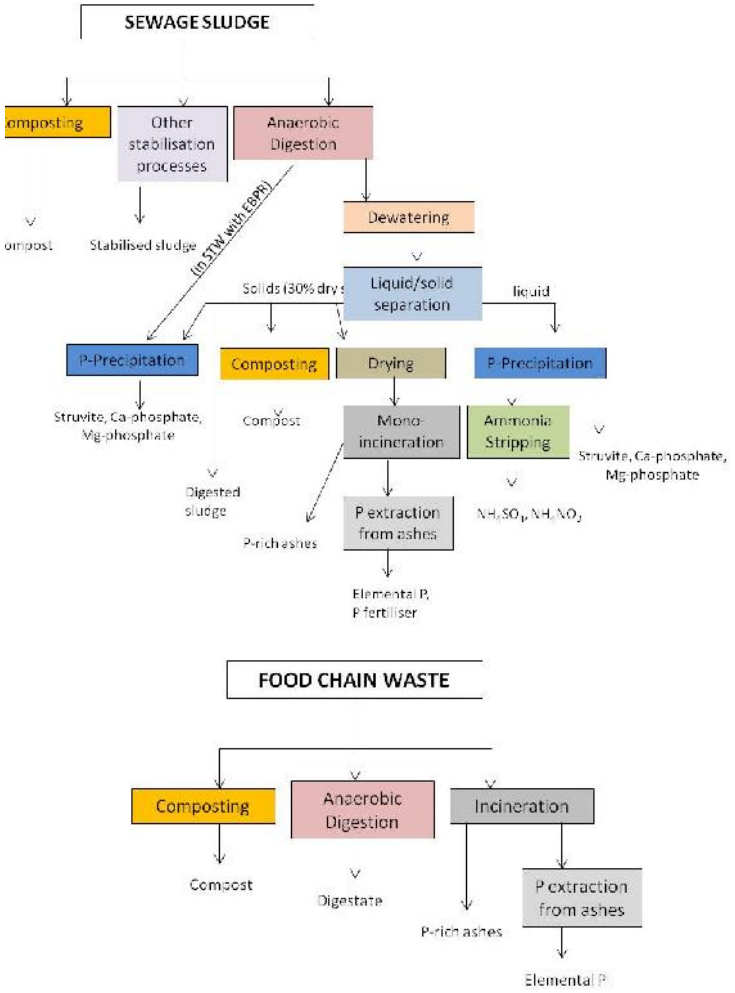
- 10 Mt of dry sludge produced annually (2003-2009 data)
- P and N in sewage sludge: ¼**3.3 Mt N** and ¼ **0.3 Mt P**
- Current fate of sewage sludge EU-27 (Millieu et al. 2010):
  - 42% applied to agricultural land, big variation in EU
  - 27% incineration
  - 23% landfill
  - 7.5% other (e.g. compost)
- Challenges for sludge:
  - Increase recovered amounts and recovery rates.
  - Increase knowledge & specification of nutrient content
  - Address concerns about soil, plant and human health

Municipal and food chain waste

- Less information is available.
- Definitions of waste vary among member states.
- 88 Mt/yr biodegradable/organic waste (0.55 Mt N and 0.11 Mt P)
  - 11.3 Mt compost (used in gardens)
  - 56 Mt digestate (80% used in agriculture)
- 25 Mt/yr of slaugherhouse waste and wastewater: 0.28 Mt P
  - Most of it is incinerated
- Separation and collection challenges

Nutrient recovery – processes and products





Challenges of NRR

Characteristics of material flows of nutrients

- Large volumes, of often highly dilute, heterogeneous, material
- Continuous daily flows, multiple sources, spatially dispersed; but use of fertilisers is highly seasonal
- Multiple decentralised, relatively small production units for recovery (cf fertiliser manufacturing)
- Compared to fertilisers: relatively heterogeneous inputs and products
- Safety concerns: presence of: heavy metals, pathogens, pharmaceuticals, smell; in products destined to be added to soil.
- No presumption that the products of NRR are perfect substitutes for mineral fertilisers: price, consistency, nutrient content and availability
- Workable business models not yet widely known.

Justifications for collective action

- The sheer technical, logistical, attitudinal challenge
- Thus infant industry argument for assistance; R&D, info, encouragement: private and public sector involvement here
- The environmental market failure – externality – argument for encouraging NRR
- Market imperfection case too

- The technologies exist, the sector *is* developing, but will not take-off spontaneously

- There is strong advocacy in the EU:
  - Sign up to the Sustainable Development Goals
  - The action plans for the Bioeconomy and Circular Economy
    - regulatory coherence important
  - The new fertiliser regulation published last week

- But more will be required for a step change in NRR activity

Possible actions to boost NRR

1. Information, research and development

2. Market stimulants - carrots
   - Obligations,
   - Voluntary targets
   - Investment and start-up grants
   - Direct subsidies
   - Fiscal reliefs

3. Penalties and restrictions - sticks
   - Nutrient surplus or fertiliser taxes
   - Landfill and incineration prohibitions/gate fees

Recommendations (16)

1. Better data (2)
2. Regulatory coherence (1)
3. Appropriate policies to find optimal NRR contribution (5)
4. Back the Circular Economy action plan (3)
5. Consumer acceptance and land manager mobilisation (4)
6. Optimal level of livestock production and consumption (1)

Conclusion

- NRR has an important role to play in better nutrient management
- Substantial scope to increase NRR in the EU
- Because of the intrinsic nature of the materials, processes, products and businesses this will not spontaneously take-off
- Therefore purposive incentives and actions required
- But first rigorous cost benefit, cost effectiveness analysis must be conducted.

We thank our sponsors

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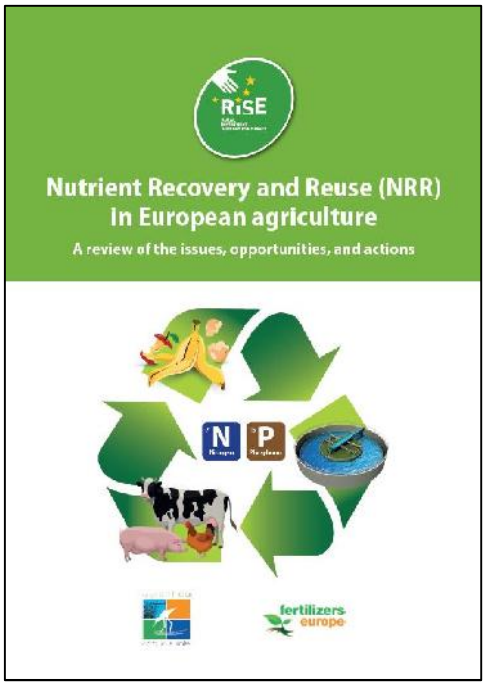

If you have been . . .
thanks for listening!

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