Mangement of biowastes and regulations for their use in Norway

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Outlines

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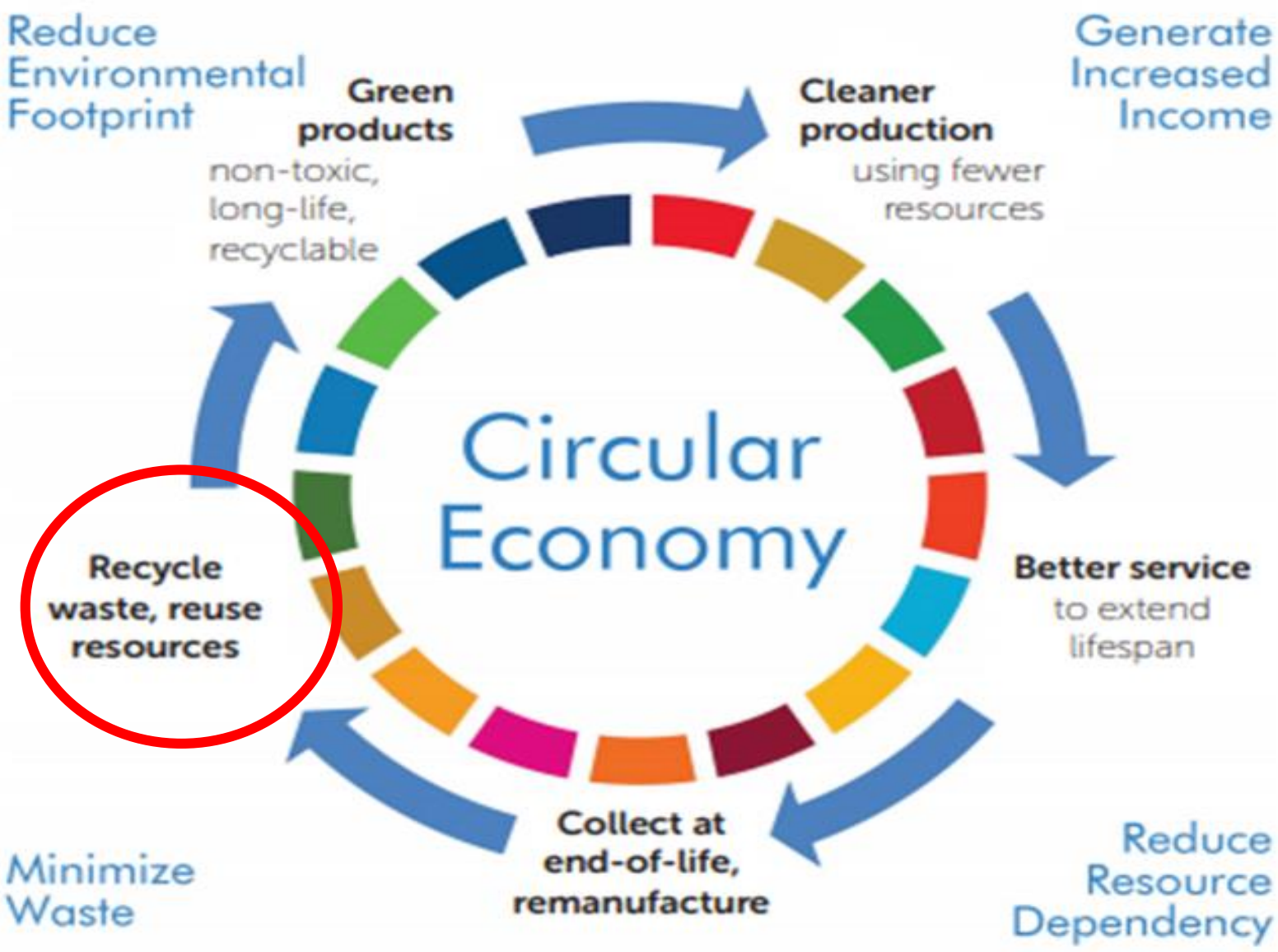
- Introduction
- Organic wastes
- Biological treatments
- Regulations for use in agriculture
- Organic wastes and Phosphorus

Organic wastes in Norway

Waste policies and regulations in Norway and the EU are based on the principle of the wastes hierarchy, describing general priorities concerning the treatment of wastes;

- firstly prevention,
- then reuse,
- material recycling ,
- energy recovery and
- lastly disposal (EU commission 2008)

Soil



Adopted from Nesse and Sogn (2019) (personal communication)

Organic wastes in Norway

- **In Norway, biogas production has emerged primarily as waste treatment method. Biogas potential in 2020 is estimated to 2.3 TWh (Norwegian Environmental Agency, 2013)**

- **SSB (2015) reported that total consumption of biogas constituted nearly 3% of national bioenergy use, the amount of biogas was 361 GWh in Norway.**

Organic wastes in Norway

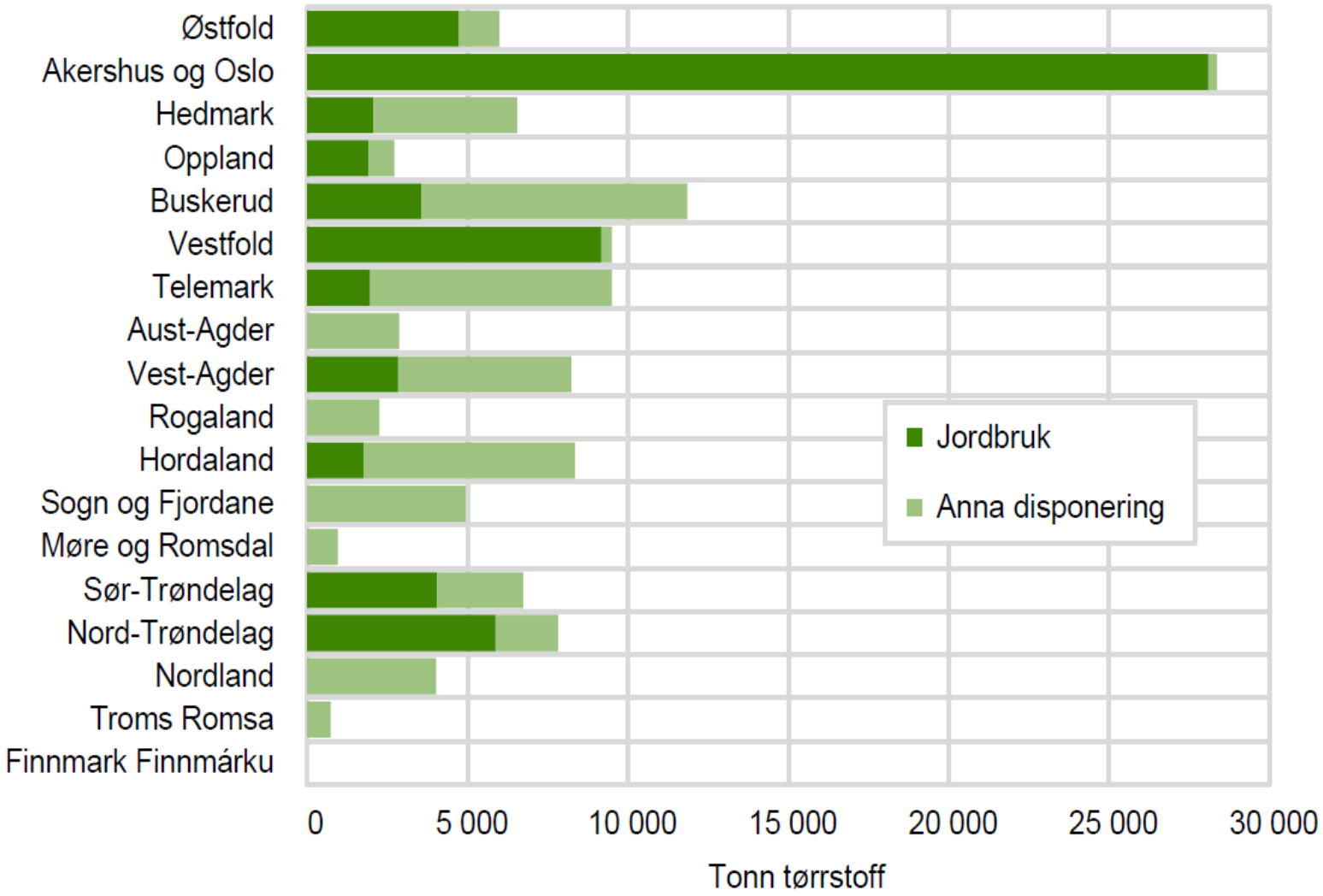
Organic wastes in Norway

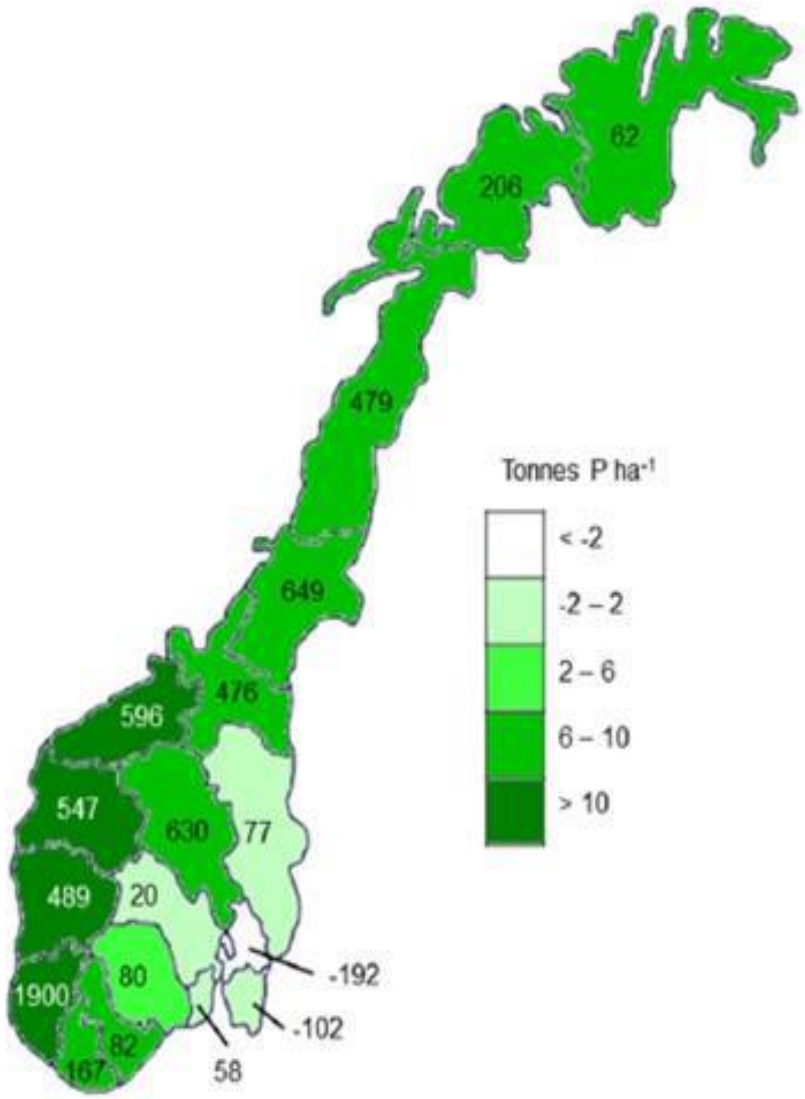
Soil

- Animal manure
- Fish sludge
- Compost
- Biogas digestate
- Waste water (sludge)
- Garden waste
- Slaughter waste
- Wood processing waste

Adopted from Nesse and Sogn (2019) (personal communication)

Figur 8.10 Mengd avløpsslam disponert til jordbruksføremål og anna disponering[1]. Fylke. 2017





SSB, Jordbruk og miljø 2018

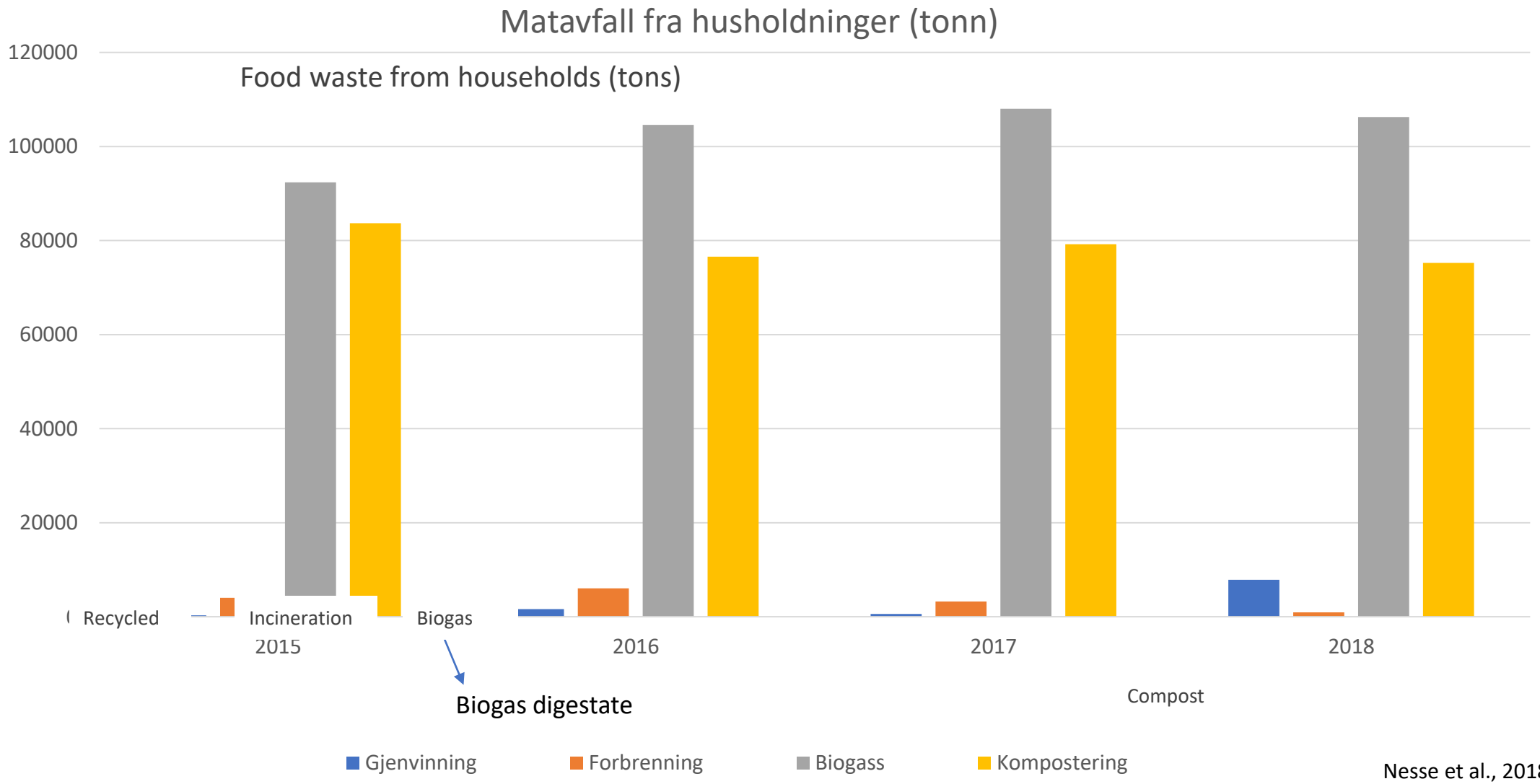
Hanserud et al., (2016)
NutrCyclAgroecosyst., 2016

Total household wastes in Norway

Waste type	Total tonn y^{-1}	Sent to mat recov.,compost, biogass (% wt)	Sent to energy use & disposal (% wt)	Others (%wt)
Source separated-wet org. wastes	189135	96.6	3.2	0.2
Garden and park wastes	153766	97.7	1.4	0.8
Plastic wastes	39809	96.4	3.5	0.2
Rest wastes	977123	0.0	99.7	0.3

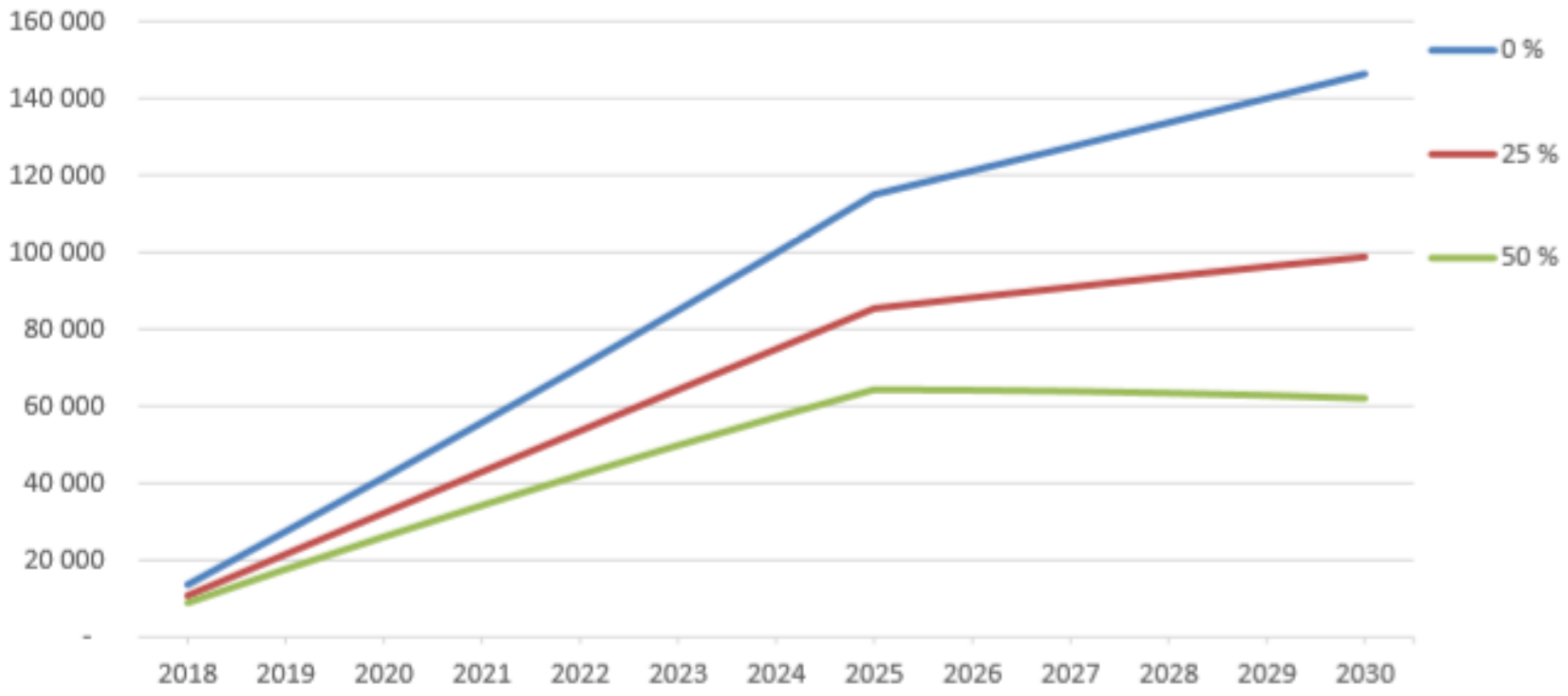
Østfoldforskning (mepex report (2017)

Variation between different wastes



Nesse et al., 2018

Increased collection of food wastes (ton)at different reduction levels



Østfoldforskning (=R.25.19, 2019

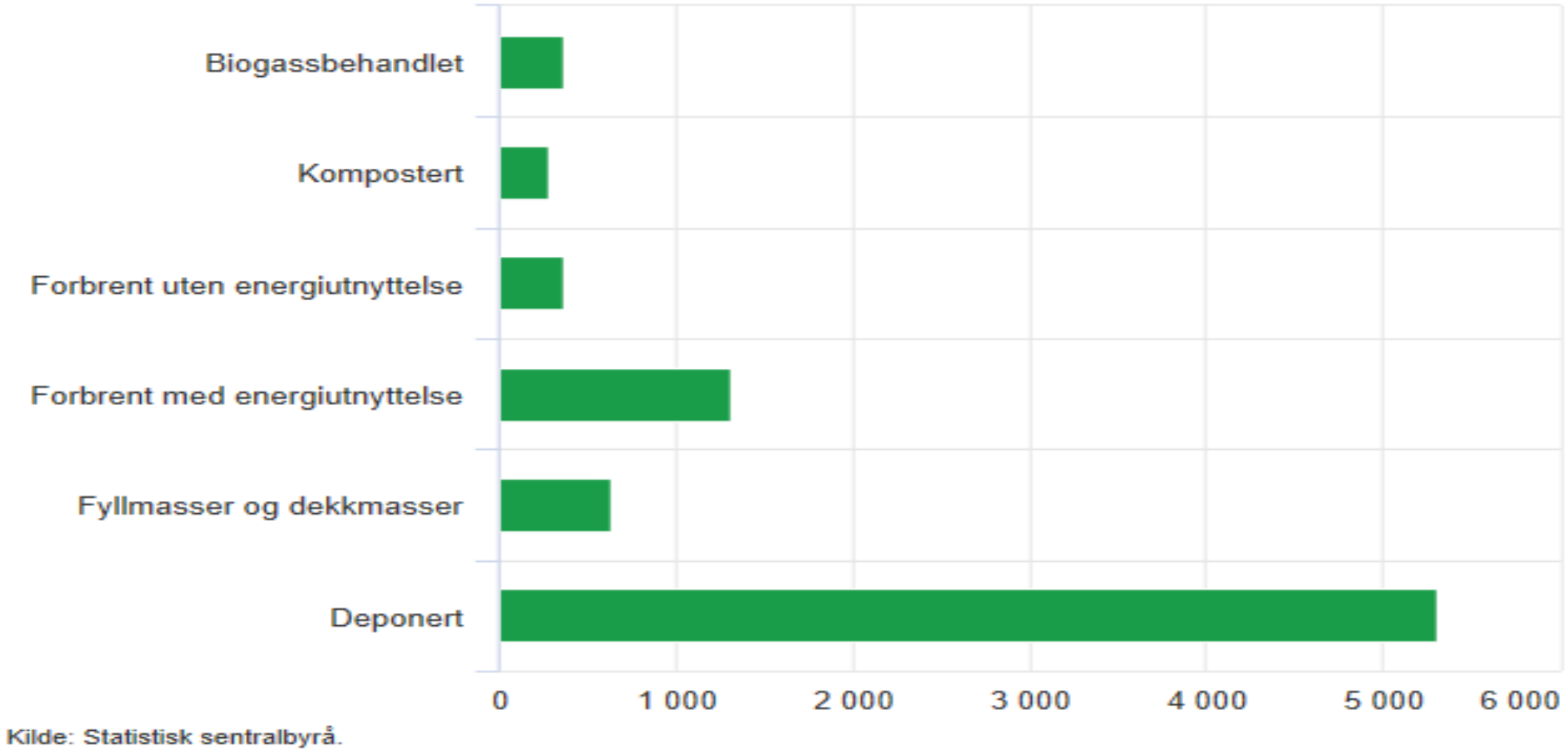
Biological treatments

Waste management, or resource production?

- A resource for the farmer
  - Nutrients
  - Soil amendment
  - Predictability
- Disperasal of
  - Plastics
  - Metals
  - Organic contaminants
- Analysis Challenges

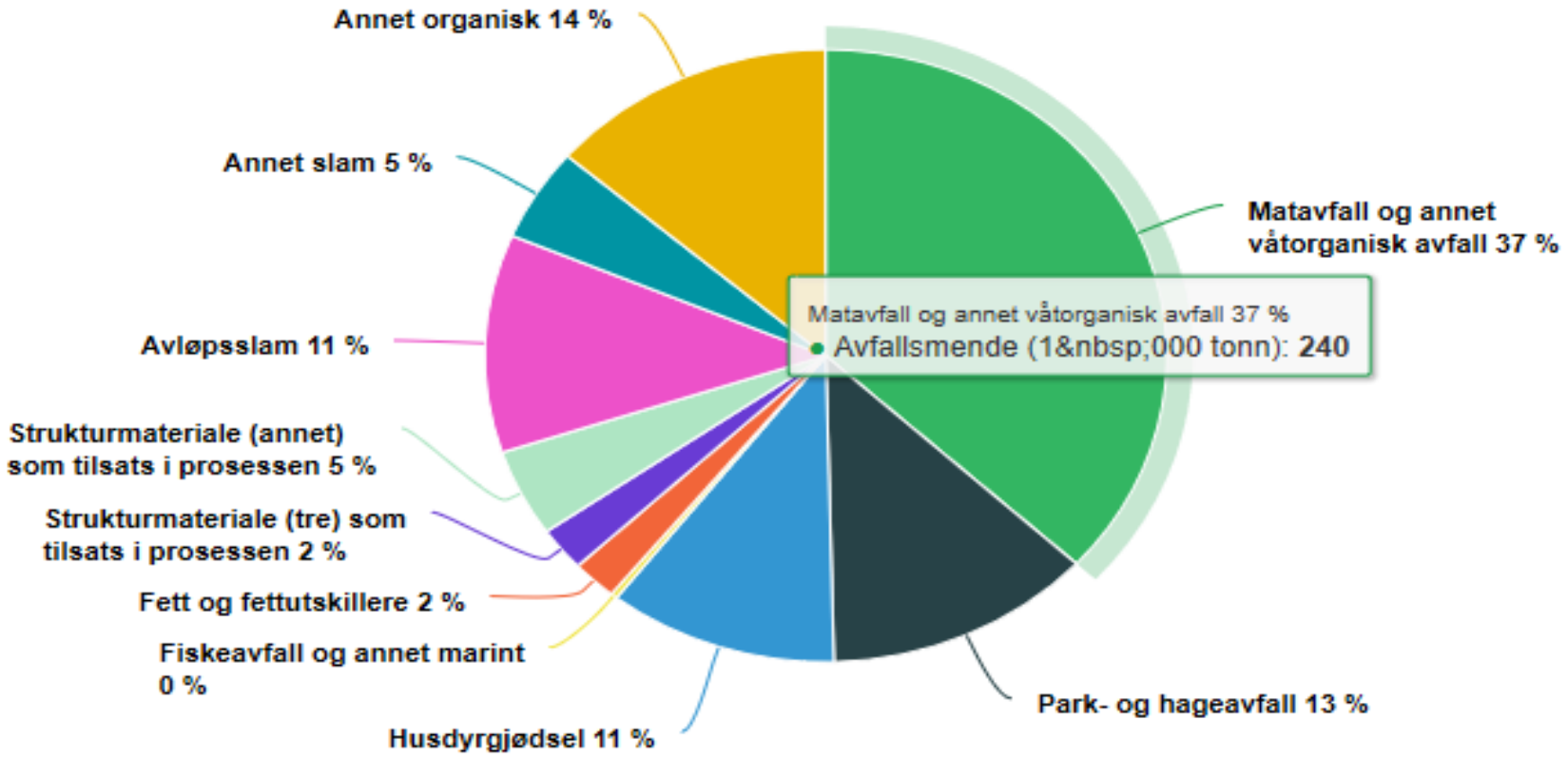
Adopted from Nesse and Sogn (2019) (personal communication)

Treatment methods for wastes (1000t) in Norway (SSB 2017)



SSB (Report 25 Sept. 2018)

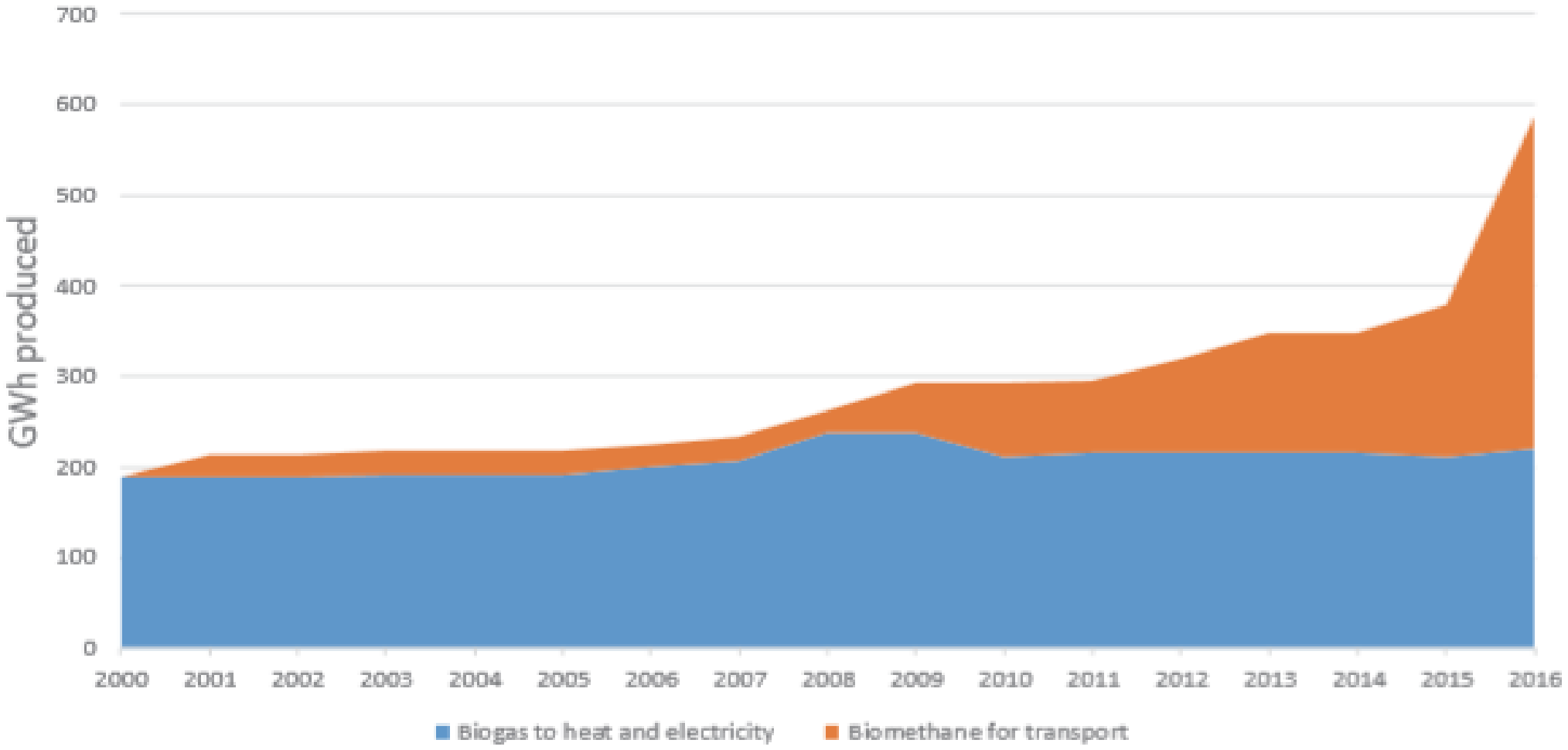
Biological treatment of wastes (SSB 2017), Distribution in different types



Kilde: Statistisk sentralbyrå.

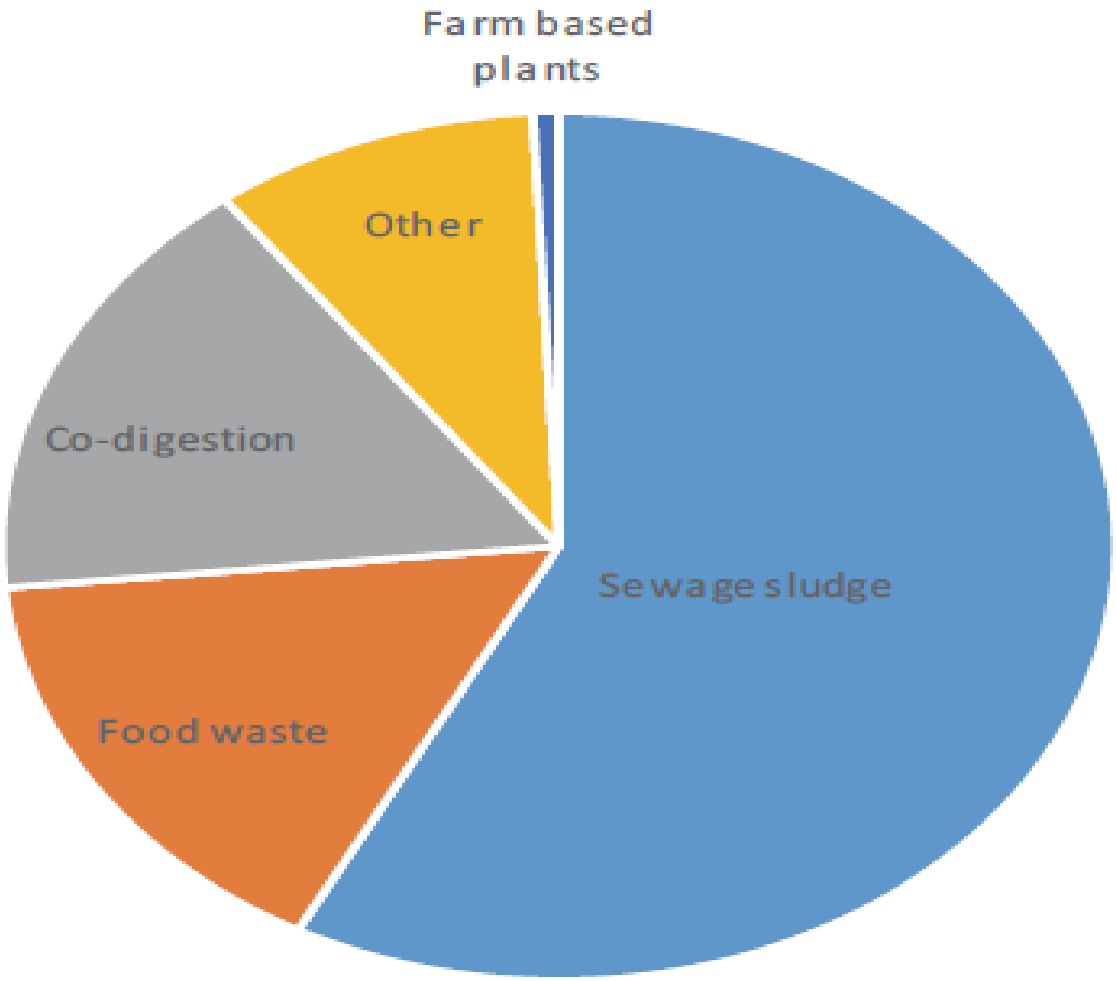
SSB (Report 25 Sept. 2018)

Biogas production in Norway from 2000 to 2016



Lyng (PhD thesis 2018)

Biogas based on substrate used per GWh biogas produced



Most plants use sewage sludge and food wastes.
Co-digestion is either sewage sludge and food wastes or sewage sludge and manure

Lyng (PhD thesis 2018)

Biogas production

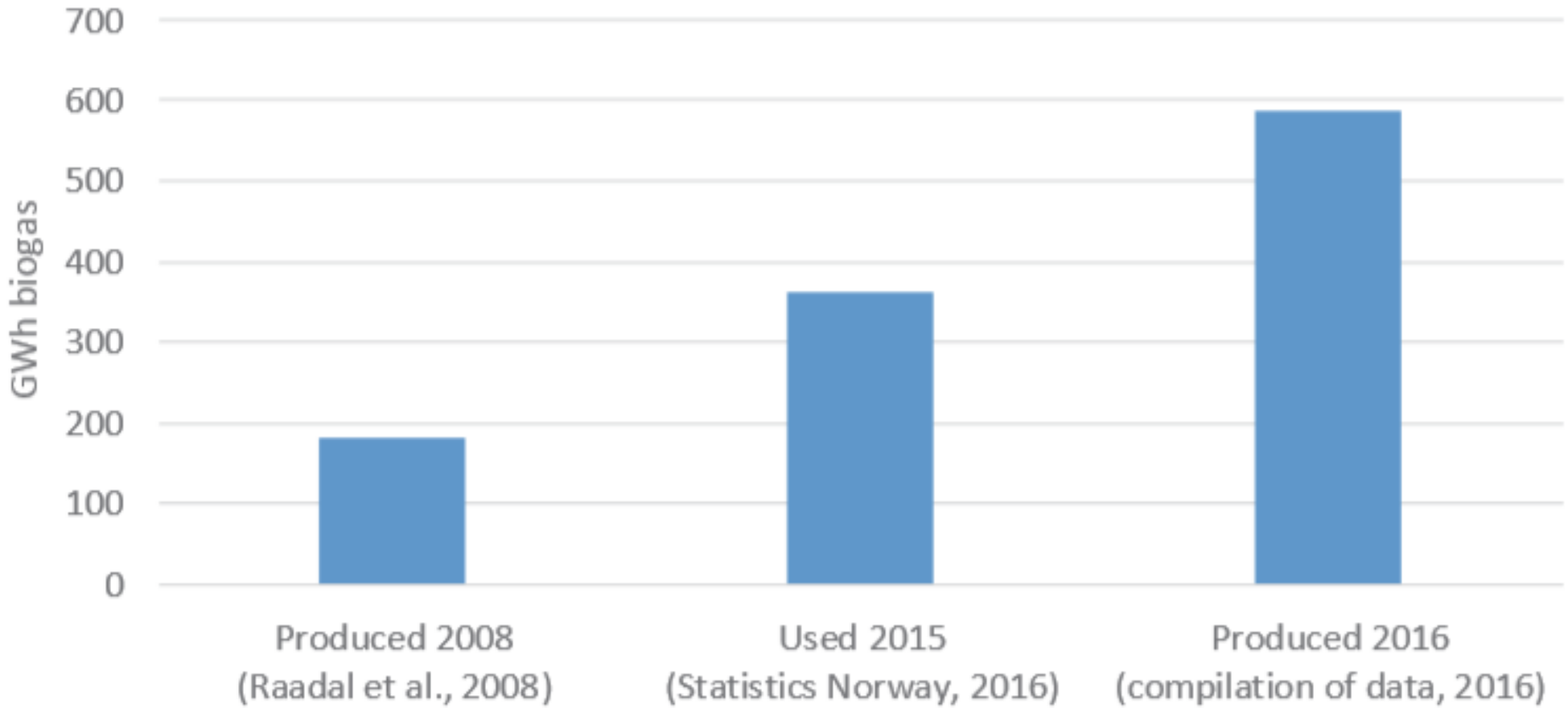


Figure 3 Data on biogas produced and used in Norway in 2008 and 2016

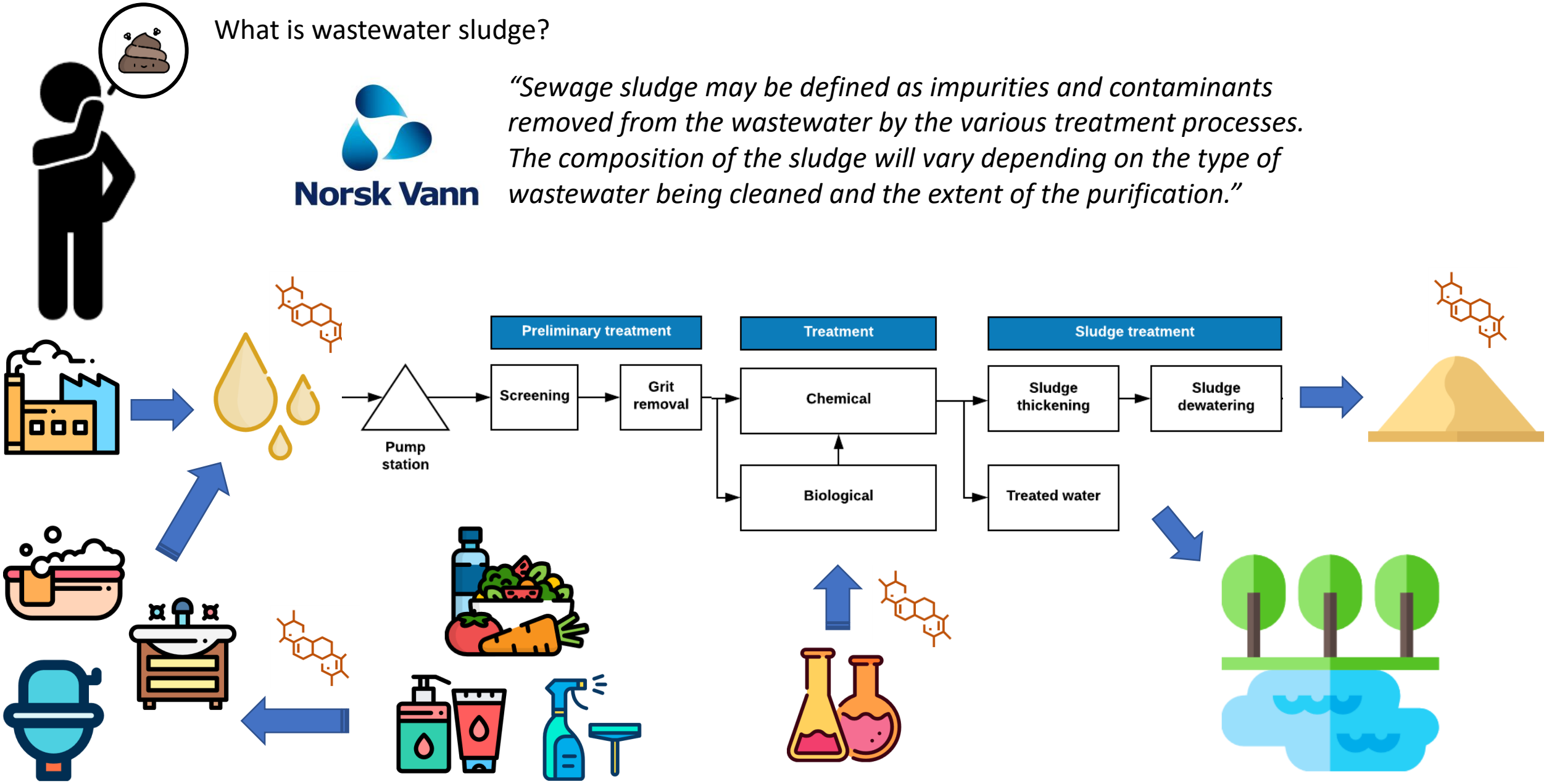
Lyng (PhD thesis 2018)

Regulations for use in agriculture

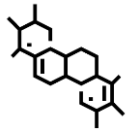
What is wastewater sludge?

Norsk Vann

"Sewage sludge may be defined as impurities and contaminants removed from the wastewater by the various treatment processes. The composition of the sludge will vary depending on the type of wastewater being cleaned and the extent of the purification."



What does wastewater sludge contain?

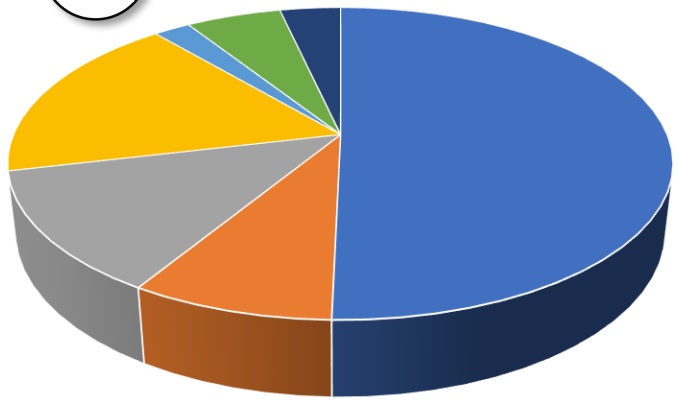


- **Heavy metals**: Cadmium, Lead, Mercury, Nickel, Zinc, Copper, Chromium.
- **Nutrients**: Nitrogen and Phosphorus.
- **Contaminants**: Dioxins and furans, flame retardants, metals, 1,2-dibromo-3-chloropropane (DBCP),...
- **Pesticides**: DDT, Lindan (HCH/HCB), ...
- **Medicine residue**: Sulfamerazine, bisopropol, clarithromycin,…

- **Foreign objects**: Plastic, glass, stones.
- **Bacteria**: Salmonella, coliform bacteria (TKB).

How is wastewater sludge used in Norway?

Data from Statistics Norway:
11788: Kommunalt avløpsslam (K) 2015 - 2017



Why is it allowed to use wastewater sludge in agriculture if it contains so much impurities and contaminations?

GJØDSELVAREFORSKRIFTEN – Organic fertilizer regulation

COUNCIL DIRECTIVE (86/278/EEC) – on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture

FACILITATION

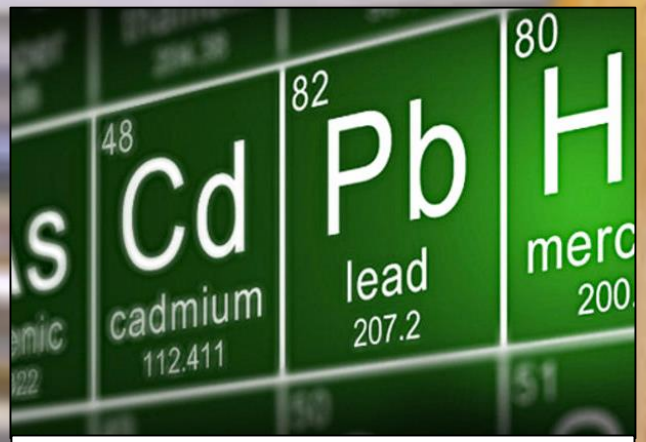
It facilitate use of these products as a resource.

PREVENTION

It prevents contamination, health and hygienic disadvantages of storing, manufacturing and using sludge-based fertilizers.

SATISFACTION

Ensure satisfactory product quality.



Heavy metals content

Organic pollutants and pesticides

Stabilization

Hygienization

Foreign objects: glass, plastic, metal

Requirements for raw materials

Limit values for heavy metals concentrations in sludge for use in agriculture

Parameter	Limit values (mg/kg DM) – Norwegian law				Limit values (mg/kg DM) – European law
	0	I	II	III	
Cadmium	0,4	0,8	2	5	20 – 40
Copper	50	150	650	1000	1000 – 1750
Nickel	20	30	50	80	300 – 400
Lead	40	60	80	200	750 – 1200
Zinc	150	400	800	1500	2500 – 4000
Mercury	0,2	0,6	3	5	16 – 25
Chromium	50	60	100	150	---

CLASS NO.:

0

Can be used for agriculture, at private gardens, parks, green areas and similar.
The amount added must not exceed the plants' need for nutrients.

I

4 tons of DM / acre / 10 years - agricultural areas, in private gardens and in parks.
5 cm thick layer mixed into the soil at the site - green areas where food or feed crops are not to be grown.

II

2 tons of DM / acre / 10 years - agricultural areas, in private gardens and in parks.
5 cm thick layer mixed into the soil at the site - green areas where food or feed crops are not to be grown.

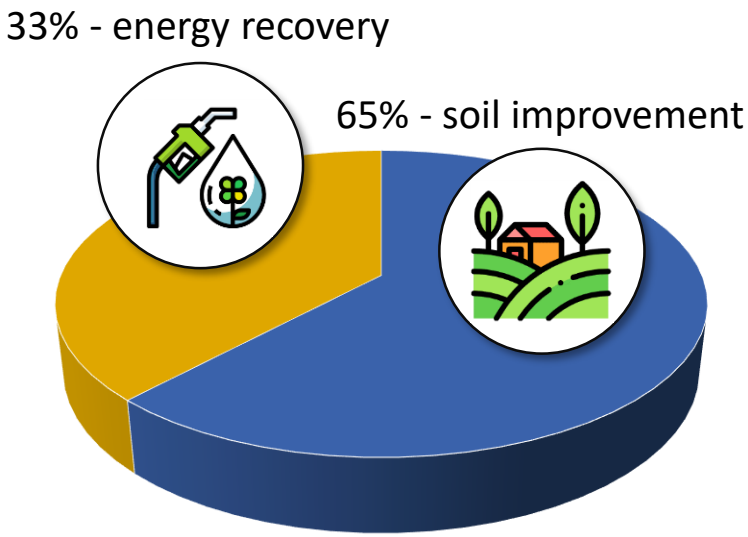
III

5 cm thick layer mixed into the soil at the site / 10 years - green areas where food or feed crops are not to be grown.
15 cm layer - as a top cover for landfills.

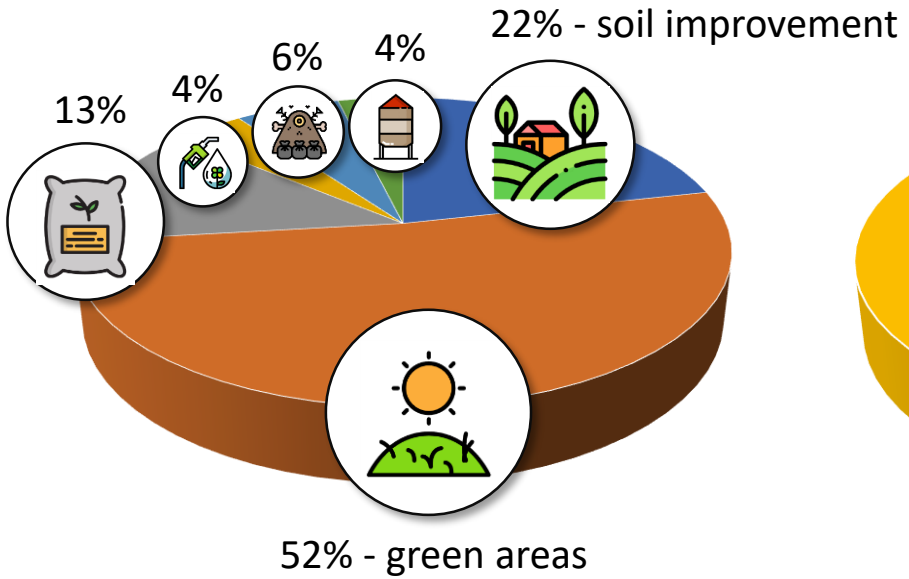
Limit values for concentrations of heavy metals in soil

Parameter	Limit values (mg/kg DM) – Norwegian law	Limit values (mg/kg DM) – European law
Cadmium	1	1 – 3
Copper	50	50 – 140
Nickel	30	30 – 75
Lead	50	50 – 300
Zinc	150	150 – 300
Mercury	1	1 – 1,5
Chromium	100	---

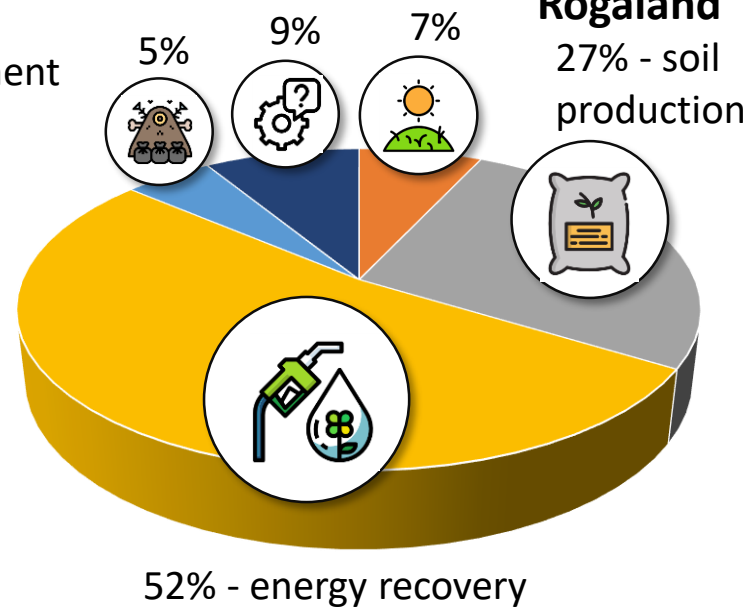
Oslo og Akershus



Hordaland



Rogaland



Corn area Oslo and Akershus*: 569 700 acres

Corn fields capacity for WWT sludge: 113 940 tons DM/ year

Produced WWT sludge: 41 692** tons DM (37% of capacity)

Animals per farm (2017)*: 72,5**

Corn area Hordaland*: 200 acres

Corn fields capacity for WWT sludge: 40 tons DM/ year

Produced WWT sludge:** 8 162 tons DM

Animals per farm (2017)*:** 39,9

Corn area Rogaland*: 28 200 acres

Corn fields capacity for WWT sludge: 1 159 tons DM/ year

Produced WWT sludge:** 5 798 tons DM

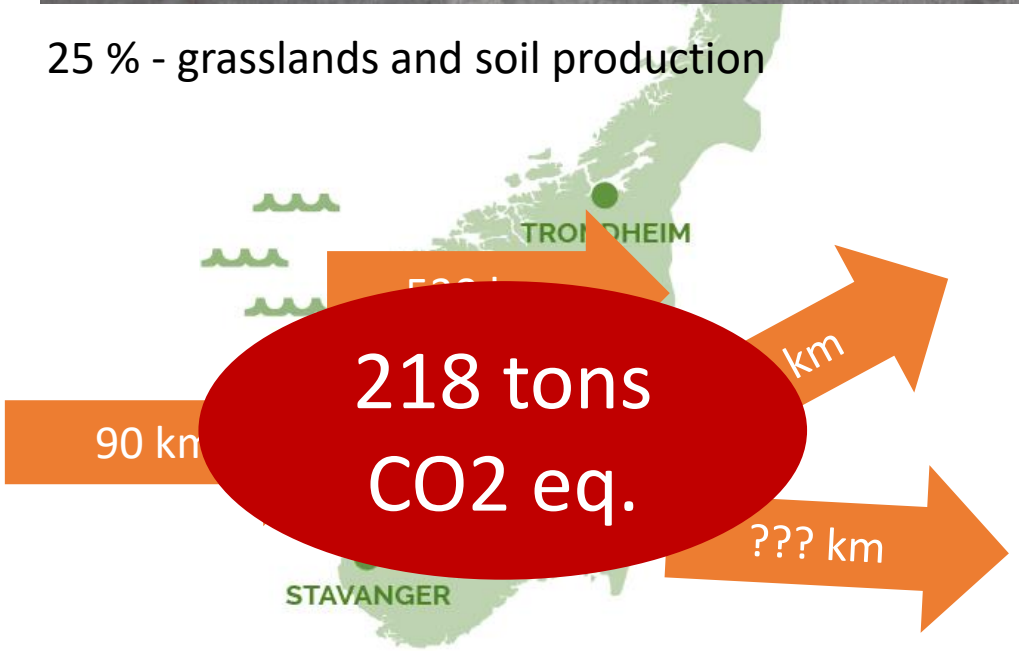
Animals per farm (2017)*: 74,7**

* Ref. SSB: Jordbruksbedrifter med areal av korn- og oljevekster. Areal av de ulike kornslaga. Fylke (2016)

** Ref. SSB: Kommunalt avløpsslam, etter region, statistikkvariabel og år (2017)

*** Ref. SSB: Dyretal per jordbruksbedrift med vedkomande husdyr, etter fylke og bruksstorleik (2017)

25 % - grasslands and soil production



Organic wades and Phosphorus

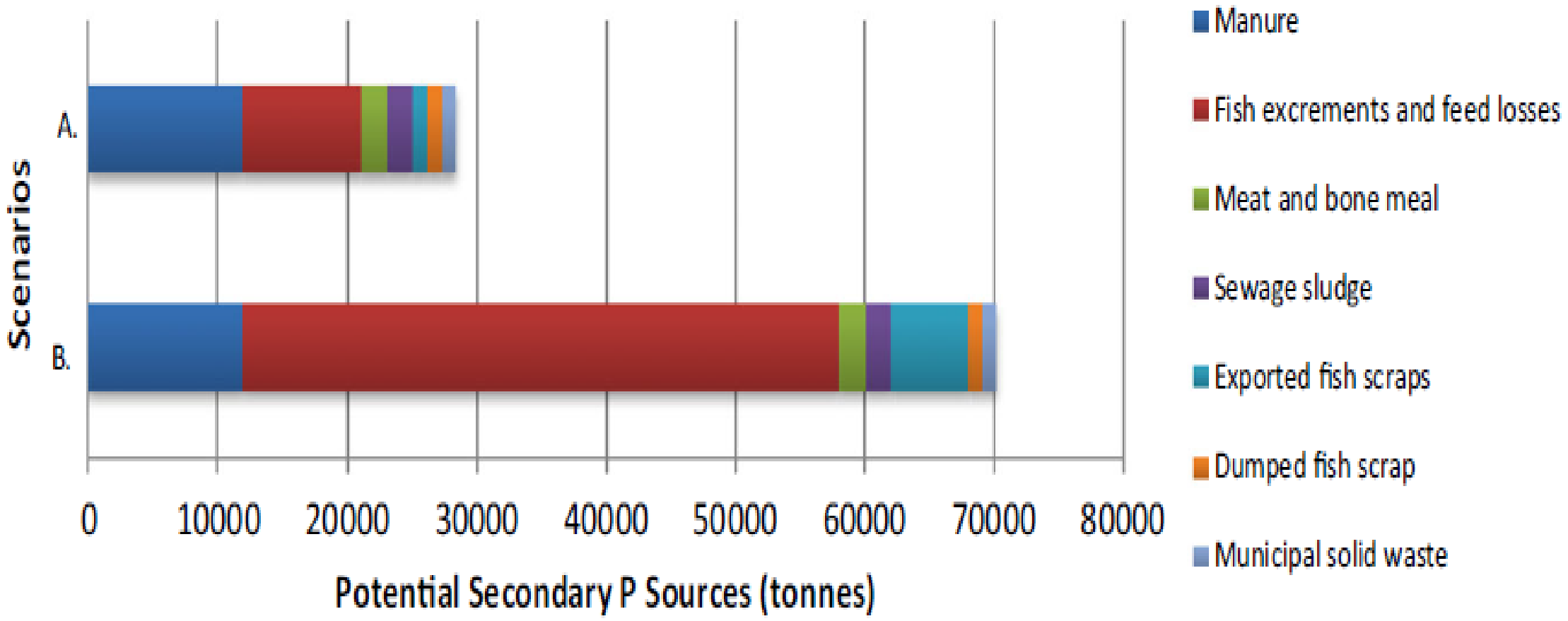
Posphorus (P) in organic wastes

- P fertilizer demands globally are primarily met through the mining of limited, non-renewable phosphate rocks.

- Overall, food production accounts for above 90% of the global mineral P demand.

- Organic wastes contain nutrient including P and hence must be explored as secondary P sources for agriculture.

Potential secondary P sources for A. 2009–2011 and B. 2050 scenario in tonnes P



Adapted from Hamilton et al. 2015

Potential secondary P

- The 2050 scenario reveals the future significance of the aquaculture sector.

- With fish production at 5 million tonnes P/yr and technologies held constant, lost P to marine waters reaches 45,000 tonnes P/yr through fish excrements and feed losses

- Compared to the 2009–2011 model, this far exceeds the mineral fertilizer demands of agriculture.

Potential secondary P

- The results indicate that, with current technologies, such growth could lead to a dramatic increase in P losses to marine waters as well as the dependency on imported P in fish feedstuff.

- In terms of P recycling, however, the overall amount of potential secondary P sources drastically increases from the base-case scenario to the 2050 scenario.

Agronomic use efficiency (RAE) of P

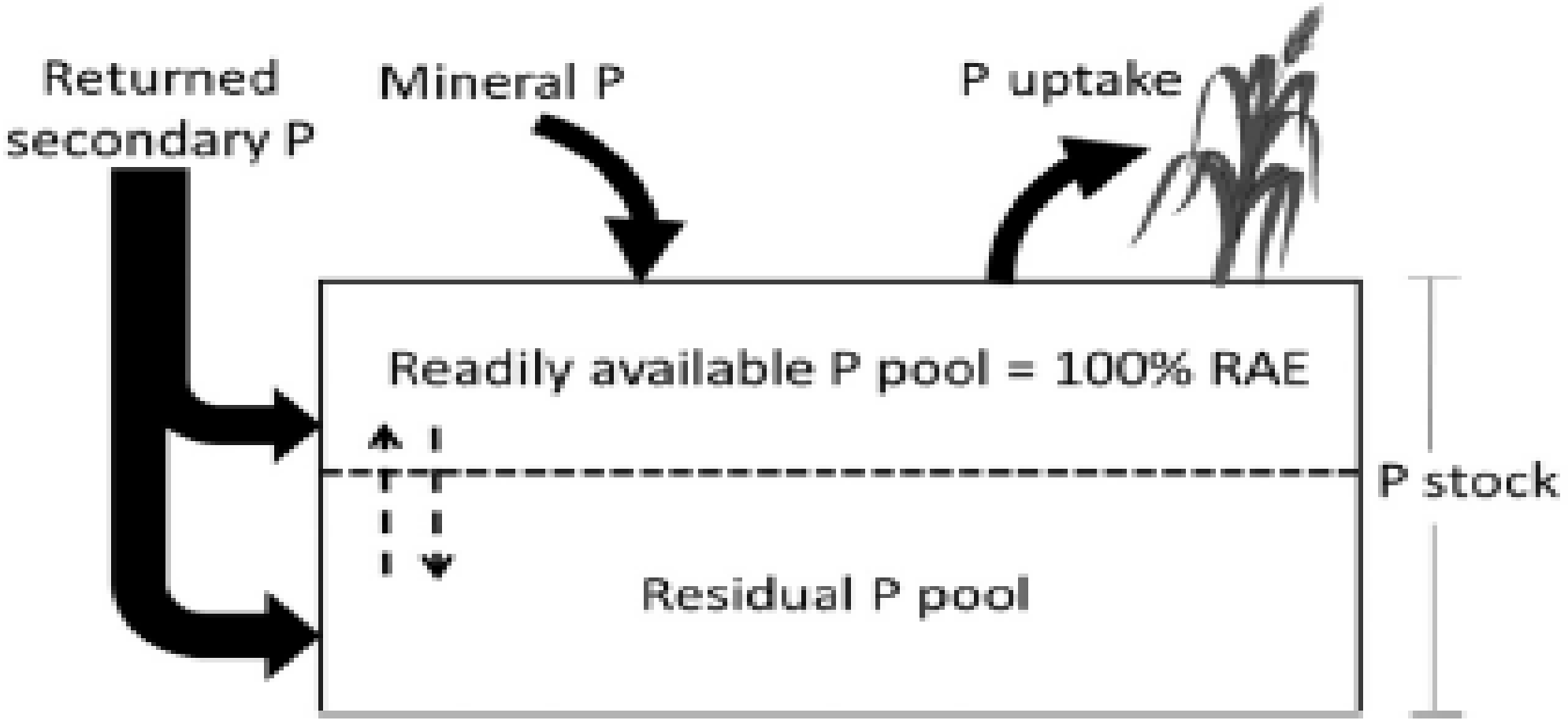


Fig. 1. Conceptual drawing of relative agronomic efficiency (RAE).

Hamilton et al. 2016

RAE of P

- Last slide provides a schematic illustrating how RAE is defined.

- The soil stock is divided into two pools: a readily-available P pool and a residual P pool.

- The readily-available P pool represents the P that is immediately available to plants while the residual P will only be made available to plants through microbial or chemical processes (the upward dotted arrow).

RAE) of P

- For optimal yields, plants require a critical amount of P in the readily-available P pool.

- Therefore, for most soils, readily-plant available P must be added, as the rate of transfer from the residual pool to the readily-available pool is insufficient to reach this critical value at the time needed by the crop (Syers et al., 2008).

- The downward dotted arrow represents the conversion of available P to residual P over time.

RAE of P

- As shown in the last slide , mineral fertilizer is used as a benchmark, as all water-soluble mineral P will be readily-available for plants (RAE = 100%, per definition).

- RAE estimates the fraction of the secondary P fertilizers that will enter the readily available soil P pool and, thus, can substitute water-soluble mineral P fertilizer during the first growing season.

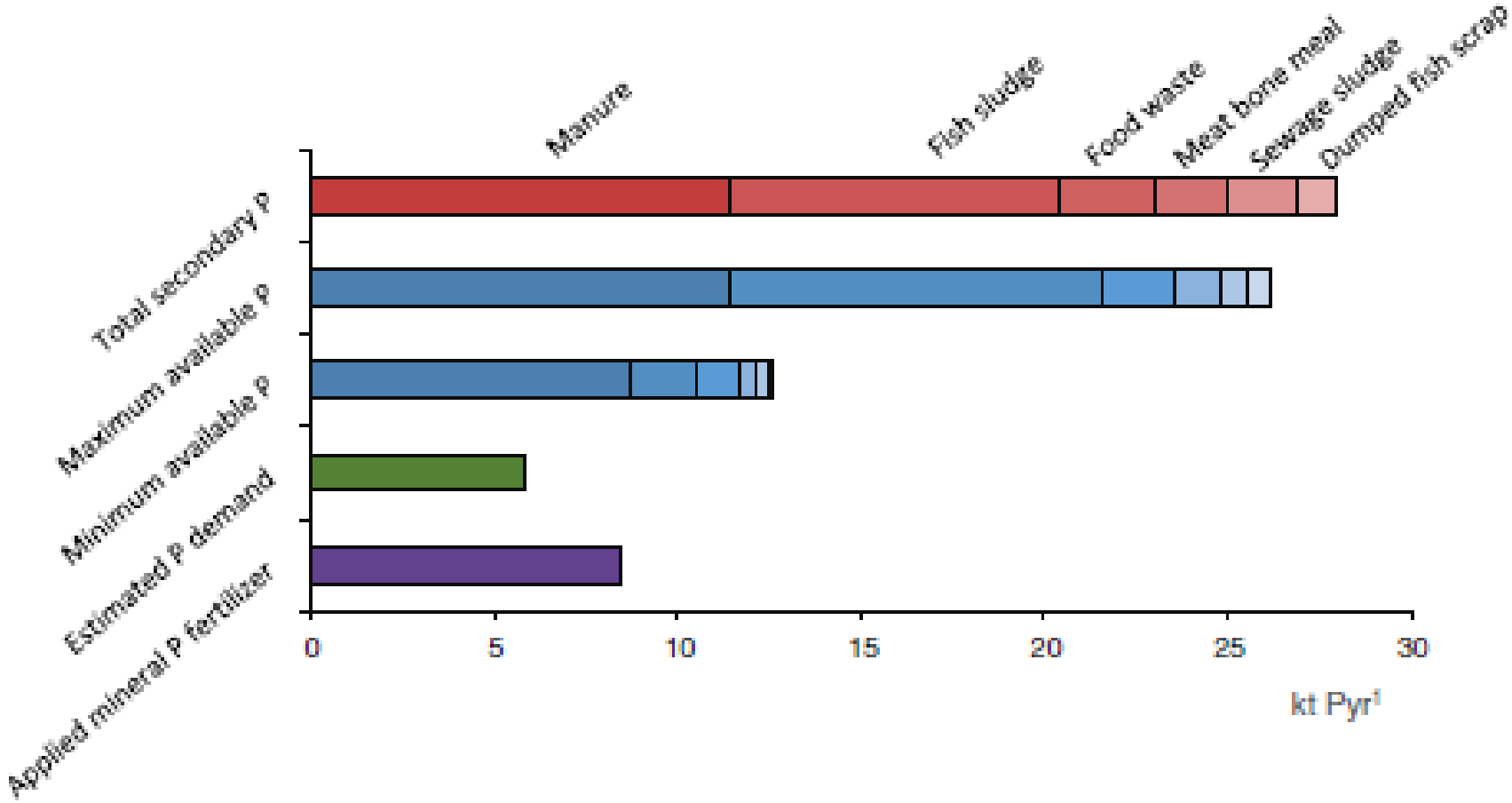
-

RAE of P

- The remaining P in secondary P resources enters the residual P soil pool.

- Therefore, the higher the fraction of secondary P that enters the readily-available P pool, the better it serves as a replacement for mineral P fertilizer and the less it will contribute to accumulation of P in the soil (Ekholmet al., 2005)

Potential of secondary P resources



Total secondary P, maximum and minimum P recycling potential of secondary P resources, estimated P fertilization demand and mineral P fertilizer applied in 2009–2011

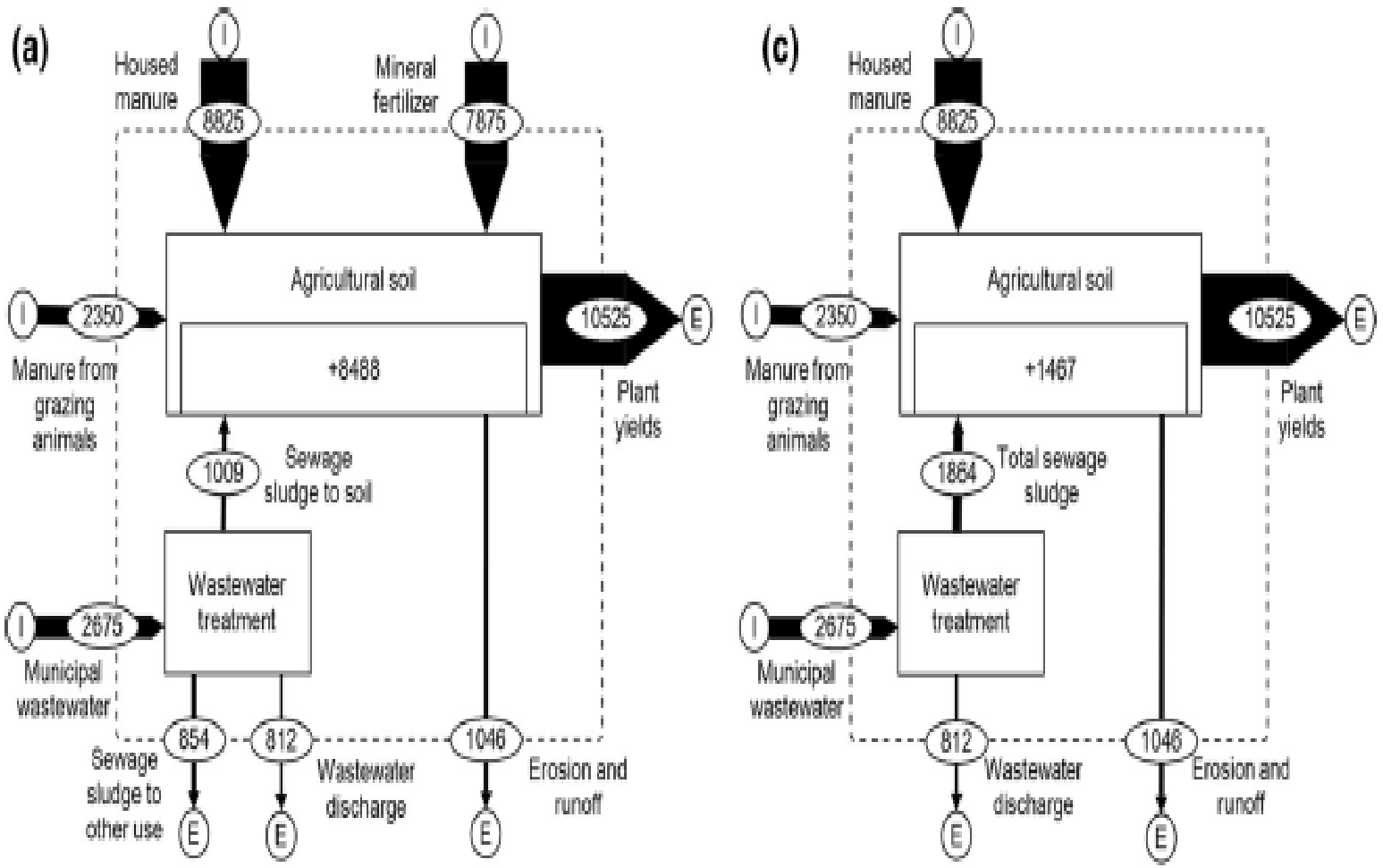
Hamilton et al. 2016

Potential of secondary P resources

- When considering the minimum plant-availability of P in manure, this resource alone could potentially meet the fertilization demand of Norway (estimated at 5.8 kt plant-available P/yr).

- This will also avoid the accumulation of residual P.

- Overall, it was found that the plant-available fertilizer recycling potential of Norwegian secondary P resources ranged from 12.7 to 26.3 kt plant-available P/year (Hamilton et al. 2016)



FR0: Status quo soil P balance

• FR1: Soil P balance without MF, maintenance fertilization strategy

Fig.(a) FR0: annual P balance for agricultural soil in Norway (tonnes P year-1), 2009–2011. c FR1 : annual P balance for agricultural soil in Norway (tonnes P year-1), 2009–2011.(Hanserud et al. (2015)

P balances

- FR1 In this fertilizer regime, we wanted to see whether plant-available P in manure and sewage sludge, would be sufficient alone to provide the amount of P fertilizer required according to a maintenance fertilization strategy. Mineral fertilizer therefore omitted.

- Considering plant-availability significantly reduced the recycling potential of most secondary P resources.

P balances

- There is still substantial opportunity to substitute mineral P fertilizer, with manure showing, by far, the largest potential as large quantities nationally, with between 8.7 and 11.4 kt plant-available P/yr are available..

- Therefore, even when considering the minimum plant availability of P in manure, this resource alone could potentially meet the fertilization demand of Norway (estimated at 5.8 kt plant-available P/yr), while avoiding the accumulation of residual P (Hamilton et al. 2016).