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ECOSYSTEM SERVICE: GREEN WASTE – EXCESS BIOMASS AND NUTRIENTS IN AN AGRICULTURAL PERSPECTIVE

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SOIL ECOSYSTEM SERVICES

› The role agriculture plays in maintaining ecosystem services, such as water retention, soil fertility, carbon storage and climate regulation, is increasingly recognised.

Table 1
Sub-problems at level 1, 2 and 3 of the problem tree. Grey cells in the third column represent ecological indicators for which data are available for the five case-study compounds nickel, cadmium, chlorpyriphos, lindane, and diazinon.

Sub-problems at level 1: ecosystem service	Sub-problems at level 2: ecological requirements	Sub-problems at level 3: susceptible ecological indicators	
Soil fertility	General biodiversity aspects	1	Biodiversity indices
	Microbial aspects	2	Arginine deaminase activity
		3	Carbon sources utilization diversity
		4	Cellulase activity
		5	Microbial biomass and activity
		6	Mycorrhizal infestation
		7	Nitrification
		8	Phosphatase activity
		9	Soil respiration
		10	Sulphur oxidation
		11	Urease activity
	Plant aspects	12	Dicotyledons biomass (fodder quality)
		13	N content (fodder quality)
		14	Litter standing crop
		15	Root density
		16	Root turnover
		17	Vegetation biomass
		18	Vegetation standing crop
	Fauna aspects	19	Anecic earthworms
		20	Ants
		21	Cattle meat quality
		22	Collembola
		23	Earthworm community structure

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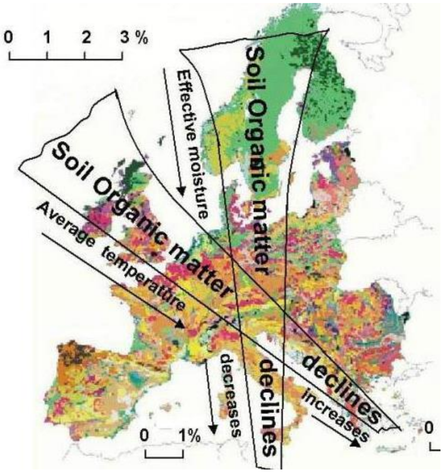
IMPACTS ON SOIL ECOSYSTEM HEALTH AND SERVICES



› Present trends for cultivated soils:

- › aromaticity increasing
- › **carbon content decreasing**
- › biological activity decreasing
- › water holding capacity decreasing
- › yields have stopped increasing upon increased use of pesticides
- › .....
- › **Scarcity in phosphorous reserves** for mineral fertilizer production

› The Challenge:

- › reversal of the decline in soil organic matter within agro-ecosystems by returning **high quality P rich organic matter**, minerals and nutrients to the soils

SUSTAINABILITY-RELATED ISSUES

- Resource scarcity
- Environmental pollution
- Food safety

PHOSPHORUS IS AN ESSENTIAL AND NON-SUBSTITUTABLE NUTRIENT

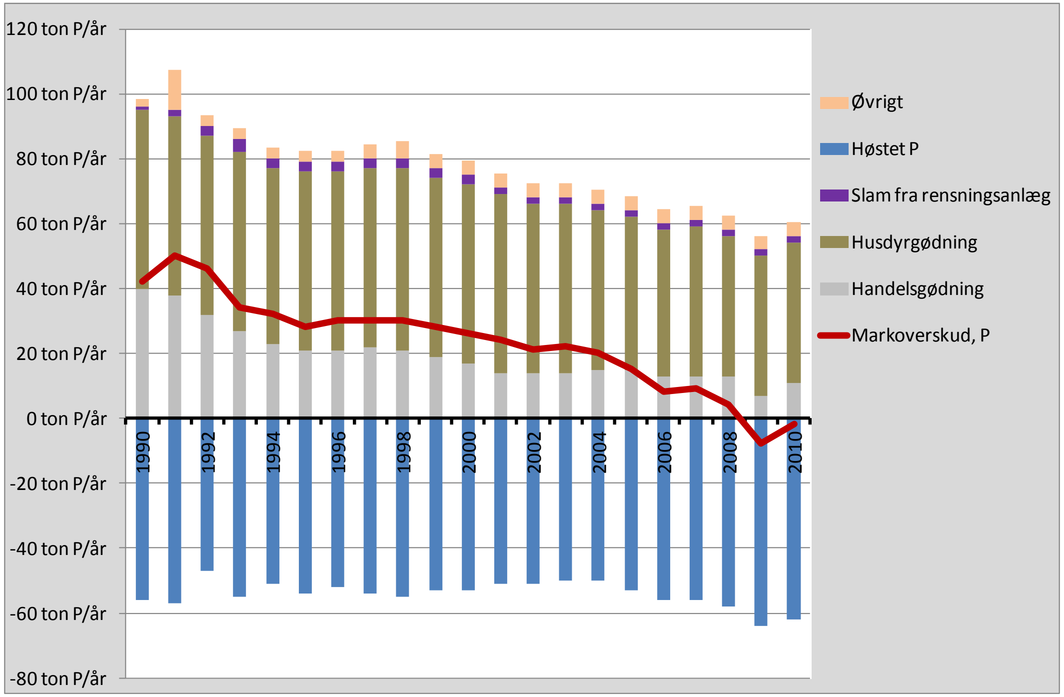
- the point when the demand for phosphorus from mineral reserves will exceed the available supply estimated to occur in about 30 years (Cordell et al., 2011).

- Agricultural P-demand in DK: 53.000 t/yr
- Import: 15-20.000 t/yr

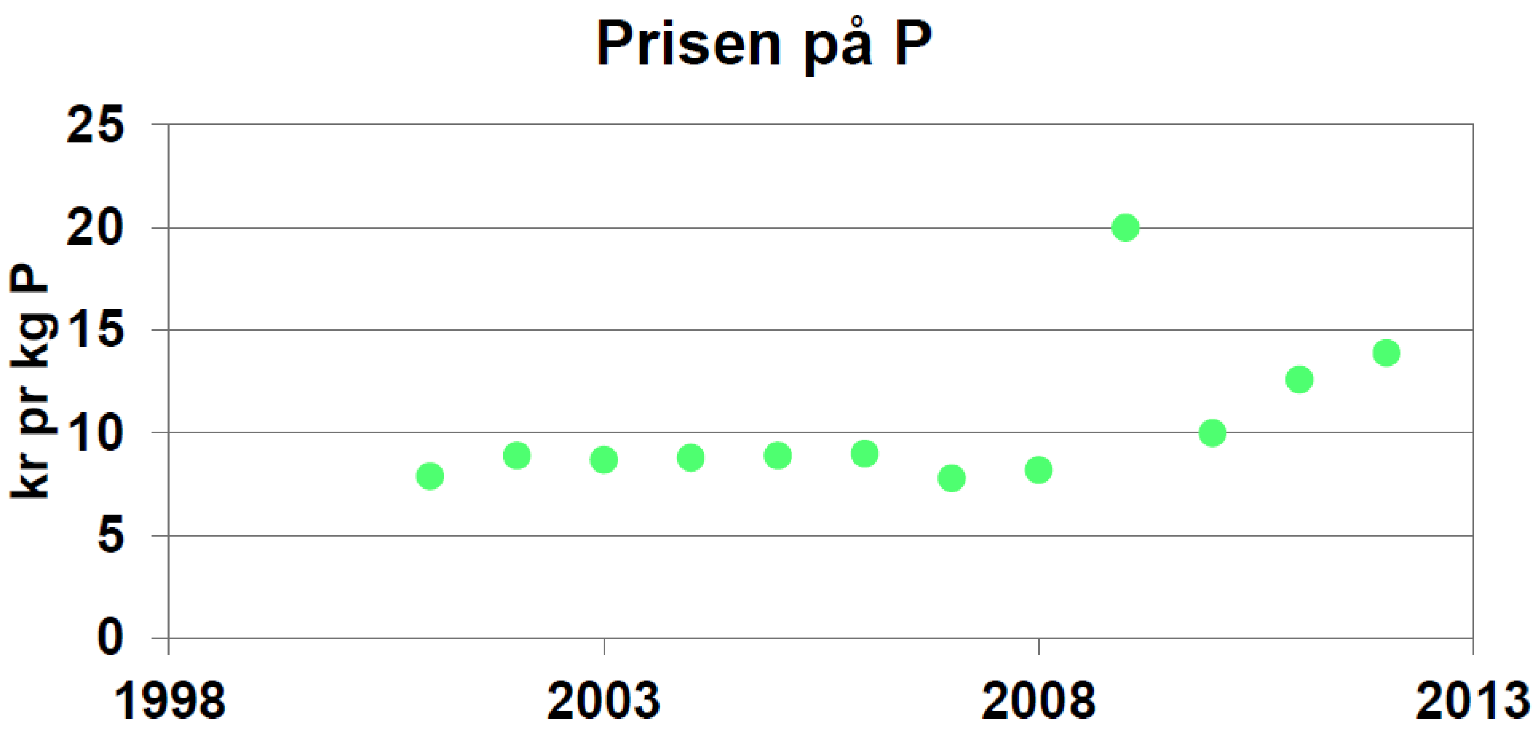
- P recycling potentials:

- WWTP: 5.000 t/yr
- Manure: 45.000 t/yr
- Household/service/industries: 9.000 t/yr

P SUPPLY AND DEMAND IN DK



INCREASE IN THE PRINCE OF MINERAL FERTILIZER



NEED FOR BIOLOGICAL RECYCLING

-The government has a vision that the organic farm area must be doubled in 2020.

-Currently the rate of conversion to organic farming is 7-8,000 hectares annually, but if the government's objectives to follow the figure as high as 18,000 hectares annually.

- Scarcity in organic fertilizer to grow organic crops
- One solution may be to transform the sludge, municipal waste and industrial waste from the cities to nutritious fertilizer.

BIOMASS RECYCLING

- The benefits of biological recycling instead of incineration;
- no slag and flue gas cleaning,
- fertilizer and organic matter recycled to agriculture,
- conservation of natural resources (phosphorus extraction areas) as well as increased awareness of resources and recycling.

UNEXPLORED BIOMASS P RECYCLING

Biodegradable waste, DK [1000 tons]

	total amount	Composted/recycled	biogas potential	Combusted/Unexplored biomass recycling	P amounts [ton]
Household	784-856	56-59	725	90	800
Private garden waste	697	663	35	5	
Service sector	206	42	165	80	100
Garden/park waste	553-714	548	6	5	500
Industry (mainly Food)	6173-8536	6049-7760	109	3	3000
WWTP	140	60-70	264	50	4000-5000
Agricultural waste (mainly manure)	34000-45000	32300-42750			50000

Soure:Econet report for the Dansih EPA and ENS

INDUSTRIAL RECOVERY OF PHOSPHORUS FROM BIOWASTE

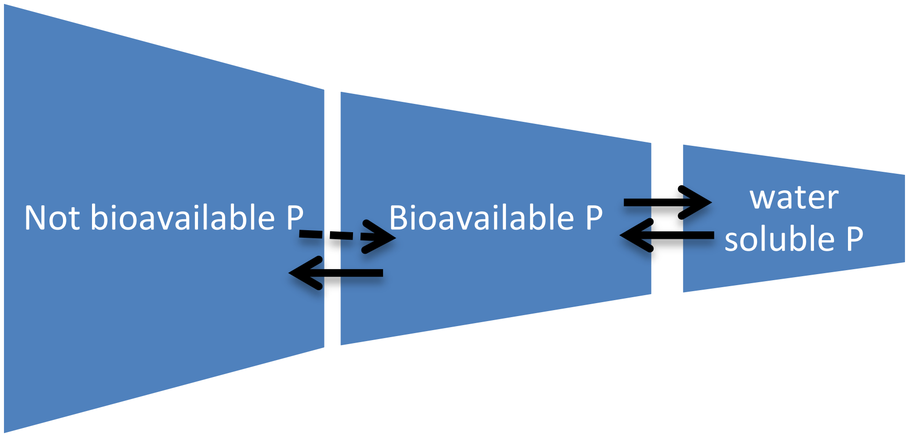
- for reuse as a raw material in the fertilizer industry has played an increasing role in improving the sustainability of phosphorus use (Morse et al., 1998)

-applying the biowaste as fertilizer on agricultural land enables the phosphorus to be recycled

- displaces carbon-intensive production of conventional mineral fertilizers and reduces the rate of depletion of scarce mineral resources (Morse et al., 1998; Niero et al., submitted January 2013).

SOIL P AND FERTILIZER VALUE OF PHOSPHOROUS

› *wide variation in phosphorus concentrations and bioavailability between potential future biobased fertilizer products*



› *Need for biobased fertilizer products of varying fertilizer value of phosphorous*

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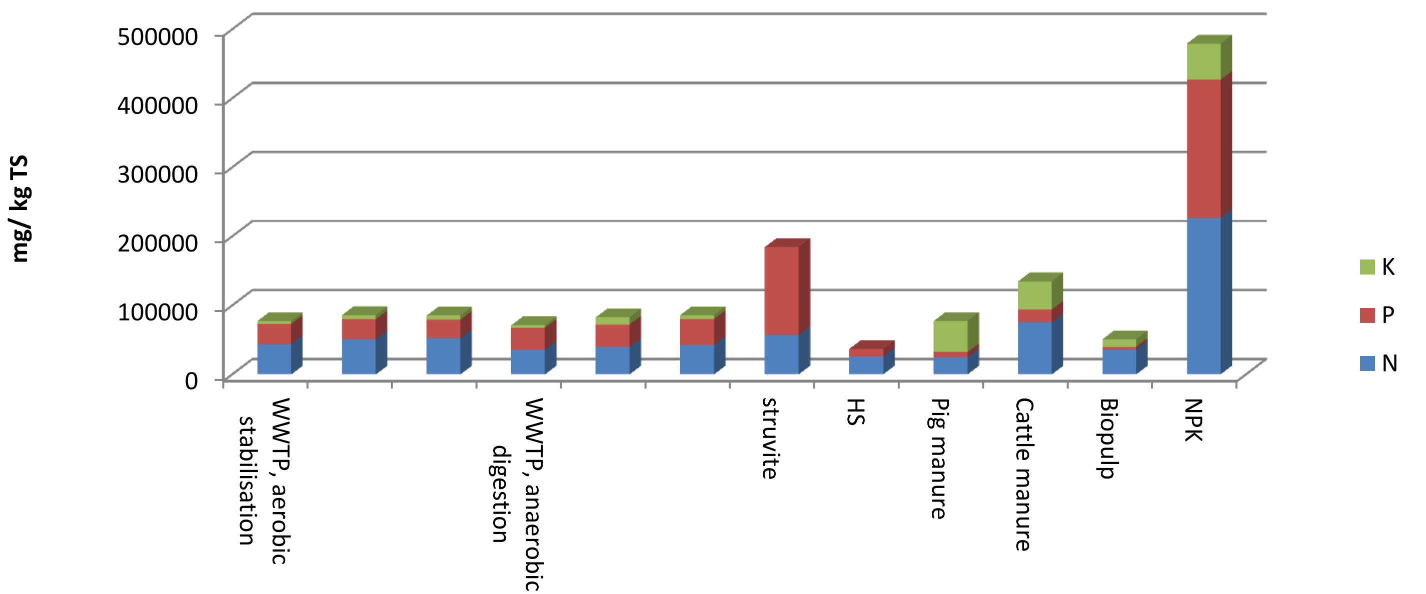
FERTILIZER VALUES - NPK



MULTIPLE CHALLENGES

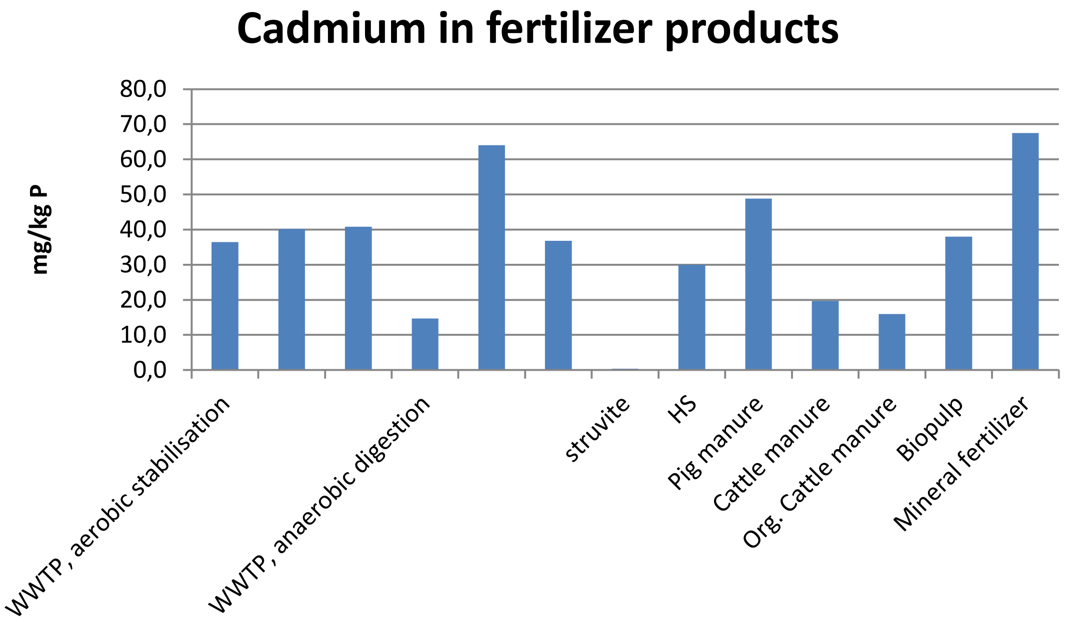
- Life cycle impact assessment
- Resource scarcity, Environmental Pollution, Food safety

- impacts on ecosystem services in terms of
-
- soil quality – drawbacks from P recycling
- carbon sequestering - digestate
- fertility/biomass yields – fertilizer value of P

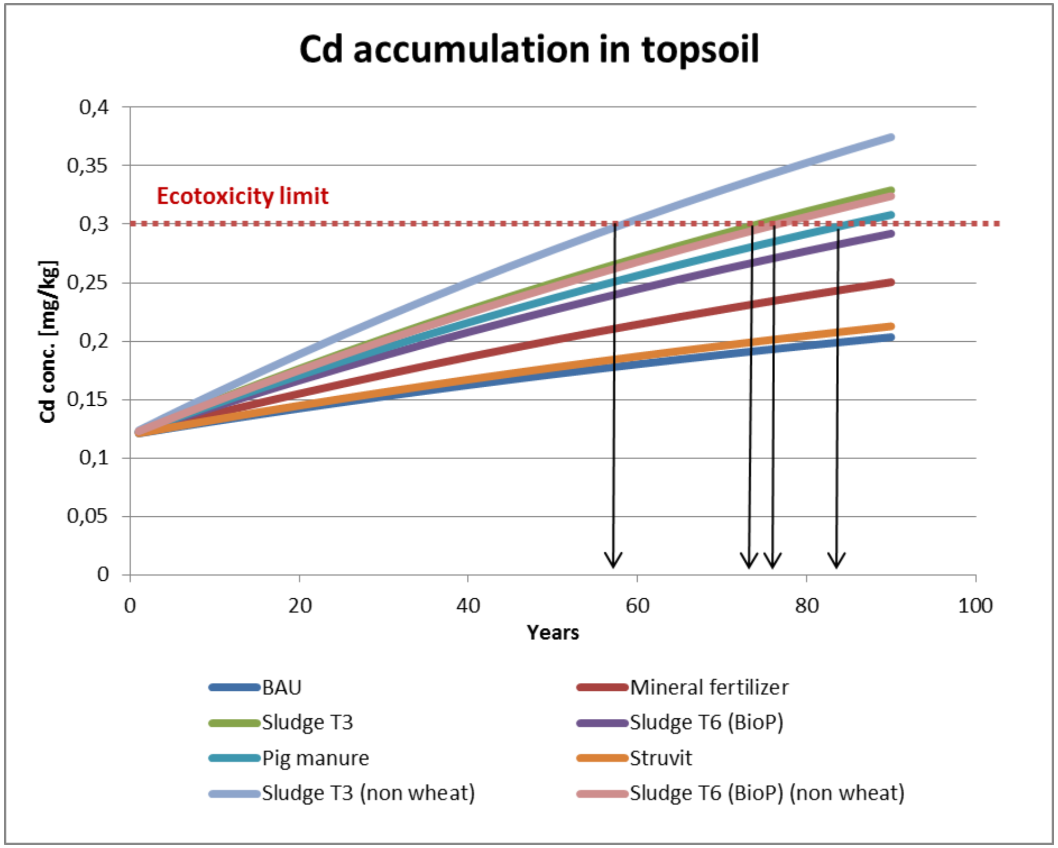
- Challenge

- Combining the right ressource flows and techologies

BIOMASS QUALITY ASPECTS



FERTILIZERS SCENARIOS



QUALTY CRITERIA AND PRODUCT QUALITIES

Quality Criteria, Fertiliser type	Cd	Pb	Cr	Hg	Ni	NPE	LAS
EU cut-off values for mineral fertilizers [mg/kg]	3	150		2	120		
Sludge spread on agricultural soils [mg/kg slam]	**0.8**	120	100	**0.8**	**30**	**10**	**1300**
Sludge spread on agricultural soils [mg/kg P]	100	10000		200	2500		
Mineral Fertilizer	Cd	Pb	Cr	Hg	Ni	NPE	LAS
NPK [mg/ kg dw]	1.4	2.7		0.1	84.0		
NPK [mg/kg P]	68	135		4	4200	0	0
Biowaste, [mg/kg dw]							
WWTP digestate	1.2	36.2	20.8	0.9	20.6	4.1	58.4
Cattle manure	**0.4**				6.3	2.1	15.5
Organic Cattle manure	**0.3**				2,9	1.2	20.3
Pig manure	**0.4**	4.0		0.0	10.2	2.4	40.0
mixed manure household and industrial organisc waste	1.1	16.0	16.0	0.5	17.0		
HS	**0.3**	2.2		0.1	13.8	1.1	530.0
Biopulp	**0.2**	6.0	8.0	0.1	6.9	2.5	156.0
Biowaste/residues, [mg/kg P]							
WWTP digestate	39	1362	710	29	772	108	1530
Cattle manure	20				336	114	826
Organic Cattle manure	16					66	1079
Pig manure	49	528			1347	310	5283
mixed manure household and industrial organisc waste	51	740		23	760		
HS	30	200		5	1255	100	48182
Biopulp	38	1500	2000	16	1725	625	39000
Upgrading wastewater derived products, [mg/kg dw]							
struvit	0.1	0.2		0.1	0.5		
Fosforsalt(KK-proces 1)	0.022	0.0		0.011	0.3		
Fosforgødning(KK-proces 3B) KK	0.3	0.2		0.4	23.0		
Upgrading wastewater derived products, [mg/kg P]							
struvit	0.43	1.57		0.78	3.53		
Fosforsalt(KK-proces 1)	0.60	0.70	2.90	0.30	2.90		
Fosforgødning(KK-proces 3B) KK	19.50	116.00	225.00	18.50	283.50		

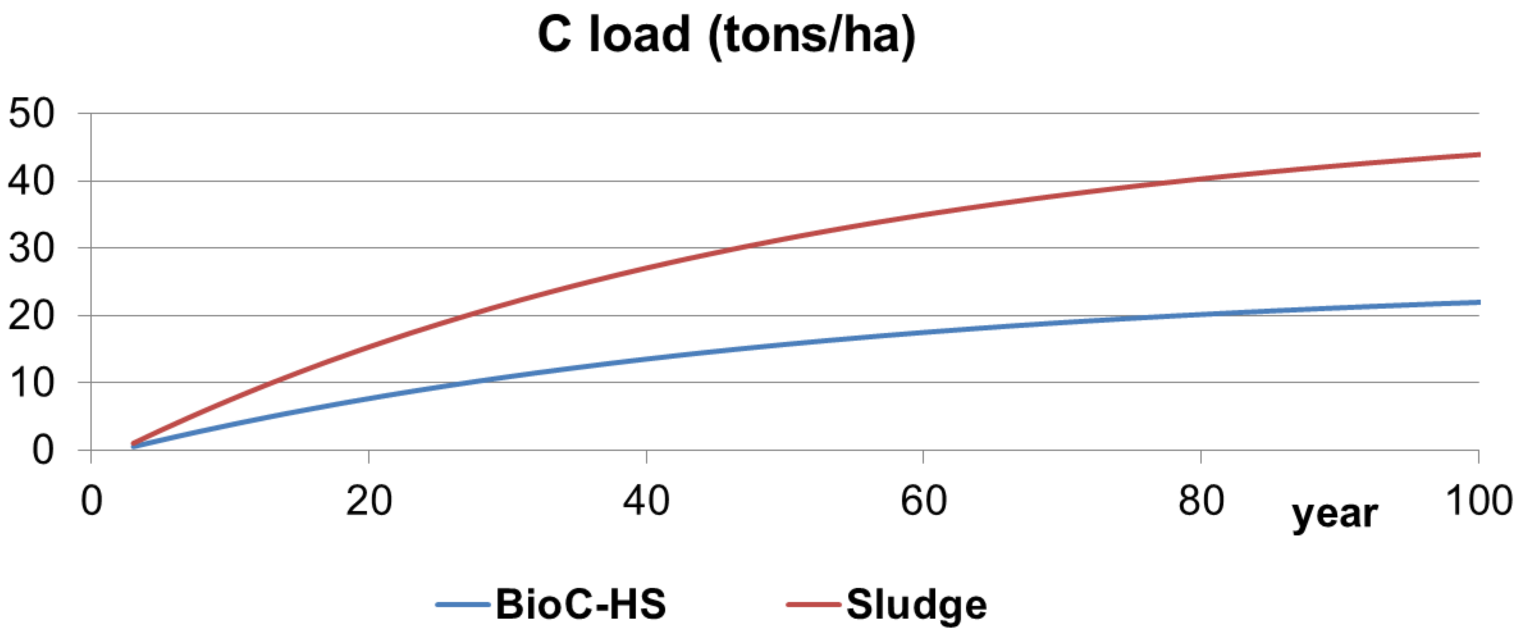
SLUDGE VERSUS BIOCORRECTED AMENDMENT

- Sewage sludge vs. biocorrected sludge amendment
- Quality of the two biomass resources

[mg/kg dm]	Sludge	BioC-HS	Diff	change [%]
DM (%)	25	8	17	69
Total P	12,300	11,000	1,300	11
Total N	38,000	26,000	12,000	32
Pb	56	2	54	96
Cd	2	0	1	79
Zn	580	37	543	94
Ni	22	14	8	38
Cr	30	1	29	96
Hg	0.5	0.1	0.4	80

POTENTIAL FOR CARBON STORAGE

›



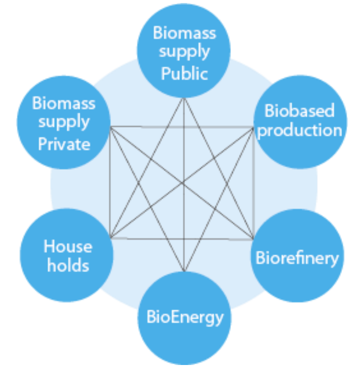
RESTORING THE CARBON BALANCE

- Soil organic matter is a crucial soil ecosystem service component

- Is biological recycling as management practice a realistic/sustainable solution towards "enhanced soil carbon sequestration"

- and

- may it counterbalance soil respiration or CO2 efflux under the existing management practices?



ECOSYSTEM MANAGEMENT

› Existing national and global institutions are not well designed to deal with the management of open access resources, a characteristic of many ecosystem services.

› Many existing institutions at both the global and the national level have the mandate to address the degradation of ecosystem services but face a variety of challenges in doing so related to the need for greater cooperation across sectors and the need for coordinated responses at multiple scales

› Quality of biomass resources needs to be monitored and exchanged in ecoindustrial networks

COSTS AND BENEFIT OF PHOSPHORUS RECOVERY

› Benefits
› of the fertilizer value of phosphorus
› reduced use of limited rock phosphate reserves

› Costs
› (cadmium-related) externalies
› Technologies for biological phosphorus recovery

› Another perspective is the use of the external cost estimates to design economic policy instruments (ecotaxes, incentives) for future clean technologies

INNOVATIVE RESOURCE MANAGEMENT SYSTEM AND TECHNOLOGIES

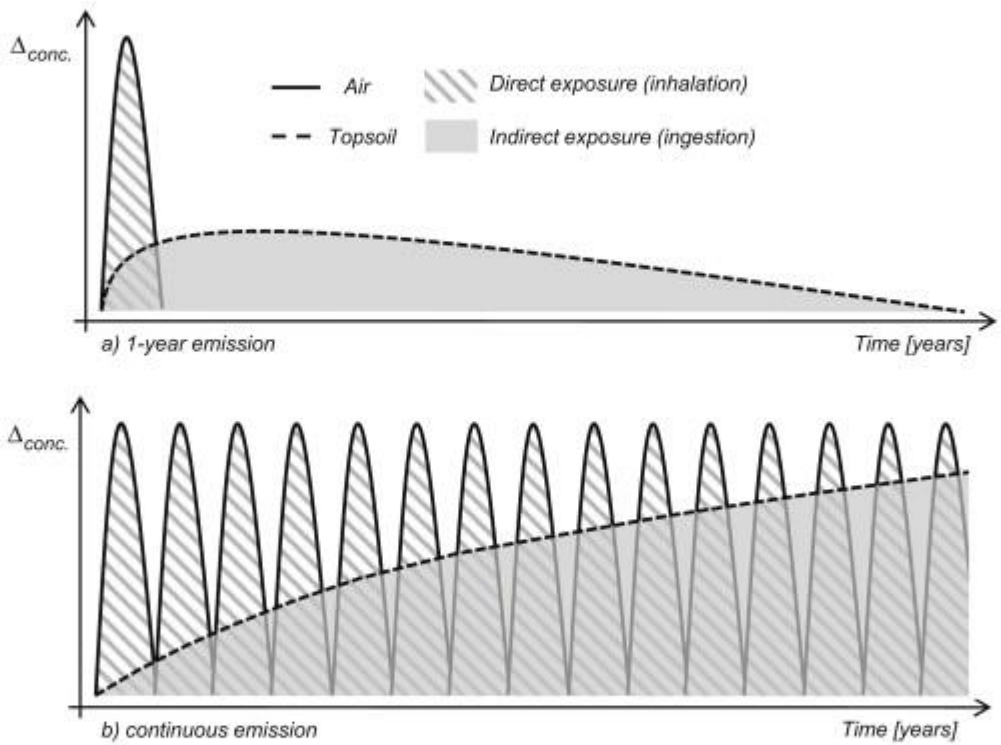
- Harmonised outsorting of the organic fraction of household waste in a combined biogasification of sludge and manure seems a feasible solutions for recycling of high quality P-enriched fertilizer products/digestates.

- 50% of manure: 20 million tons + 2-5 million tons organic biomass
- Leaves 5-8 mill tons organic biomass available for biogasification at WWTPs

I THANK YOU FOR YOUR ATTENTION!

EXTERNALITITES FROM COMBUSTION

› Lead



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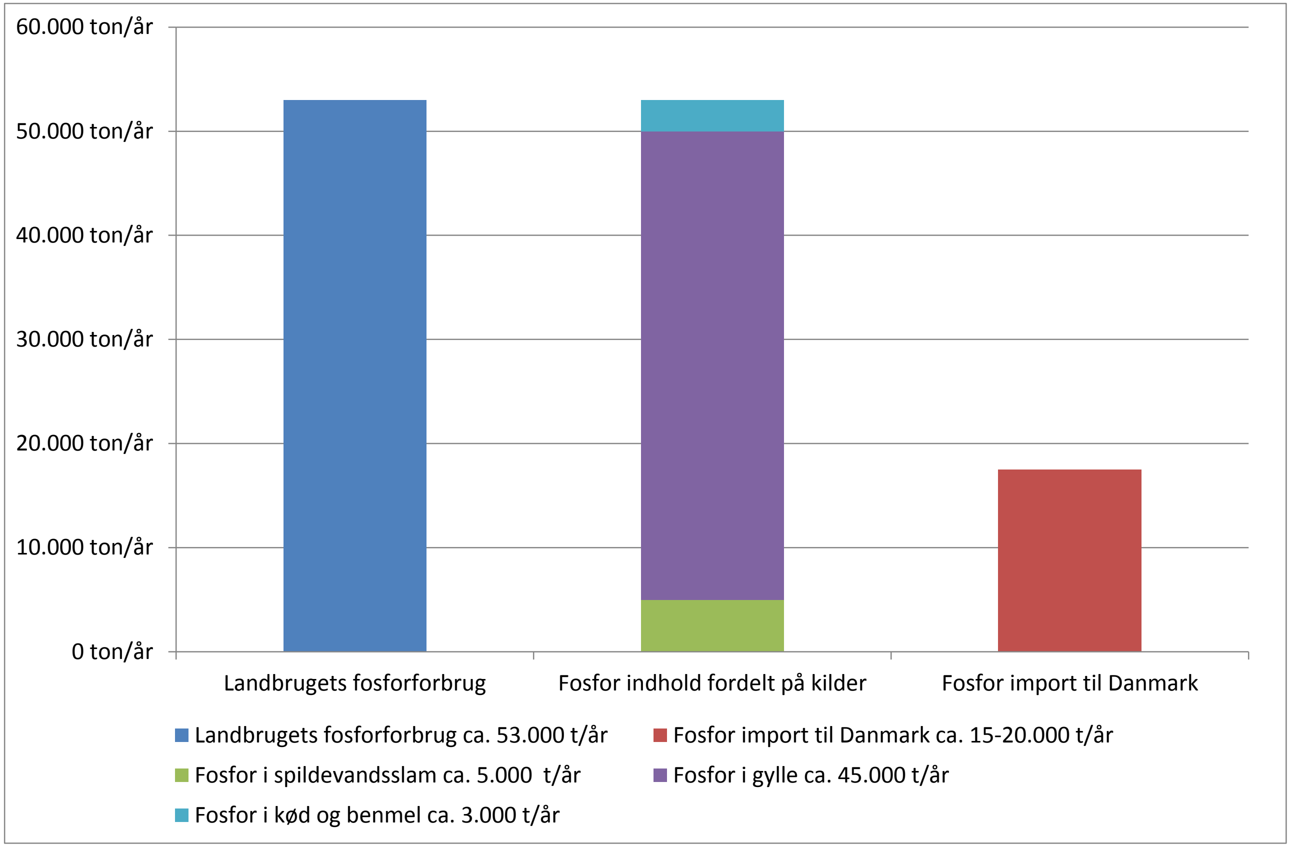
PHOSPHOROUS SUPPLY AND DEMAND - DK



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VARYING SOIL PHOSPHOROUS CONTENT