



# Modelling environmental consequences of waste application on agricultural land

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# Life cycle assessment and Inventory factors

Inventory factors are used for environmental impact assessments such as life cycle assessments

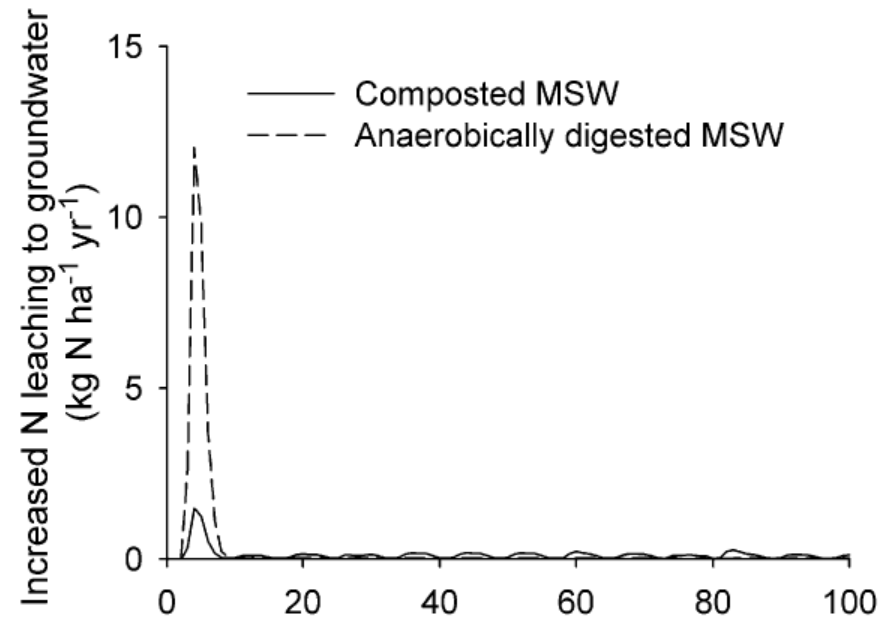
Consists of emission factors and resource consumption factors  
sequestration factors and improved productivity factors

$$k_x = \frac{E_{x,P} - E_{x,S}}{S_P}$$



# Importance of assessment time

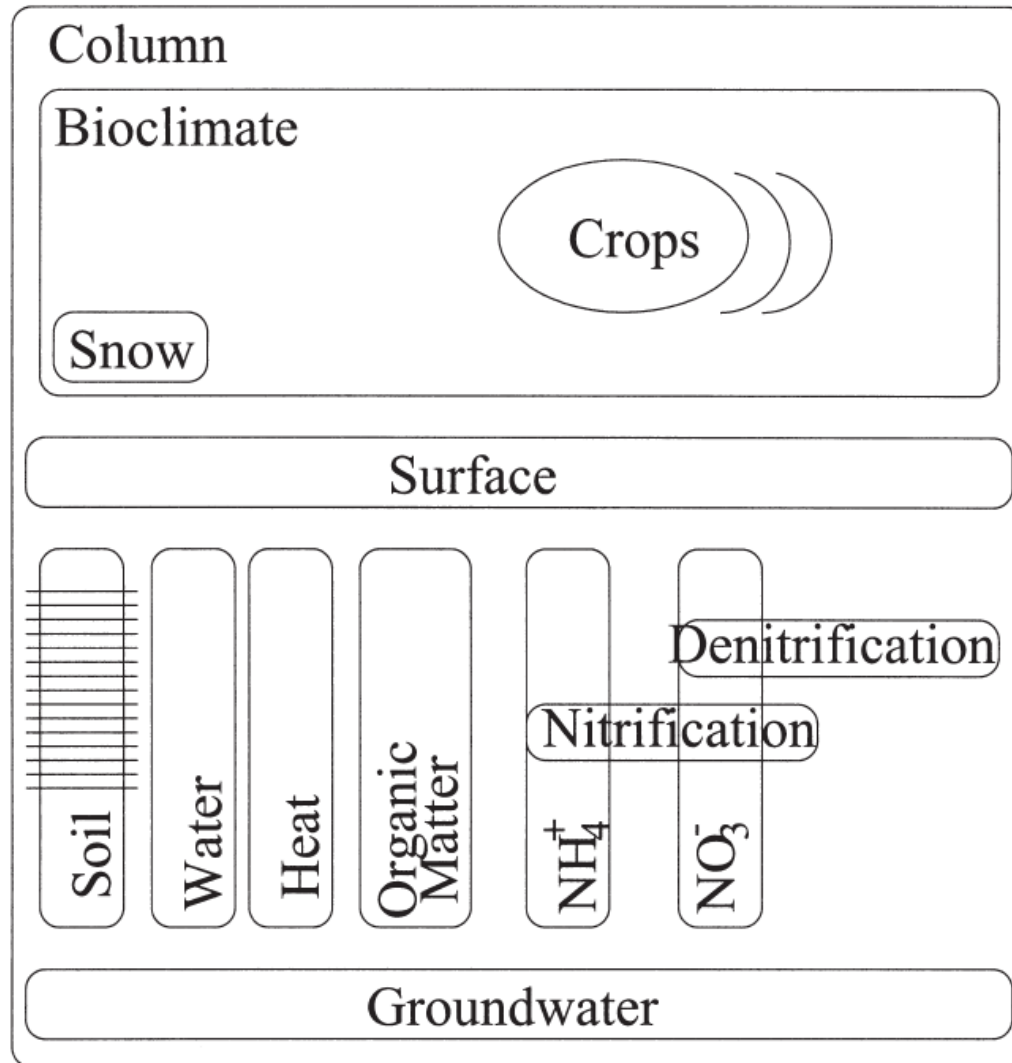
Assessment time becomes very important for agricultural systems



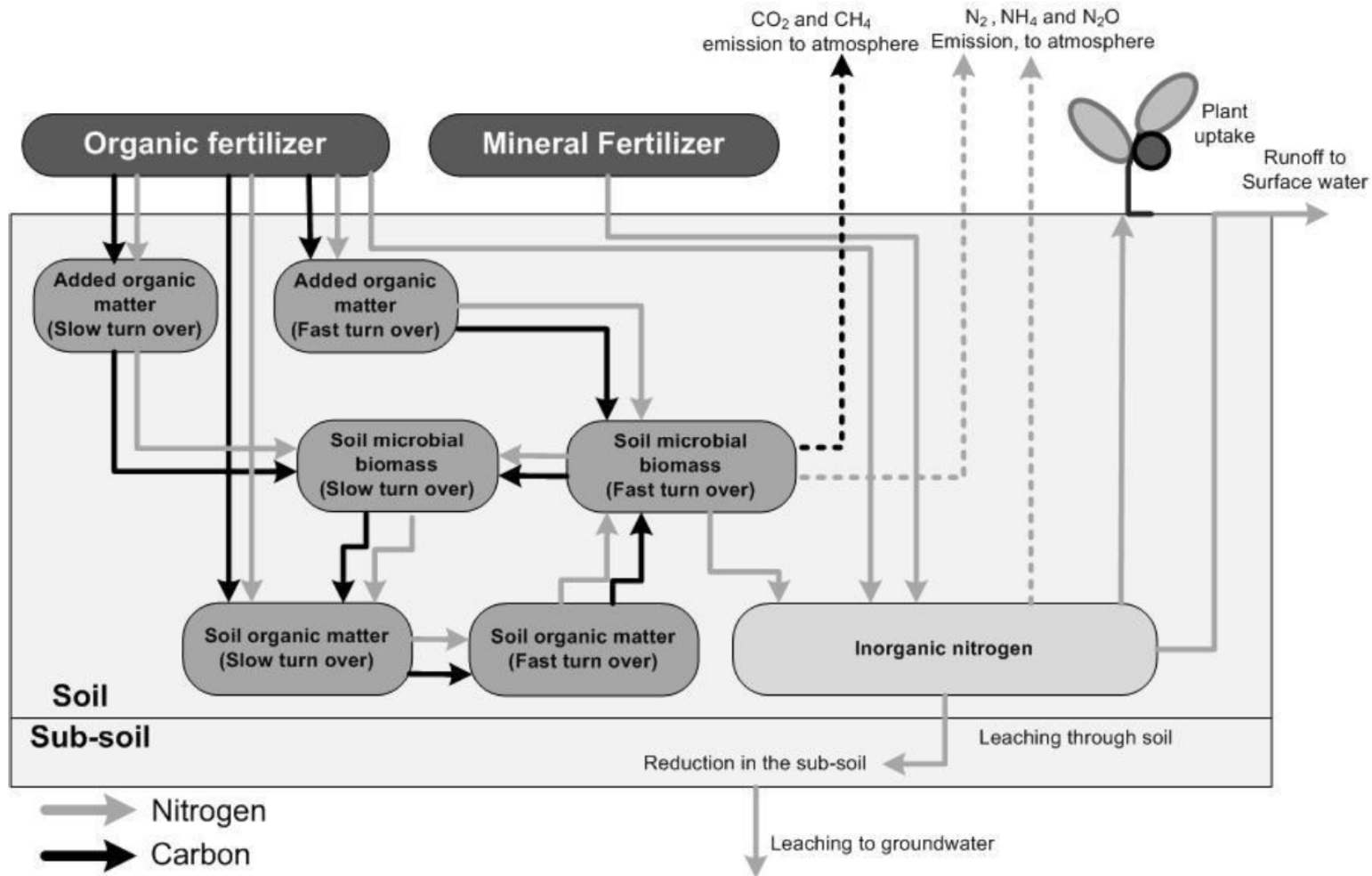
Ability to predict long-term effects becomes important



# The Daisy model

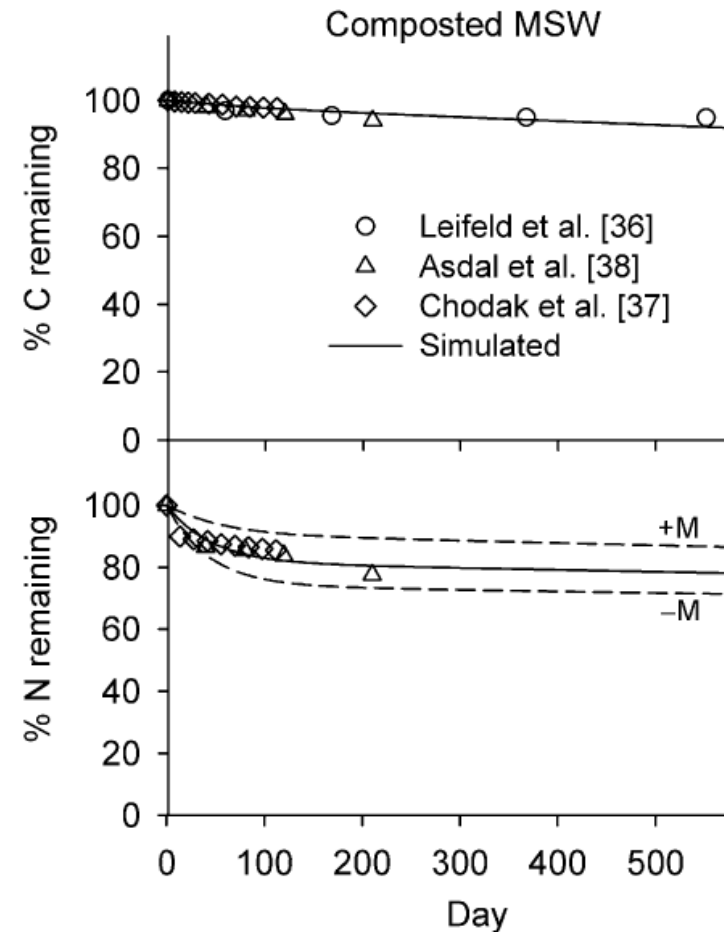


# C and N dynamics in Daisy



# Using Daisy for prediction of long-term emission

Fitting the model to short-term mineralization data

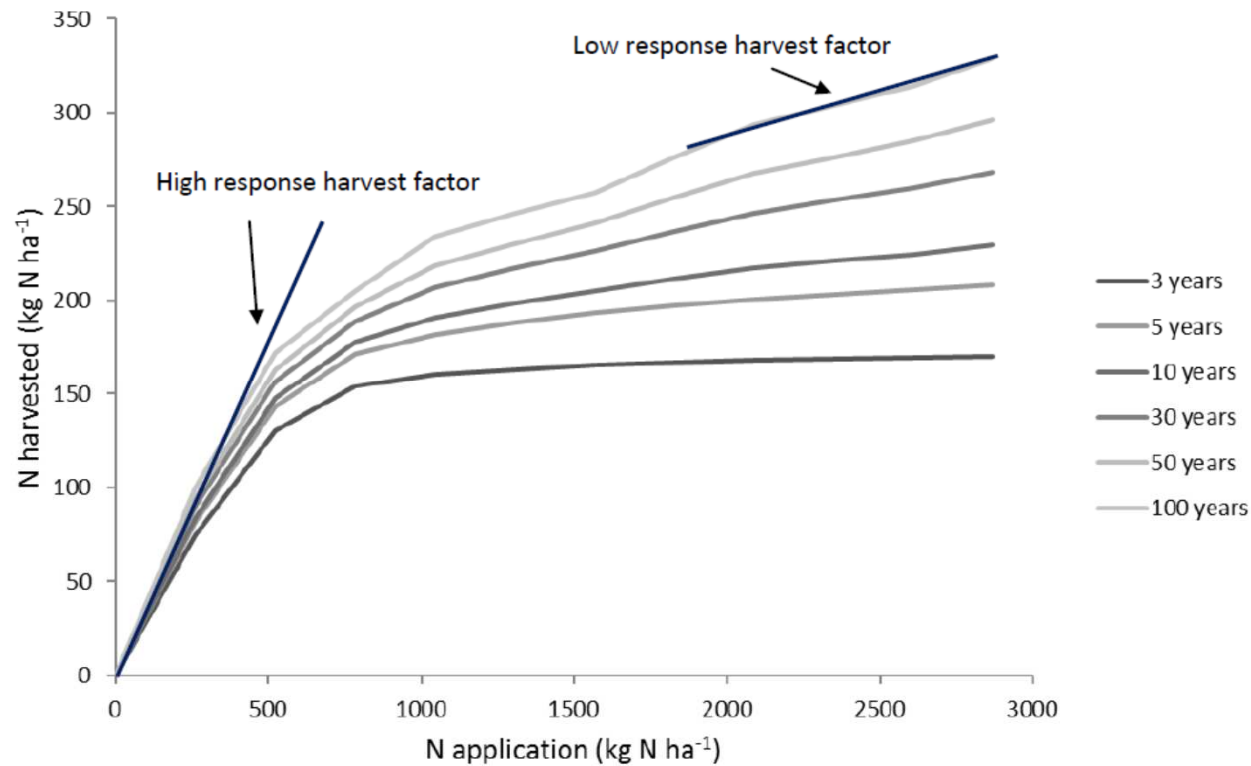


Extrapolating to infinity



# Handling non-linearities of agricultural systems

Effect of land application of waste depends very much on fertilization status.



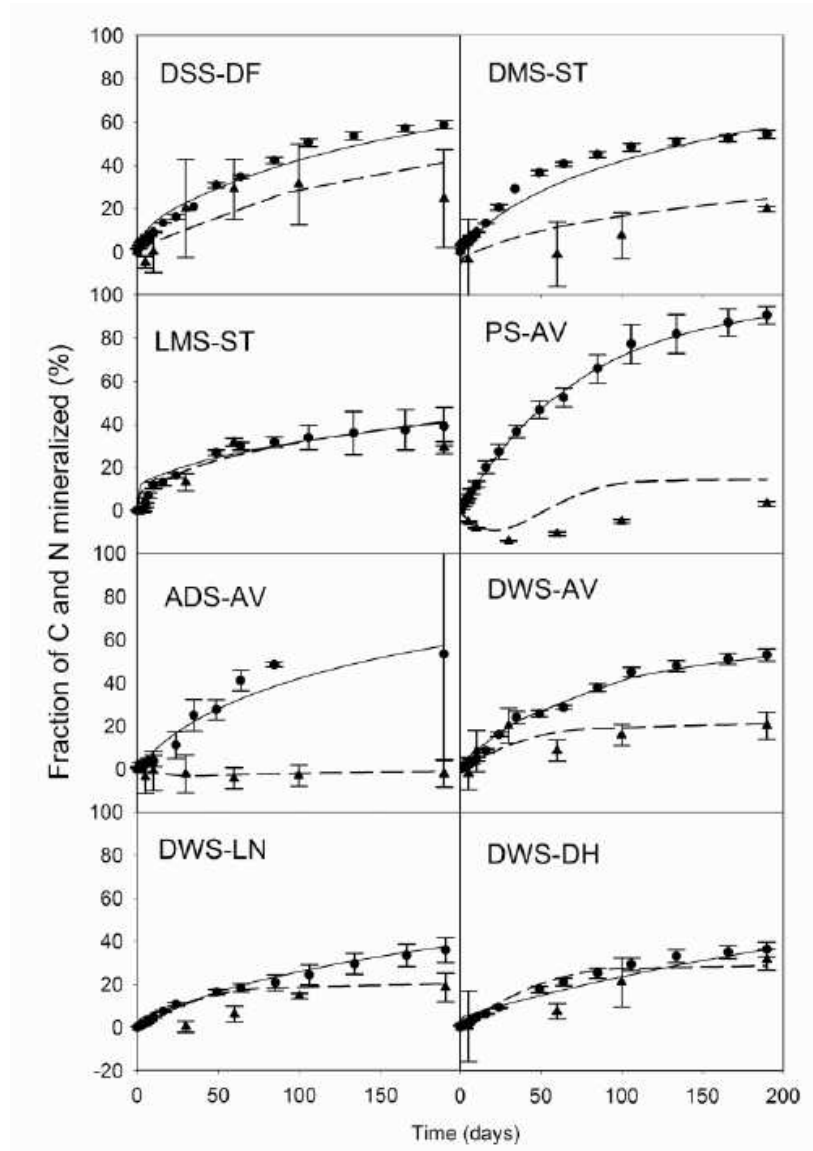
# Study of environmental consequences of sludge treatment options

Abbrev.*	Name of WWTP	Sludge Treatment
DSS-DF	Frederikssund	Dewatered secondary sludge (DSS) is sludge from an aeration basin, which after addition of polymer coagulants was dewatered using a centrifuge.
DMS-ST	Staffanstorps	Dewatered mixed sludge (DMS) is a mixture of sludge from primary sedimentation (primary sludge) and secondary treatment processes (secondary sludge), which after addition of polymer coagulant was dewatered by a centrifuge.
LMS-ST		Limed dewatered mixed sludge (LMS) is the mixture of DMS-ST treated with lime at the mixing ratio of 180 kg lime/kg sludge on a dry basis.
PS-AV	Avedøre	Primary sludge (PS) is sludge from the primary sedimentation basin
ADS-AV		Anaerobically digested sludge (ADS) is generated by anaerobic digestion (mesophilic) of primary and secondary sludge.
DWS-AV		Dewatered anaerobically digested sludge is ADS-AV, which after addition of polymer coagulants was dewatered using a centrifuge.
DWS-LN	Lynetten	Dewatered anaerobically digested sludge is primary and secondary sludge, which has been anaerobically digested (mesophilic) and dewatered using a centrifuge after addition of polymer coagulants.
DWS-DH	Damhusåen	Dewatered anaerobically digested sludge is primary and secondary sludge, which has been anaerobically digested (mesophilic) and dewatered using a centrifuge after addition of polymer coagulants.





# Fit to mineralization experiment



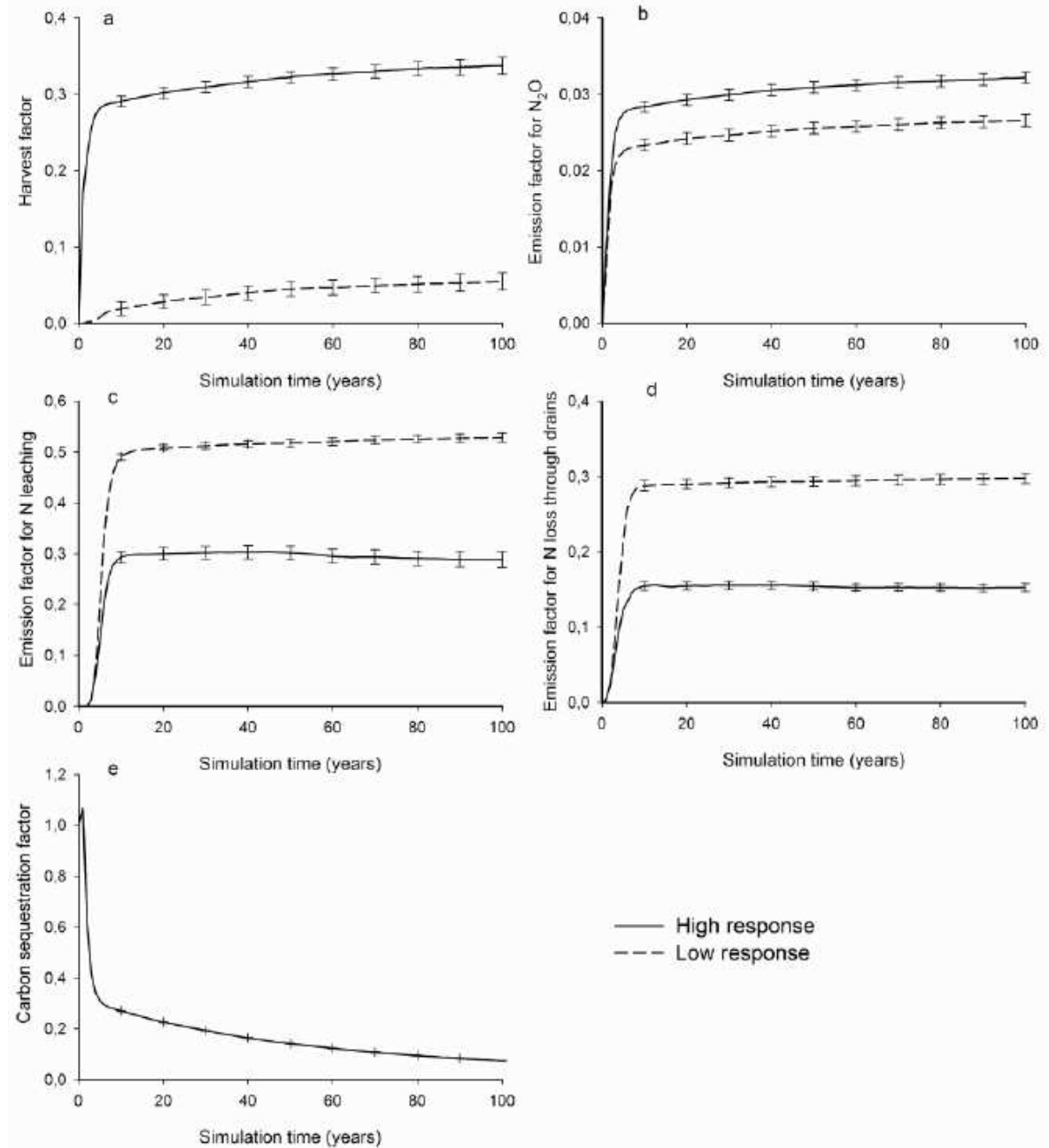
# Included simulations

Precipitation regime	Low (Germany)			Medium (Denmark)			High (Netherland)					
Soil type	Coarse sand			Sandy loam			Clay					
Applied fertilizer material	DSS-DF	DMS-ST	LMS-ST	PS-AV	ADS-AV	DWS-AV	DRS-AV	DWS-LN	DWS-DH			
Sludge Appl. (mineral N)	0 kg	30 kg	60 kg	90 kg	120 kg	150 kg	180 kg	210 kg	240 kg	270 kg	300 kg	330 kg
Random: Crop at application x Application Year (8 x 8 = 64)	Spring barley	Winter wheat	Winter wheat	Winter barley	Winter oil seed rape	Winter wheat	Winter wheat	Winter wheat	Maize			
	Year 1960	Year 1961	Year 1962	Year 1963	Year 1964	Year 1965	Year 1966	Year 1967				

**Figure 1** Overview of performed simulations. All combinations of each factor were simulated. The factors were 3 different precipitation regimes (low medium and high), 3 different soil types (coarse sand, sandy loam and clay). These were simulated for the 12 different sludge derived fertilizers and 12 fertilization application levels. Finally, the random effects of crop and climate in the year of application were simulated. The total number of simulations performed was 82,944.



# Inventory factors for dewatered sludge



# Inventory factors for different sludge types

