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Parameterisation of LCI/LCIA models of agricultural systems emissions under future pressures

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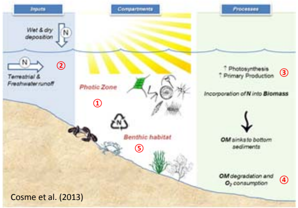
MOPC06

The problem (I)
Marine eutrophication
(nitrogen emitted from fertilisers application)

Excessive increase of primary production and organic matter accumulation [4]

Ecosystem response to an excessive input of nutrients

Results in excessive oxygen depletion and impacts on biota, ecosystem and (socio)economy



Increased emissions of nutrients

Life Cycle Assessment (LCA) as a management tool

Assesses impacts from emissions

LCI, calculates emissions inventories (Q_i)

LCIA, estimates potential impacts ($CF_{i\,j}$)

Impact = $Q_i * CF_{i\,j}$

LCI models emissions to the environment:
N from fertilisers application
Chemicals from applied pesticides

LCIA models fate, exposure and effects, e.g.:
Oxygen depletion and effects on biota
Human/Eco-toxicity in multimedia USEtox®

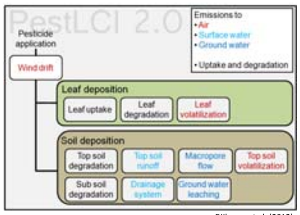
The problem (II)
Ecotoxicity
(chemicals emitted from pesticides application)

Additional pesticide applications result in additional pesticide emissions

Pesticides are toxic by design: pesticides reaching non-target organisms result may in toxic impacts to other organisms, including humans

Climate change affects type and nature of pests

Increased emissions of chemicals



Dijkman et al. (2012)

Conclusion!
Assess, use tools, manage.

Drivers for increased pressure in future emissions scenarios [1, 2]

Human population growth
Demand for more food/feed and efficient agro-systems
Increased application of fertilisers and pesticides

Climate change
Temperature increase, sea level rise
Freshwater inflow, nutrients/chemicals runoff
Desertification, erosion, poorer soils
Droughts, floods, storms

+ overfishing, invasive species, land occupation/change/degradation, competition with other land uses

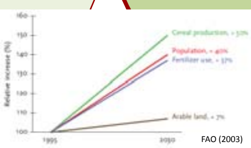
Influence of Temp. in the marine eutrophication model

Temperature is not modelled directly, but other parameters do vary with T:

Metabolic rates (increased productivity, respiration, remineralisation) and organic matter

Increased species sensitivity to stress and pole ward species distribution

Climate zones aggregated by SST



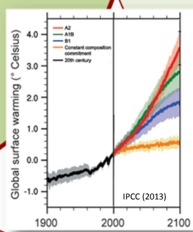
How is Temp. included in the LCI model PestLCI

Temperature is, along with rainfall, an input to the model's database, affecting a number of processes in the field:

Higher volatilization from leaves and soil with increasing temperature: higher air emissions

Higher dissipation of pesticides in soil with increasing temperature: less emissions to freshwater and groundwater

Also check Poster MO288



Examples of modelled/estimated impacts of marine eutrophication
(nitrogen emitted from fertilisers application)

4°C increase and 20% more N emissions result in 63% larger bottom-hypoxic area in the Gulf of Mexico [1]

By 2050, 10^9 ha of natural ecosystems changed to agriculture land, globally, and 2.4-fold increase in N-driven marine eutrophication [2]

4°C increase and -0.96 mgO_2/L (solubility) hypoxic areas will double, up to 38% of total bottom area in the Danish Straits (worst case scenario) [5]

Algal blooms in 80% of fertiliser applications in Gulf of California, and 27-59% of N-fertiliser will be applied upstream of N-deficient marine ecosystems by 2050 [6]

Overall, increased occurrence, frequency, intensity, and duration of eutrophication and hypoxia [1].

Expected conditions [1, 2, 3]

Temperature increase
↑ oceans' stratification
↓ oxygen solubility
↑ metabolic rates
↑ marine eutrophication

Hydrologic cycle
↑ precipitation = ↑ discharge and runoff
↓ precipitation = ↓ productivity/fisheries

Ecosystem
↑ habitats loss, stress on species
↑ ecosystem simplification
↓ ecosystem services, biodiversity

Pesticide emissions in Danish agriculture in a future climate [7]

Emissions of pesticides in the production of wheat and barley were compared for different climates:

Current Danish climate (2010) and climate forecasted for Denmark in 2050 ([CO_2]: 400->550 ppm, T: +2°C)

Emissions to air increased 1% (barley) and 10% (wheat), emissions to groundwater increased 103% and 13%, emissions to surface water fell 66% and 50%.

Not accounted: increased dosage of some chemicals and the addition of new pesticides.

Overall, increased emissions of pesticide to air and groundwater, decrease in emission to surface water.

Presented at: Basel 2014 SETAC Europe

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