

Nitrogen footprint of protein-free products

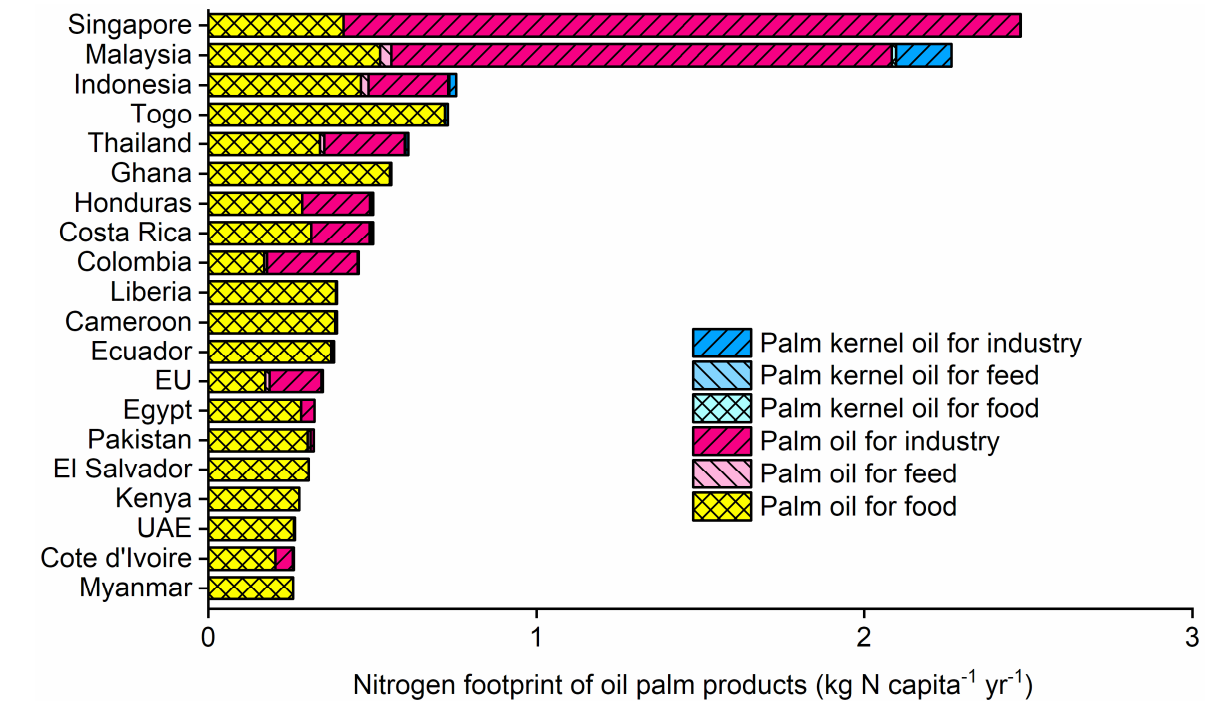
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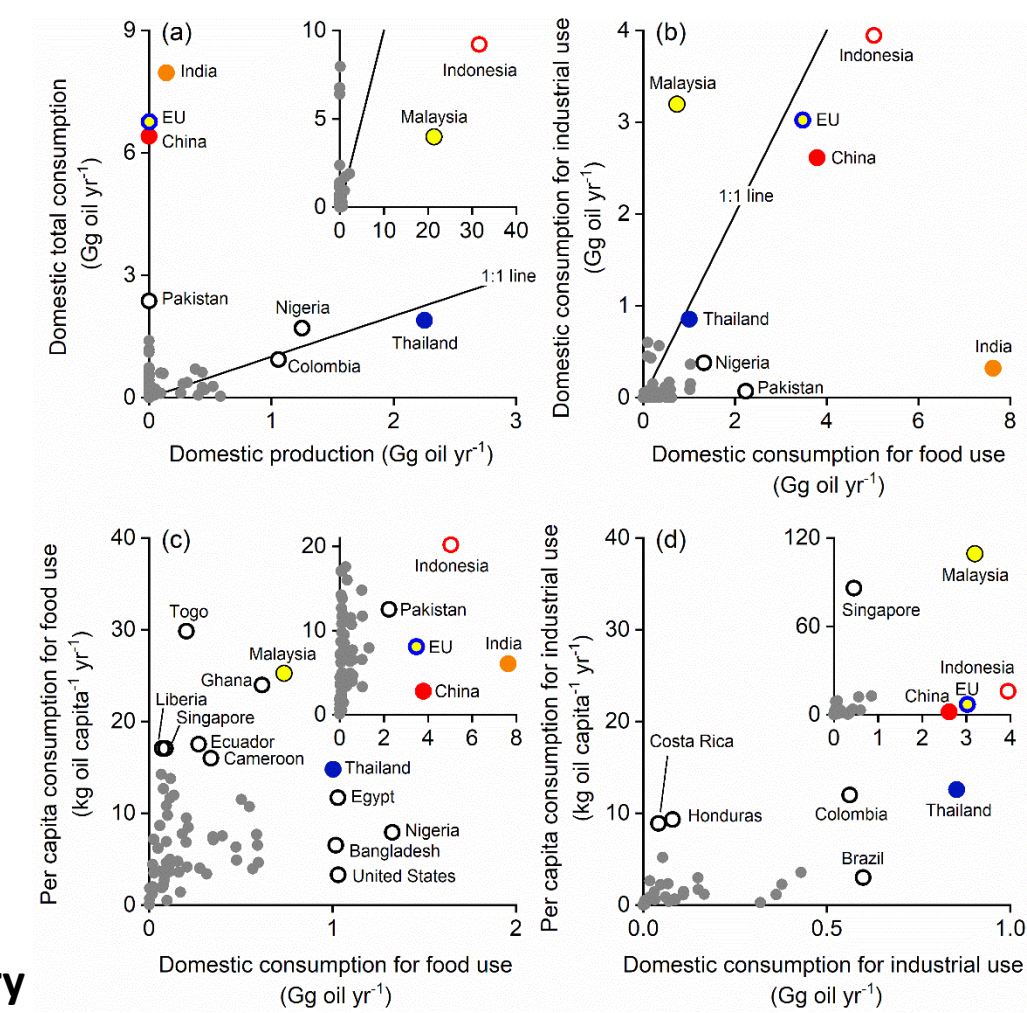


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Top 20 in per capita nitrogen footprint of oil palm products



Background

- Nitrogen (N) footprint: A useful indicator of potential N pollution
- N-calculator method: A bottom-up approach to obtain N footprint
- Expansion needed: Enable to calculate N footprint of protein-free (no N-containing) products
- Example: Oil palm and its products, palm oil (PO) and palm kernel oil (PKO)

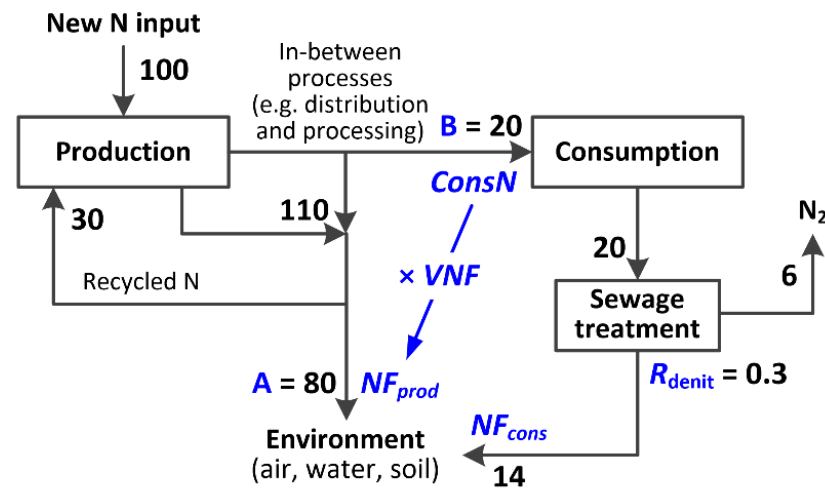
Results and discussion

- Alternative factor: Virtual N factor for protein-free foods ($VNFree$), potential N load per unit weight of consumed food (also applicable to N-free product)
- Global mean $VNFree$ determined: PO, 0.0241 kg N kg⁻¹ oil; and PKO, 0.0037 kg N kg⁻¹ oil
- Food use: Less than 2% of the total food N footprint
- Industrial use: High in some countries
- Total N footprint of protein-free products: Must be large because oil palm consumes only 8–12% of the N fertilizer for sugar and oil crops

Production and consumption from 2010 to 2014:

- (a) domestic production and consumption,
- (b) domestic consumption for food and for industry,
- (c) domestic and per capita consumption for food,
- (d) domestic and per capita consumption for industry

(a) Case: Foods containing protein

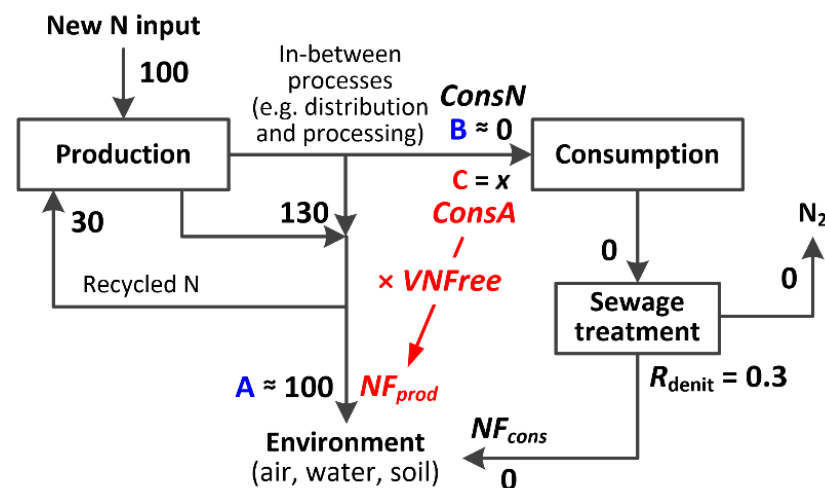


$NF = NF_{prod} + NF_{cons}$
 $NF_{prod} = VNF \cdot ConsN$
 $NF_{cons} = (1 - R_{denit}) \cdot ConsN$

NF : N footprint of item i
 NF_{prod} : Food-production N footprint of item i
 NF_{cons} : Food-consumption N footprint of item i
 VNF : Virtual nitrogen factor of item i
 $ConsN$: Consumption of item i as N weight
 R_{denit} : Ratio of complete denitrification

$VNF = \text{Total N loss to the environment from production to just before consumption (A)} / \text{Consumed N amount (B)}$
 $VNF = A / B = 80 / 20 = 4.0$

(b) Case: Protein-free foods



$VNF = A / B = 100 / 0 \approx \infty$
 $NF_{prod} = VNF \cdot ConsN = \infty \times 0$ (practically 0)
 Note: NF_{prod} cannot be evaluated

Suggestion in the present study:
 $NF_{prod} = VNFree \cdot ConsA$

$VNFree$: Virtual nitrogen factor for protein-free food of item i
 $ConsA$: Consumption of item i as food weight

$VNFree = \text{Total N loss to the environment from production to just before consumption (A)} / \text{Consumed food amount (C)}$
 $VNFree = A / C = 100 / x$

Note: values are an example as relative amount of N

Nitrogen footprint concept: (a) foods containing protein, (b) protein-free foods with a methodological recommendation

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Further reading:
 Hayashi K, Oita A, Nishina K (2020) Concealed nitrogen footprint in protein-free foods: an empirical example using oil palm products. *Environmental Research Letters*, 15, 035006.

