Modelling changes in exposure to persistent organic pollutants from transitioning to plant-based diets: A global perspective

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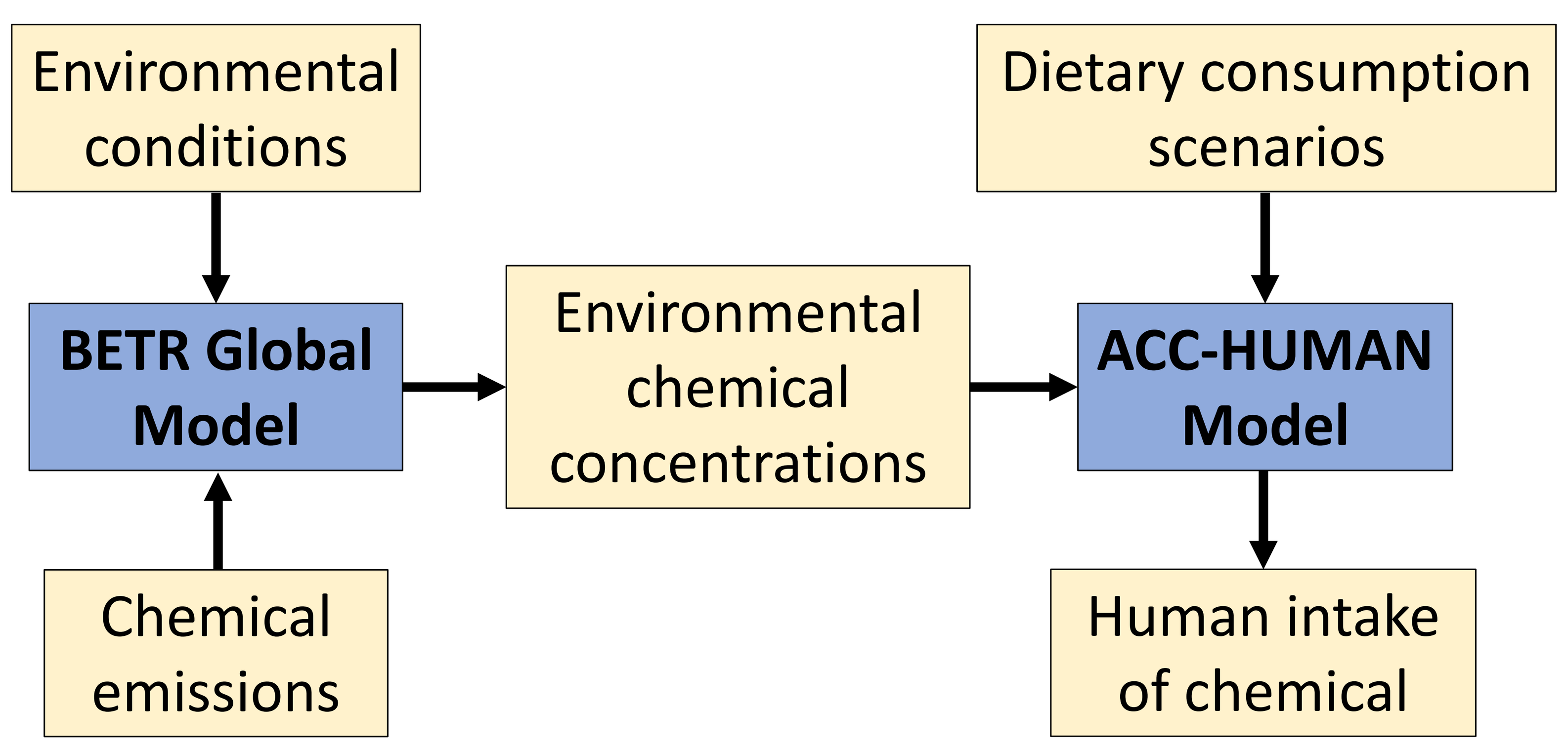
Background

- Animal agriculture has a large environmental footprint (e.g., from greenhouse gas emissions, land use, and water usage). Plant-based agriculture generally has less of a footprint (e.g., Poore and Nemecek, 2018).
- Animal food products (such as fish, dairy, and beef) are a route of exposure for some bioaccumulative persistence organic pollutants (POPs).
  - E.g., Arrebola et al., 2018 found that animal-based foods contributed 2-4 times more to POP serum levels than plant-based foods in a Spanish population.
- Sales of plant-based alternatives to meat and dairy products are rapidly increasing (e.g., Smart Protein Project, 2021).
- ***Research Question: How might a shift towards plant-based diets impact ingestion exposure to persistent organic pollutants?***

Analysis Framework



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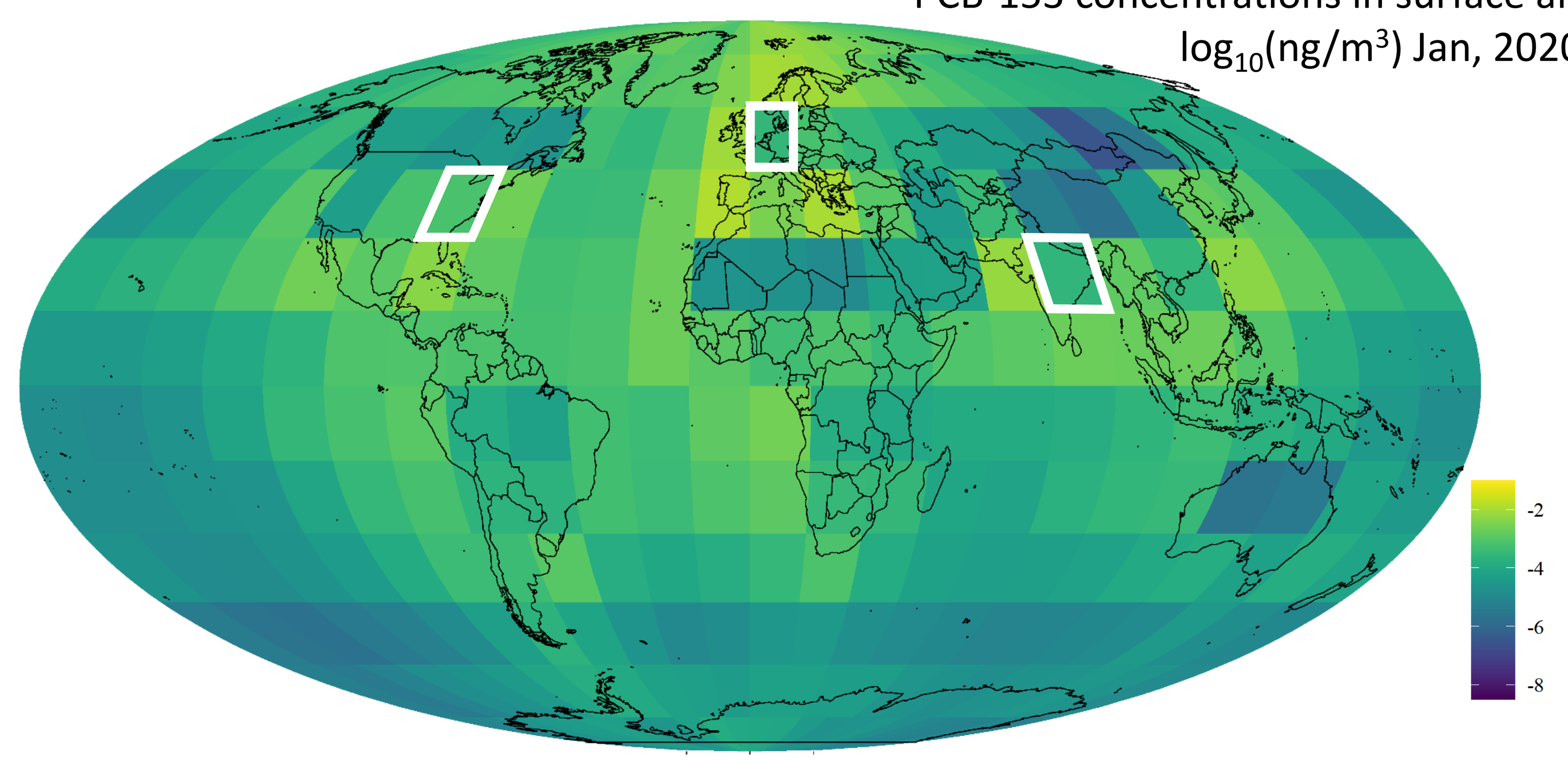
Marie Curie Actions

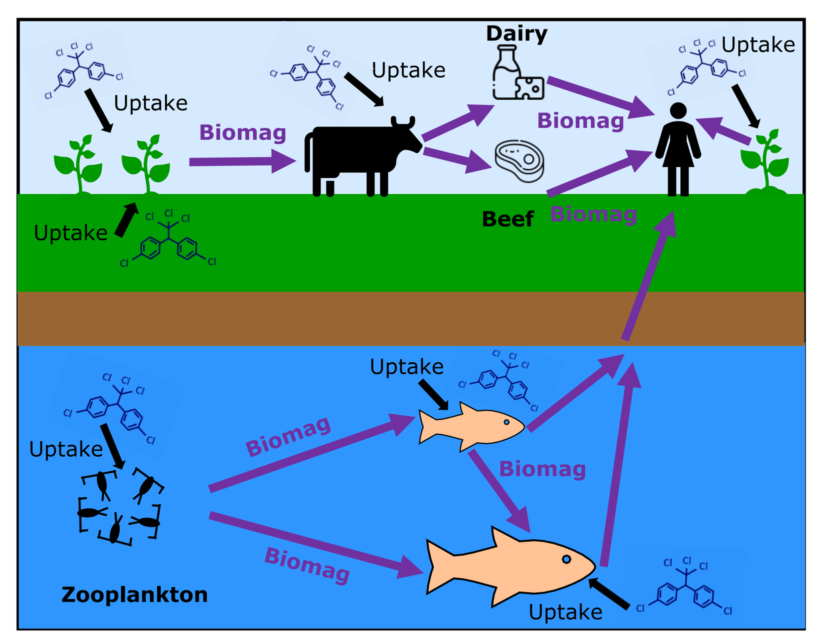
Methods

BETR-Global Modelling

PCB-153 concentrations in surface air
$log_{10}(ng/m^3)$ Jan, 2020



ACC-HUMAN Model



Adapted from Fig. 1 of Czub and McLachlan, 2004 (*Biomag = Biomagnification)

- **BETR-Global:** Global chemical fate and transport model simulated PCB-153 environmental concentrations from 1950-2049. Emissions from Breivik et al., 2016.
- **ACC-HUMAN:** Bioaccumulation & human exposure model simulated chemical uptake & biomagnification in food web (Czub and McLachlan et al., 2004; Undeman and McLachlan, 2011). BETR-Global outputs from 2020 and 2049 used; assumed all food grown and consumed in 3 highly-populated grid cells.
- **Dietary consumption scenarios:** Omnivorous, vegetarian, and vegan diets.

Dietary Consumption Scenarios

Food Item	Omnivorous Diet (g/day)	Vegetarian Diet	Vegan Diet
Planktivorous Fish	58	0	0
Piscivorous Fish	58	0	0
Meat	301	0	0
Dairy	561	561	0
Lettuce	141	176	212
Grain	353	441	530
Fruit (apple)	706	883	1059
Root fruit (carrot)	61	76	92
Tuber (potato)	324	405	486
Estimated calorie intake (kcal/day)	3014	2782	3015

Results

Preliminary Human Ingestion Exposure: picograms PCB-153/day

Region	Diet	2020	2049
Eastern US	Omnivorous	323000	1870
	Vegetarian	27600	156
	Vegan	784	4.43
Central Europe	Omnivorous	30000	74.2
	Vegetarian	13600	28.7
	Vegan	386	0.814
Northern India	Omnivorous	86800	470
	Vegetarian	7470	30
	Vegan	212	0.851

Vegetarian diets display up to **~1-order of magnitude decrease** in exposure.

Vegan diets display over **2-orders of magnitude decrease.**

Discussion/Conclusions

- Exposure values should be interpreted with caution as:
  - Additional food types & focus on micronutrient equivalency in construction of alternative diets is needed.
  - Geographic variability in diets is not considered.
- Additional POPs should be investigated.
- With limitations in mind, ***a transition to plant-based diets could lead to a decrease in human ingestion exposure of chemicals with properties similar to those of PCB-153***, in line with findings from Zhao et al, 2018.

Acknowledgements

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Citations:

- Poore and Nemecek, 2018. DOI: 10.1126/science.aaq0216
- Arrebola et al., 2018. DOI: 10.1016/j.scitotenv.2018.03.283
- Smart Protein Project, 2021: smartproteinproject.eu/plant-based-food-sector-report
- Breivik et al., 2016. DOI: 10.1021/acs.est.5b04226
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- R Core Team, 2019: https://www.R-project.org/
- Wickham, 2016. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.