Design Optimization of Passive Sampling Prototypes with Periodic Vibration for Porewater Measurements of Polychlorinated Biphenyls

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POSTER GROUP 1
Session: A6.

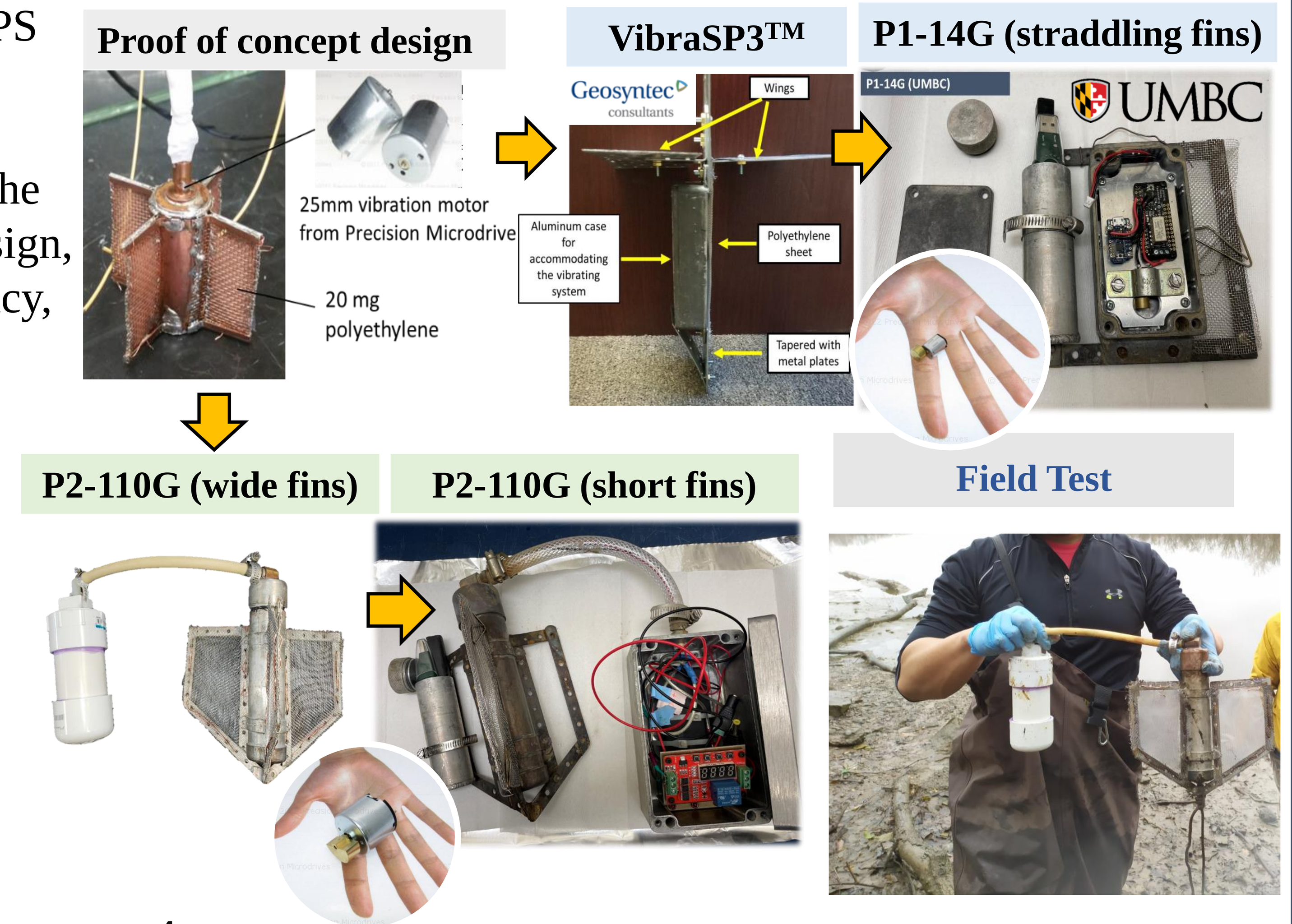
INTRODUCTION

- Passive Sampling (PS) allows measurement of **freely dissolved concentrations** of hydrophobic contaminants in sediment porewater (useful for assessment of fate, transport, and bioavailability.)
- In-situ measurements of sediment porewater concentrations is challenged by:
  - Slow mass transfer through the water boundary layer (WBL) outside the polymer.
  - Long equilibration times for more hydrophobic compounds.
  - Error prone equilibrium corrections using Performance Reference Compounds (PRC)
- Innovative approach of **mechanical disruption of the WBL** by introducing periodic vibration on the sampling platform for sediment porewater measurements (Jalalizadeh et al., 2016,2017)

Research Aim: Optimize sampling methods for sediment porewater measurements of strongly hydrophobic compounds, by introducing vibration on the passive sampling platform with the aim of faster approach to equilibrium, accurate bioavailability estimations for improved site risk assessments, targeted remedy selection, and post-remedy monitoring.

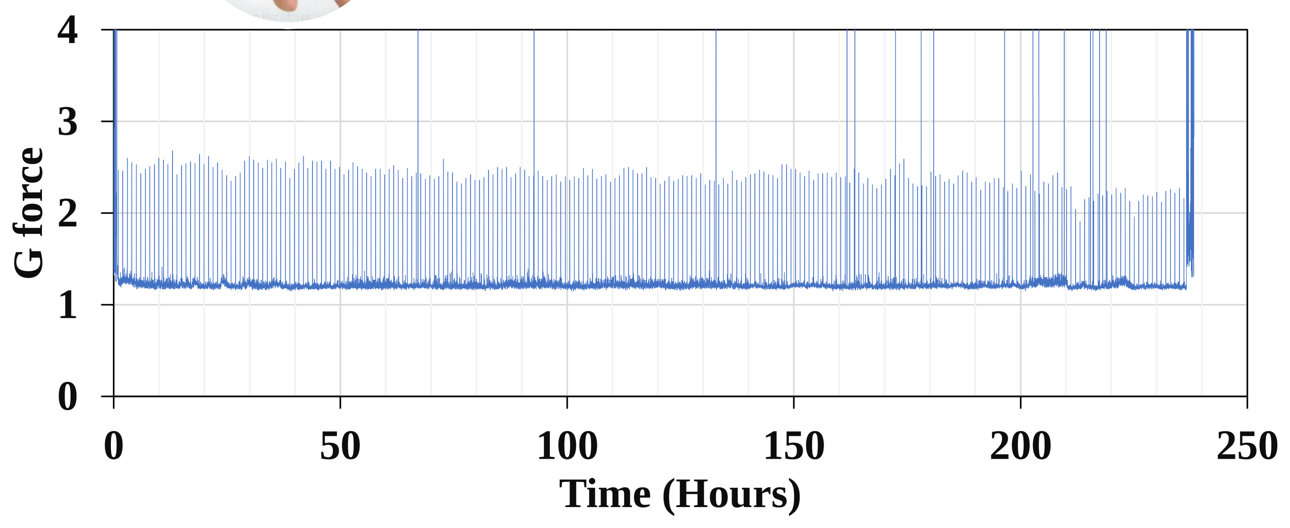
MATERIALS AND METHODS

- 2 new prototypes of vibrating PS developed.
  Key motivations:
  - Increase mass of PE from the initial proof-of-concept design,
  - Optimize vibration frequency, power consumption and approach to equilibrium,
  - Ensure robustness for field deployment (new feature: vibration datalogger)
  - Cost



- **Field Test:** Kingman Lake in Washington D.C. 10-day long deployment [10-20 Dec 2019]
- **In-Lab Study:** Time series tracking of mass transfer for optimized designs.

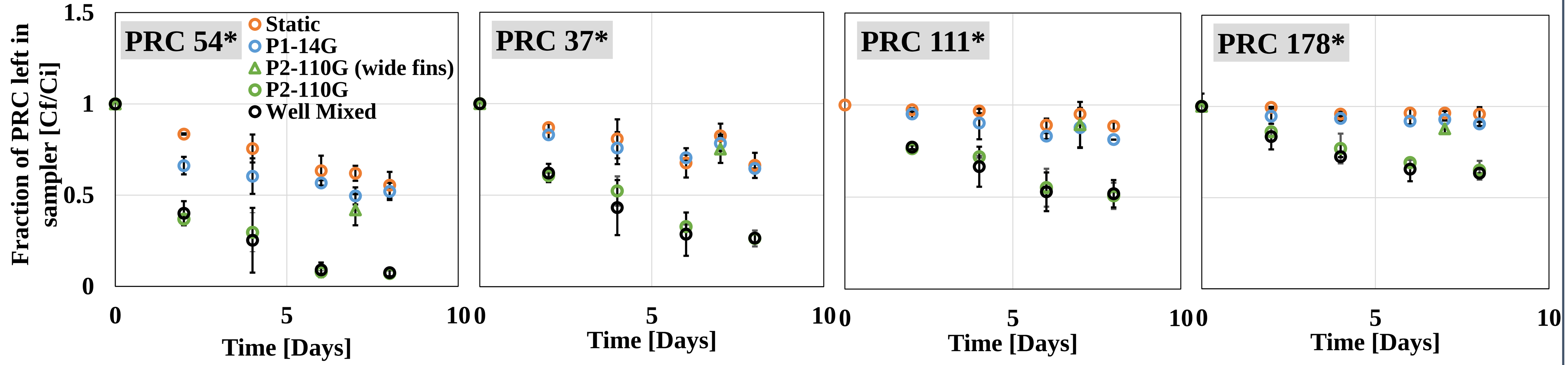
Homolog Group	PCB compd.	Log K_{ow}	Log K_{pew} [Lw/LPE]
Tetra	PCB 54*	5.21	4.85
Tri	PCB 37*	5.83	5.58
Tetra	PCB 47*	5.85	5.61
Penta	PCB 111*	6.76	6.68
Hexa	PCB 138*	6.83	6.76
Hepta	PCB 178*	7.14	7.13

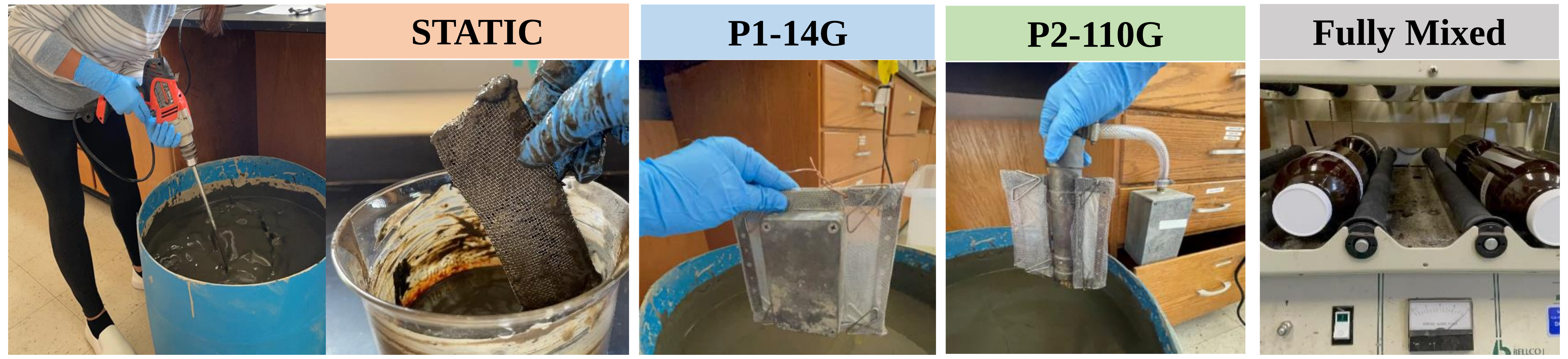


P2_110G vibrated with an amplitude of ~2.5G while inside 3" of sediment throughout the deployment time of 10days

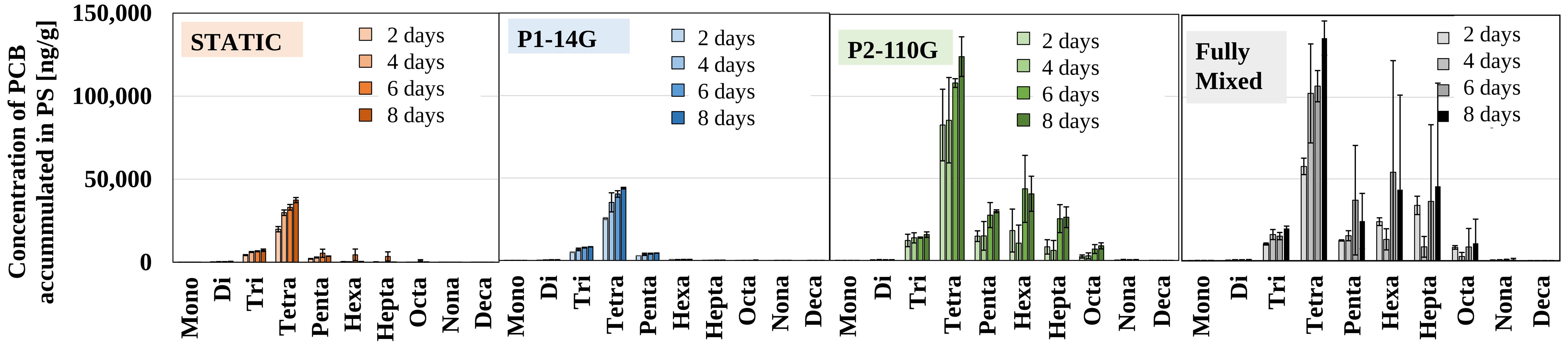
RESULTS

Fraction of PRC left in passive sampler after consecutive exposure periods ($C_{final}/C_{initial}$)

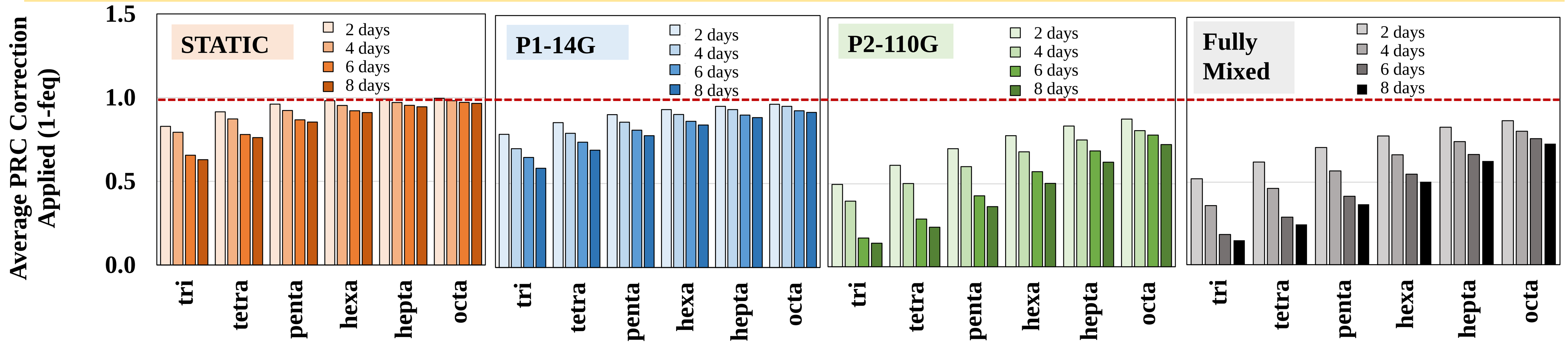




Homolog distribution of PCB concentration accumulated in passive sampler [ng/g]



Homolog distribution (abundant homologs only) of required PRC correction (1-feq)

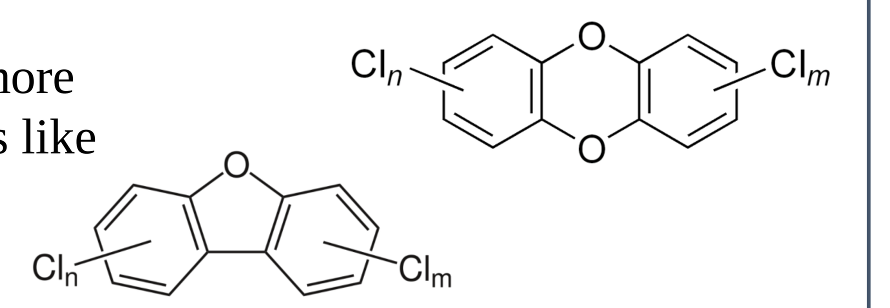


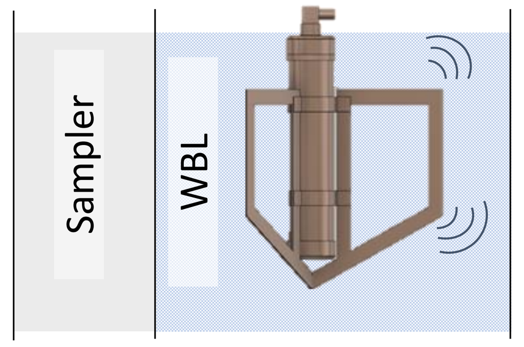
DISCUSSION

- P2 (more powerful) closer to equilibrium than P1 (less powerful + inefficient power distribution)
  - P1 and static: lost 50% of tetra PRC 54 and 10% of hepta PRC 178 in 8 days
  - P2 (wide fins): lost 60% of tetra PRC 54* and 10% of hepta PRC 178* in 8 days
  - P2 (shorter fins): lost 90% of tetra PRC 54* and 35% of hepta PRC 178* in 8 days (efficient distribution of power)
- Major homolog groups accumulated in:
  - Static and P1: tri-penta
  - Fully Mix and P2: tri-octa => powerful vibration helps accumulation of more hydrophobic compounds under similar exposure time periods.
- PRC Corrections for equilibrium applied for major homolog groups are higher in general for static and P1 as compared to P2 and fully mixed (=> systems closer to equilibrium need less corrections)

ONGOING/FUTURE WORK

- Extend applications to more hydrophobic compounds like dioxins and dioxin like compounds.





- Modeling framework for porewater measurements using Fick's Diffusion.
- Need for field vibration to enable short-term surface water measurements in the field (mathematical modeling, in-lab and field experiments).

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Sponsors
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