Actively Shaken In Situ Deployment: An Innovative Approach to Accelerate Equilibrium in Passive Samplers

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Passive sampling saves us lots of money and time in investigation, risk assessment, remedial design, and remedial monitoring compared to traditional sampling.

Importance of determining the freely dissolved concentration ($C_{\text{free}}$)
SP³™: (SiREM Passive Polyethylene Porewater-surface water Sampler)

- Low density polyethylene
- Stainless steel wings

www.siremlab.com
Correction for non-equilibrium

- Freely dissolved concentrations ($C_{\text{free}}$) determined from equilibrium concentrations in passive samplers
- For strongly hydrophobic compounds, equilibrium is achieved after a long time (more than a year for some compounds)
- Performance reference compounds (PRCs) are used to predict equilibrium concentrations
- Desorption kinetics of PRCs are used to correct for non-equilibrium
Source of errors in correction for non-equilibrium

High $K_{ow}$ compounds have slow kinetics in static sediment

Large errors in corrections for non-equilibrium and long (1-2 month) deployment times

More uncertainties in $C_{free}$ estimation
Research motivations

- *In situ* measurements of $C_{\text{free}}$ of high Kow compounds are challenged by
  - Extremely slow mass transfer rates
  - Inaccuracy of PRC adjustment methods

Shaking the thermometer
Faster reading!

US Patent application published by U. Ghosh and M. Jalalizadeh in March 2018
Conclusions from research

Benefits of vibration shown by research

- Enhancing the sampling rates & improving accuracy of estimating $C_{\text{free}}$
- Reducing the deployment times from 4-8 weeks to 1 to 2 weeks
- Potential for eliminating the use of PRCs
- Potential for measuring $C_{\text{free}}$ of strongly hydrophobic compounds (e.g., dioxins & furans)

Potential benefits in field deployments

- Faster and more accurate measurements
- Reducing risk of loss, destruction & vandalism, which can reduce costs
- Cost savings associated with purchase, impregnation, analysis, & data interpretation
- Extending the capability of passive sampling techniques
VibraSP3™ Platform

A vibrating platform for deployment of currently-available commercial passive sampling devices (SP3™ samplers)
Circuit layout of the vibrating system

- The microcontroller can be programmed for any vibrational sequence
- The battery life for a 2 week deployment can sustain a 5-sec vibration every 4-6 hours
- Affordable/reusable/rechargeable vibrating device

Mini microcontroller
3.7 V lithium battery (rechargeable)
3 V (14.3 G) Vibration motor from Precision Microdrives
Aluminum case
Technical Approach for Field Deployment

- Platforms deployed in a marine sediment (10-15 ft water depth) in a harbor
  - Static platforms
  - Vibrating platforms (5 sec vibration every 4 hours)
- Deployment times: 7 and 14 days
- 10 rare PCB PRCs in each sampler (di- to octa- PCBs)
- % losses of PRCs (% to equilibrium) from static and vibrating deployment modes compared to evaluate kinetics
Field Deployment

Push-pole system

Underwater camera

VibraSP3™

VibraSP3 deployed in sediment
Retrieval

- After both the 7-day and 14-day deployments, the samplers were retrieved.
- VibraSP3™ samplers were intact and fully-functioning (still sealed and vibrating)
Results
PRC losses after 7 days: Static vs. Vibrating passive samplers

- Only 1 Vibra sampler used in the 7-day evaluation (limited number of prototypes), 3 static samplers
- % losses of most PRCs improved by a maximum factor of 2
Results
PRC losses after 7 days: Static vs. Vibrating passive samplers

- The frequency of vibration in field deployment was 4-hour pause and 5 s pulse

With 2-min pause (5 s pulse) in lab experiment (Jalalizadeh & Ghosh 2017)
Results
PRC losses after 14 days: Static vs. Vibrating passive samplers

- % loss of the lower molecular weight PRCs were not statistically different
- % loss of PCB-192 and PCB-204 improved by a factor of 3 (*statistically different) and achieved a 10% level of equilibration
- Can turn up the vibrational frequency and power to improve equilibration
Results
PRC losses after 14 days: Static vs. Vibrating passive samplers

With 2-min pause (5 s pulse) in lab experiment (Jalalizadeh & Ghosh 2017)

- The frequency of vibration in field deployment was 4-hour pause and 5 s pulse
Summary

- Designed a robust waterproof vibrating platform for increasing sampling rate of passive samplers
- Successfully deployed the vibrating platform in marine sediment field conditions for 14 days
- The vibrating platform increased sampling rates for the most hydrophobic compounds (hepta- and octa- PCBs) to acceptable levels within 14 days
- Further increases in sampling rates possible with adjustment to design to increase frequency and strength of vibration
  - Possible to achieve acceptable levels of equilibration with very hydrophobic compounds within 14 days (instead of 28 to 56 days)
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Thank You For Listening

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