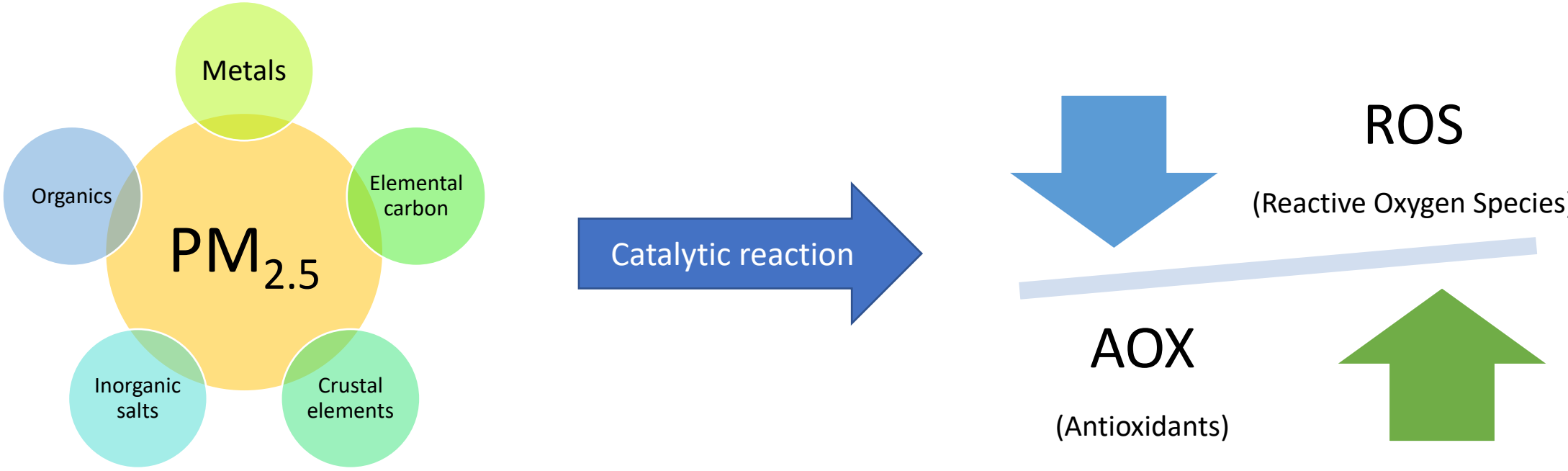
Exploring Oxidative Potential Measurements for SPARTAN

Vishal Verma
Assistant Professor
Civil and Environmental Engineering
University of Illinois at Urbana Champaign

Fourth International SPARTAN Meeting, May 18, 2023, Washington University in St. Louis

The overarching theme of our aerosol oxidative potential measurement lab @Illinois

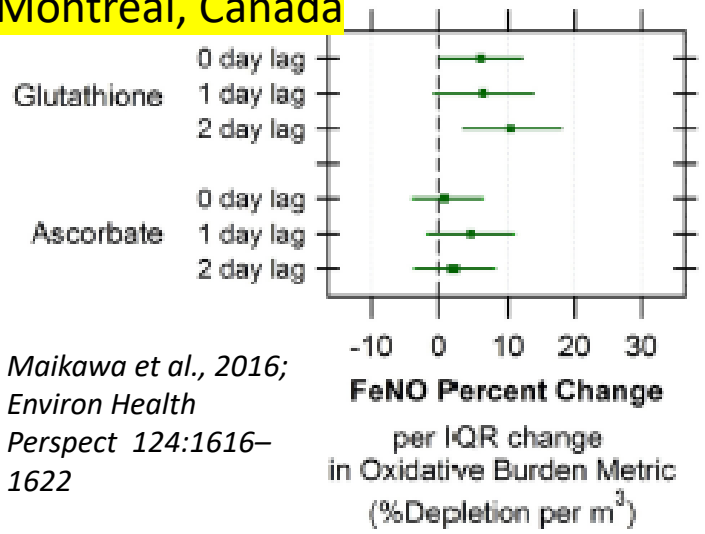
Ambient particulate matter induces oxidative stress

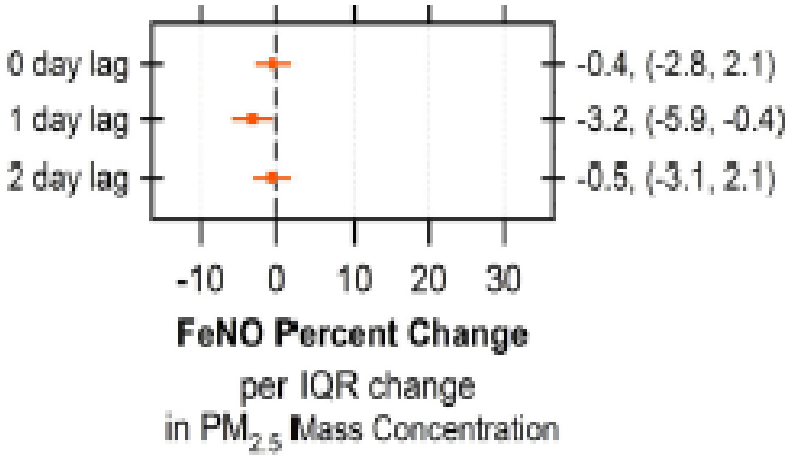


This ability of PM to induce oxidative stress is defined as the Oxidative Potential (OP).

Health relevance of OP (Epidemiological Perspectives)

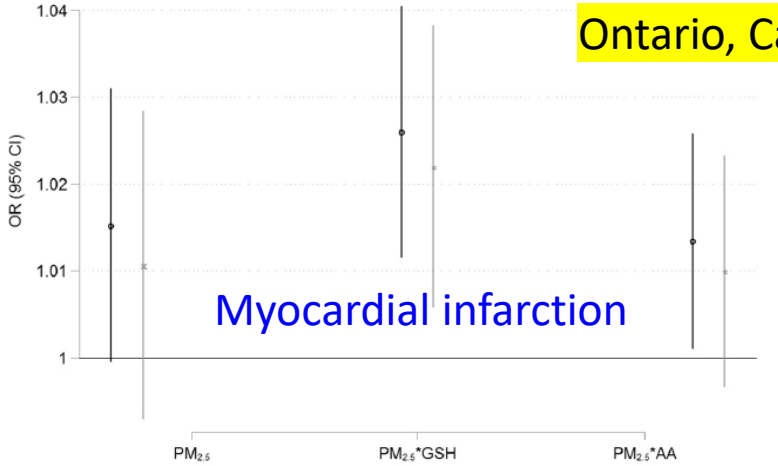
Montreal, Canada





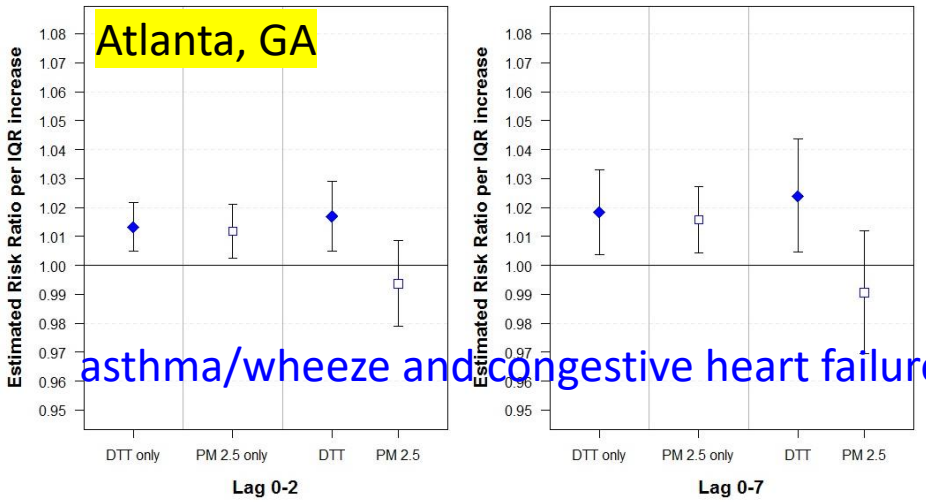
Maikawa et al., 2016; Environ Health Perspect 124:1616–1622

Ontario, Canada



Weichenthal et al. Environmental Health (2016) 15:46

Atlanta, GA



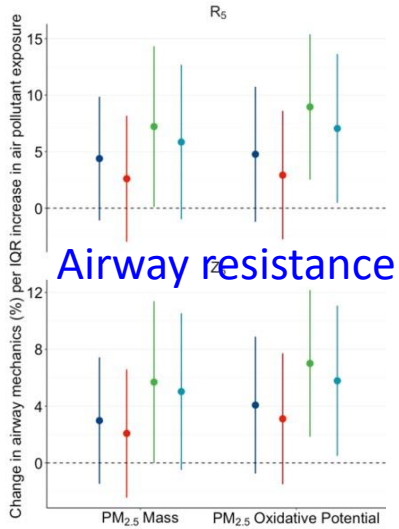
Bates et al., 2015, Environmental Science and Technology; Vol. 49, 13605−13612

Netherland

Component adjusted	EI	Asthma incidence OR	(95% CI)
At birth address			
OP^{DTT}	0.2	1.10**	(1.01 to 1.20)
OP^{ESR}	252	1.03	(0.90 to 1.17)
NO_2	8.4	1.12**	(1.01 to 1.25)
$PM_{2.5}$ absorbance	0.29	1.06	(0.96 to 1.16)
$PM_{2.5}$	1.2	1.08	(0.94 to 1.25)
At current address			
OP^{DTT}	0.2	1.06	(0.97 to 1.15)
OP^{ESR}	252	1.02	(0.88 to 1.17)
NO_2	8.4	1.08	(0.97 to 1.21)
$PM_{2.5}$ absorbance	0.29	1.03	(0.93 to 1.15)
$PM_{2.5}$	1.2	1.02	(0.87 to 1.18)

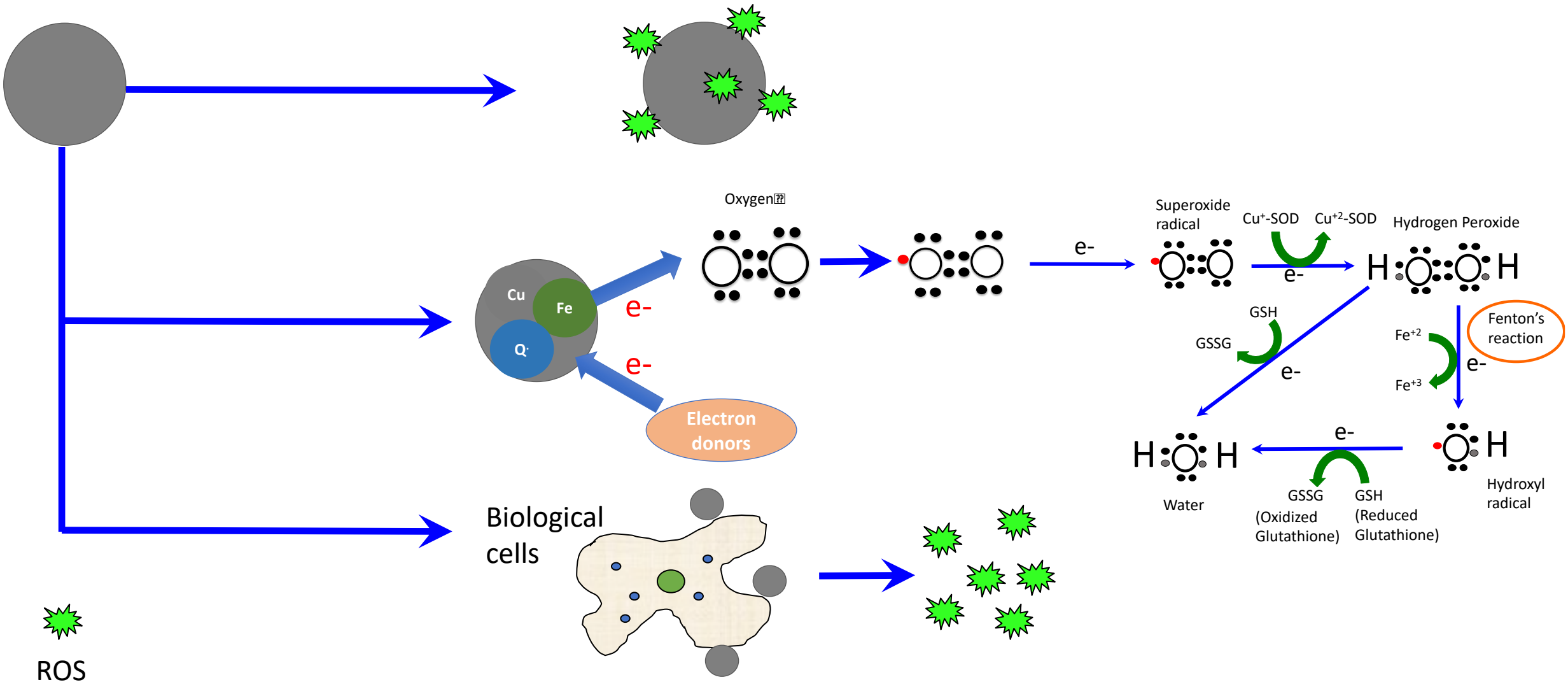
Yang A, et al. Occup Environ Med 2016;73:154–160. doi:10.1136/oemed-2015-103175

Shanghai, China



He et al. ES&T(2021), 55, 3101-3111

Modes of PM Oxidative Potential



High-throughput Automated and Online Instruments for Real-time OP measurements

Automated DTT Instrument in our UIUC lab

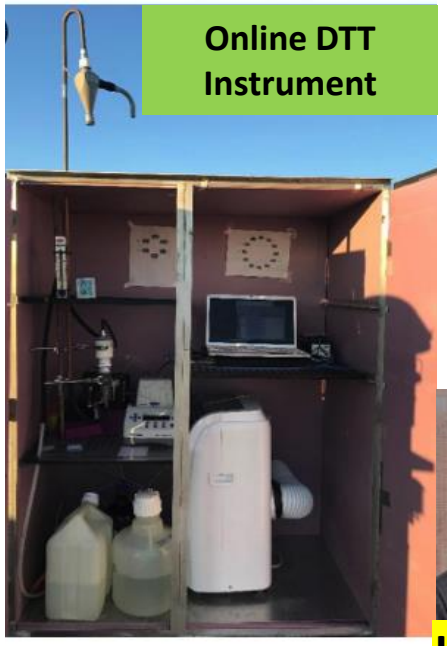
Fang et al., 2015, Atmos. Meas. Tech., 8, 471–482.

Semi-Automated Multi-Endpoint ROS Activity Analyzer (SAMERA)

Haoran Yu

Yu et al., 2019, Aero. Sci. & Tech. 54:3, 304-320

Online DTT Instrument



Joseph Puthussery

Puthussery et al., 2018, Atmos. Meas. Tech., 11, 5767–5780.

Semi-automated instrument for Cellular Oxidative Potential Evaluation (SCOPE)

Sudheer Salana

Salana et al., 2021: Atmos. Meas. Tech., 14, 7579–7593, 2021

OP analysis for SPARTAN Network

- 13 $PM_{2.5}$ samples (4-5 samples x 3 sites) sent to our aerosol lab in April, 2023.
- Sites:

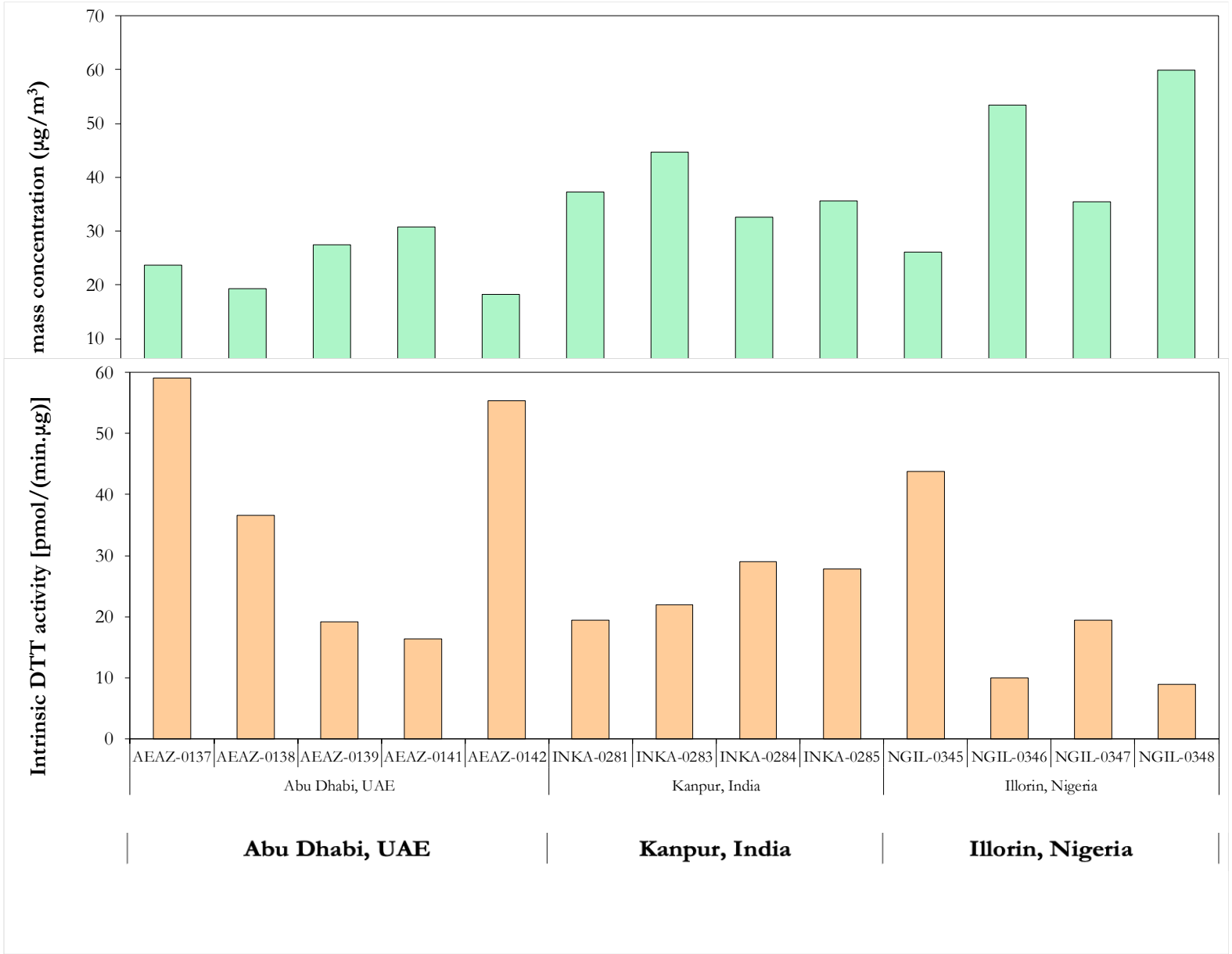
✓Abu Dhabi

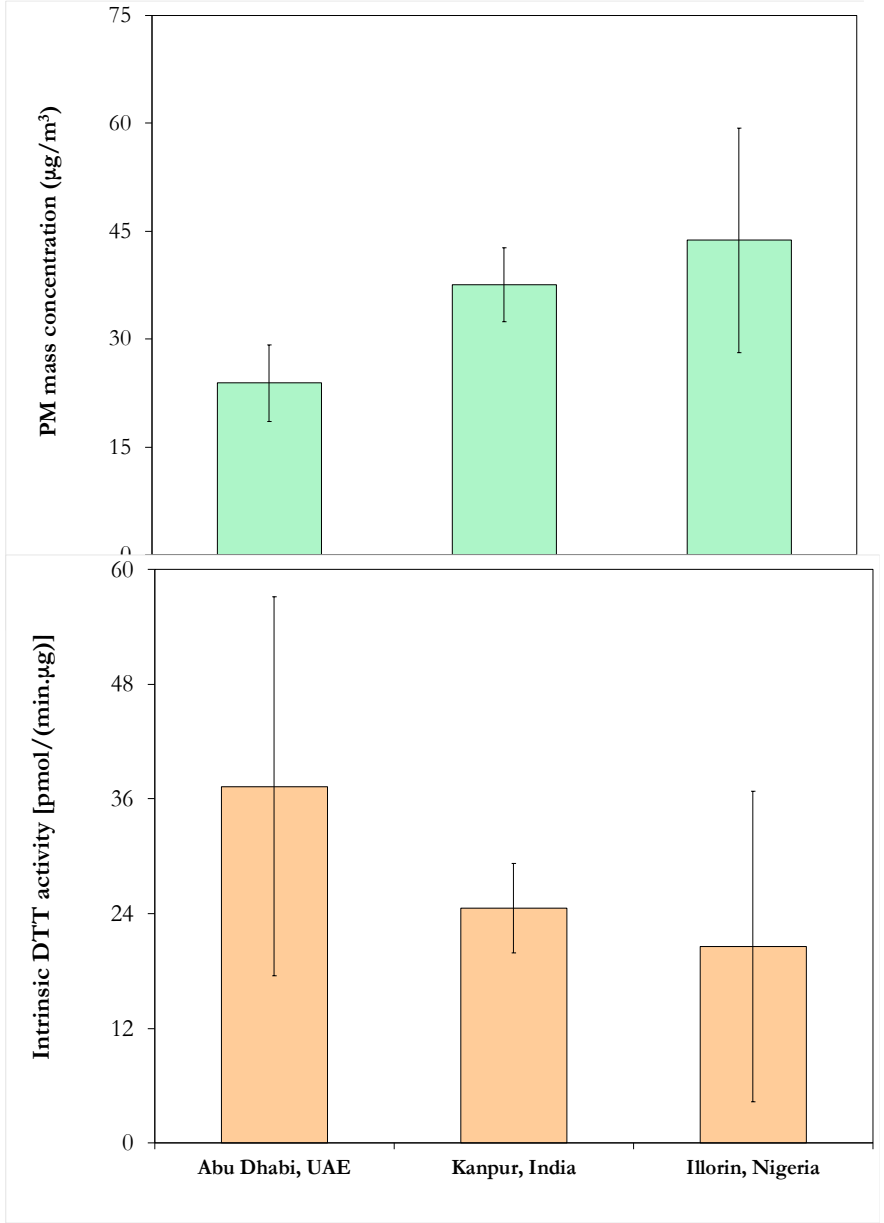
✓Kanpur (India)

✓Illorin (Nigeria)

- ~24 hours time-segregated sampling.
- Samples were extracted in 6 mL of water after wetting the filter with methanol.
- Extracts were assayed for DTT and GSH assay.
- $PM_{2.5}$ concentration in extracts varied from 20-40 µg/mL.

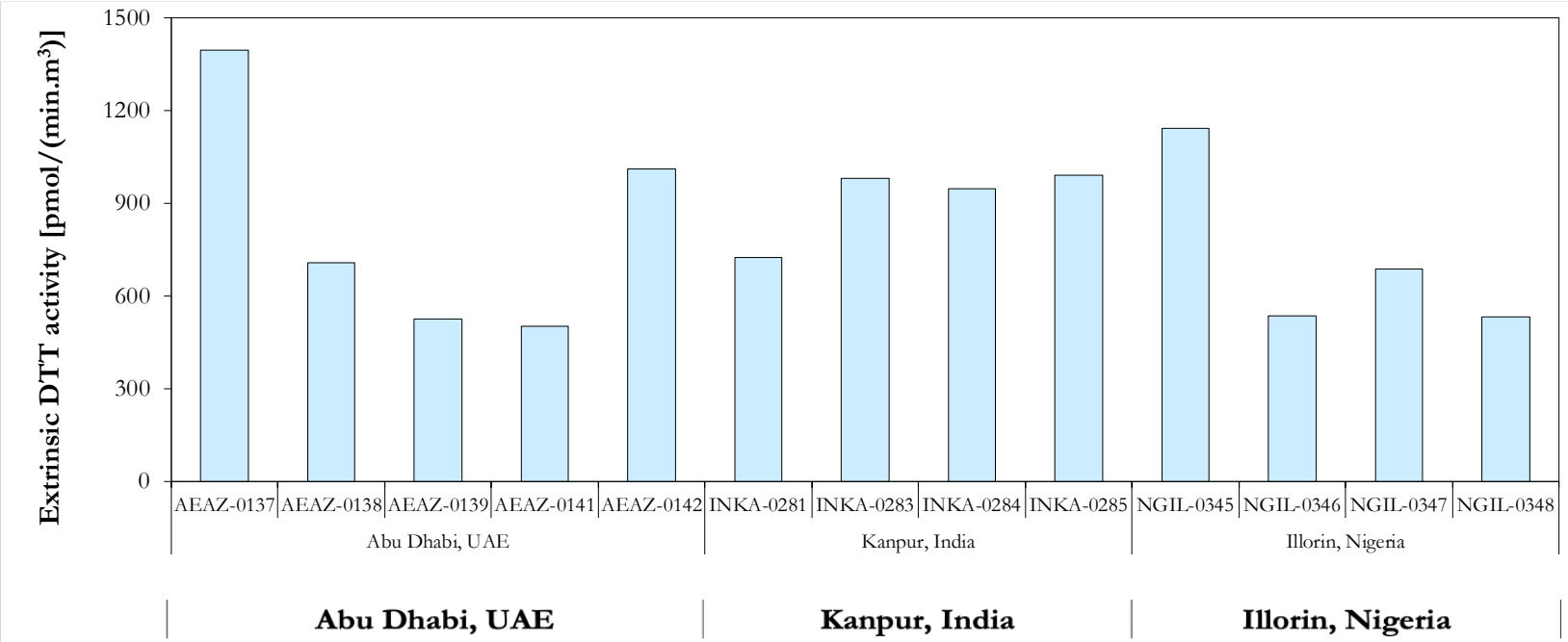
Intrinsic DTT activity (mass normalized)

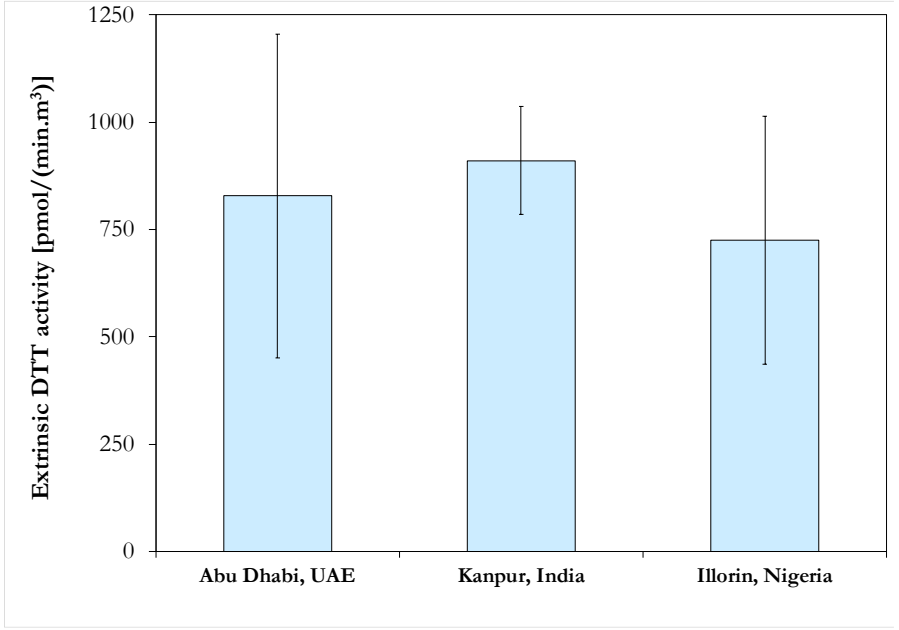


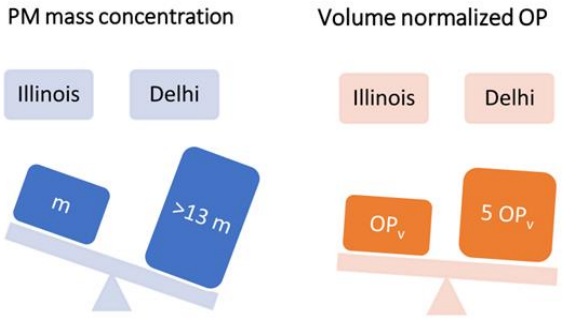


Overall DTT activity (volume normalized)

Overall DTT activity = Extrinsic DTT activity = Intrinsic DTT activity (pmol/min/µg) x PM mass concentration (µg/m^3 of PM)



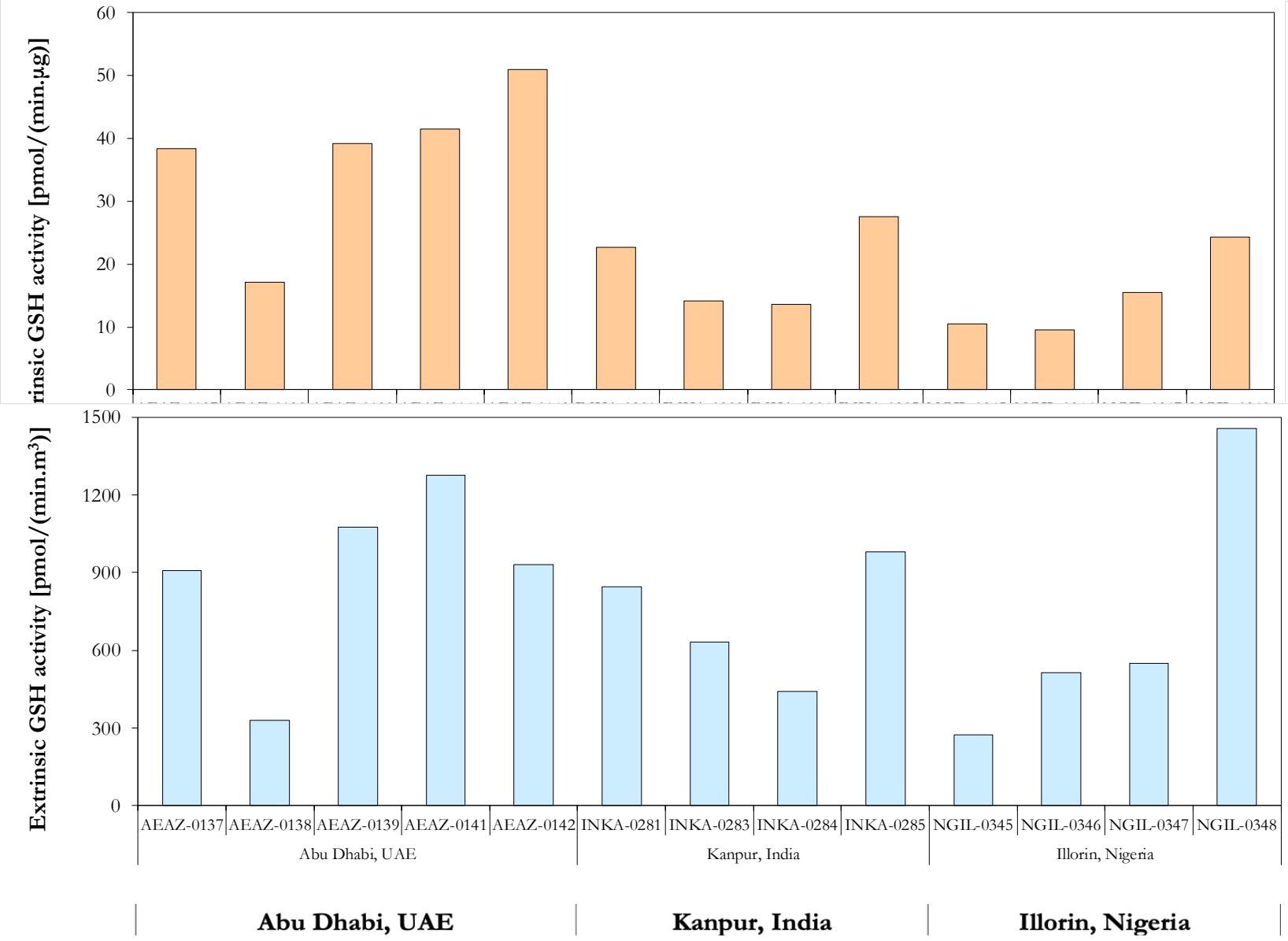


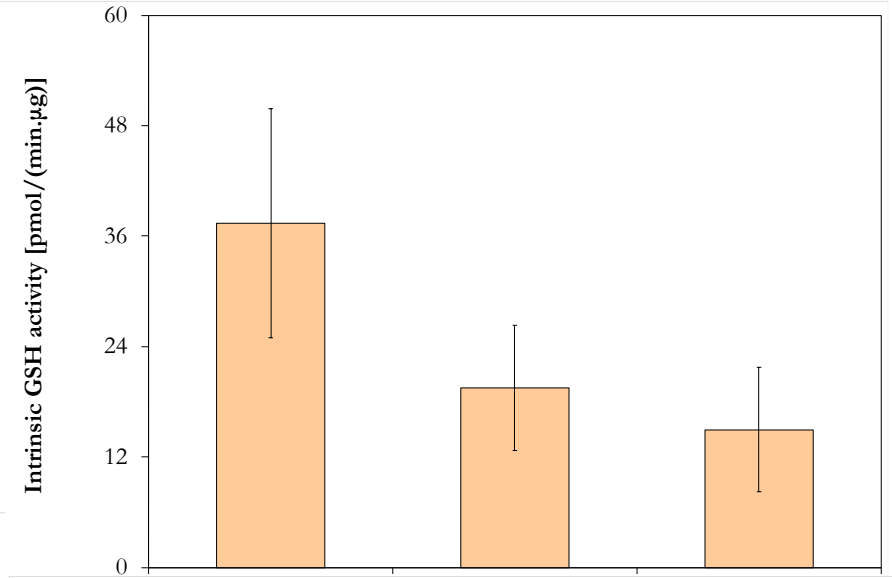


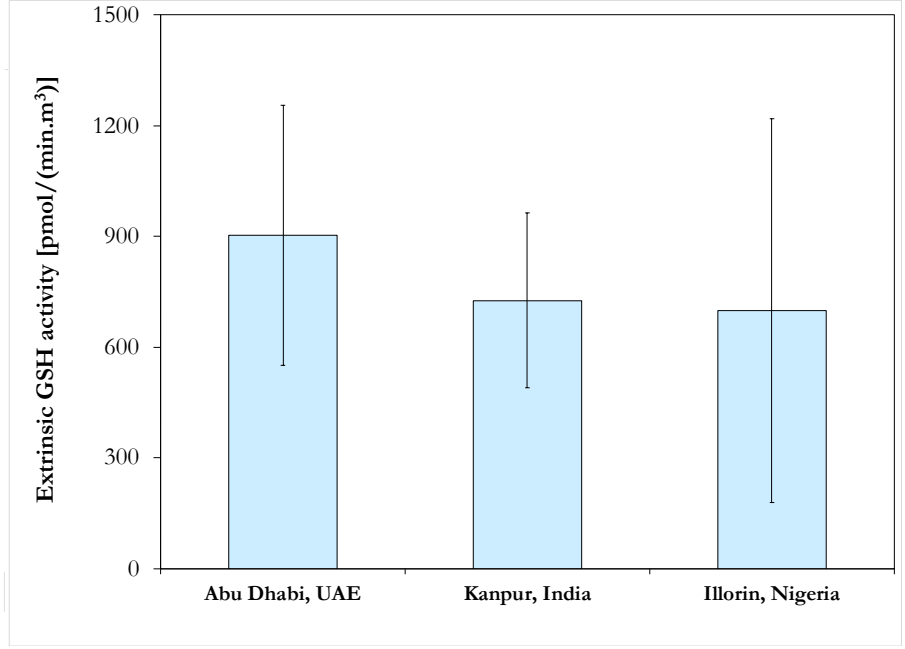
Non-proportional relationship between PM mass and oxidative potential.

Puthussery et al., 2020; Environ. Sci. Technol. Lett, 7, 504−510

Glutathione (GSH) activity







Summary

- With current mass loading on SPARTAN filters, the OP analyses for key endpoints (e.g. DTT and GSH) can be conducted.
- This OP measurement could serve as additional avenue to assess the intrinsic toxicity and subsequent health effects for the PM pollution across the world.
- The OP dataset obtained can be extremely useful for the epidemiologists to integrate it into their models for predicting mortality and morbidity from PM pollution.

Thank you