Investigating the levels of indoor and outdoor particulate matter in six Southeast Asian cities

Professor Anil Namdeo

Fellow Royal Meteorological Society

Chartered Scientist, Chartered Environmentalist

Dept of Geography & Environmental Sciences

Northumbria University, Newcastle, UK

Adam Giandomenico

CEO

Particles Plus

NAAMC
24 August 2022

Northumbria University NEWCASTLE

PARTICLES PLUS

Outline

- Air Quality & Health – global and Southeast Asia (SEA) perspectives
- Air Quality Standards
- Simultaneous PM monitoring in six SEA cities (indoor and outdoor)
- Equipment
- Results
- Key Messages

Air Pollution Declared as Group 1 Carcinogen

International Agency for Research on Cancer

World Health Organization

PRESS RELEASE
N° 221

17 October 2013

IARC: Outdoor air pollution a leading environmental cause of cancer deaths

Lyon/Geneva, 17 October 2013 – The specialized cancer agency of the World Health Organization, the International Agency for Research on Cancer (IARC), announced today that it has classified outdoor air pollution as *carcinogenic to humans* (Group 1). [1]

After thoroughly reviewing the latest available scientific literature, the world's leading experts convened by the IARC Monographs Programme concluded that there is *sufficient evidence* that exposure to outdoor air pollution causes lung cancer (Group 1). They also noted a positive association with an increased risk of bladder cancer.

Particulate matter, a major component of outdoor air pollution, was evaluated separately and was also classified as *carcinogenic to humans* (Group 1).

Air Pollution is a Global Public Health Hazard

Air pollution contributes to about 7 million early deaths annually, while burdening the global economy upwards of $2.9 trillion per year.

Between 7 and 33% of deaths from COVID-19 are attributable to long-term air pollution exposure.

2020 World Air Quality Report reveals substantial air quality changes

Northumbria University NEWCASTLE

New Findings

Diabetes

In 2017, exposure to $PM_{2.5}$ was the third leading risk factor for type 2 diabetes deaths and DALYs, after high blood sugar and high body mass index

Neurological Disease

Special Reports | Environment Reports | Health & Social Care Reports

The link between traffic-related air pollution and neurologic disease?

March 19, 2019

Pamela Lein and Rhianna Morgan discuss organosulfates and the growing connection between air pollution and neurologic disease

Cognitive Decline

BBC | Sign in | News | Sport | Weather | iPlayer | Sounds

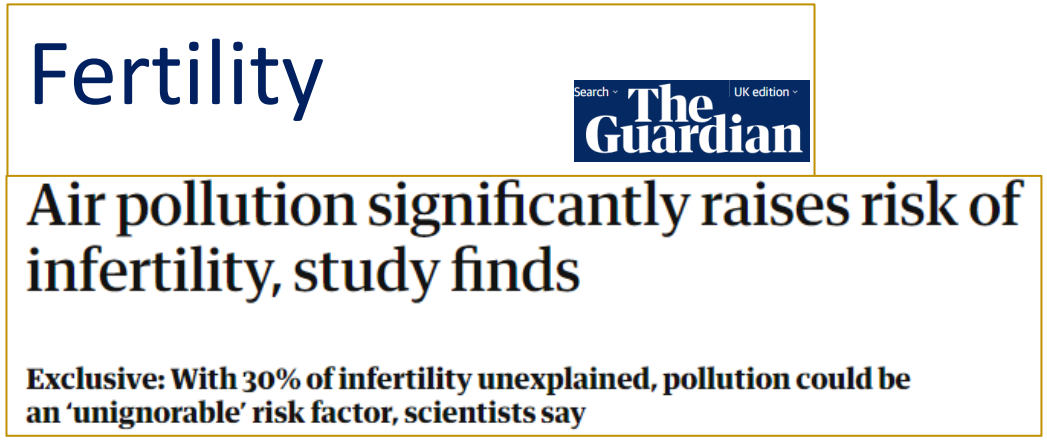
NEWS

Home | UK | World | Business | Politics | Tech | Science | Health | Family & Education

Health

Air pollution may harm cognitive intelligence, study says

Fertility



Search | The Guardian | UK edition

Air pollution significantly raises risk of infertility, study finds

Exclusive: With 30% of infertility unexplained, pollution could be an 'unignorable' risk factor, scientists say

Childhood Obesity

ehp Environmental Health Perspectives

Environ Health Perspect. 2017 Jun; 125(6): 067005. PMCID: PMC5743454
Published online 2017 Jun 14. doi: 10.1289/EHP261 PMID: 28669938
Research

Individual and Joint Effects of Early-Life Ambient $PM_{2.5}$ Exposure and Maternal Prepregnancy Obesity on Childhood Overweight or Obesity

Guangyun Mao,[1,2,3,*] Rebecca Massa Nachman,[4,*] Qi Sun,[5,6,*] Xingyou Zhang,[7] Kirsten Koehler,[4] Zhu Chen,[3] Xiumei Hong,[3] Guoying Wang,[3] Deanna Caruso,[3] Geng Zong,[8] Colleen Pearson,[8] Hongkai Ji,[9] Shyam Biswal,[4]

AIRPORT – A feasibility study of the impact of the level of exposure to ambient Air Pollutants on Outcomes of assisted Reproductive Technologies (Northumbria University, UK)

Northumbria University NEWCASTLE

PARTICLES PLUS

WHO New Air Quality Guidelines (2021)

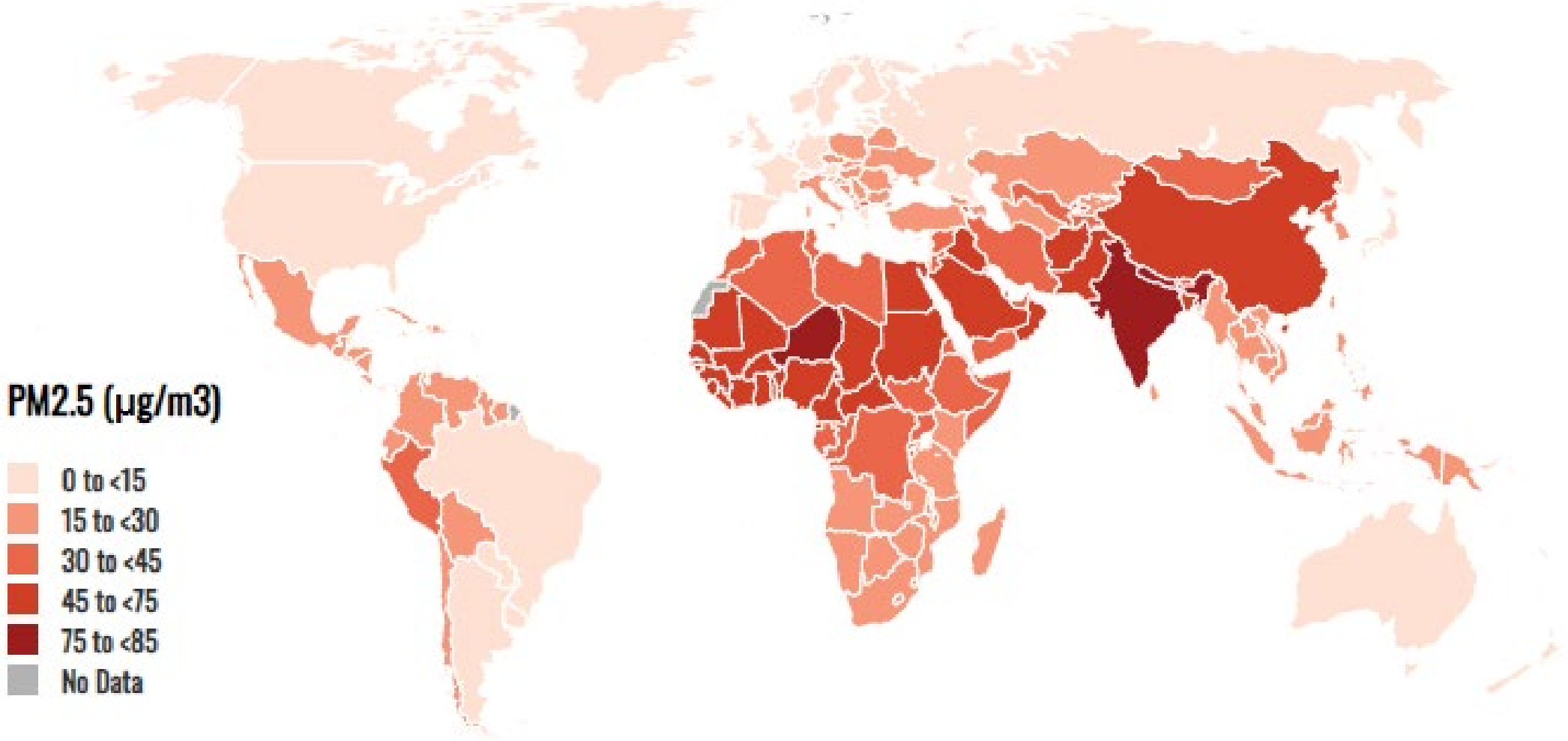
WHO AIR QUALITY GUIDELINES

	2005	2021
NO2	40 µg/m³, annual	**10 µg/m³, annual**
PM2.5	10 µg/m³, annual	**5 µg/m³, annual**
PM10	25 µg/m³, annual	**15 µg/m³, annual**
Ozone	100 µg/m³, 8-hour max	**100 µg/m³, 8-hour max**

Northumbria University NEWCASTLE

PARTICLES PLUS

Annual Average Population Weighted $PM_{2.5}$ Concentration in 2019

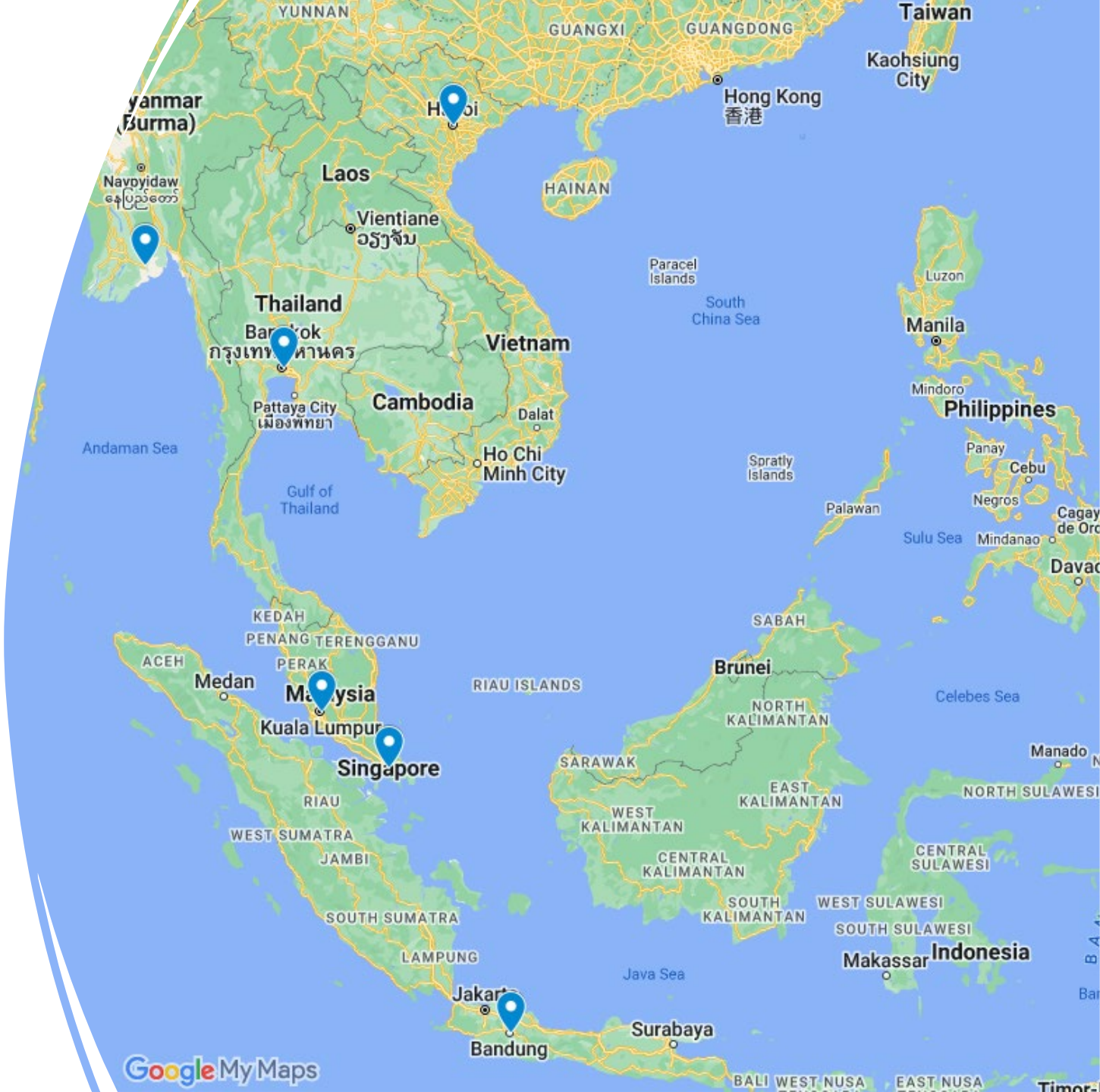


Northumbria University NEWCASTLE

PARTICLES PLUS

Study Locations in Southeast Asia

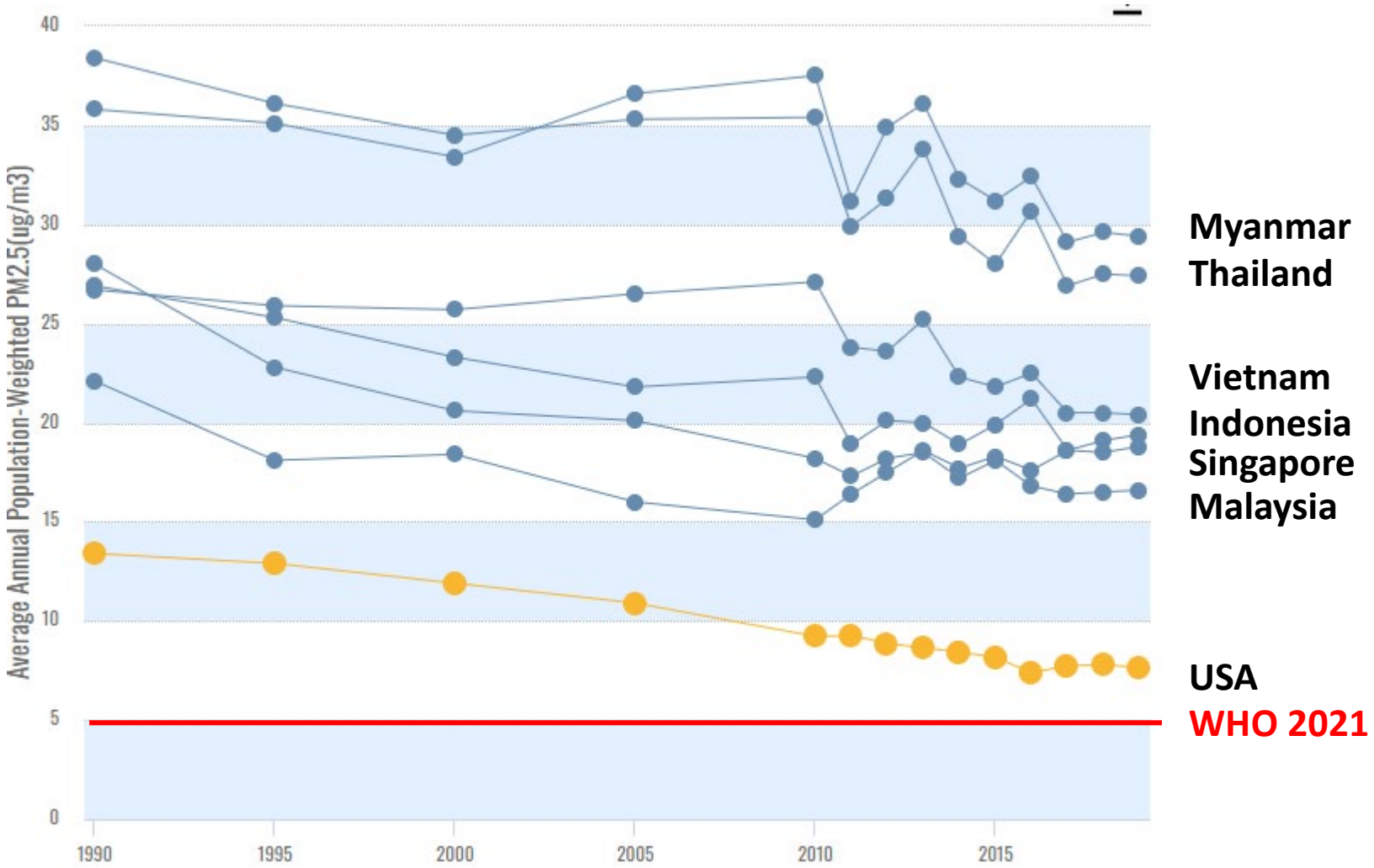
- Bandung, Indonesia
- Bangkok, Thailand
- Hanoi, Vietnam
- Kuala Lumpur, Malaysia
- Singapore
- Yangon, Myanmar



Average Annual Population-Weighted $PM_{2.5}$

2019

Indonesia	19.4
Malaysia	16.6
Myanmar	29.4
Singapore	18.8
Thailand	27.4
Vietnam	20.4
USA	7.66

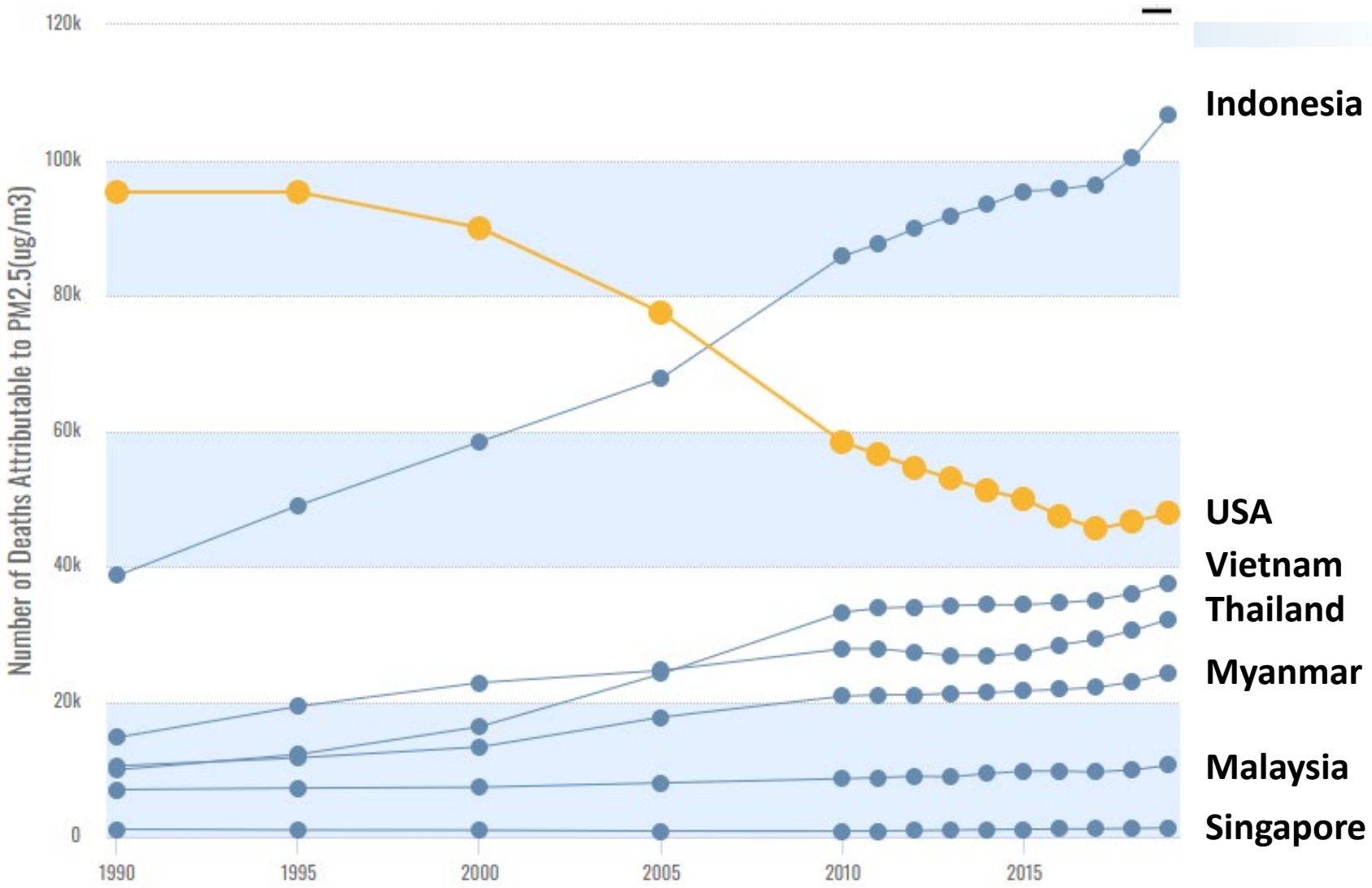


Health Effects Institute (2020); State of Global Air (2020); Data source: Global Burden of Disease Study (2019).

Deaths Attributable to $PM_{2.5}$

2019

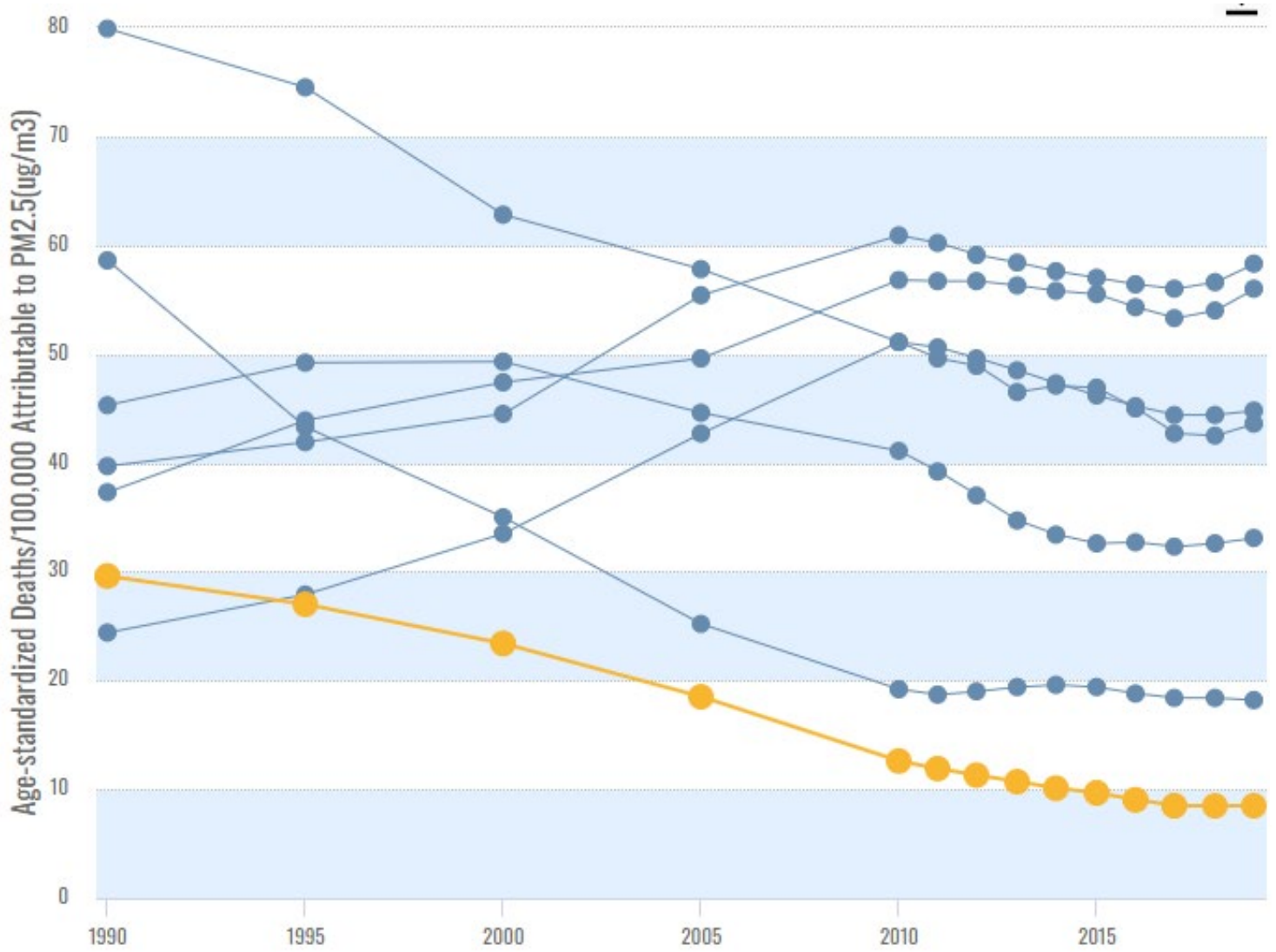
Indonesia	106,700
Malaysia	10,600
Myanmar	24,200
Singapore	1,330
Thailand	32,200
Vietnam	37,500
USA	47,800



Health Effects Institute (2020); State of Global Air (2020); Data source: Global Burden of Disease Study (2019).

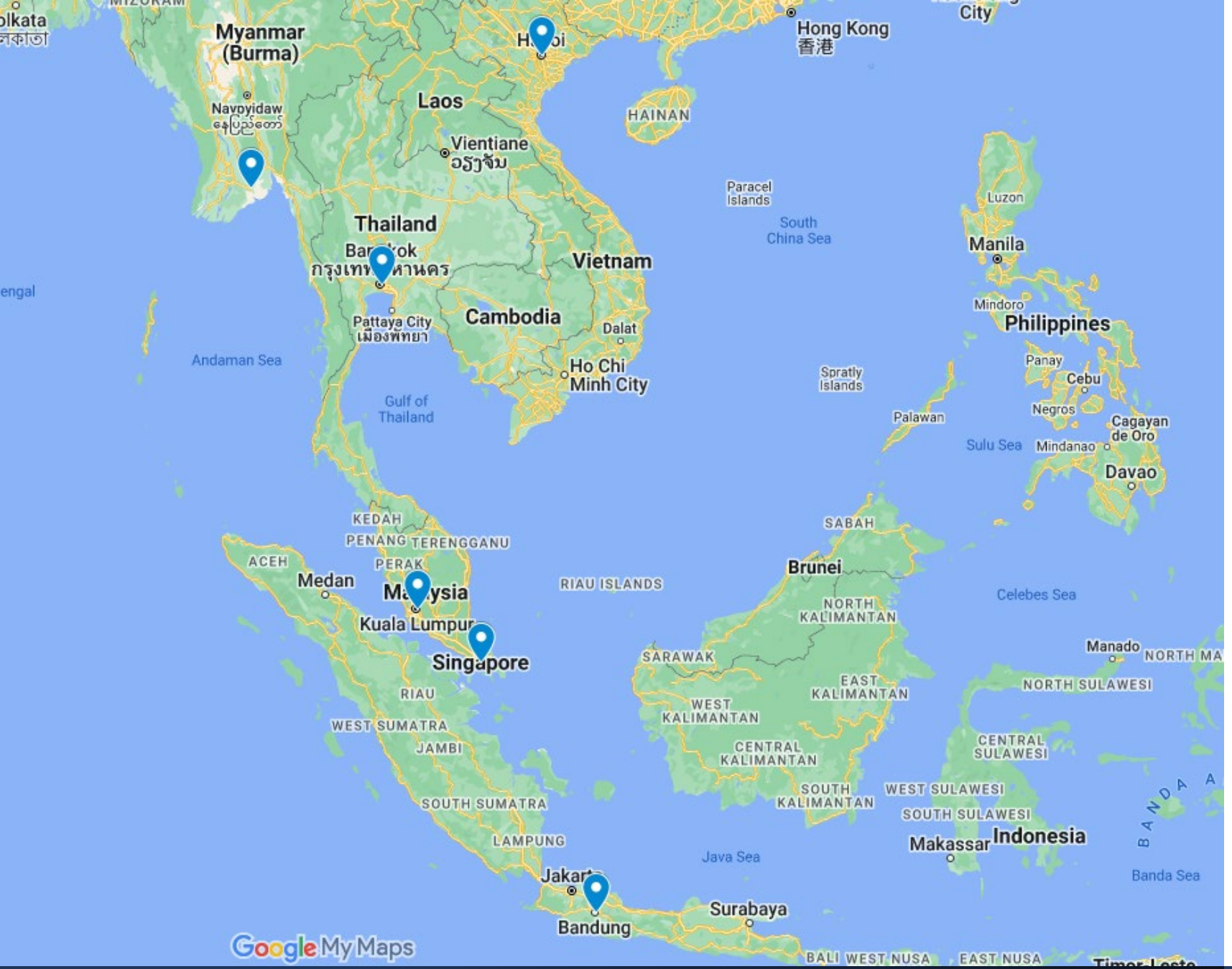
Age Standardized Deaths/ 100,000 Attributable to $PM_{2.5}$

2019



Northumbria University NEWCASTLE

PARTICLES PLUS



Study Locations in Southeast Asia

- Bandung, Indonesia
- Bangkok, Thailand
- Hanoi, Vietnam
- Kuala Lumpur, Malaysia
- Singapore
- Yangon, Myanmar

Participating Institutions

ID	Institute	City	Country
AIT	Asian Institute of Technology	Bangkok	Thailand
EQM	Environmental Quality Management Co. Ltd	Yangon	Myanmar
HUNER	Hanoi University of Natural Resources and Environment	Hanoi	Vietnam
NITB	National Institute of Technology Bandung	Bandung	Indonesia
NUS	National University of Singapore	Singapore	Singapore
UPM	Universiti Putra Malaysia	Kuala Lumpur	Malaysia

Monitoring Campaign

- Simultaneous monitoring in eight cities (results for six presented here; other two are Newcastle, UK and Boston, MA, USA)
- August 3 to August 18; 2020
- Simultaneous outdoor and indoor monitoring at each location
- Monitoring frequency – 1 minute
- Mass concentrations ($\mu g\ m^{-3}$) $PM_{2.5}$
- Particle number counts (PNC) ($\#/m^3$) – six size channels
  - 0.3 µm, 0.5 µm, 1.0 µm, 2.5 µm, 5.0 µm and 10.0 µm

Equipment used

- Particles Plus 7301 for indoor monitoring
- Particles Plus EM10000 for outdoor monitoring

Particles Plus Series 7300 Indoor AQMs

Used to monitor in fixed location for long term analysis and studies

Includes Particulate, Temp, RH, CO_2 & TVOC

Particles Plus 7301, 7501, 7301-AQM1 & 7301-AQM2

Battery backup, long term data storage, IOT

Northumbria University NEWCASTLE

PARTICLES PLUS

Particles Plus Series EM10000 Outdoor AQMs

Designed for gas and particle pollutant measurements to better understand atmospheric chemistry and environmental public health.

Includes Particulate, Temp, RH, CO2 & TVOC

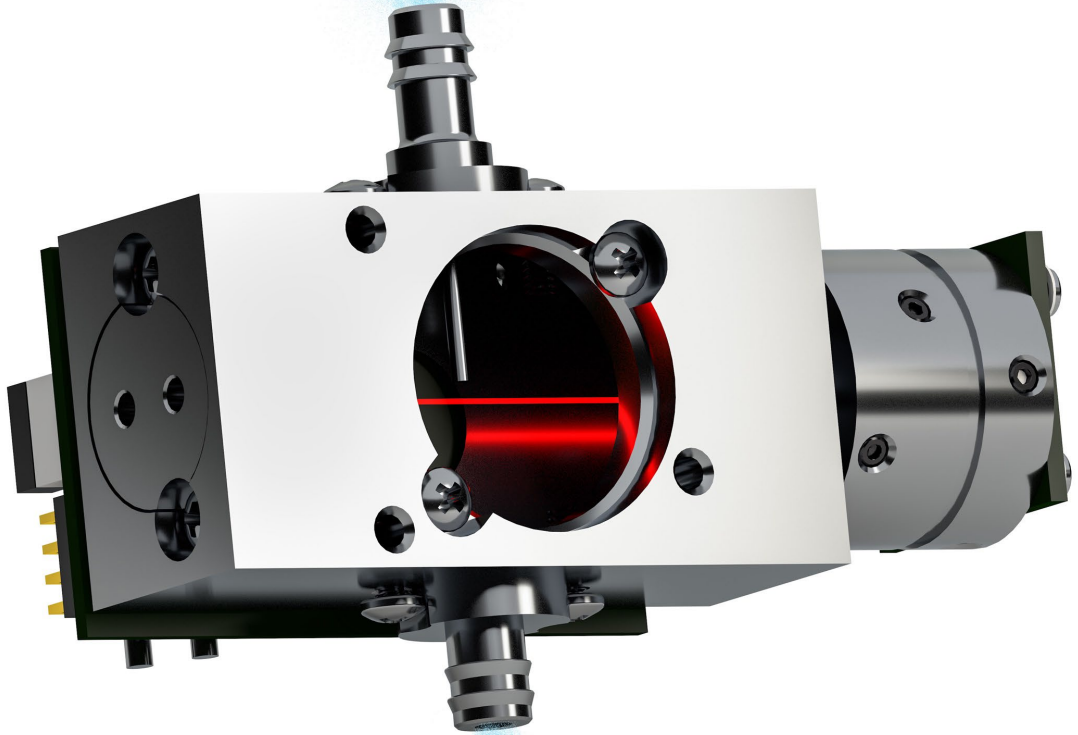
Particles Plus EM-10000 and EM-11000

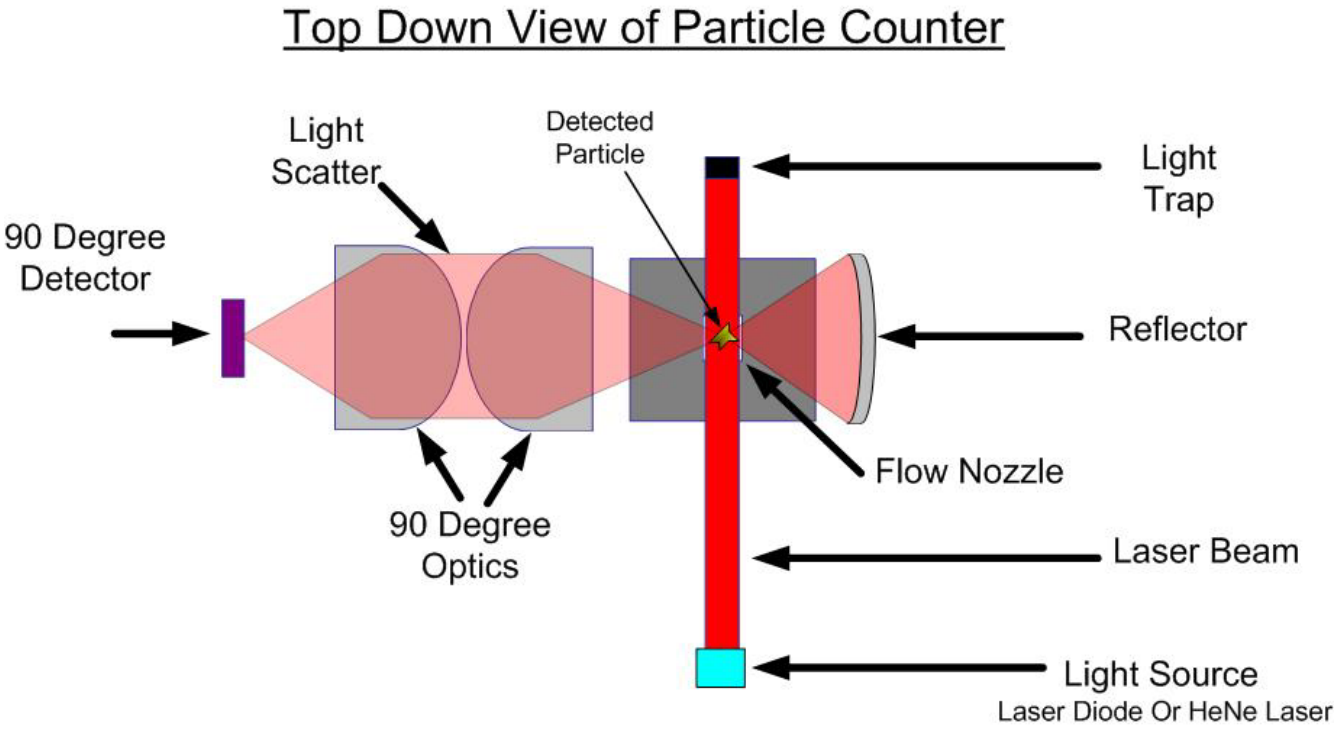
Long term data storage, IOT

Northumbria University NEWCASTLE

PARTICLES PLUS

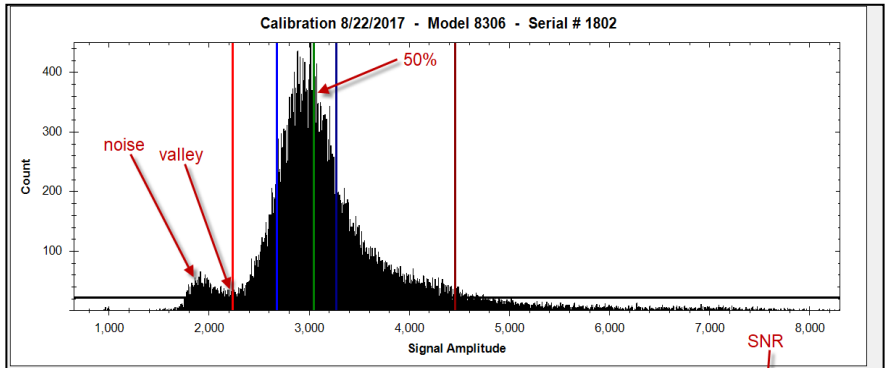
Particle Counters





Calibration Standard: ISO 21501-4

- Size calibration (Signal to noise ratio> 2:1)
- Size resolution (<=15% on one channel)
- False count rate (5 minutes 0 counts)
- Sampling flow rate (+/- 5% of target flow rate)
- Counting efficiency (50 +/-20%, 100 +/-10%)
- Verification of size setting (size error < 10%)
- Maximum particle concentration (<10% loss at max)
- Sampling time (within 1% of stated sample time)
- Response rate (0.5% after 10 seconds)
- Calibration interval (recommended 1 year or less)



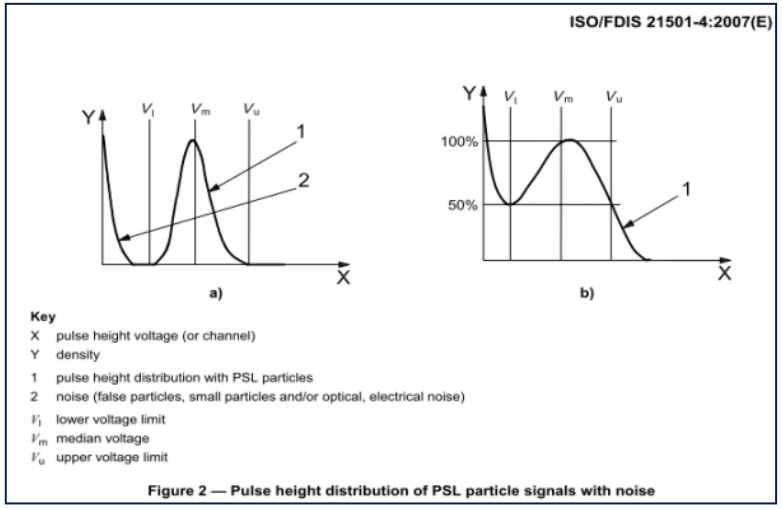


Figure 2 — Pulse height distribution of PSL particle signals with noise

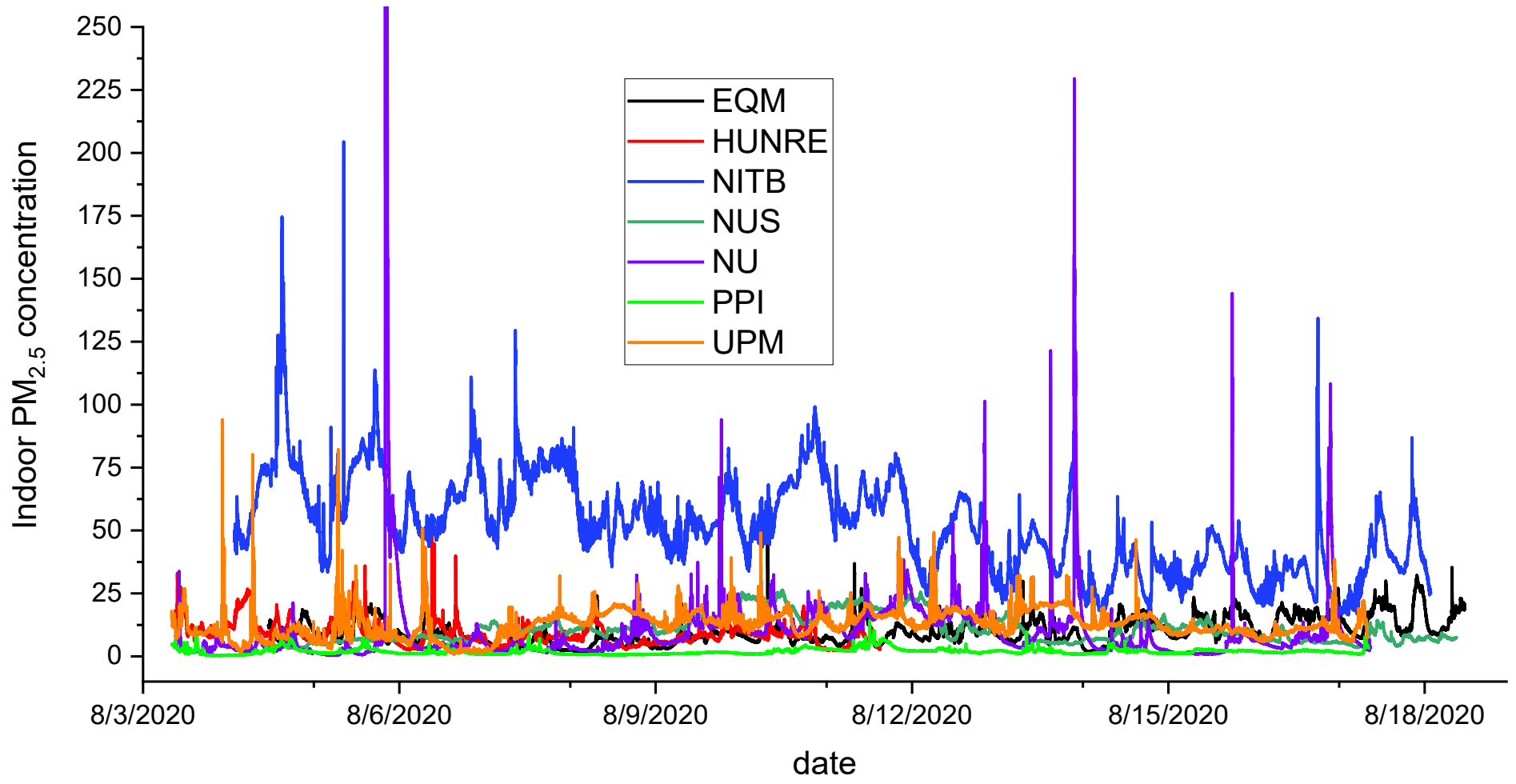
Northumbria University NEWCASTLE

PARTICLES PLUS

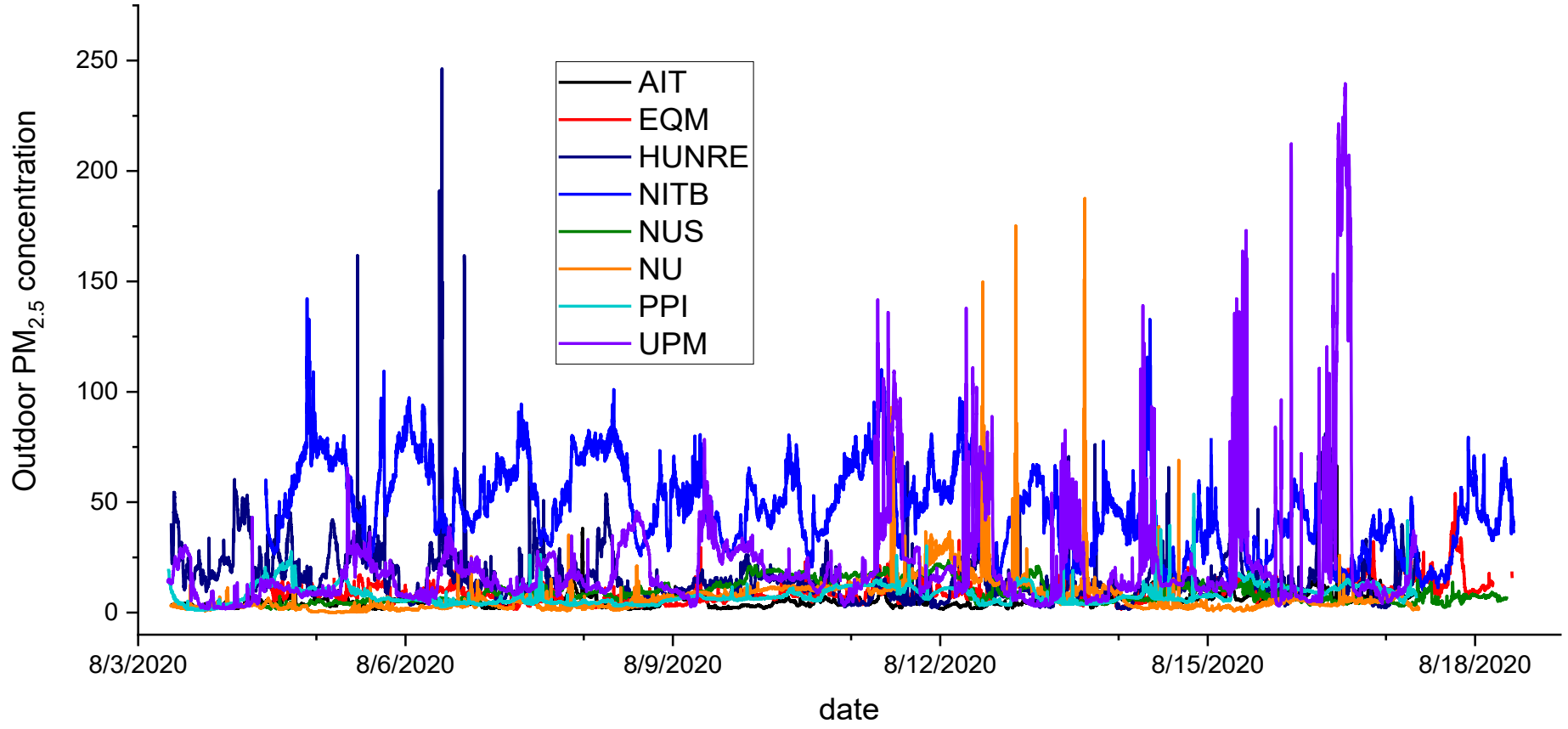
Statistical Analysis for $PM_{2.5}$

Site / ID	Indoor (mean ± SD) (min-max) µg/m³	Outdoor (mean ± SD) (min-max) µg/m³	Indoor/Outdoor ratio (mean ± SD) (min-max)
AIT (Bangkok)	---	5.5±2.9 (1.4-66.5)	-
EQM (Yangon)	10.1±5.2 (1.7-55.1)	9.4±4.9 (1.5-54.1)	1.07±0.39 (0.17-5.02)
HUNER (Hanoi)	5.3±5.6 (0.0-54.2)	16.0±12.1 (1.5-246.3)	0.34±0.31(0.0-1.98)
NITB (Bandung)	51.6±18.7 (16.4-204.5)	46.7±19.3 (10.2-142.1)	1.03±0.71 (0.22)
NUS (Singapore)	10.8±5.4 (3.2-26.4)	9.1±4.7 (1.6-30.3)	1.23±0.20 (0.36-2.82)
UPM (Kuala Lumpur)	12.5±5.5 (0.8-94.1)	19.7±24.1 (1.7-239.6)	1.10±1.12 (0.04-41.45)

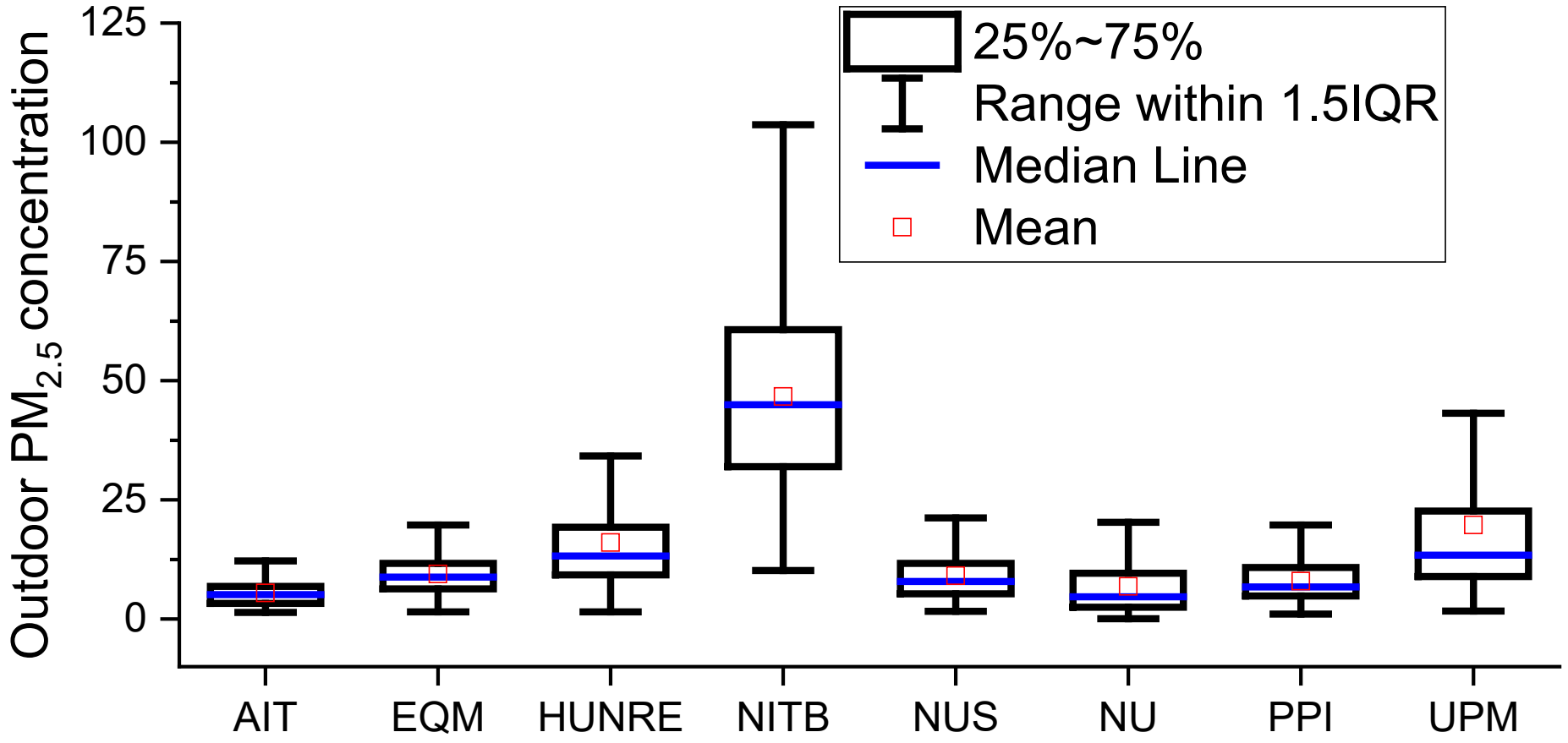
Time Series (Indoors)



Time Series (Outdoors)



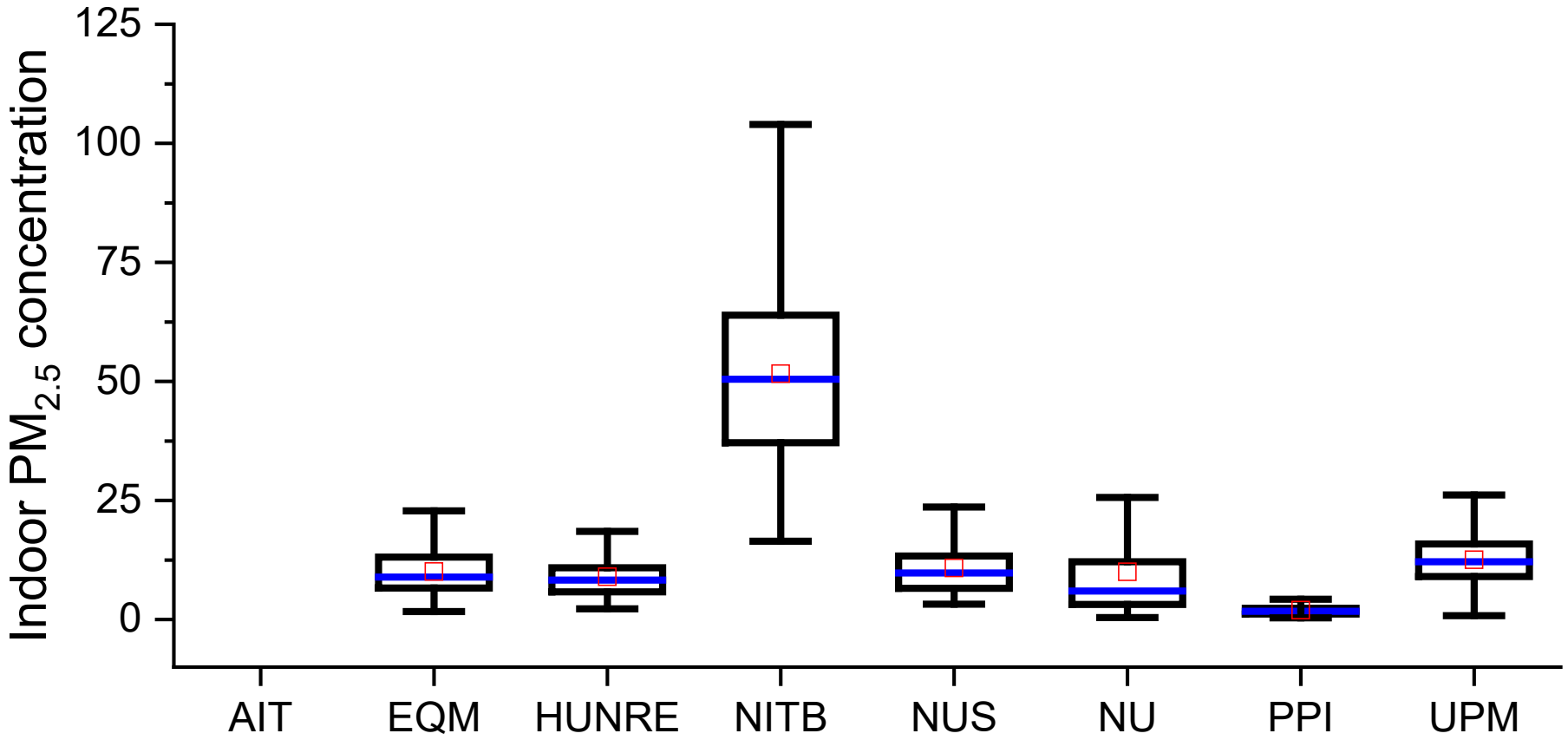
Outdoor $PM_{2.5}$



Northumbria University NEWCASTLE

PARTICLES PLUS

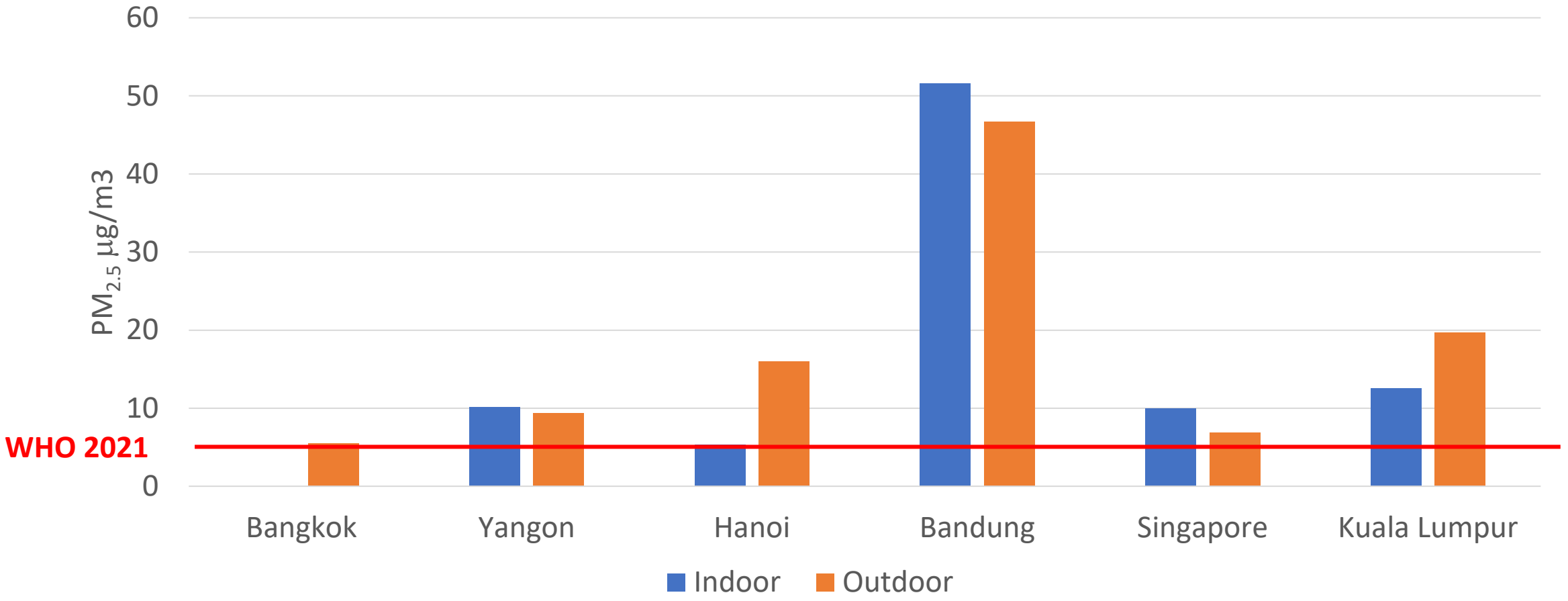
Indoor $PM_{2.5}$



Northumbria University NEWCASTLE

PARTICLES PLUS

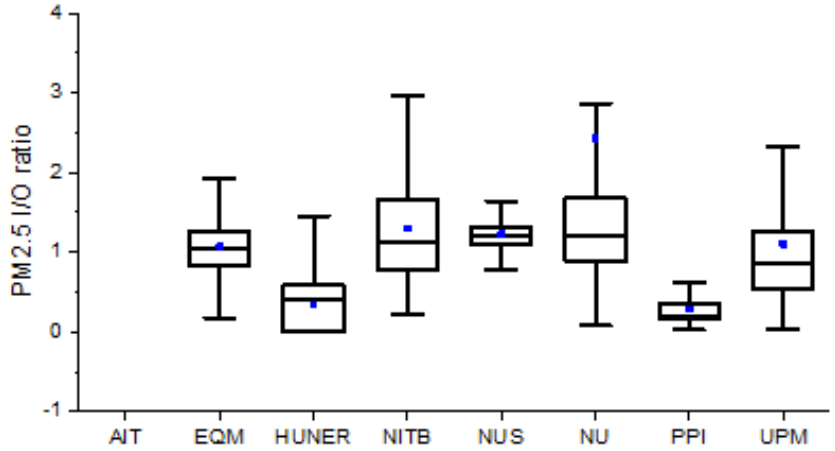
Indoor and Outdoor $PM_{2.5}$ Concentrations

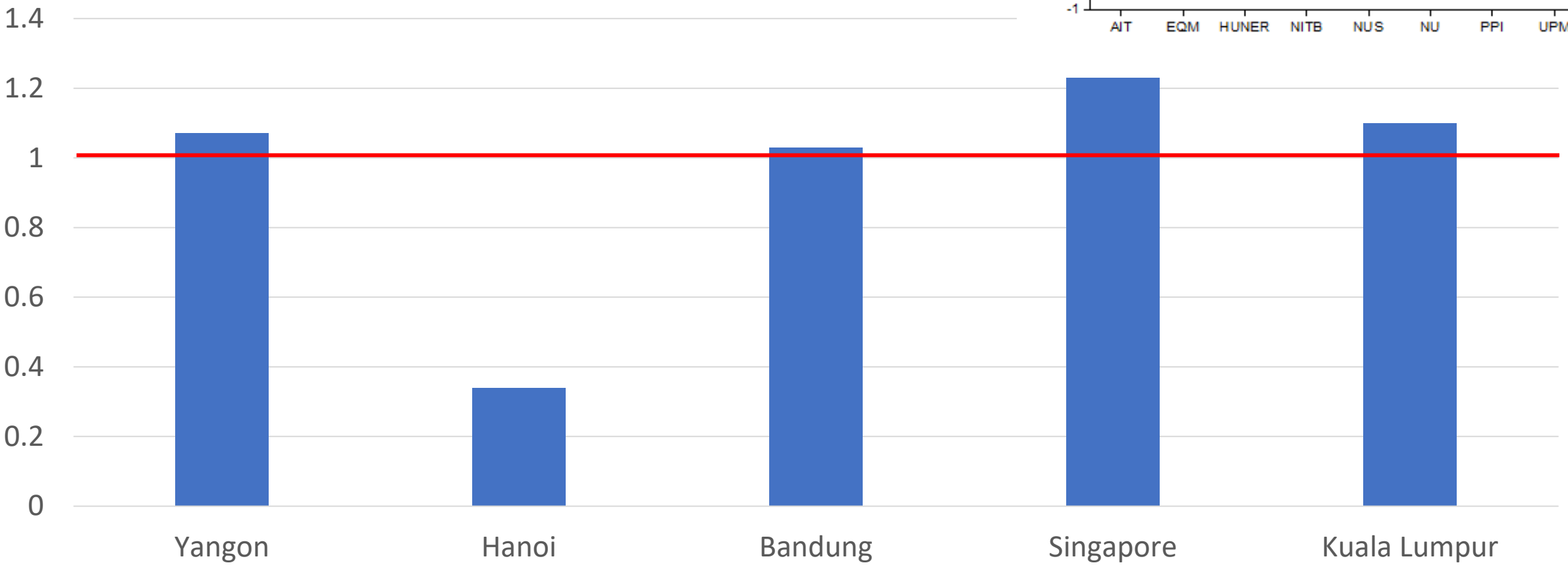


Northumbria University NEWCASTLE

PARTICLES PLUS

Indoor/Outdoor Ratios - $PM_{2.5}$

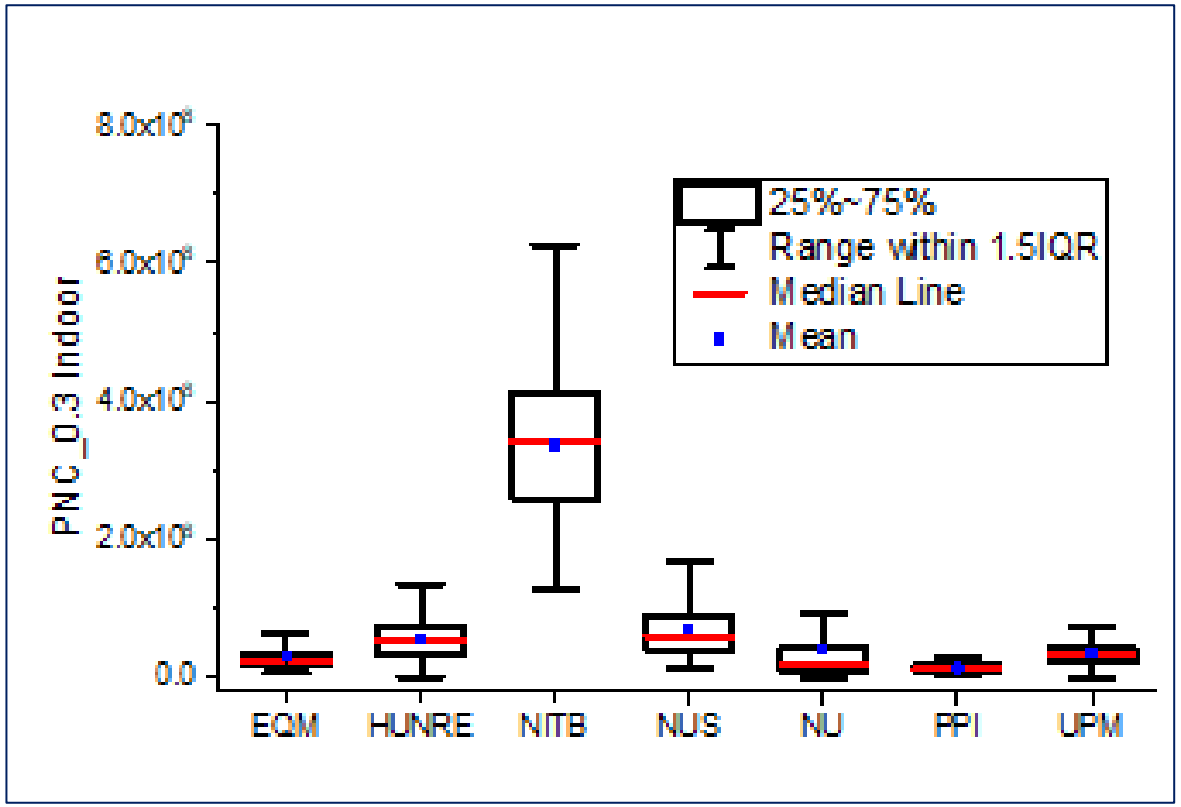


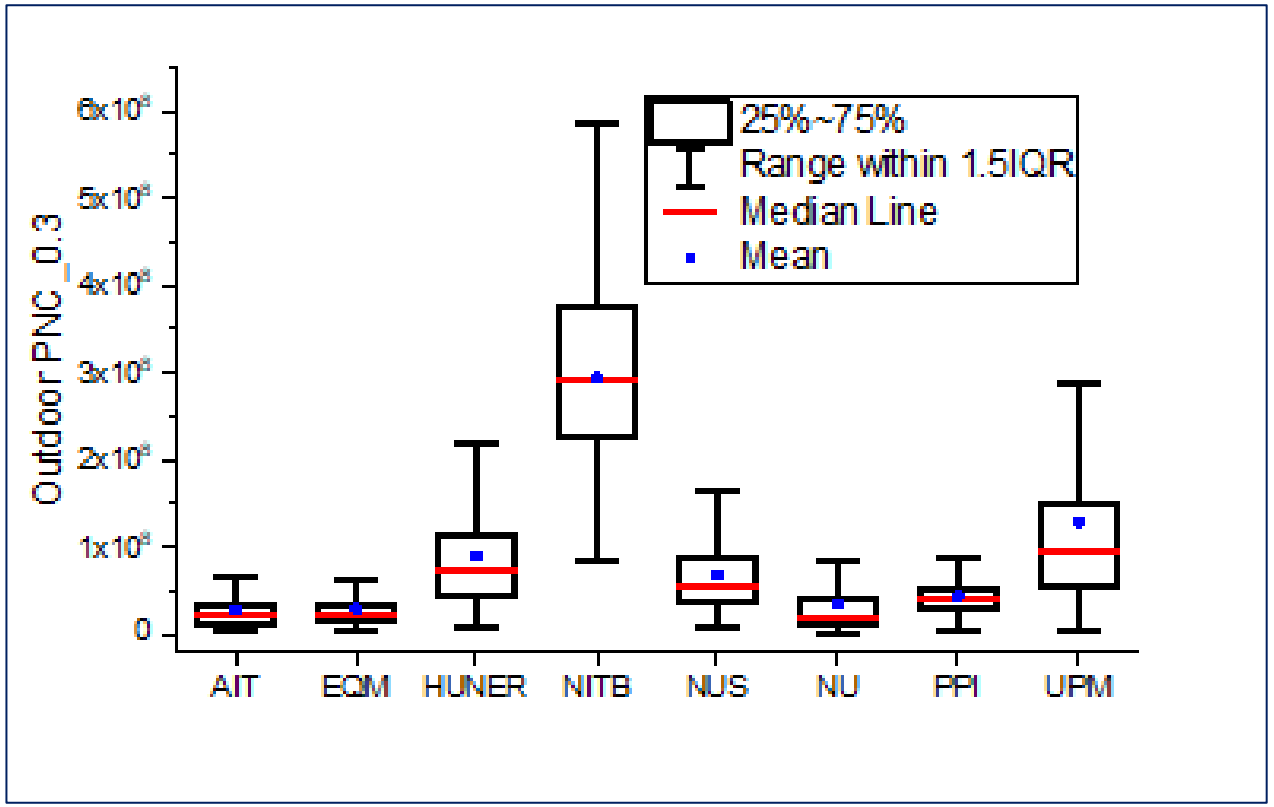


Northumbria University NEWCASTLE

PARTICLES PLUS

PNC 0.3 µm – Indoor and Outdoor





Indoor

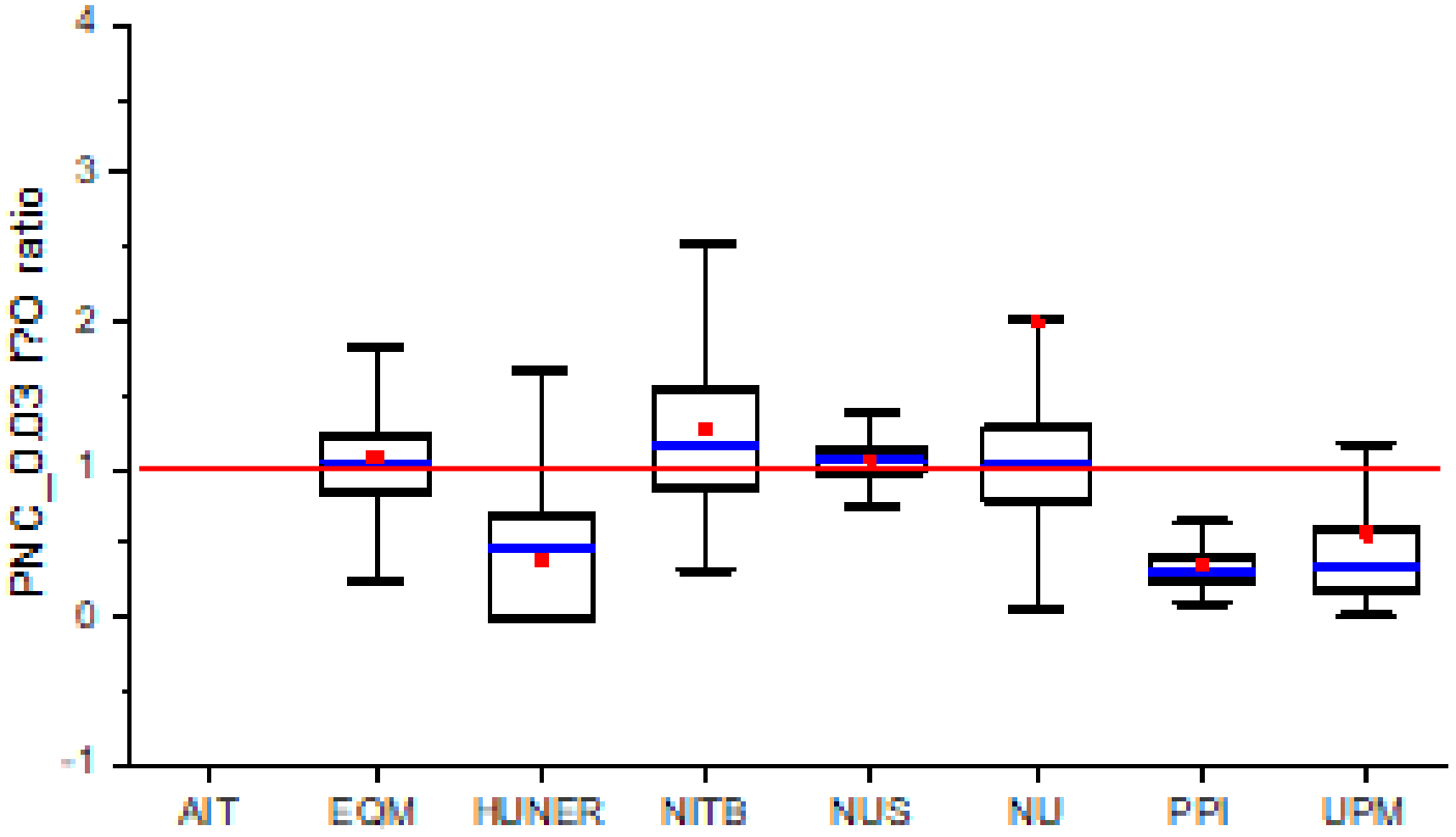
Outdoor

Northumbria University NEWCASTLE

PARTICLES PLUS

Indoor and Outdoor Ratios: PNC 0.3 µm

PNC 0.3 µm Indoor and Outdoor Ratios

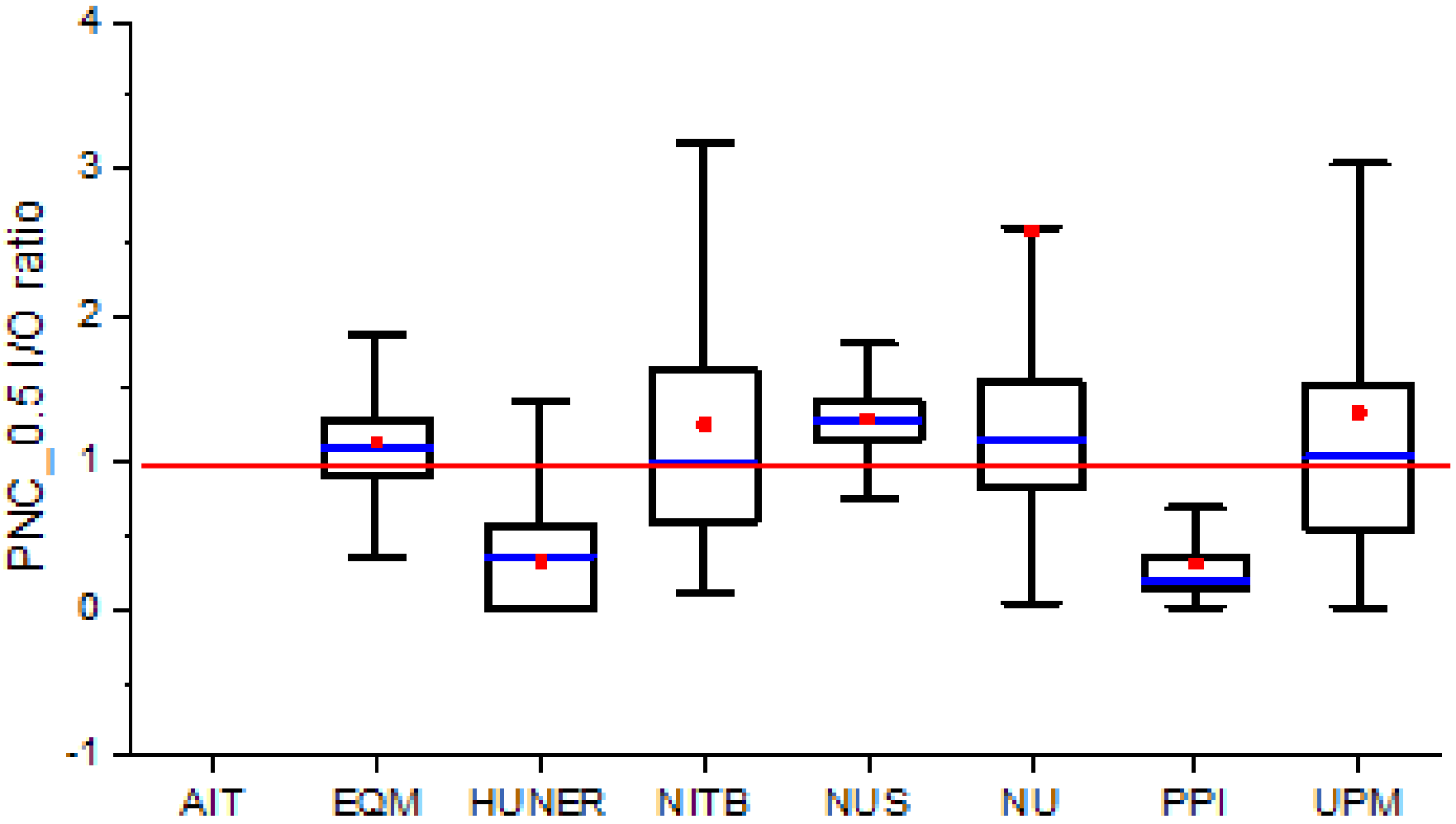


Northumbria University NEWCASTLE

PARTICLES PLUS

I/O PNC 0.5 µm

PNC 0.5 µm Indoor and Outdoor Ratios

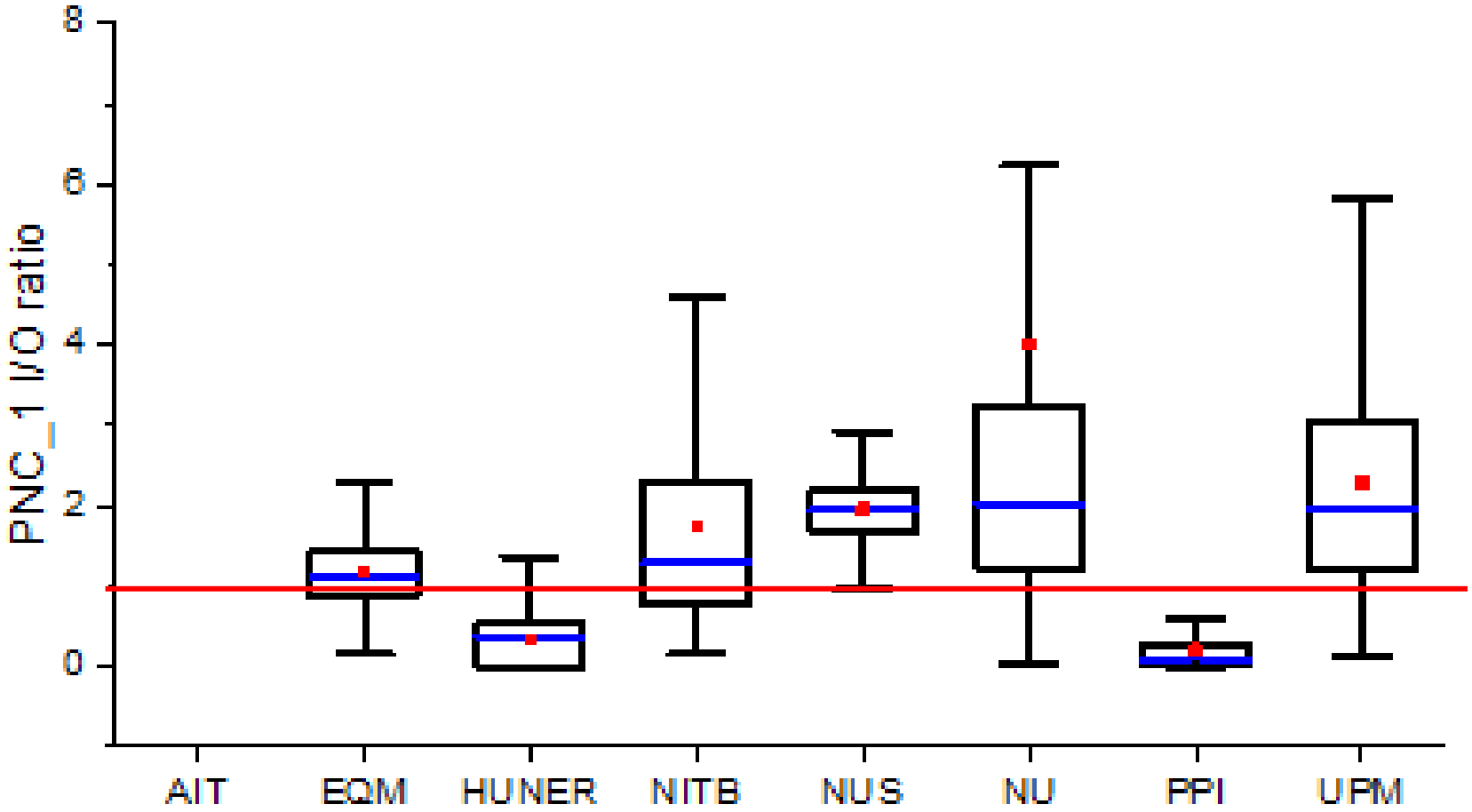


Northumbria University NEWCASTLE

PARTICLES PLUS

I/O PNC 1 µm

PNC 1 µm Indoor and Outdoor Ratios

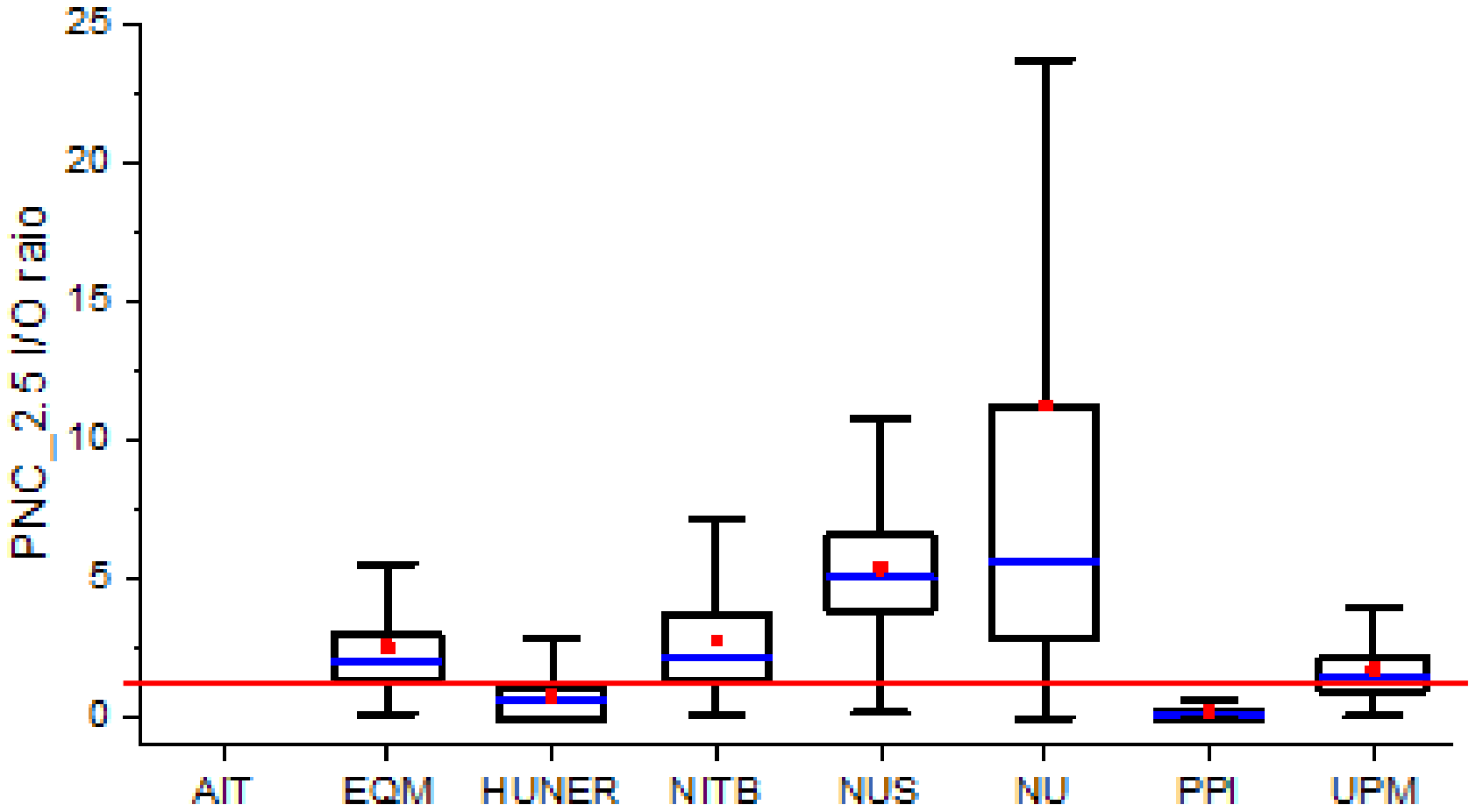


Northumbria University NEWCASTLE

PARTICLES PLUS

I/O PNC 2.5 µm

PNC 2.5 µm Indoor and Outdoor Ratios

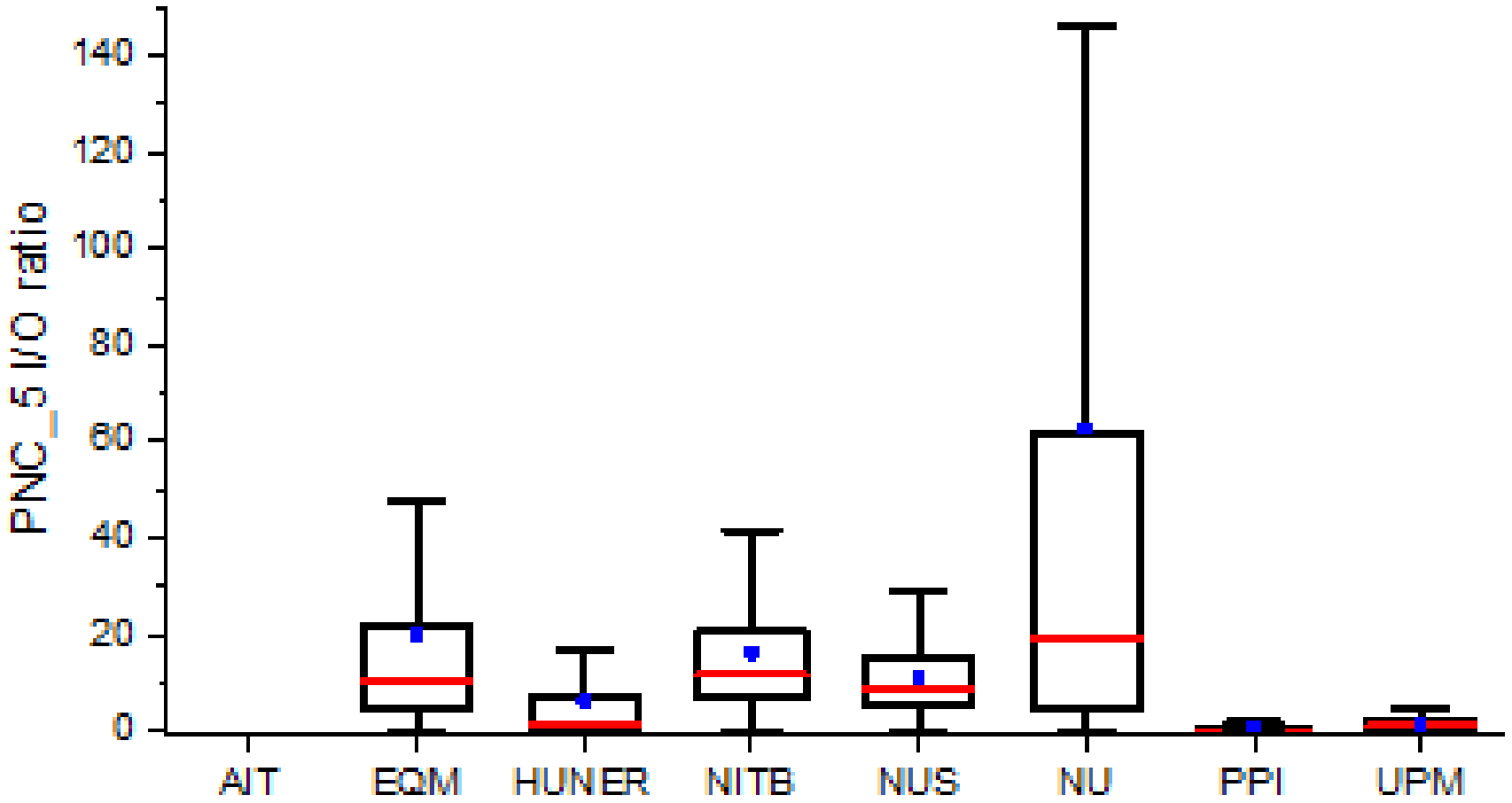


Northumbria University NEWCASTLE

PARTICLES PLUS

I/O PNC 5 µm

PNC 5 µm Indoor and Outdoor Ratios

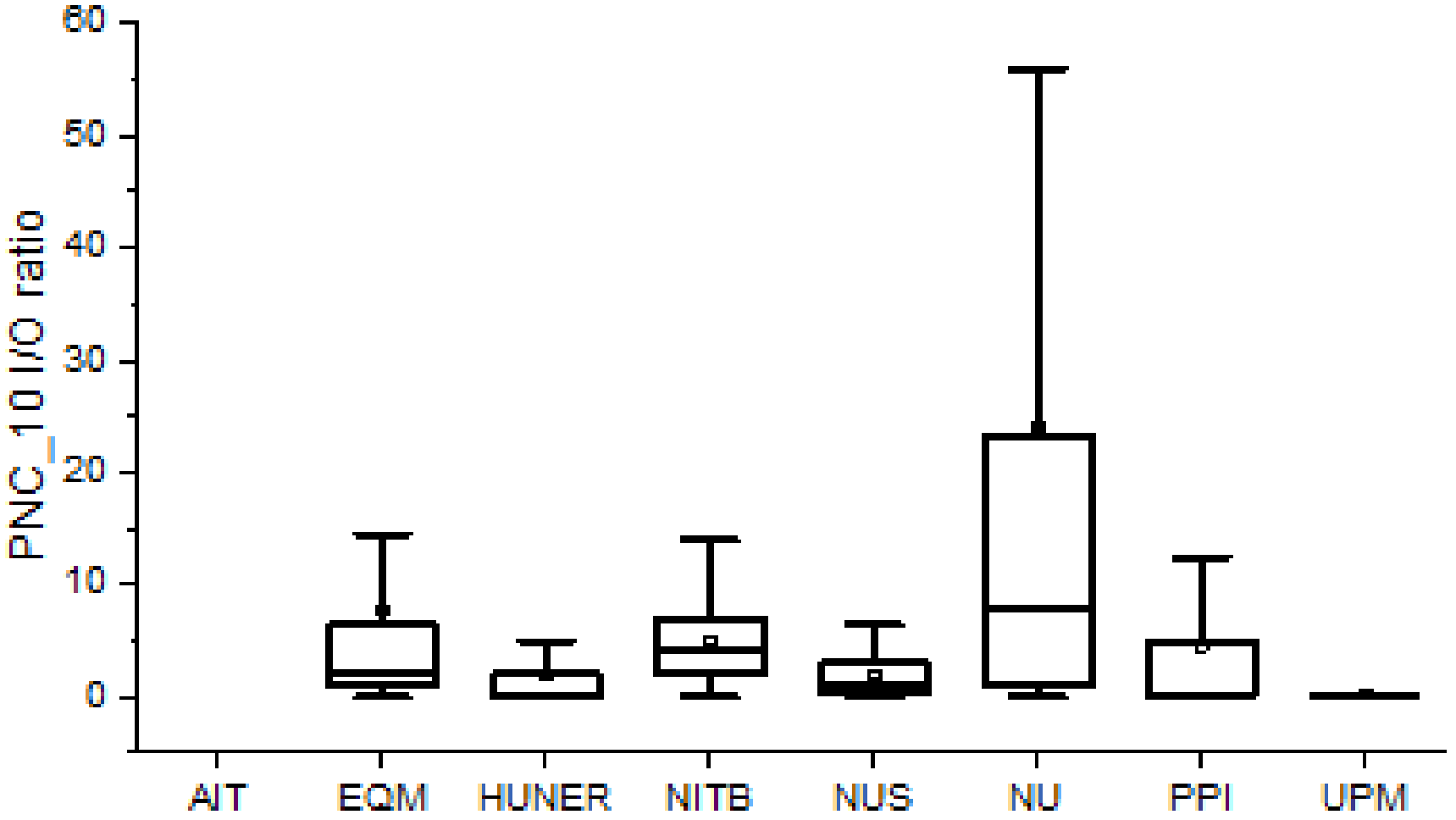


Northumbria University NEWCASTLE

PARTICLES PLUS

I/O PNC 10 µm

PNC 10 µm Indoor and Outdoor Ratios



Key Messages 1 of 2

- $PM_{2.5}$ – Population weighted annual average concentrations are higher in Southeast Asian (SEA) countries
- $PM_{2.5}$ related disease burden (rate) is higher in Southeast Asian countries
- Indonesia, Myanmar, Malaysia, Thailand and Vietnam – upward trajectory in terms of $PM_{2.5}$ levels and disease burden
- Monitored $PM_{2.5}$ in capital cities of Indonesia, Myanmar, Malaysia, Thailand and Vietnam is higher than the country average
- Indoor/outdoor ratios of $PM_{2.5}$ (mass concentrations) are higher than 1 in Bandung, Singapore, Kuala Lumpur and Yangon (except Hanoi) indicating resuspension or generation of indoor $PM_{2.5}$

Key Messages 2 of 2

- In Hanoi (Vietnam) – I/O ratios for 0.3, 0.5, 1.0 and 2.5 µm particles are lower than 1 indicating significant generation of outdoor larger particles
- In other SEA cities I/O ratios for 0.3 and 0.5 µm particles are close to 1 indicating good mixing of ultrafine particles indoors and outdoors
- In all SEA cities (except Hanoi) I/O ratios for 5 µm particles are between 5 to 20 indicating significant generation and/or resuspension of larger particles indoors
- This indicates the importance of counting particles to identify indoor and outdoor sources
- Mitigation plans can be developed for each site with further analysis of the meta data (collected for this study but not shown here)

Thank You

Questions?

Northumbria University NEWCASTLE

PARTICLES PLUS

anil.namdeo@northumbria.ac.uk