Indoor And Outdoor Relationships Of Size Fractionated Particulate Matters In Urban Residential Houses In Vietnam And Deposited Dose Estimation

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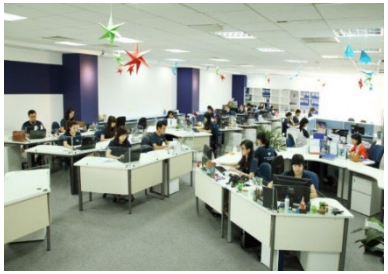
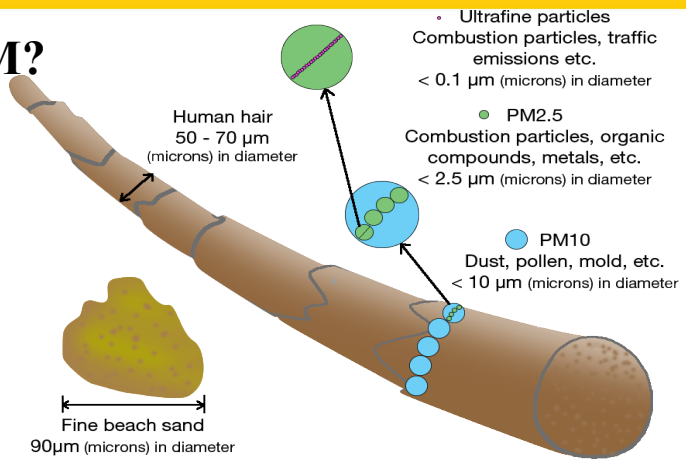
INTRODUCTION



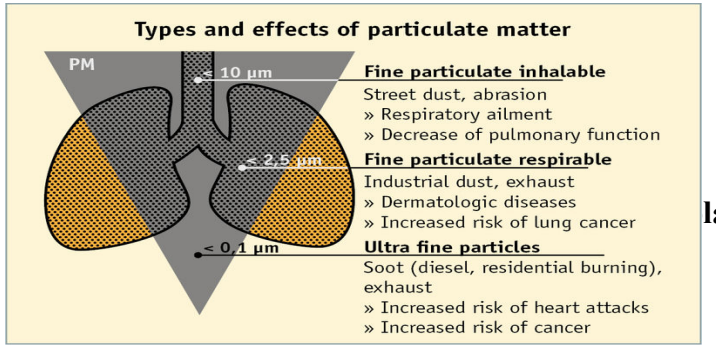
- The indoor air pollution has been a major global health concern because people spend much more time (over 90%) in enclosed sites than in outdoor areas
- A population living in the tight buildings contracted upper respiratory diseases was at rates 46 to 50 % higher than group living in better ventilated houses.
- Particulate matter was the fifth-ranking mortality risk factor in 2016 and has been known as leading cause of global burden of disease
- Household air pollution was ranked as the 10th greatest risk factor for mortality in 2019 and responsible for 2.7% of global burden of disease (GBD, 2020), which caused about 4 million premature deaths (approximately 7.7% of the global mortality)
- In 2019: $PM_{2.5}$ exposure in 56,808 deaths in VN (9.9% of natural deaths); In 2009, more than 3000 extra deaths by related PM_{10} in VN

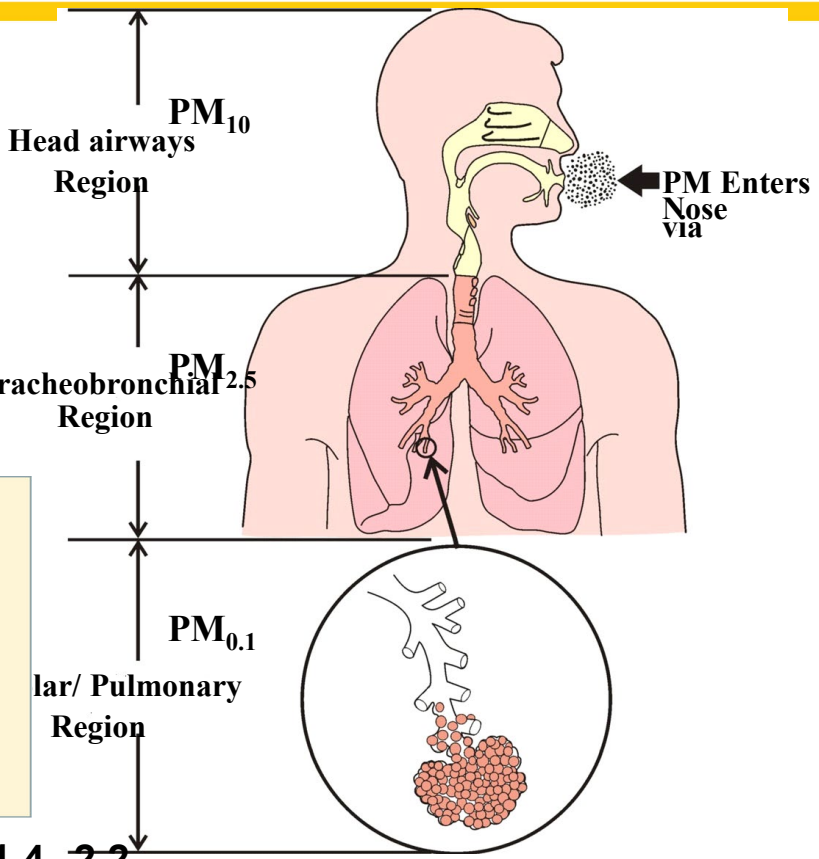
INTRODUCTION

1. What is PM?



Source: DUH





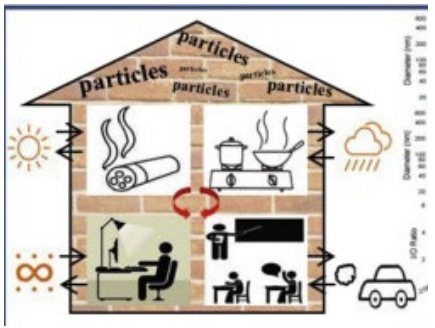
Cheng, Y.S., 2014

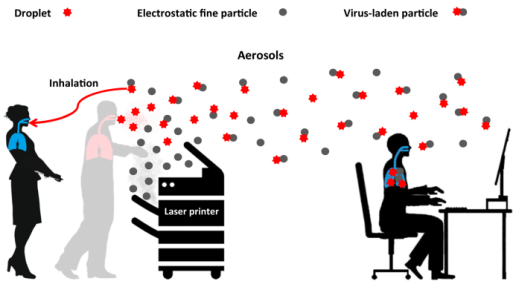
- **Hanoi: 10 µg/m³ increase in PM_{10}, $PM_{2.5}$ and $PM_{1:}$ 1.4, 2.2 and 2.5% for 5 year children for Hospital admission**

INTRODUCTION

2. PM source

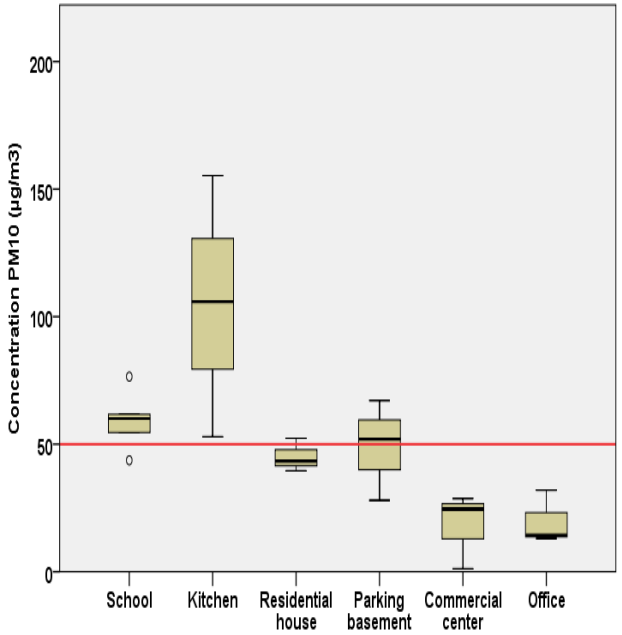
- **Outdoor environment** that has infiltrated into the indoor environment
- **Indoor actives**
  - Cooking, smoking, burning of coal, candles and incenses
  - Painting, domestic compliances (fax, printer, photocopy), construction materials, cleaning …
  - Moving

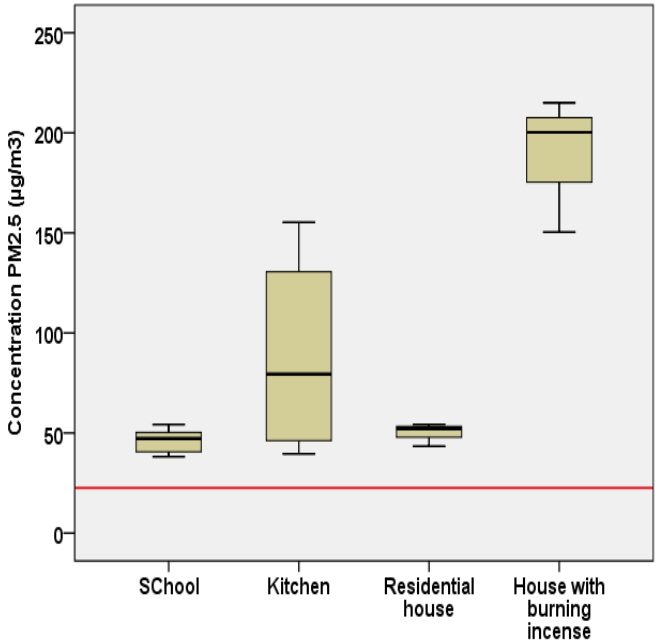


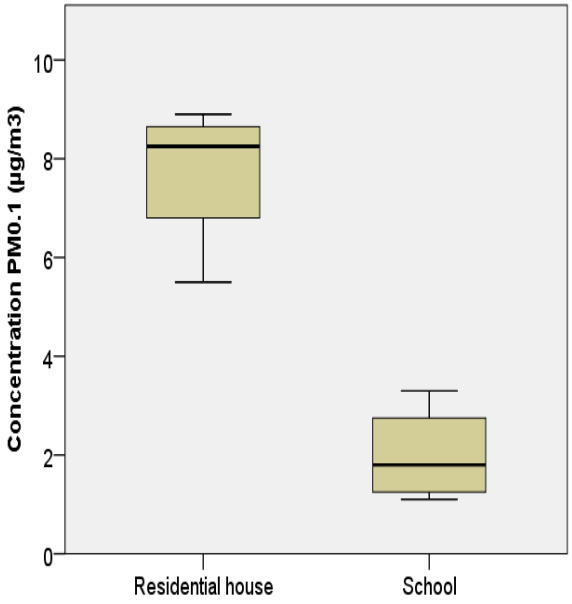


CHAPTER 3: INDOOR POLLUTANTS IN URBAN ENVIRONMENT IN VIETNAM

Current Indoor PM pollution status





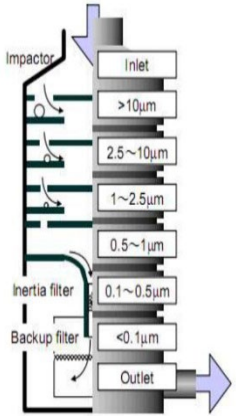


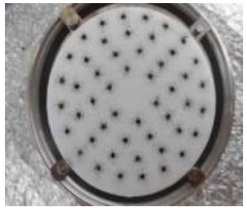
1. Sampling strategy

- Winter and Summer
- (2 weeks/sites)
- Principles: Gravity method

1320 samples

- Flow rate: 40 L/min
- Paper: Quartz, D= 55mm.
- Height: 1.5m
- Duration: 24h
- In/Out
- $PM_{0.1}$; $PM_{0.1-0.5}$, $PM_{0.5-1}$, $PM_{1-2.5}$; $PM_{2.5-10}$, $PM_{>10}$





2. Indoor-outdoor relationship

1. Ratio of I/O

$$I/O = \frac{Cin}{Cout}$$

I/O≥1.2 or I/O ≤0.8, the possible indoor or outdoor sources was dominant, 0.8<I/O<1.2: Equivalence between indoor and outdoor sources

2. Infiltration factor

$$C_{in} = F_{INF} \cdot C_{out} + Cig$$

C_{in}, C_{out}: Indoor and Outdoor PM concentration

C_{ig} : PM indoor generated in indoor source

F_{INF} : infiltration factor

3. Input for HIA US.EPA (2011)

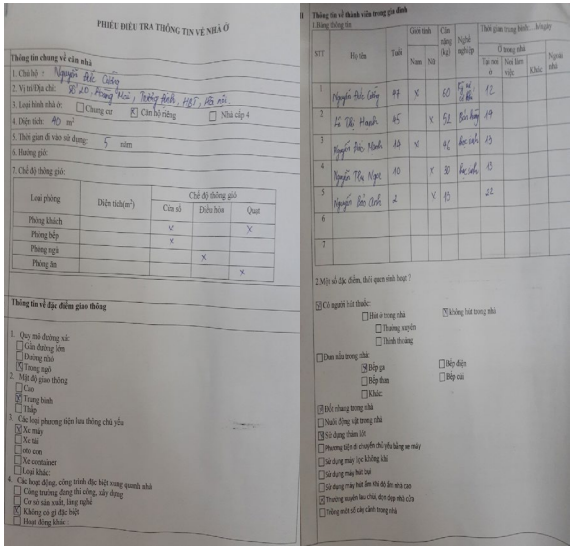
Age categories	0-1y	1-3y	3-6y	6-11y	11-<21	21- <60	>60y

Parameter	Resources
IR_A	US.EPA 2011
AT	US.EPA 2011
C(pollutants)	Sampling
ET	Questionnaire
ED	Questionnaire
EF	Questionnaire
BW	Questionnaire

MPPD model to estimate deposition fraction

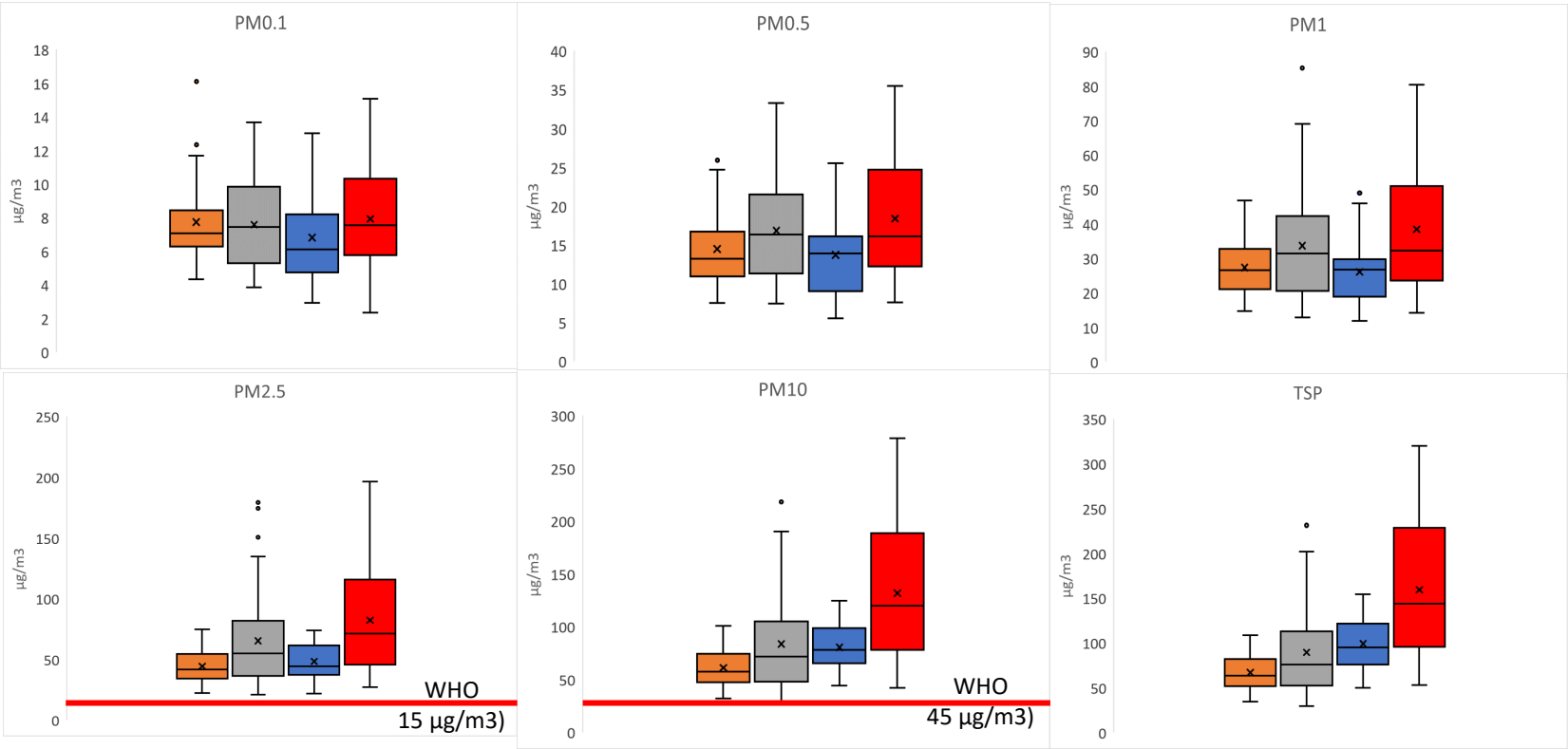
300 offline + 200 online questionnaires

Parameter	Resources
PM characteristics	Sampling
Respiratory physiological parameters (TV, BF, FRC and exposed subject characteristics)	(ICRP, 1994),
Activity pattern	Questionnaires



RESULTS AND DISCUSSION

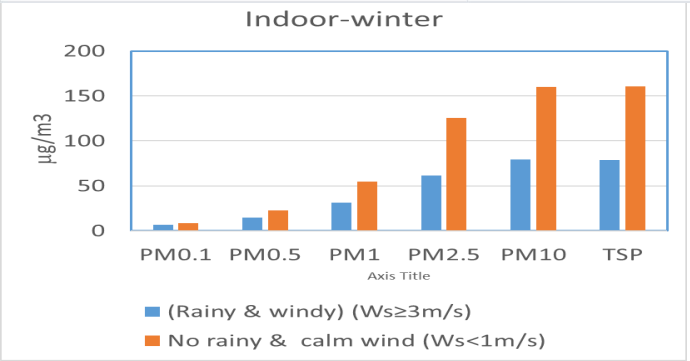
Mass concentrations of indoor and outdoor PM at different fractions

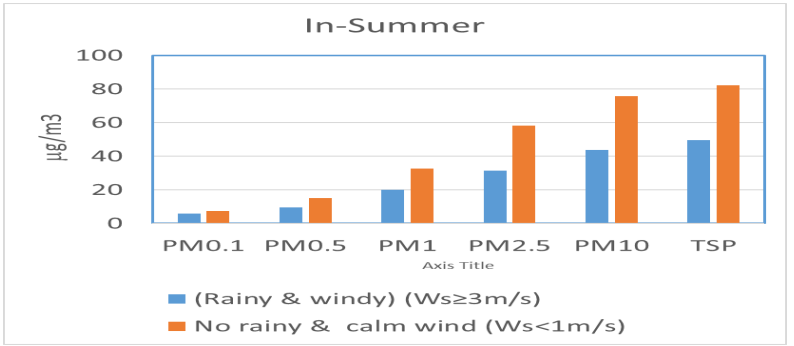


Chapter 4
Results and discussions

Intercorrelation between PM and meteorological parameters

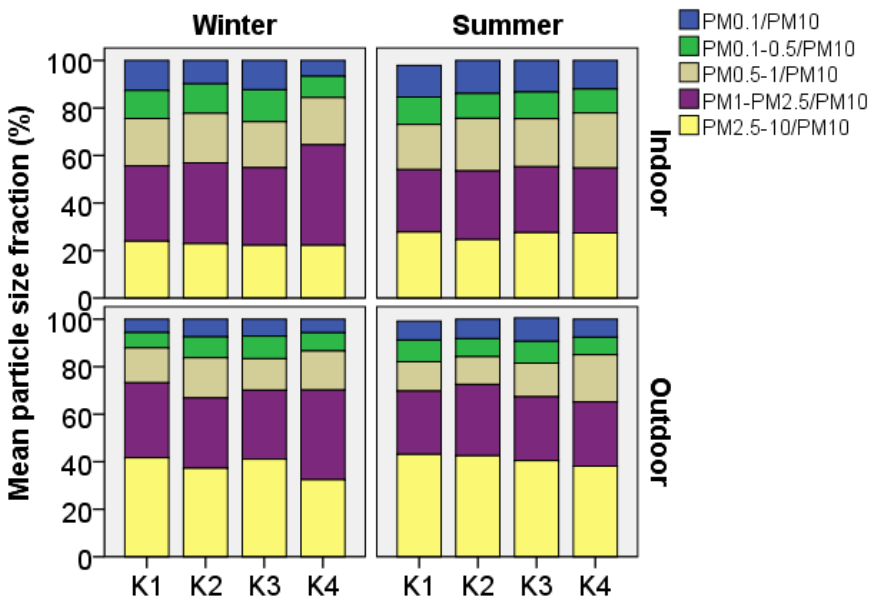
	Indoor				Outdoor			
	Pr	RH	T	Ws	Pr	RH	T	Ws
$PM_{0.1}$	-0.1	-0.1	0.1	-0.2	-0.1	0.1	-0.2	-0.3**
$PM_{0.5}$	-0.2	0.1	-0.2	-0.4**	-0.2	0.2	-0.3*	-0.4**
PM_{1}	-0.1	0.1	-0.2*	-0.4**	-0.1	0.3*	-0.4*	-0.5**
$PM_{2.5}$	-0.1	0.2*	-0.3**	-0.4**	-0.2	0.3*	-0.4*	-0.5**
PM_{10}	-0.2	0.2	-0.2*	-0.4**	-0.2	0.4*	-0.4*	-0.5**
TSP	-0.2	0.2	-0.2*	-0.4**	-0.2	0.4*	-0.4*	-0.6**

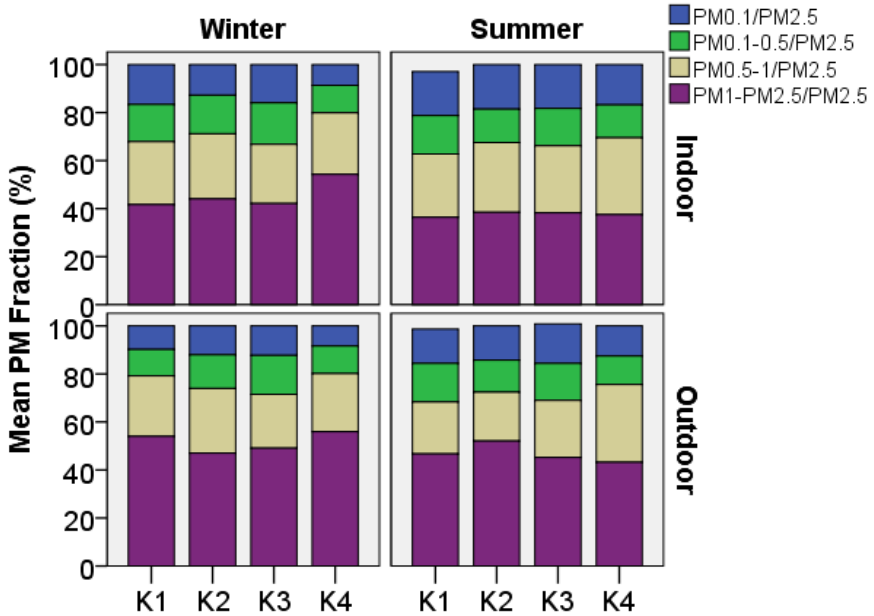




*: 0. 05 level
**: 0.01 level

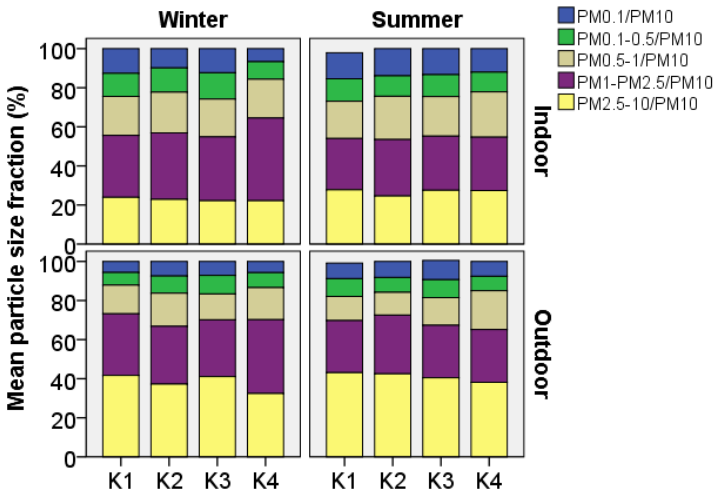
Particle Mass-Size Distribution

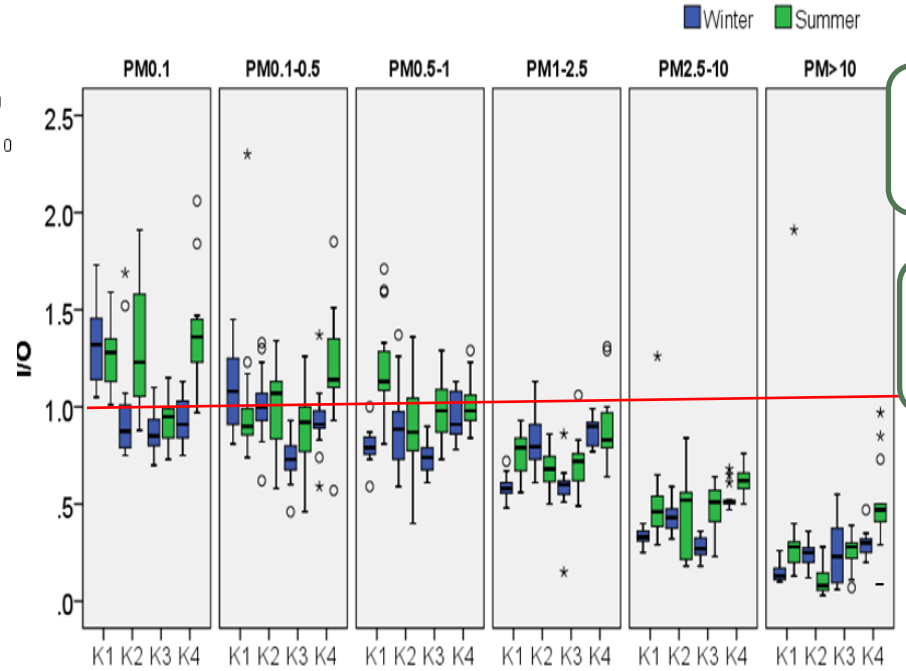




- The contribution proportions of PM fractions were relatively similar in two seasons
- $PM_{0.5\text{-}1}$ and $PM_{1\text{-}2.5}$ contributed larger proportions to $PM_{2.5}$ and PM_{10} than $PM_{0.1}$
- Indoor $PM_{0.1}/PM_{2.5}$ and $PM_{0.1}/PM_{10}$ > outdoor ratios; indoor $PM_{2.5\text{-}10}/PM_{10}$ < outdoor ratio

Indoor and outdoor ratios (I/O)





$PM_{0.1}$ I/O≥1: influence of indoor sources

$PM_{2.5-10}$ and $PM_{>10}$: I/O <1 influence of outdoor sources

- $PM_{0.1}$ contributed lower proportions than other fractions to PM_{10}
- Indoor $PM_{0.1}/PM_{2.5}$ and $PM_{0.1}/PM_{10}$ > outdoor ratios; indoor $PM_{2.5-10}/PM_{10}$ < outdoor ratio

Infiltration factors and indoor generated PM

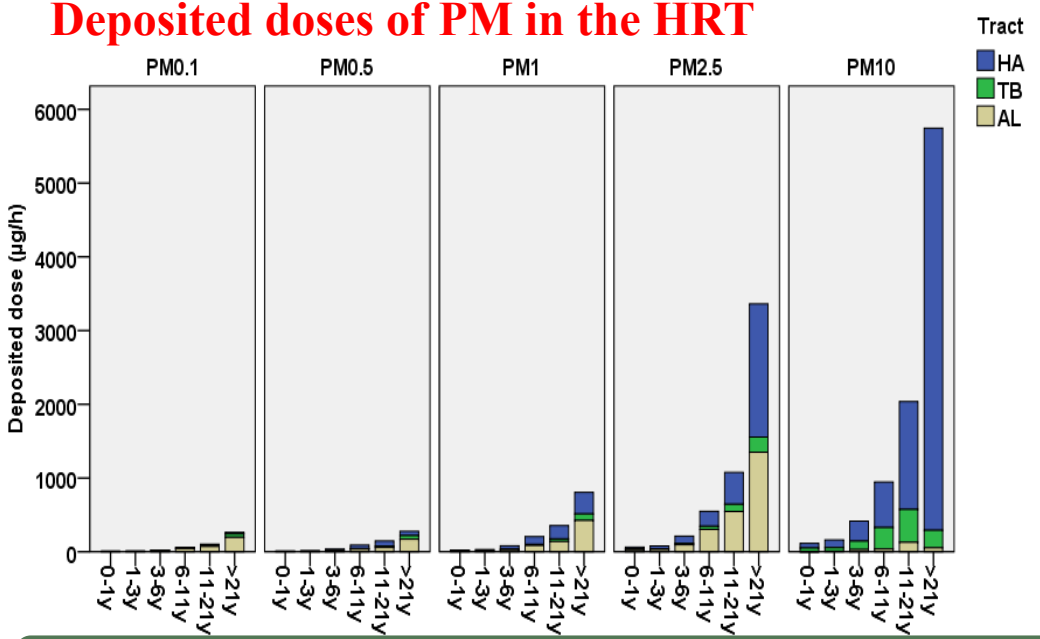
	F_{inf}	R^2	Cig/Cin (%)
$PM_{0.1}$	0.8 (0.5-1.1)	0.7-0.9	33.5 (16.1-63.3)
$PM_{0.1-0.5}$	0.8 (0.4-1.1)	0.7-0.9	20.4 (5.1-63)
$PM_{0.5-1}$	0.8 (0.6-1)	0.8-0.9	22.7 (5.8-48.7)
$PM_{1-2.5}$	0.7 (0.6-0.9)	0.7-0.9	20.7 (3.9-32.1)
$PM_{2.5-10}$	0.3 (0.2-0.5)	0.8-0.95	15 (8.8-18.8)

1- F_{inf}: fraction of outdoor particles that penetrates indoors
2- Cig/Cn (%): % indoor PM generated from indoor sources

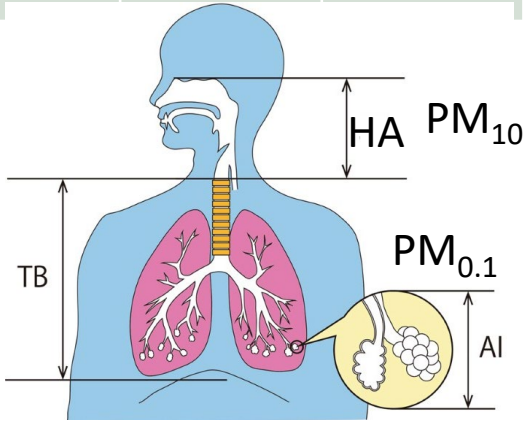
Easier to penetrate smaller sizes than bigger sizes

Majority indoor PM derived from outdoor sources

Deposited doses of PM in the HRT



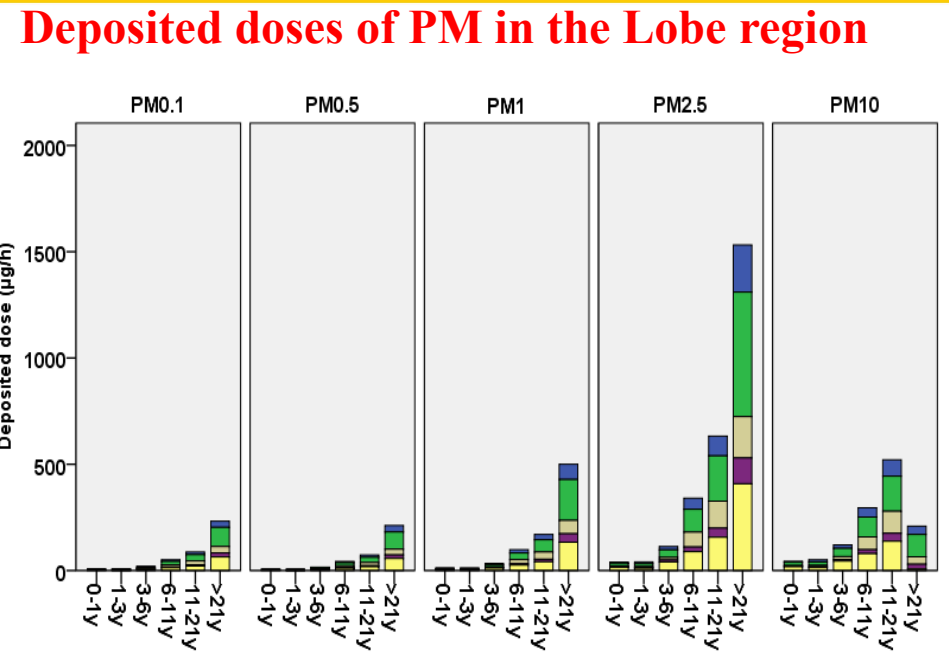
	HA (%)	TB (%)	AL (%)
$PM_{0.1}$	8.3-25.5	13.3-23.4	66.9 - 84
$PM_{0.5}$	21.5 - 56.9	8.6 - 12.2	33 - 61.1
PM_{1}	36.1 - 59.5	7.1 - 11.1	31.3 - 52.7
$PM_{2.5}$	35.7 - 53.7	6.1 - 18.7	40.1 - 45.5
PM_{10}	55 - 94.9	4.2 - 44.3	0.6 - 8.4

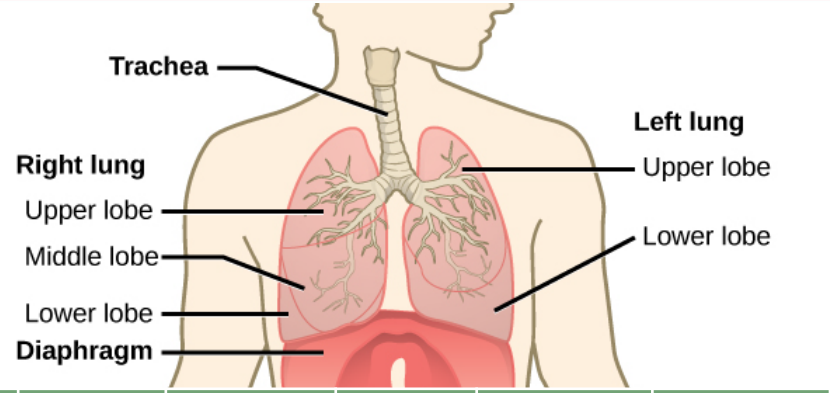


The highest PM_{10} in HA; Majority of $PM_{0.1}$ was deposited in AL

Manojkumar et al.(2019): PM_{10} HA (73%) and TB (23%) AL region (4%); $PM_{2.5}$ HA (45%); TB (9%); and AL (45%); PM_{1} HA (50%); TB (9%); and 40% in AL

Deposited doses of PM in the Lobe region





	LU (%)	LL (%)	RU (%)	RM (%)	RL (%)
$PM_{0.1}$	8.9- 21.9	25.6-30.5	7.5-17.4	5.4- 7.2	21.2 -35.5
$PM_{0.5}$	5.5 - 10.9	13.9 - 29	4.8 - 10	2.1 - 6	11.7 - 20.4
PM_{1}	5 - 9	13 -23.8	3.9 - 9.8	2 - 4.9	10.9-18.6
$PM_{2.5}$	6.1 - 11.6	16.9 - 26.7	5.2 - 15.8	2.7 - 5.4	14.2- 25.4
PM_{10}	0.7 - 6.2	1.8 -13.8	0.6-6.8	0.4 -2.5	0.1 - 10.7

$PM_{0.1}$: Highest in Lobes, PM_{10}: Lowest

% EDIs: Lower lobe > Upper lobe> Right middle lobe

Chapter 4
Conclusions

1

- ✓ High concentrations of $PM_{0.1,}$ $PM_{0.5}$, PM_1, $PM_{2.5}$ and PM_{10} are found in both seasons
- ✓ $PM_{2.5}$ and PM_{10} exceed WHO recommended values.

2

- ✓ Smaller size has better infiltration than bigger sizer
- ✓ NP influenced by indoor sources
- ✓ Coarse particles strongly influenced by outdoor sources

3

EDI distribution

- ✓ PM_{10} highest in HA; $PM_{0.1}$ highest in AL
- ✓ $PM_{0.1}$: highest in Lobes, PM_{10}: Lowest
- ✓ Lower lobe > Upper lobe> Right middle lobe for all particle sizes

Thank you for your attention