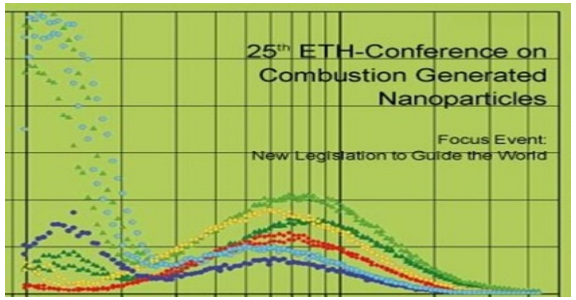

Health Risk Assessment of Particulate matters, PAHs and Heavy Metals on Children & Women in North Indian Indoor Air - An Interim Analysis

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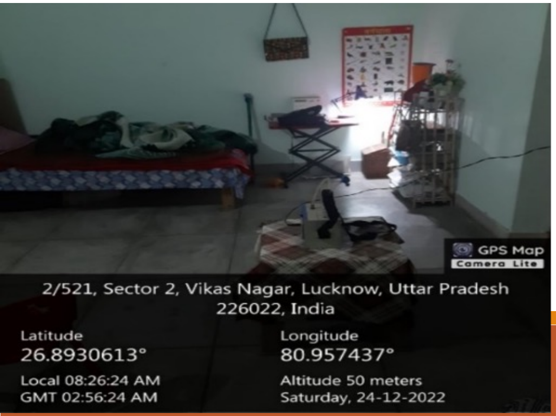
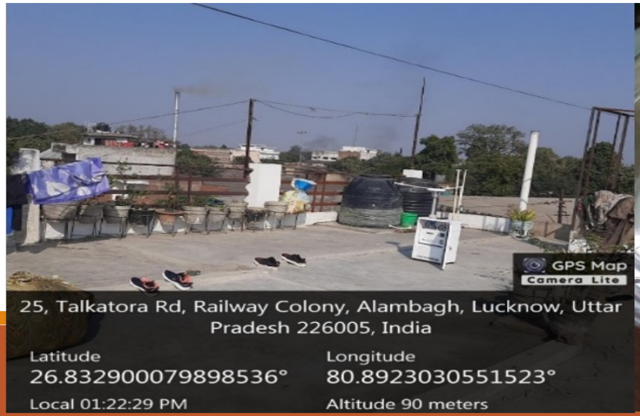
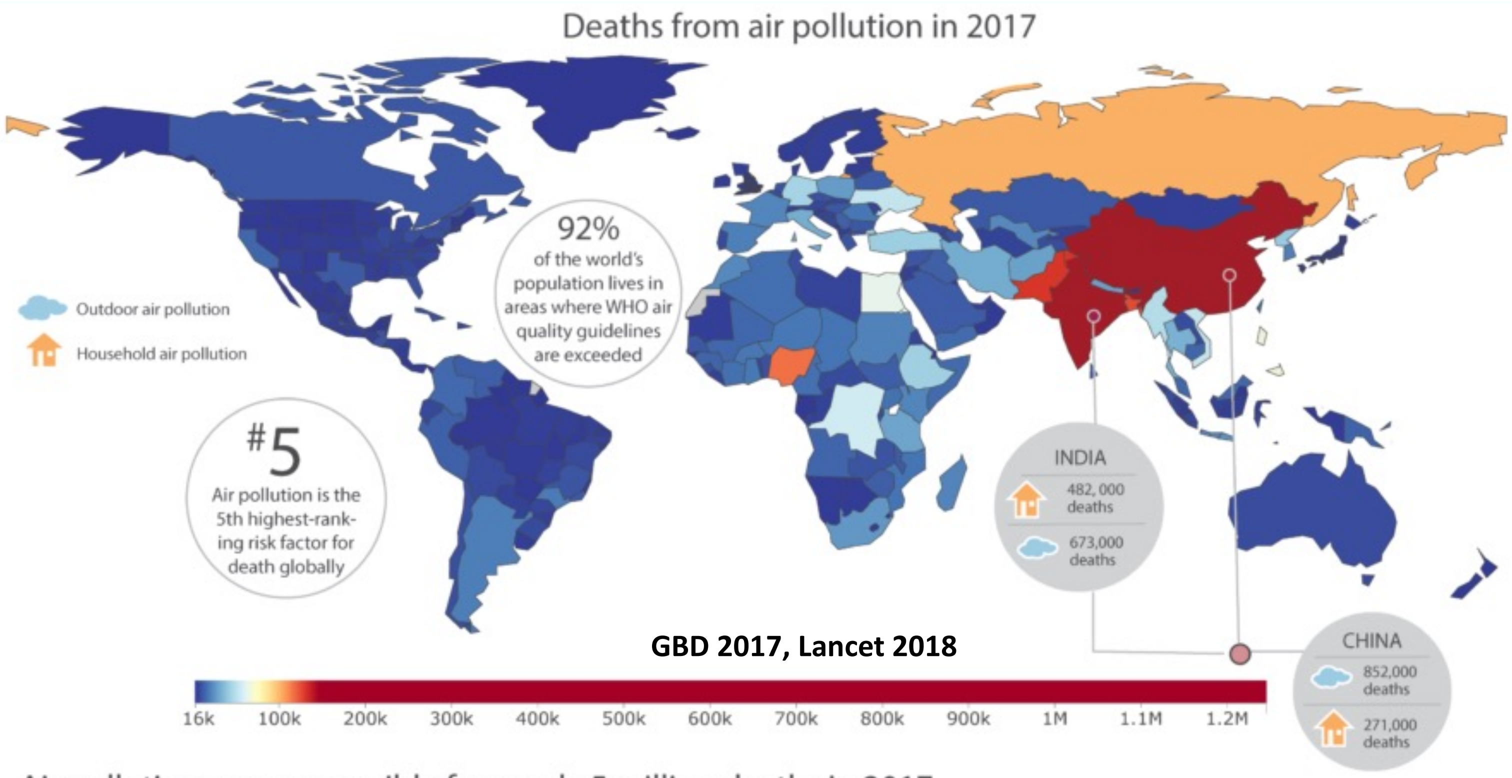
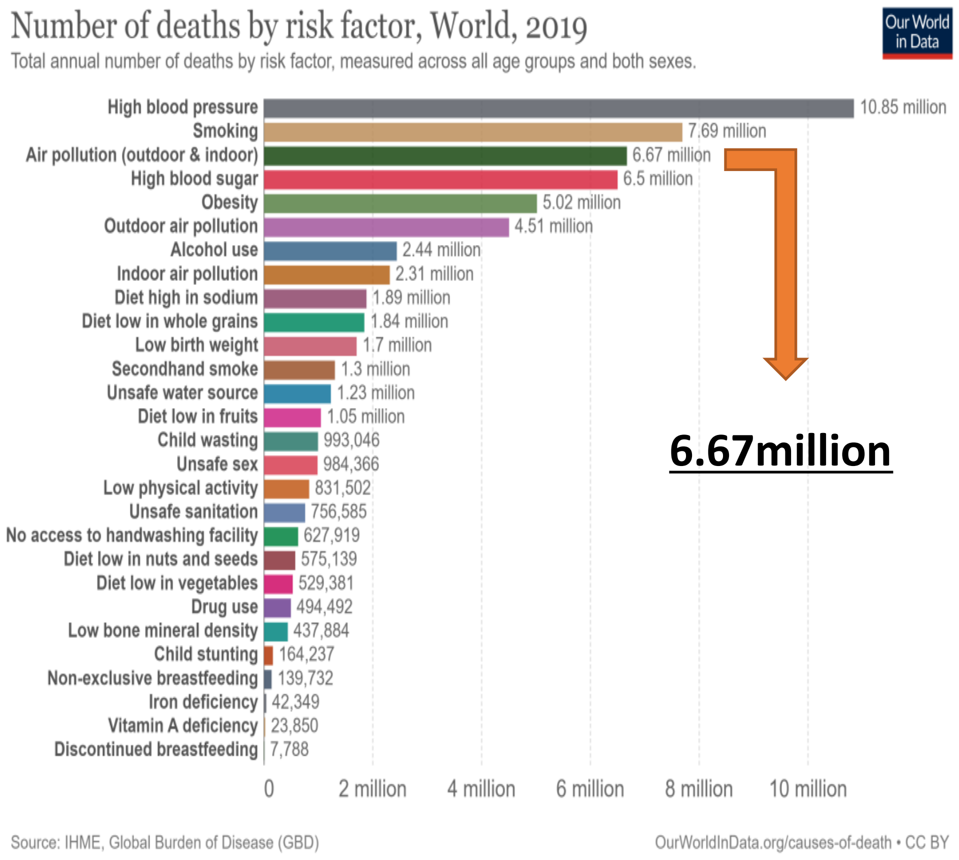
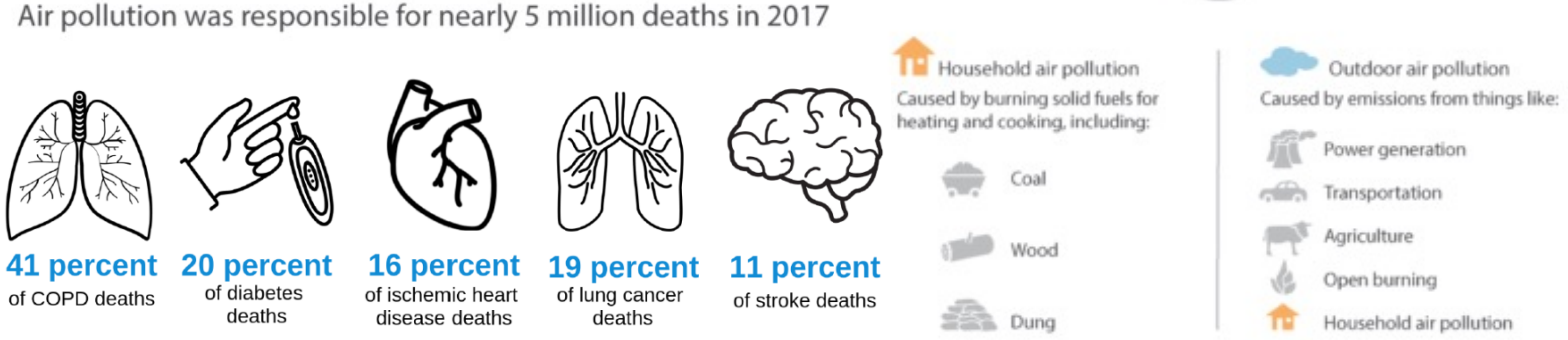


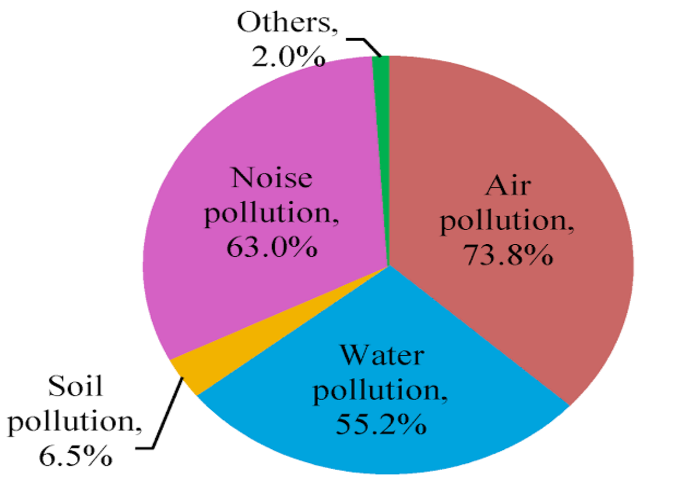


GLOBAL BURDEN OF AIR POLLUTION



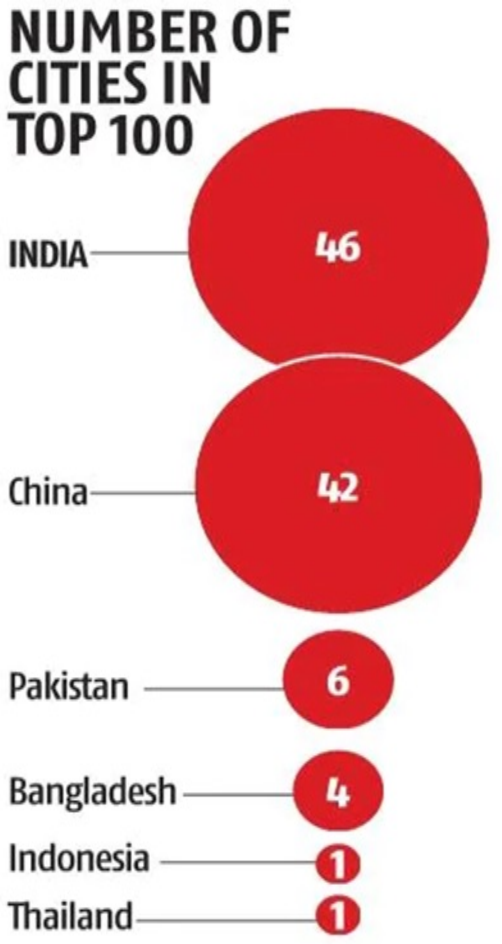






Department of Chemistry, Isabella Thoburn College.

RISK FACTORS OF MORTALITY/ DISABILITY: INDIA



Source: The 2020 World Air Quality Report

MOST POLLUTED CITIES 2020

The most polluted cities, according to the data aggregated from over 80K data points

1	Hotan (China)	110.2
2	Ghaziabad	(India)
3	Bulandshahr	(India)
4	Bisrakh Jalalpur	(India)
5	Bhiwadi	(India)
6	Noida	(India)
7	Greater Noida	(India)
8	Kanpur	(India)
9	Lucknow	(India)
10	Delhi	(India)

(PM 2.5 MICROGRAM/M³)
With inputs from *Al Jazeera*

Air pollution (ambient AND household) is 3rd leading risk factor in India!!!

'Air pollution cuts lives short by 5 yrs in India'

Country 2nd Most Polluted After B'desh: AQLI Analysis

Vishwa.Mohan
@timesgroup.com

File photo/PTI

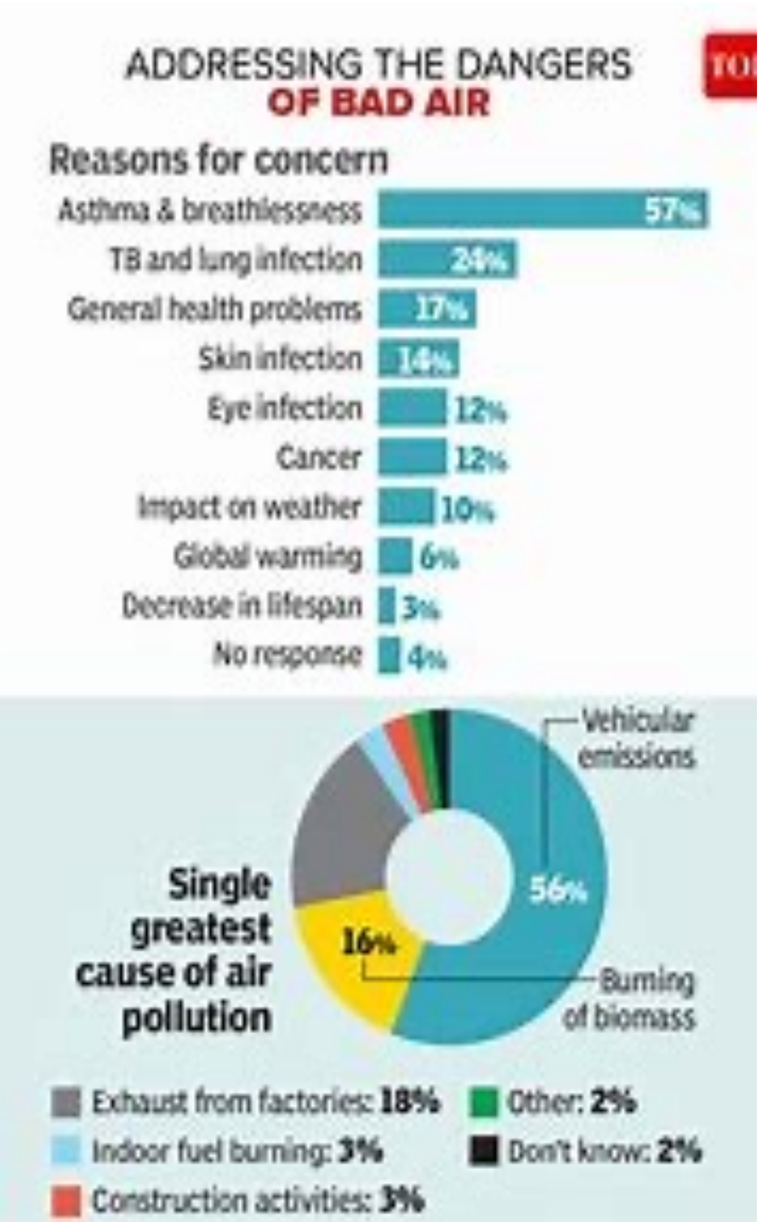
In the case of Delhi, the world's most polluted capital, people would lose 10 years of their lives in a business-as-usual scenario

New Delhi: Air pollution shortens average life expectancy in India, the second most polluted country in the world after Bangladesh, by five years, relative to what it would be if the new stringent WHO guidelines were met, according to a new Air Quality Life Index (AQLI) analysis released on Tuesday. In fact, pollution would cut 7.6 years of life expectancy of 40% of Indians who live in the Indo-Gangetic plains, says the the report released by the Energy Policy Institute at the University of Chicago (EPIC).

While most of the world breathes unsafe air shaving off two years off global life expectancy, the report noted air pollution is the greatest threat to human health in India, reducing life expectancy by five years whereas child and maternal malnutrition reduces it by about 1.8 years and smoking reduces by an average 1.5 years.

▶Continued on P 22

Indoor Environment



INDOOR ENVIRONMENT

Schools

Homes

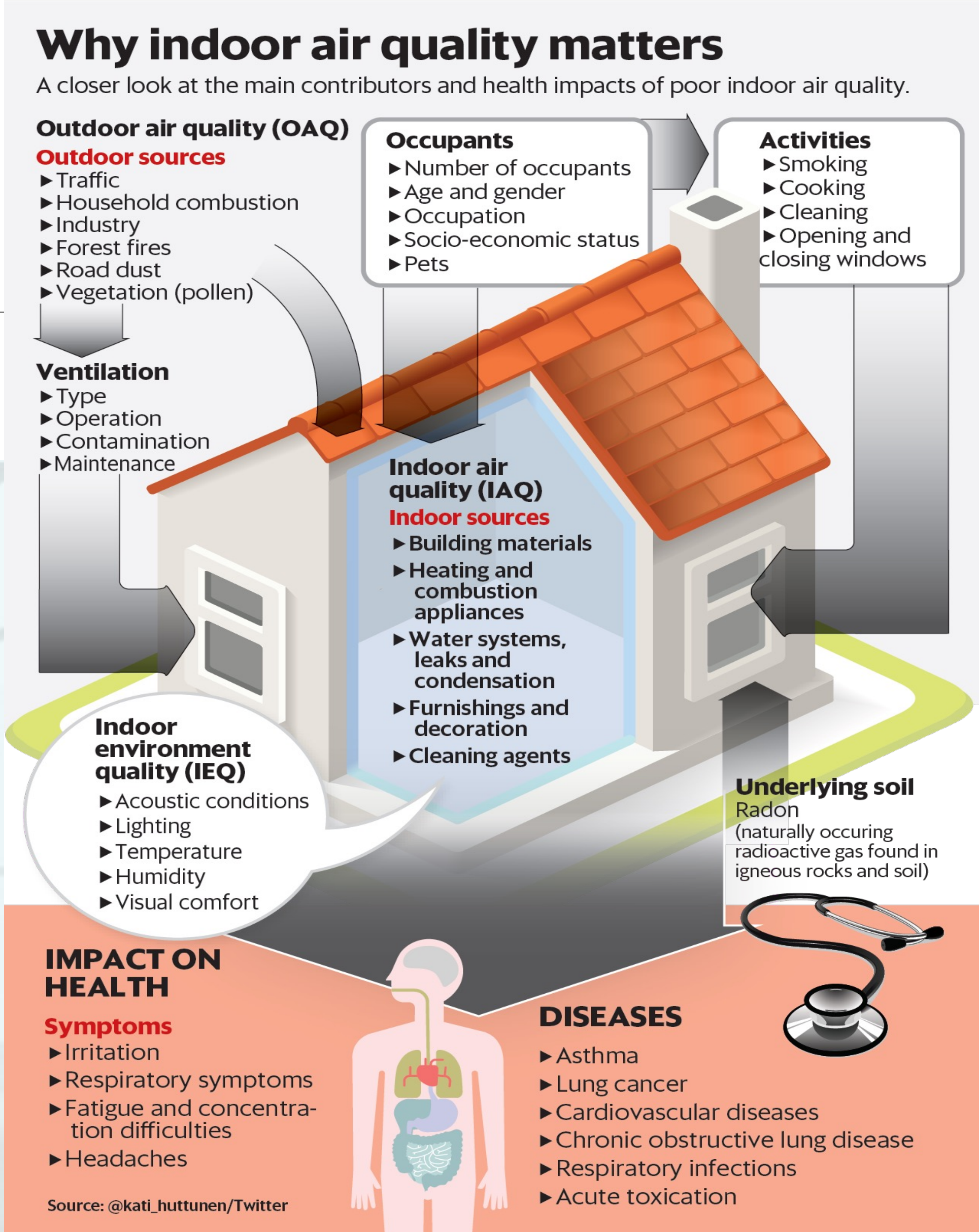
Hospitals

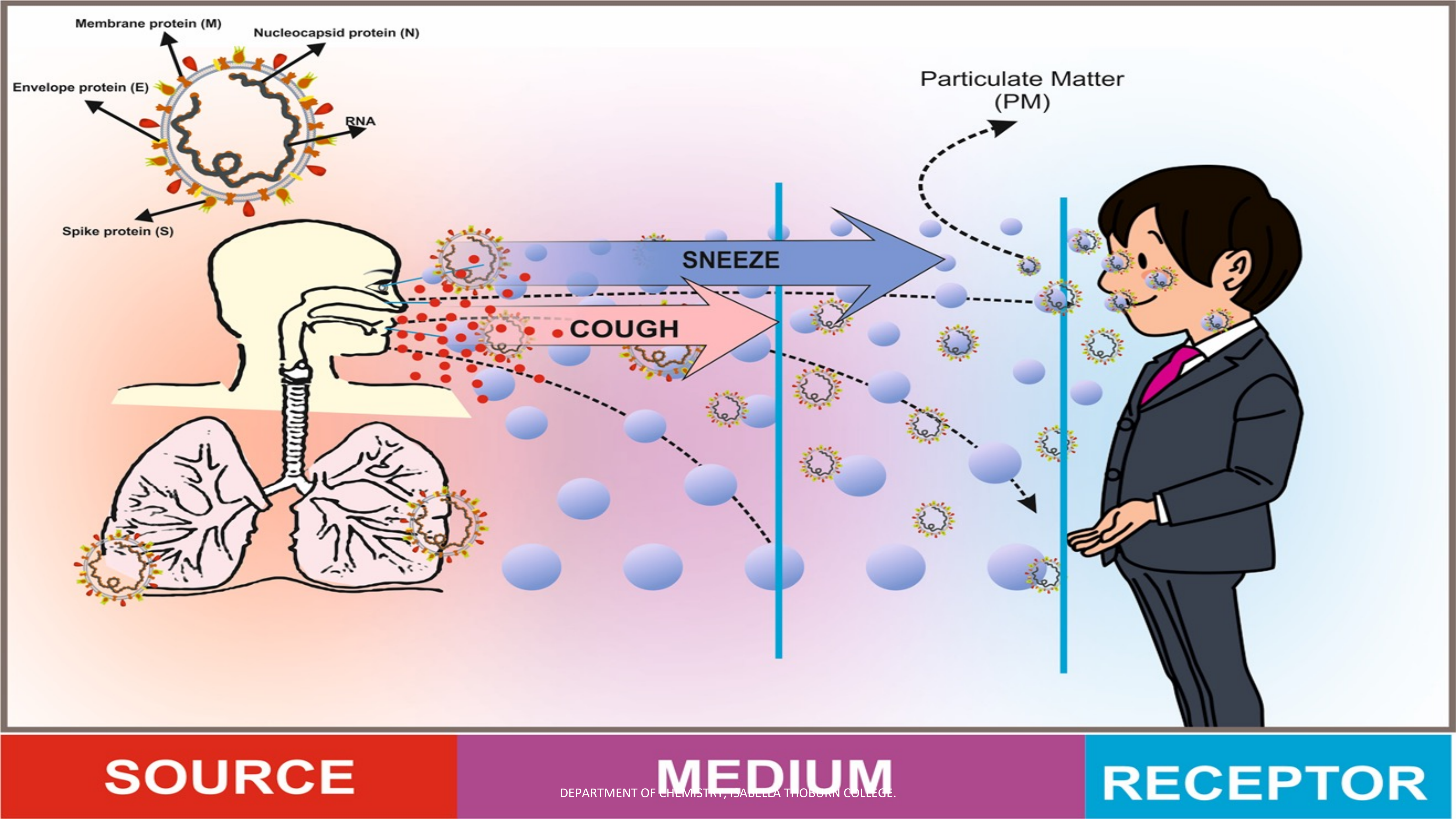
Closed public Vehicles

Workplaces

HOUSEHOLD AIR POLLUTION

According to the World Health Organization, nearly 3.1 million people die prematurely each year as a result of illnesses caused by household air pollution.




Membrane protein (M)
Nucleocapsid protein (N)
Envelope protein (E)
RNA
Spike protein (S)
Particulate Matter (PM)
SNEEZE
COUGH
SOURCE
MEDIUM
RECEPTOR

Most Vulnerable

1

CHILDREN

The lungs and respiratory system of young children remains in developing phase as a result more inhalation of air per mass. Further, their organs are more susceptible to pollutant impacts.

2

Women and Girls

The inferior status of women is entrenched from ages. Women being the home-maker in majority of Indian households are widely exposed to air pollutants.

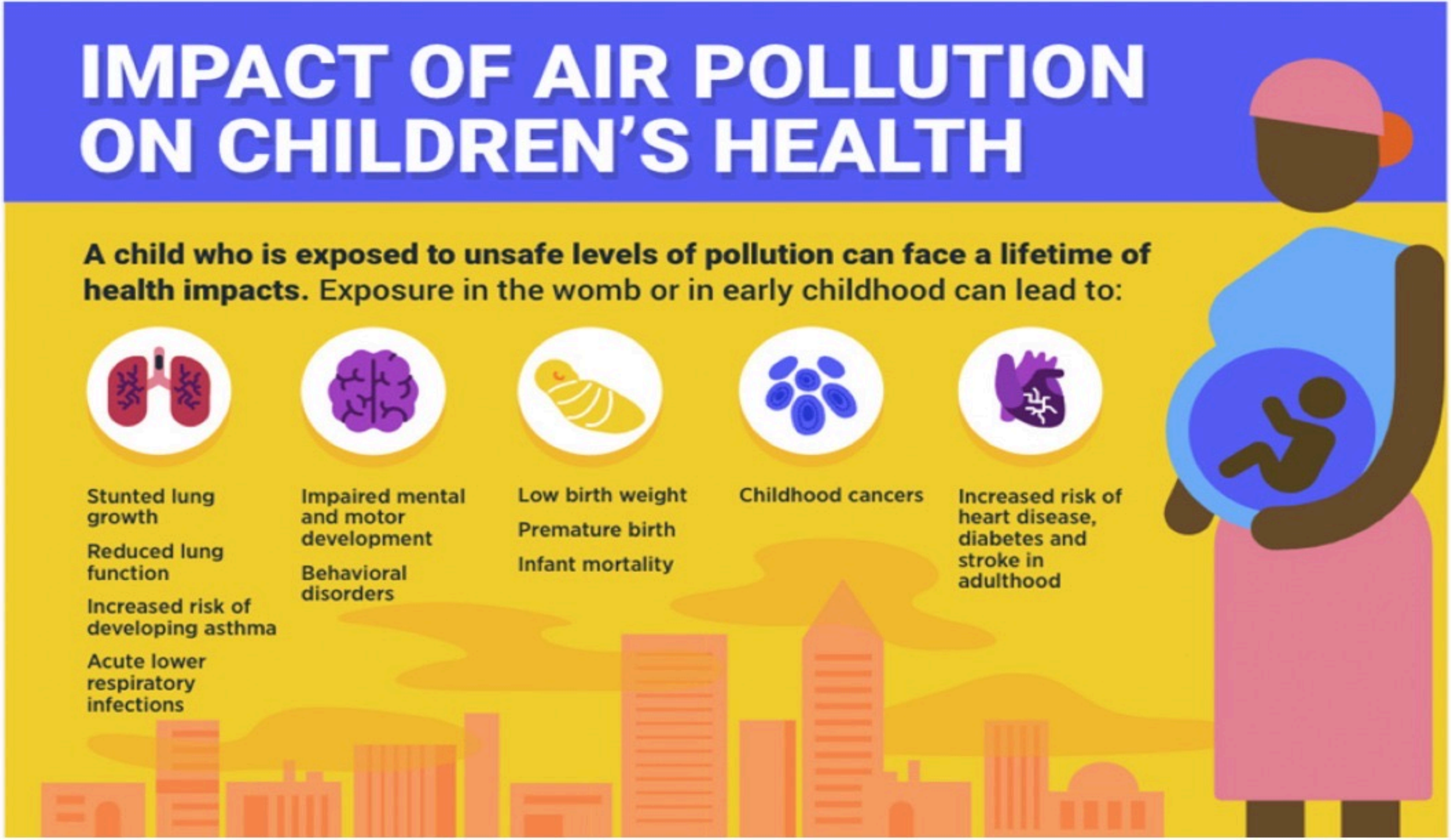
Indoor Air Pollution & Right's of unborn child

$PM_{2.5}$, Alkanes ,PAHs, CO_2, CH_4, CO , Elemental carbon ,Organic aerosaol, Ketones, Aldehydes

Emission

Women are chiefly exposed to indoor air pollutants while cooking, dusting and during other household chores

Exposure to air pollution during pregnancy can increase your risk of premature birth and low birthweight, stillbirth, or congenital abnormalities. 99% Child deaths from illnesses associated with indoor air pollution occur in low- and middle-income countries.



Because children have a longer life expectancy than adults, diseases have more time to emerge. The consequences of exposure early in life – whether via inhalation, ingestion or in utero – can lead to lifelong burdens, including increased risks of heart disease, stroke and cancer.

Objectives

- Questionnaire Survey for women and Children.
- Selection of Microenvironment.
- Monitoring in selected Microenvironments.
- Results
- Statistical Analysis for Health Risk Assessment.
- Dosimetry Modelling

QUESTIONNAIRE SURVEY

A survey was conducted among women and children of Lucknow city.

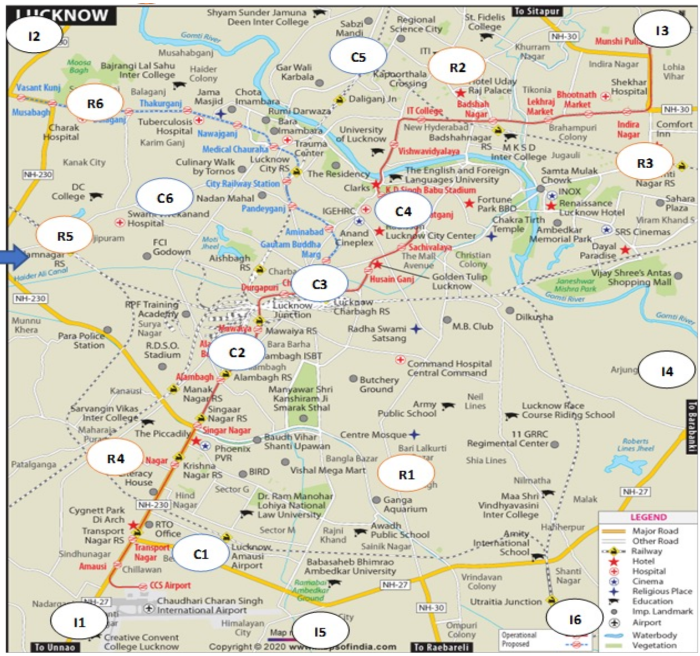
Consent was received, explaining the purpose of study from each respondent and the related query was clarified through a brochure.

Voluntary response was sought and it was clearly conveyed that the personal information will be kept confidential and used only for research purpose.

Study Location

Microenvironments

- **Residential**
- **Commercial**
- **Industrial**

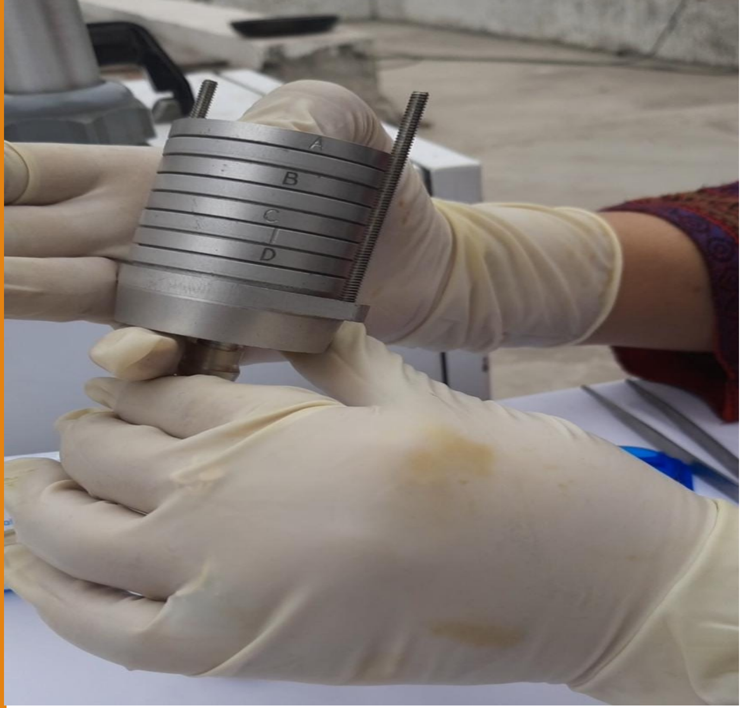


Age of Women	Health Survey Data						
	BP	B.S(mg/dl)	B.W	BMI	BMR	SMR	Water
26 year	110/61	86.0	47.8	22.9	1162	30.2	51.5
39 year	125/78	82.0	44.5	19.6	1214	30.9	53.2
51 year	128/75	87.0	62.0	24.8	1365	26.9	47.4
40 year	124/70	86.0	62.9	23.1	1371	27.6	46.8
19 year	101/66	76.0	67.6	28.5	1446	12.7	42.2
21 year	113/77	86.0	63.3	24.7	1411	29.9	46.9
56 year	101/71	80.0	69.9	33.2	1436	21.1	44.6
30 year	126/83	86.0	64.8	24.4	1440	26.6	46.0
33 year	120/72	82.0	67.6	24.2	1690	36.0	51.8
57 year	105/72	94.0	99.9	37.6	1693	24.9	41.5
43 year	125/78	82.0	86.0	33.5	1570	8.0	39.1
55 year	128/75	87.0	65.5	24.7	1394	25.8	46.4
32 year	101/71	80.0	60.6	23.7	1352	30.2	48.0
27 year	117/57	73.0	50.9	19.9	2454	33.3	49.0

Sub-micron Monitoring

Leland Legacy sample pump (SKC Cat. No. 100-3002; Inc. Eighty-Four PA USA) with five-stage Sioutas Cascade Impactor was used to collect PM in the size range of $PM_{1.0-2.5}$, $PM_{0.50-1.0}$, $PM_{0.25-0.50}$, $PM_{<0.25}$ on 25 mm PTFE filter paper and 37 mm (for $PM_{<0.25}$).

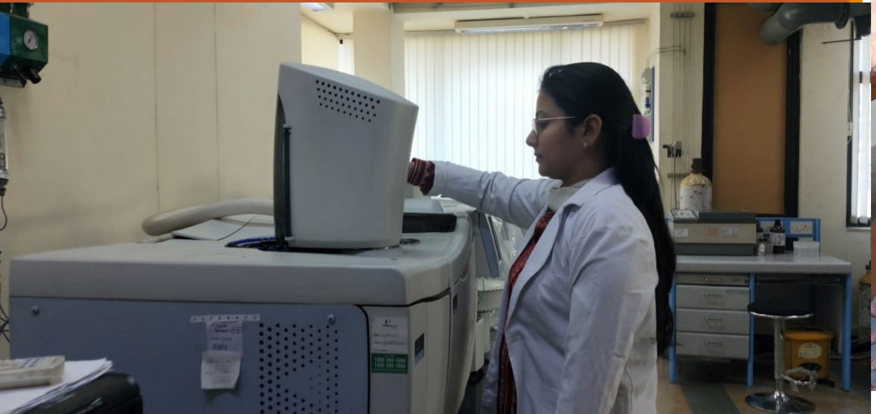
The instrument was set at air flow rate of 9 L/min for 24 h.



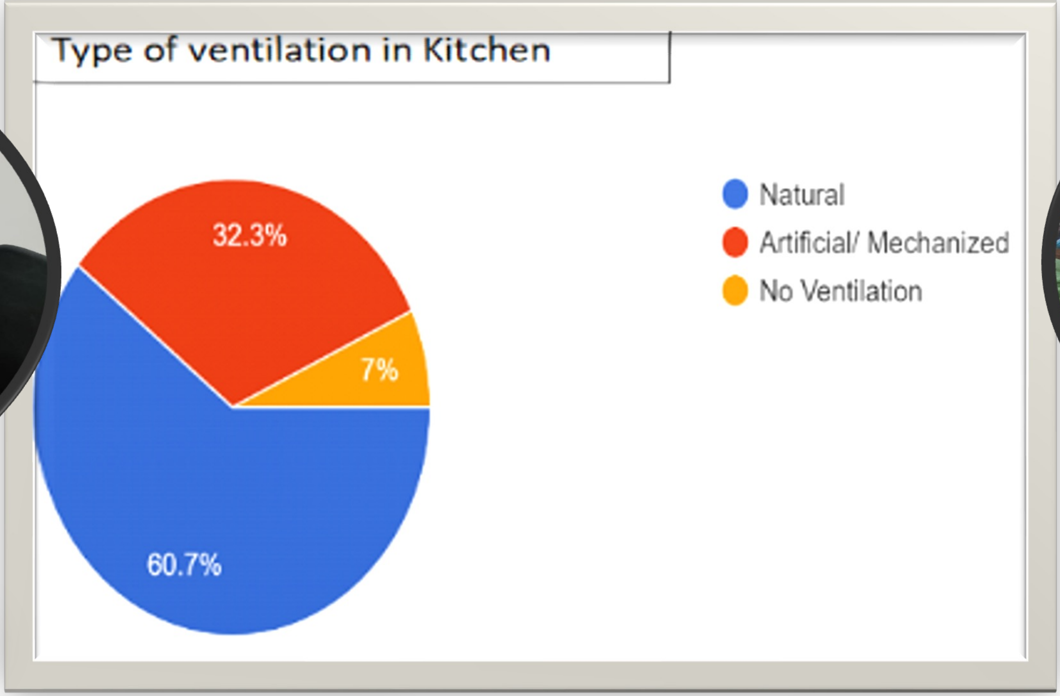
$PM_{2.5}$ sampling instrument

ENVIORNTECH APM 550 set at a flow rate of 17.57lpm for 24 hours.

[47mm PTFE Filter paper]



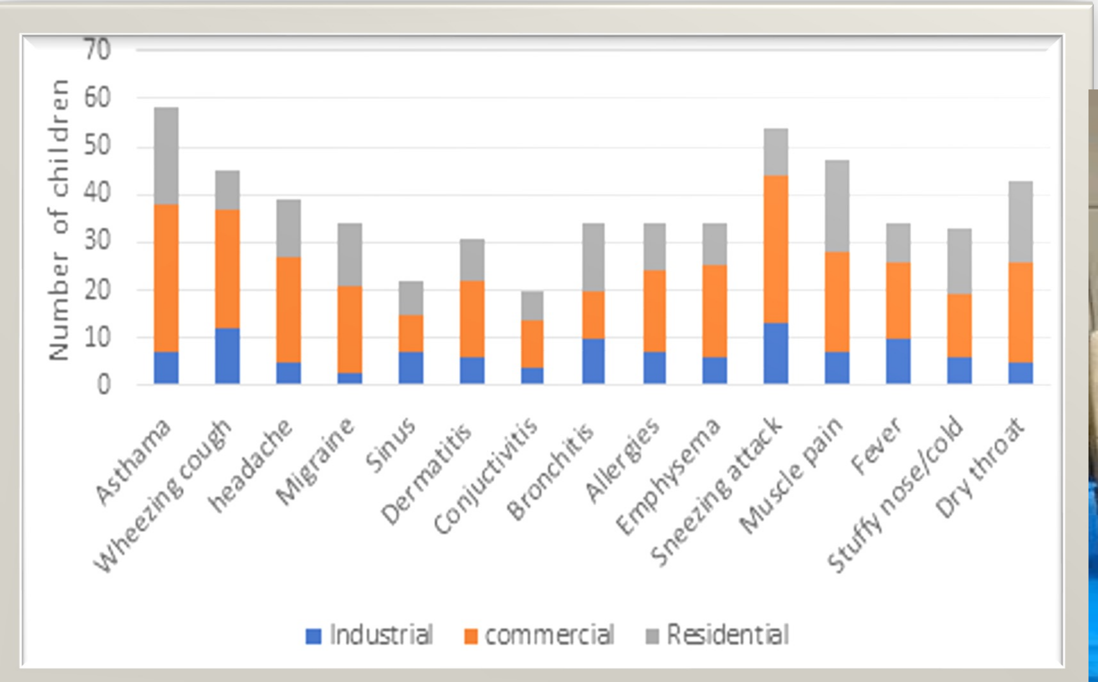
Results & Discussion

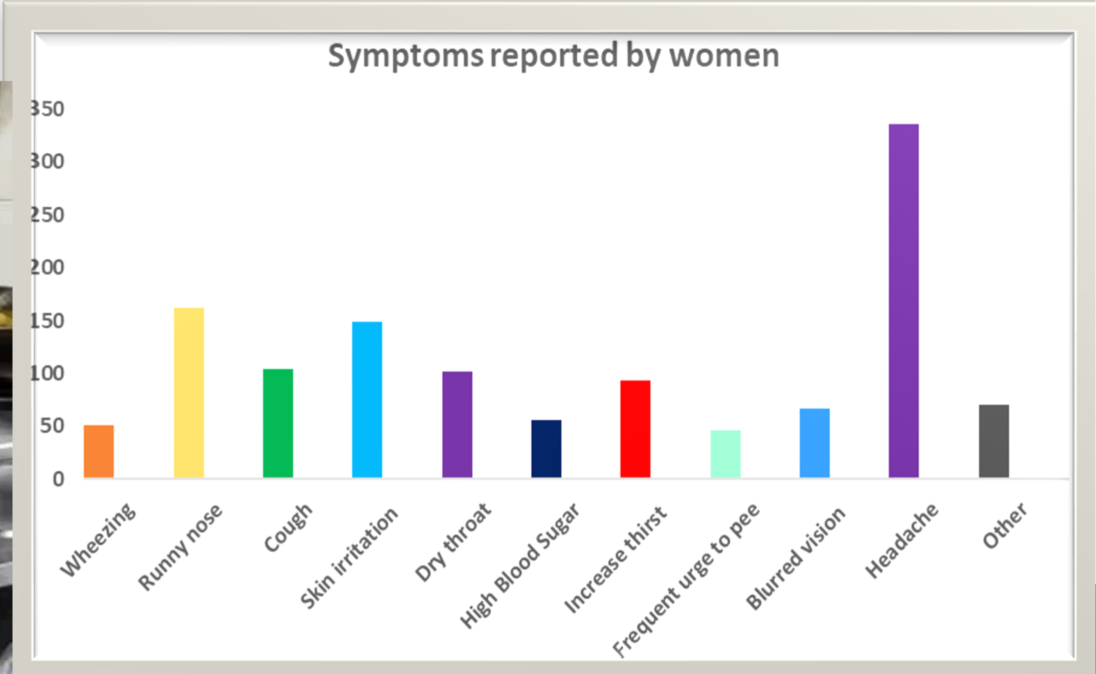


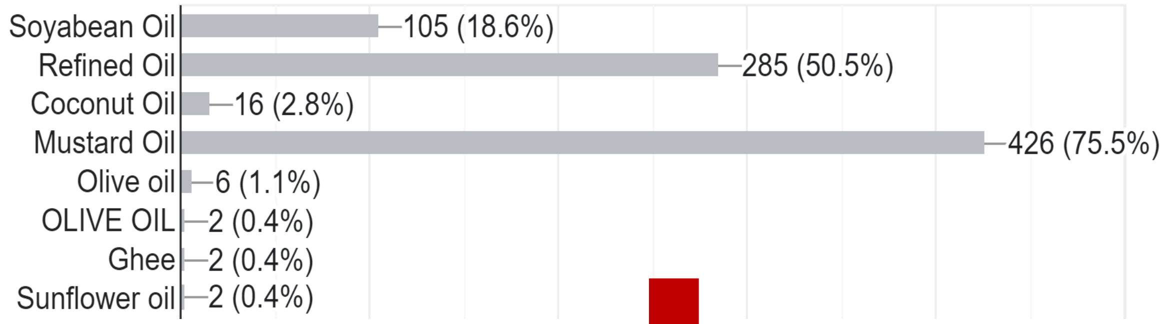
Children

Women

SURVEY



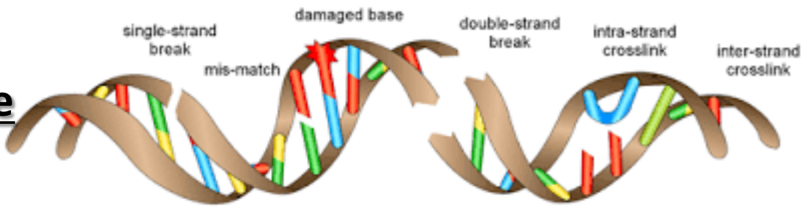




Coughing

Emotion distress

DNA damage

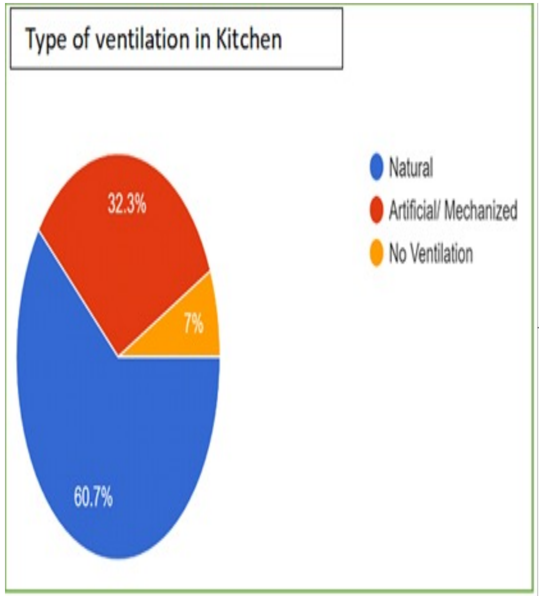


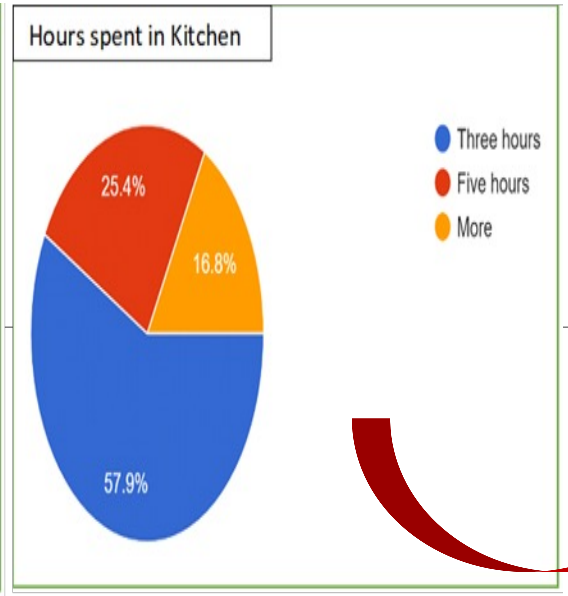
During the questionnaire survey it was also stated that 75.4% women use mustard oil for cooking followed by refined oil, soyabean oil and coconut oil.

Possible Outcomes

Literature Review

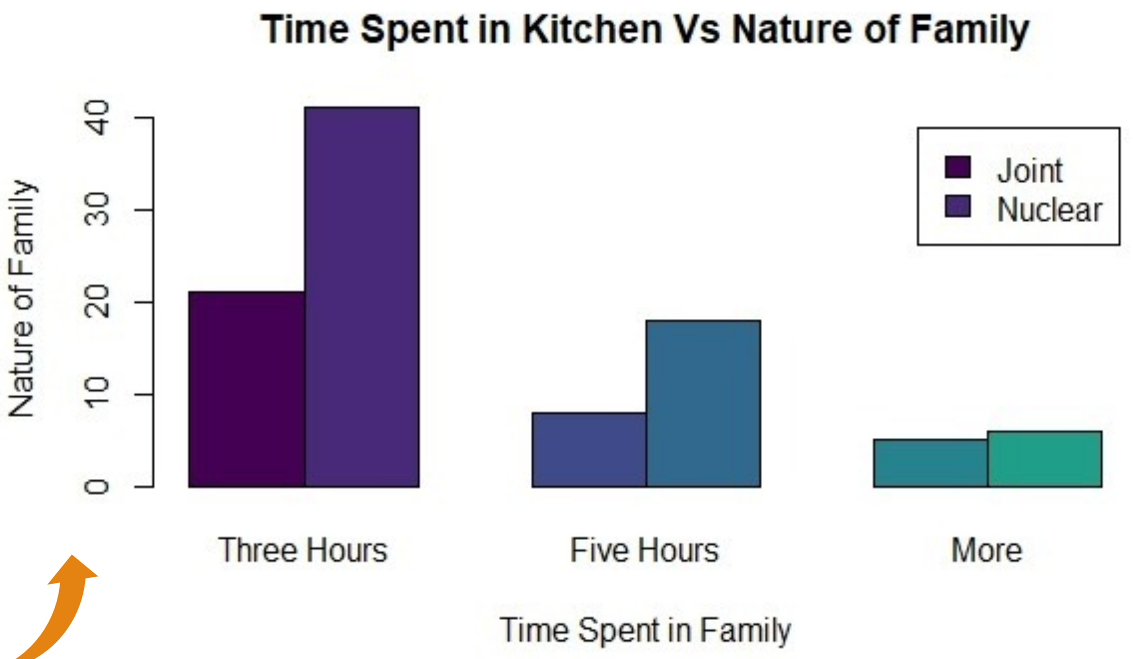
It has been reported that **fume from cooking oil can cause cervical cancer, lung cancer, diabetes, cardiovascular disease** etc . It was also reported that cooking oil affects the emotional, mental health and physiological health as from the viewpoint of DNA oxidative damage.





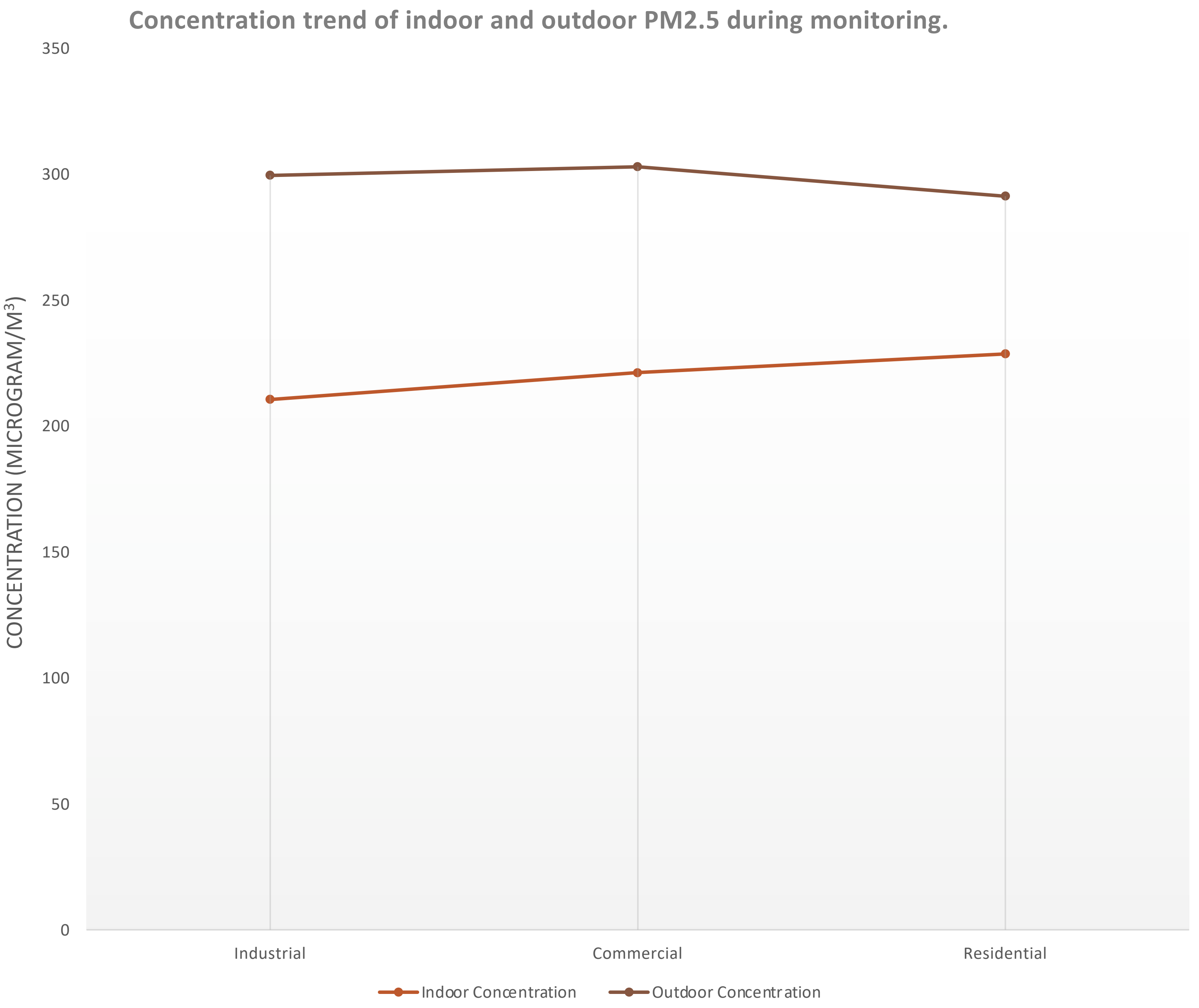
Further, it was also reported that 57.9% of the women spent more than three hours in the kitchen daily . According to a study on health risk assessment in Indian kitchen, PM2.5 in kitchen can lead to reduction in the lung capacity. Also, another study claims the indoor air quality in kitchen is much worse than outdoor.

- **An interconnection between average time spent in a day by a women and nature of family through chi-square test performed in R-studio reveled that women in joint families spent more time. According to survey 37.9% women are living in joint families in the present time.**

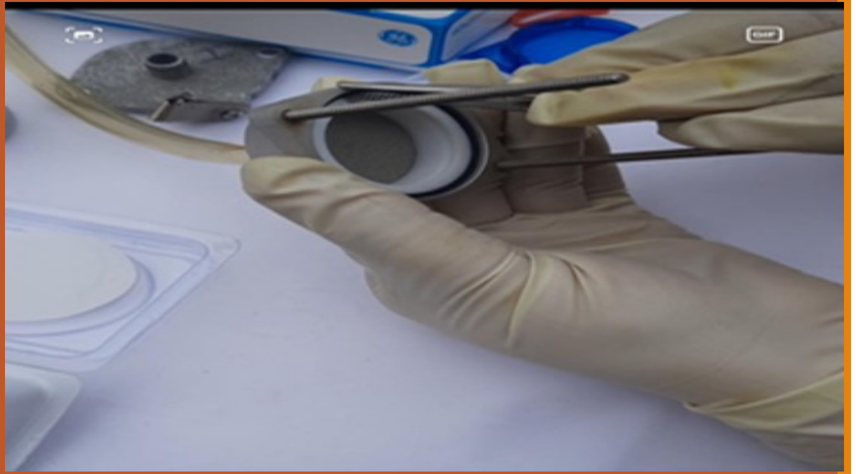


Average outdoor concentration of $PM_{2.5}$.

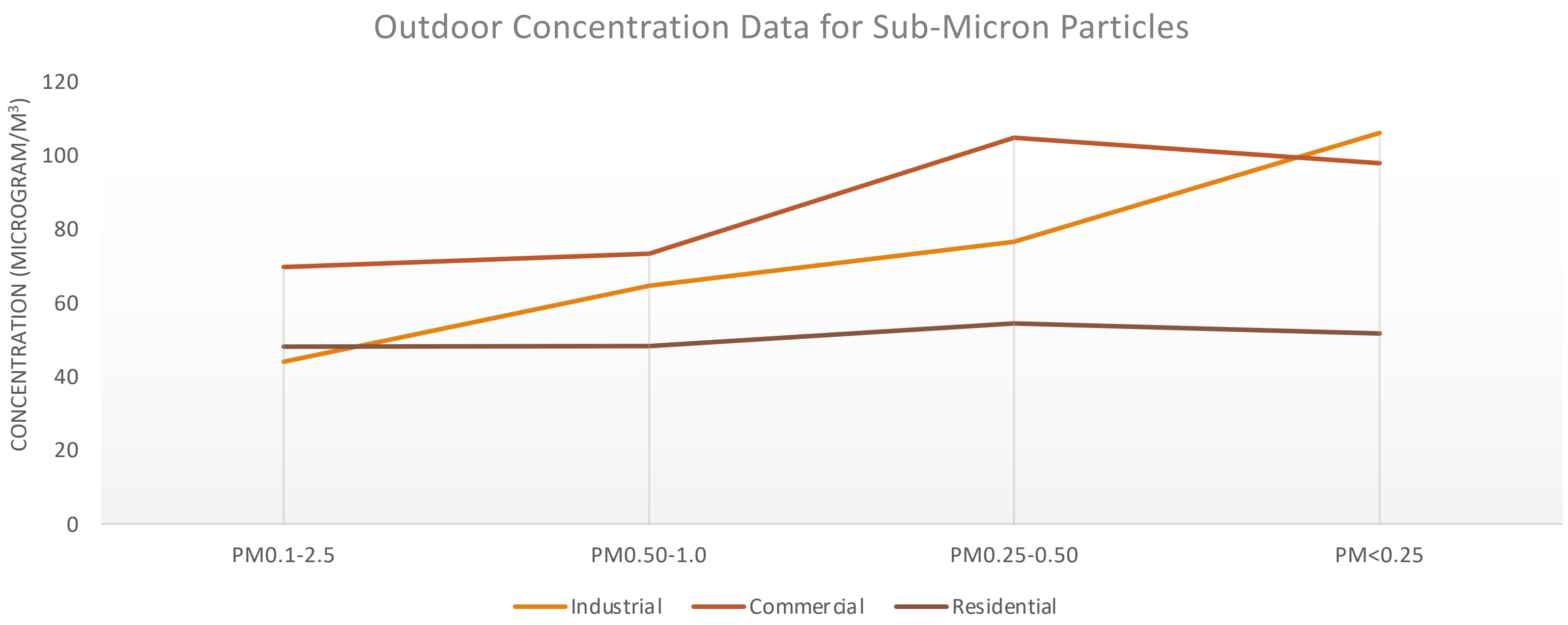
Average indoor concentration of $PM_{2.5}$.

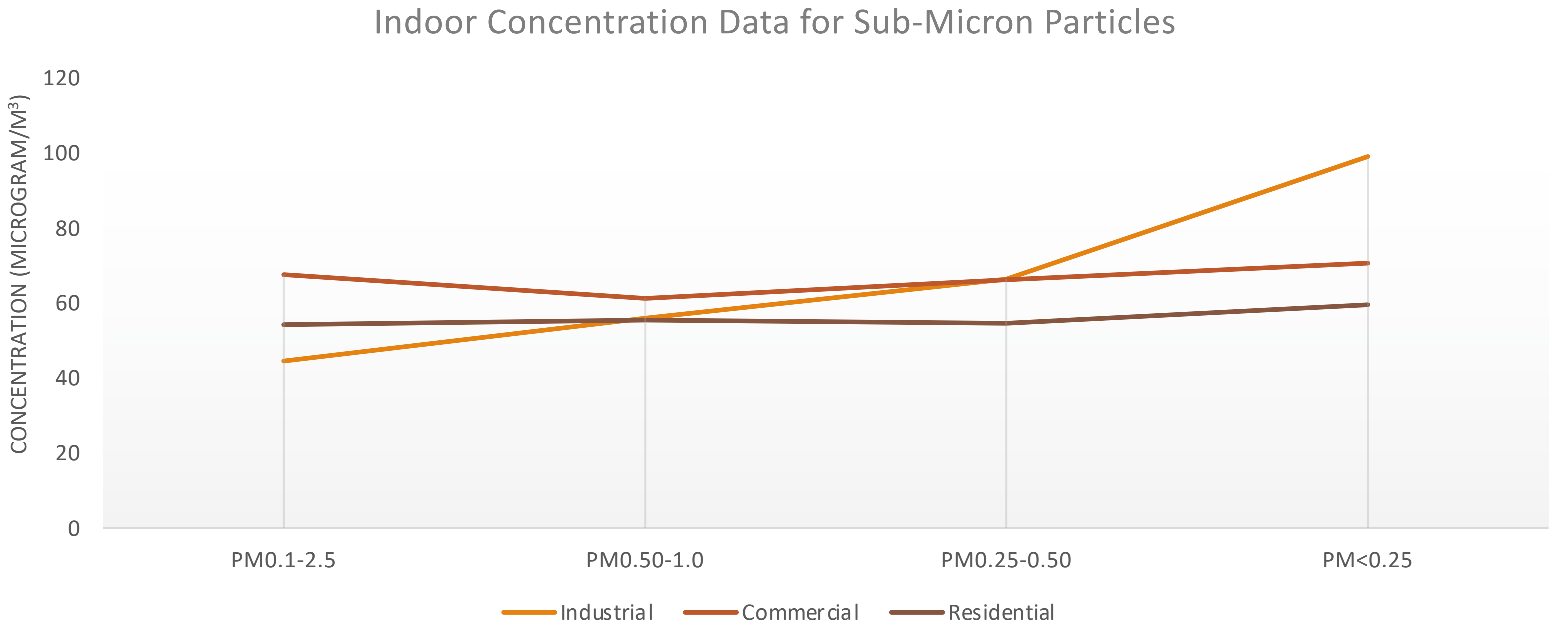


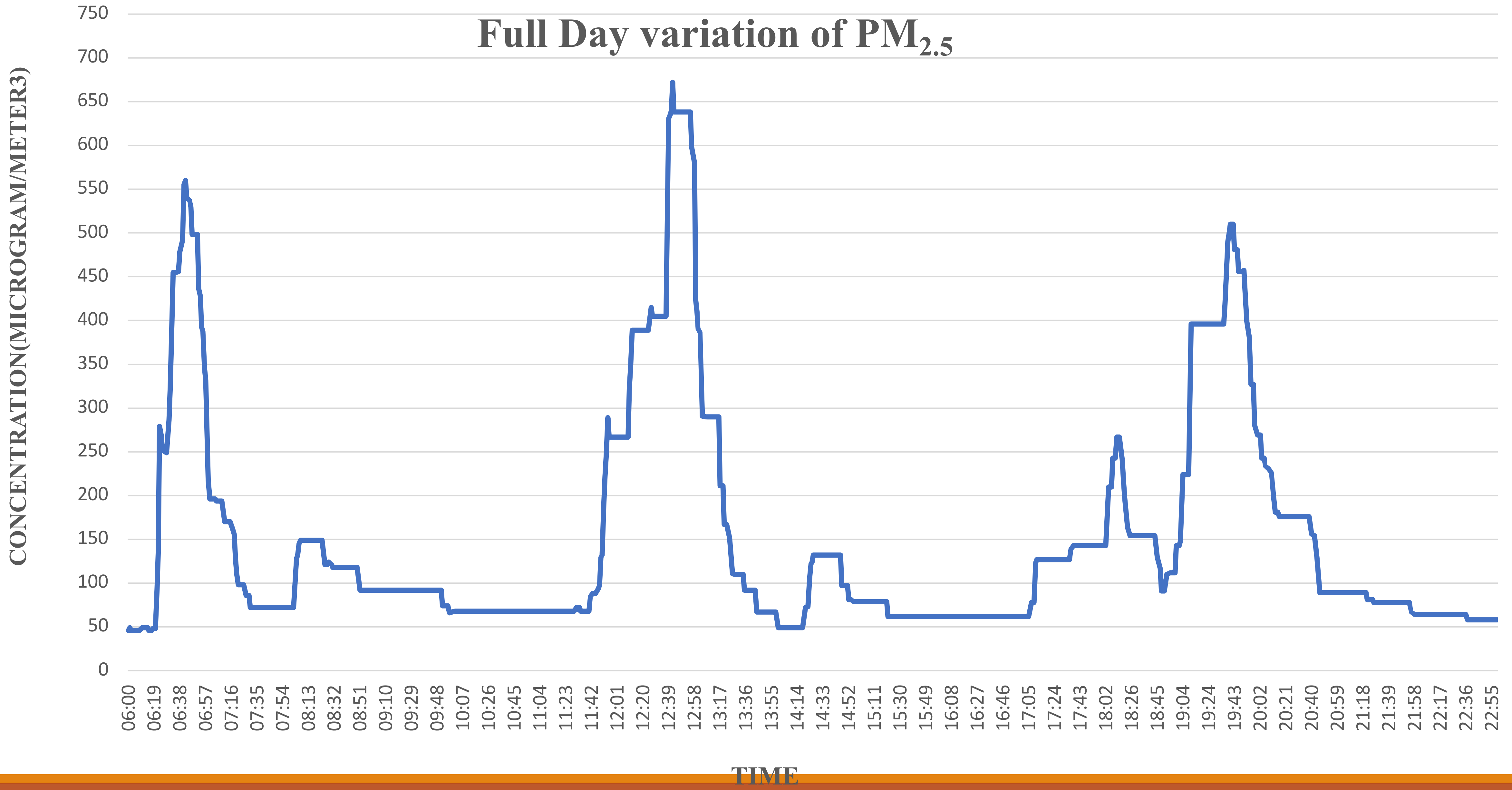
Average concentration of sub-micron in outdoors



Average concentration of sub-micron in indoors






Full Day variation of $PM_{2.5}$
CONCENTRATION(MICROGRAM/METER3)
TIME
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
06:00
06:19
06:38
06:57
07:16
07:35
07:54
08:13
08:32
08:51
09:10
09:29
09:48
10:07
10:26
10:45
11:04
11:23
11:42
12:01
12:20
12:39
12:58
13:17
13:36
13:55
14:14
14:33
14:52
15:11
15:30
15:49
16:08
16:27
16:46
17:05
17:24
17:43
18:02
18:26
18:45
19:04
19:24
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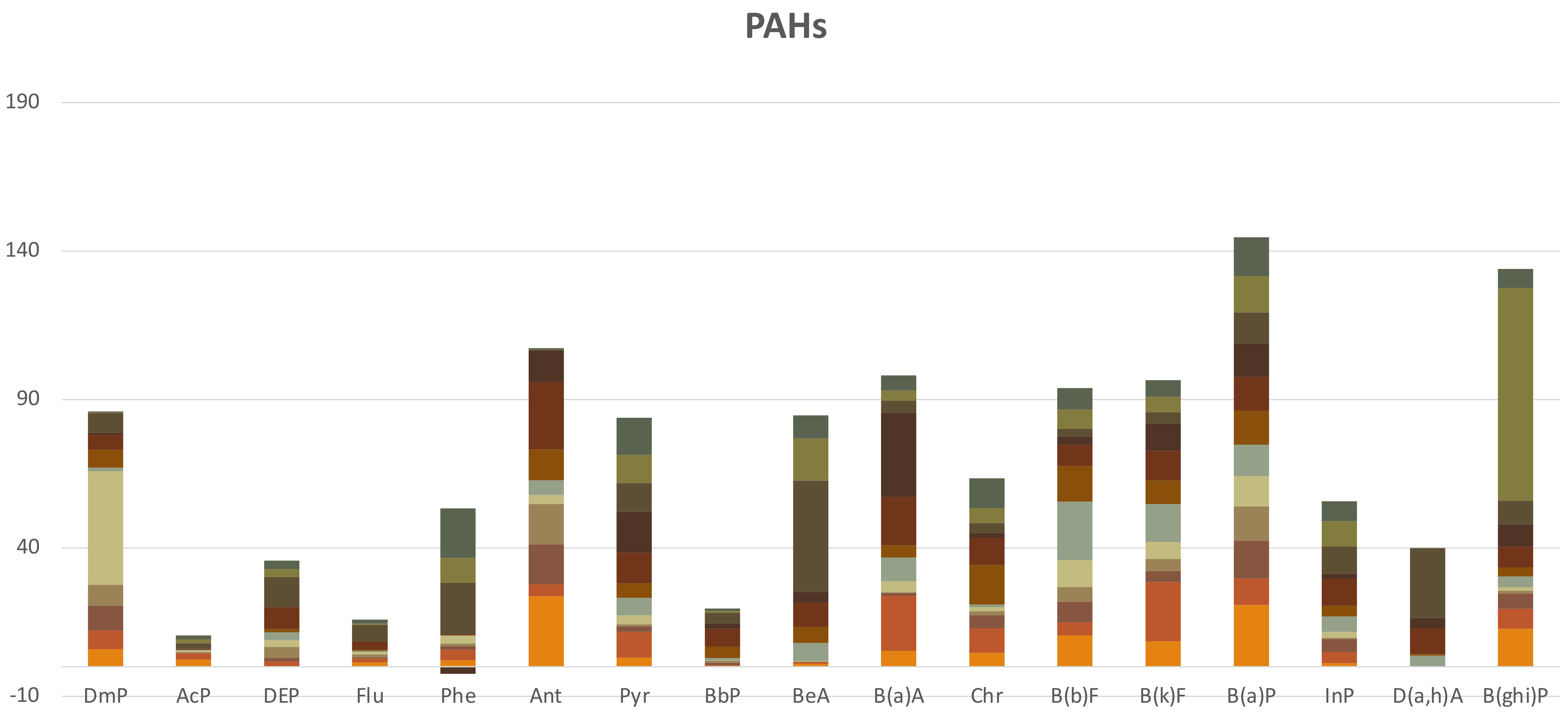
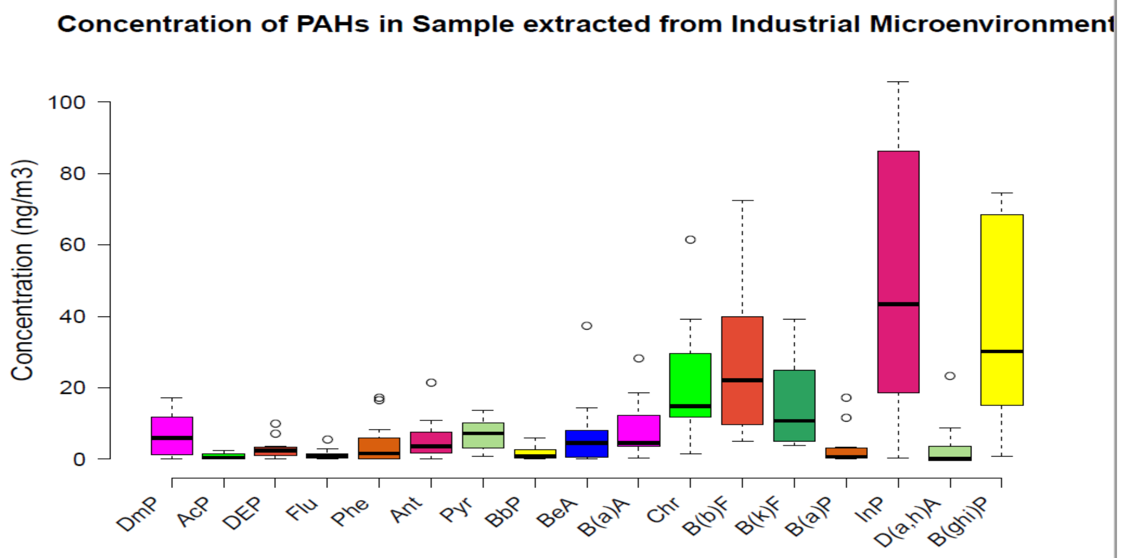
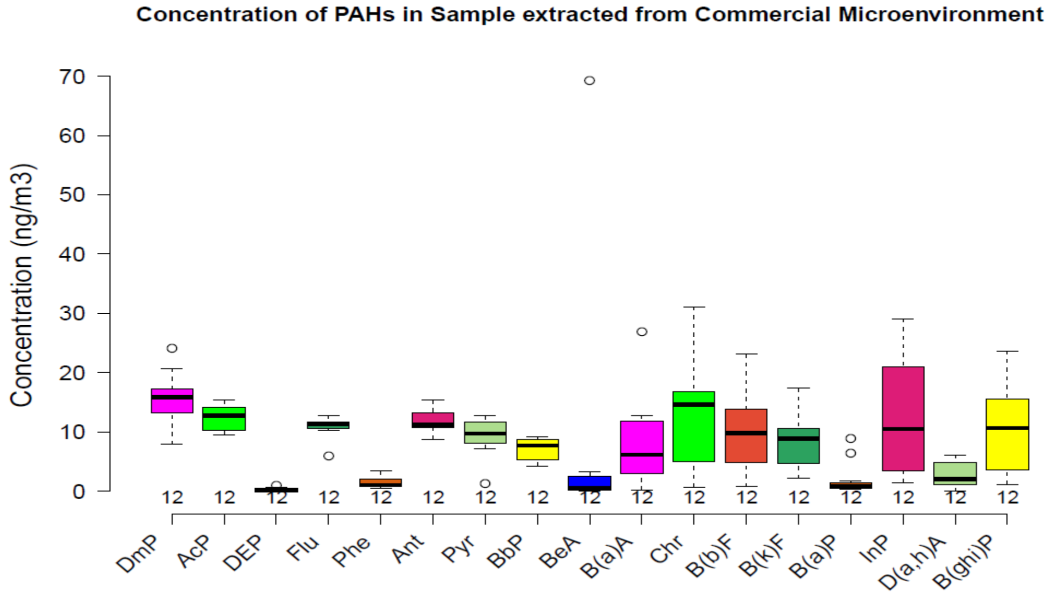
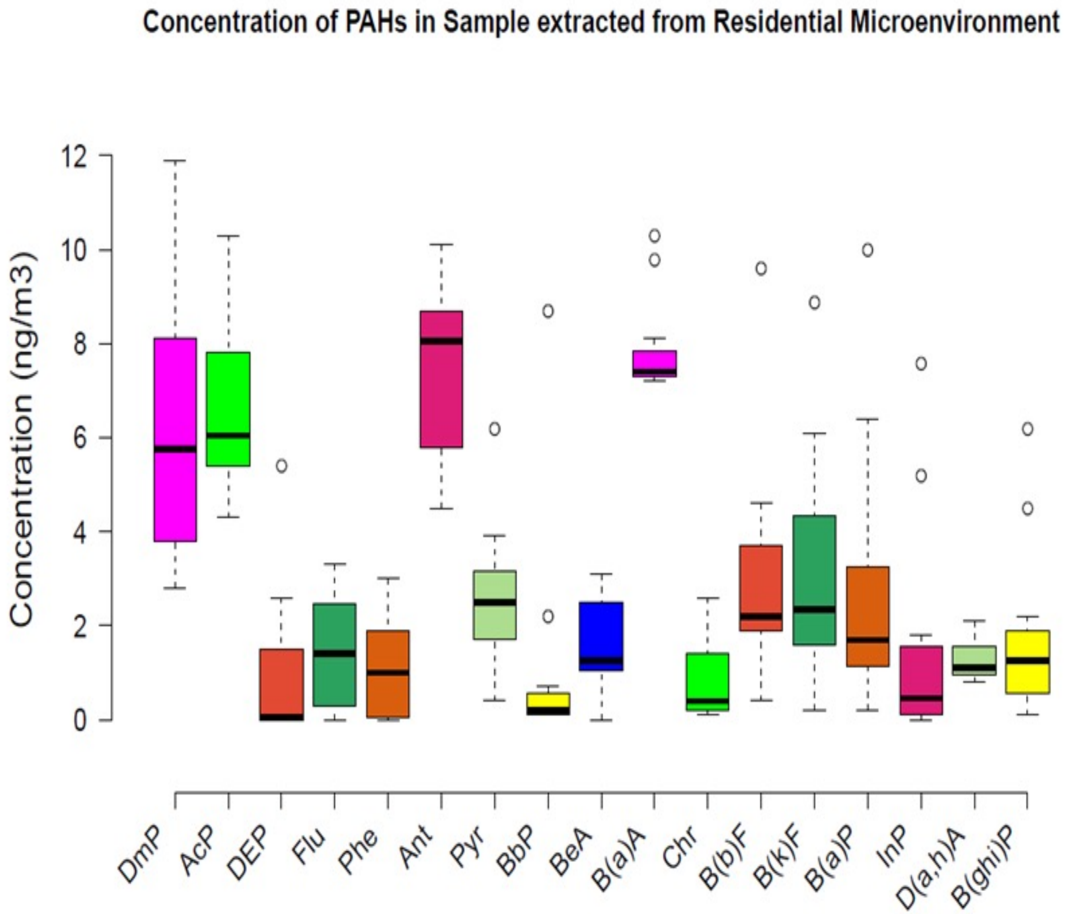
20:02
20:21
20:40
20:59
21:18
21:39
21:58
22:17
22:36
22:55

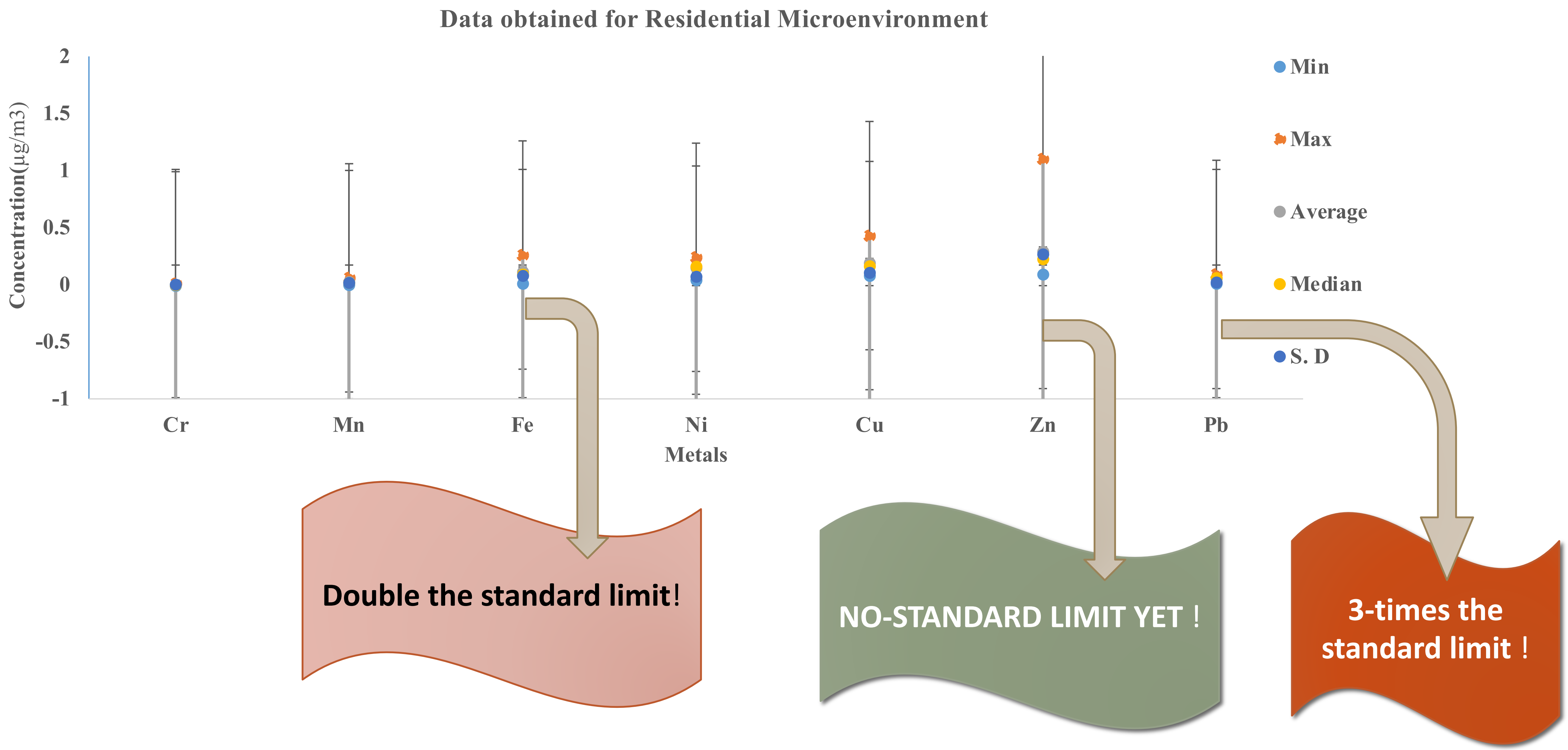

PAHs
190
140
90
40
-10
DmP
AcP
DEP
Flu
Phe
Ant
Pyr
BbP
BeA
B(a)A
Chr
B(b)F
B(k)F
B(a)P
InP
D(a,h)A
B(ghi)P

Concentration of PAHs in the three microenvironment








Data obtained for Residential Microenvironment
Concentration(µg/m3)
2
1.5
1
0.5
0
-0.5
-1
Cr
Mn
Fe
Ni
Cu
Zn
Pb
Metals
Min
Max
Average
Median
S. D
Double the standard limit!
NO-STANDARD LIMIT YET !
3-times the standard limit !

Concentrations [μg/m^3] of indoor metals associated with $PM_{2.5}$ in industrial microenvironment

Metal	RANGE	MEAN	MEDIAN	S.D
Cr	0.14-3.14	1.07	0.75	0.99
Mn	0.11-3.1	1.15	0.92	0.92
Fe	0.56-7.32	3.99	3.83	2.4
Ni	3.1-36.1	12.01	6.86	11.5
Cu	0.35-9.2	3.89	3.78	2.88
Zn	20.4-61.6	36.84	35.46	11.69
Pb	3.5-17.51	11.28	11.35	5.22

Concentrations [μg/m^3] of indoor metals associated with $PM_{2.5}$ in commercial microenvironment.

Metal	RANGE	MEAN	MEDIAN	S.D
Cr	0.12-2.82	0.96	0.67	0.85
Mn	0.09-2.79	1.03	0.83	0.79
Fe	0.5-6.58	3.58	3.44	2.08
Ni	2.7-32.4	10.61	6.17	9.80
Cu	0.31-8.34	3.50	3.39	2.48
Zn	18.39-55.44	32.40	**30.92**	10.36
Pb	2.23-13.24	7.95	7.95	3.81

Concentrations [μg/m^3] of indoor metals associated with $PM_{2.5}$ in residential microenvironment.

Metal	RANGE	MEAN	MEDIAN	S.D
Cr	0.07-1.99	0.64	0.35	0.59
Mn	0.01-1.16	0.28	1.16	0.31
Fe	0.03-2.86	1.62	2.86	0.92
Ni	0.99-13.4	5.17	13.4	3.85
Cu	0.04-3.4	1.52	3.4	1.05
Zn	1.4-15.22	6.97	15.22	4.74
Pb	1.06-10.25	4.50	10.25	3.13

Estimation of PM daily dose and exposure indices in summer season and LADD

Households (H) Number	Age of Women (Years)	Average Indoor concentrations of $PM_{2.5}$ ($\mu g/m^3$)	Daily dose (mg/kg -day)	ILCR = LADD (Life time average daily dose)*Cancer oral slope factor(CSF) (Incremental Life time Cancer Risk)
R1	26	86.6	4.765 *10^{-2}	1.53*10^{-6}
	39		5.118*10^{-2}	1.64*10^{-6}
	51		3.673*10^{-2}	1.17*10^{-6}
R2	40	55.2	1.731*10^{-2}	1.29*10^{-6}
	19		1.61*10^{-2}	1.20*10^{-6}
C1	21	94.6	4.91*10^{-2}	2.40*10^{-6}
	56		4.44*10^{-2}	5.68*10^{-6}
C2	30	119.6	3.640*10^{-2}	1.27*10^{-6}
	33		3.489*10^{-2}	4.68*10^{-6}
	57		2.36*10^{-2}	3.17*10^{-6}
I1	43	142.1	6.51*10^{-2}	5.38*10^{-6}
I2	55	167.0	6.7*10^{-2}	4.39*10^{-6}
	32		7.24*10^{-2}	4.75*10^{-6}
	27		**8.62*10^{-2}**	**5.65*10^{-6}**

Estimation of PM daily dose and exposure indices in Winter season and LADD

Households (H) Number	Age of Women (Years)	Indoor concentrations of $PM_{2.5}$ ($\mu g/m^3$)	Daily dose (mg/kg -day)	ILCR = LADD (Life time average daily dose)*Cancer oral slope factor(CSF) (Incremental Life time Cancer Risk)
R1	26	104.1	$5.72*10^{-2}$	$0.081*10^{-6}$
	39		$6.15*10^{-2}$	$0.87*10^{-6}$
	51		$4.41*10^{-2}$	$0.62* 10^{-6}$
R2	40	108.9	$3.41*10^{-2}$	$1.15*10^{-6}$
	19		$3.17*10^{-2}$	$1.48*10^{-6}$
C1	**21**	128.1	**$6.65*10^{-2}$**	**$3.23*10^{-6}$**
			$6.02*10^{-2}$	$2.92*10^{-6}$
	56			
C2	30	**202.3**	**$6.15*10^{-2}$**	**$7.12*10^{-6}$**
	33		$5.9*10^{-2}$	$6.83*10^{-6}$
I1	57		$3.99*10^{-2}$	$4.63*10^{-6}$
	43	190.6	$8.74*10^{-2}$	$5.14*10^{-6}$
I2	55	**209.1**	$8.39*10^{-2}$	$6.27*10^{-6}$
	32		$9.07*10^{-2}$	$6.78*10^{-6}$
	27		**$10.8*10^{-2}$**	**$8.08*10^{-6}$**

PAHs and Risk Assessment

Households	Carcinogenic PAHs (ng/m^3)	TEF (Toxicity equivalency Factor)	$\sum BaP_{eq} = \sum C_i$ x TEF	LLCR (Lifetime Lung cancer risk) = $\sum BaP_{eq}$ x Unit risk (UR)
R1	Acp	0.01	0.051	$0.44*10^{-5}$
	Ant	0.001	0.0089	$0.07*10^{-5}$
	Chr	0.1	0.02	$0.17*10^{-5}$
	Inp	0.01	0.004	$0.03*10^{-5}$
	B(a)P	1.0	4.2	**$36.54*10^{-5}$**
R2	Acp	0.01	0.103	$0.89*10^{-5}$
	Ant	0.001	0.0078	$0.06*10^{-5}$
	Chr	0.1	0.01	$0.08*10^{-5}$
	Inp	0.01	0	0
	B(a)P	1.0	1.5	**$13.05*10^{-5}$**
C1	Acp	0.01	0.024	$0.20*10^{-5}$
	Ant	0.01	0.078	$0.67*10^{-5}$
	Chr	0.1	1.47	$12.78*10^{-5}$
	Inp	0.01	0.162	$1.40*10^{-5}$
	B(a)P	1.0	0.8	$6.96*10^{-5}$
C2	Acp	0.01	0.021	$0.18*10^{-5}$
	Ant	0.001	0.0041	$0.03*10^{-5}$
	Chr	0.1	3.83	$33.32*10^{-5}$
	Inp	0.01	0.367	$3.19*10^{-5}$
	B(a)P	1.0	0.9	**$7.83*10^{-5}$**
I1	Acp	0.01	0.139	$1.20*10^{-5}$
	Ant	0.001	0.0132	$0.11*10^{-5}$
	Chr	0.1	**5.05**	**$43.93*10^{-5}$**
	Inp	0.01	0.908	$7.89*10^{-5}$
	B(a)P	1.0	13.4	**$116.58*10^{-5}$**
I2	Acp	0.01	0.132	$1.14*10^{-5}$
	Ant	0.01	0.088	$0.76*10^{-5}$
	Chr	0.1	2.54	$22.09*10^{-5}$
	Inp	0.01	0.281	$2.44*10^{-5}$
	B(a)P	1.0	**0.9**	**$7.83*10^{-5}$**

Heavy Metals

Category	MICROENVIRONMENT	S(I)	W(I)	S/W(C)	P-value
Cr	Industrial	0.04±0.10	0.009±0.078	2.48±8.9	0.089393
	Commercial	0.00075±0.003	0.0085±0.022	0.245±0.8	0.281383
	Residential	0.00041±0.0044	0.002±0.0037	0.48±0.85	0.321388
Mn	Industrial	0.021±0.018	0.214±0.14	0.180±0.288	0.001087
	Commercial	0.210±0.122	0.029±0.054	0.178±0.24	0.000361
	Residential	0.184±0.12	0.025±0.01	0.238±0.22	0.001438
Fe	Industrial	0.33±0.465	**0.958±0.215**	0.470±0.84	0.005059
	Commercial	0.155±0.11	0.255±0.25	2.53±4.4	0.193636
	Residential	0.11±0.081	0.47±0.47	1.35±3.52	0.021683
Ni	Industrial	0.44±0.29	0.58±0.27	1.07±1.43	0.172807
	Commercial	0.249±0.18	**0.799±0.49**	0.532±0.56	0.004299
	Residential	0.148±0.072	0.340±0.280	0.907±0.90	0.049686
Cu	Industrial	0.155±0.14	0.512±0.24	0.412±0.40	0.002618
	Commercial	0.288±0.18	0.375±0.21	1.24±1.20	0.419344
	Residential	0.19±0.10	0.213±0.10	1.75±2.9	0.536963
Zn	Industrial	0.329±0.30	**1.07±0.35**	0.37±0.35	0.000166
	Commercial	0.299±0.32	**0.822±0.366**	0.359±0.299	0.000563
	Residential	0.29±0.26	0.68±0.35	1.26±3.07	0.02798
Pb	Industrial	0.38±0.17	**0.865±0.217**	0.467±0.21	6.18E-05
	Commercial	0.11±0.07	0.34±0.26	1.48±3.38	0.016694
	Residential	0.056±0.022	0.30±0.25	0.55±0.66	0.00749

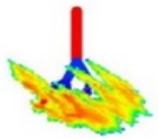
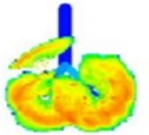
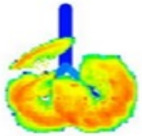
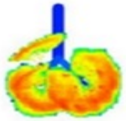
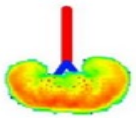
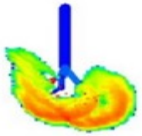
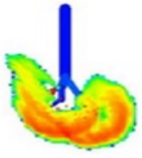
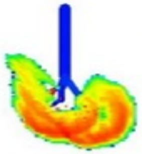
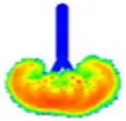
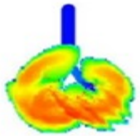
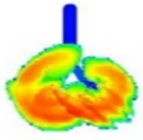
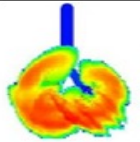
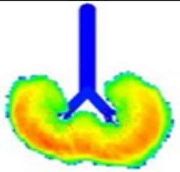
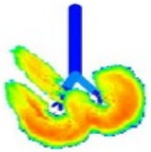
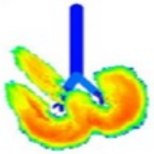
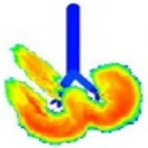
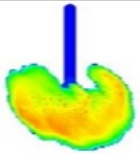
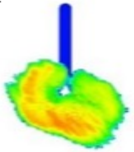
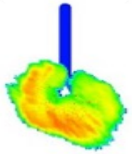
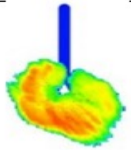
Age	Risk factor	Summer Risk Assessment Dermal Absorbed dose (DAD); Chronic daily intake (CDI)							Winter Risk Assessment						
		Cr	Mn	Fe	Ni	Cu	Zn	Pb	Cr	Mn	Fe	Ni	Cu	Zn	Pb
Up to 1 year	CDI	0.05x10^{-12}	0.06 x10^{-12}	0.60x10^{-12}	0.65x10^{-12}	0.51x10^{-12}	0.80x10^{-12}	0.48x10^{-12}	0.017x10^{-12}	0.52x10^{-12}	1.46x10^{-12}	1.49x10^{-12}	0.95x10^{-12}	2.2x10^{-12}	1.13x10^{-12}
	DAD	0.0007x10^{-12}	0.0009x10^{-12}	0.008x10^{-12}	0.009x10^{-12}	0.007x10^{-12}	0.011x10^{-12}	0.006x10^{-12}	0.002x10^{-12}	0.007x10^{-12}	0.020 x10^{-12}	0.02x10^{-12}	0.013x10^{-12}	0.03x10^{-12}	0.018x10^{-12}
1-3 year	CDI	0.02x10^{-12}	0.03x10^{-12}	0.33x10^{-12}	0.35x10^{-12}	0.28x10^{-12}	0.44x10^{-12}	0.26x10^{-12}	0.009x10^{-12}	0.29x10^{-12}	0.80x10^{-12}	0.81x10^{-12}	0.52x10^{-12}	1.23x10^{-12}	0.72x10^{-12}
	DAD	0.0003x10^{-12}	0.0005x10^{-12}	0.004x10^{-12}	0.004x10^{-12}	0.003x10^{-12}	0.006x10^{-12}	0.003x10^{-12}	0.0001x10^{-12}	0.004x10^{-12}	0.011x10^{-12}	0.011x10^{-12}	0.007x10^{-12}	0.016x10^{-12}	0.010x10^{-12}
3-6 year	CDI	0.018x10^{-12}	0.002x10^{-12}	0.22x10^{-12}	0.23x10^{-12}	0.19x10^{-12}	0.29x10^{-12}	0.17x10^{-12}	0.006x10^{-12}	0.19x10^{-12}	0.53x10^{-12}	0.54x10^{-12}	0.34x10^{-12}	0.82x10^{-12}	0.48x10^{-12}
	DAD	0.0002x10^{-12}	0.0003x10^{-12}	0.003x10^{-12}	0.003x10^{-12}	0.002x10^{-12}	0.004x10^{-12}	0.002x10^{-12}	8.62x10^{-17}	0.002x10^{-12}	0.007x10^{-12}	0.007x10^{-12}	0.004x10^{-12}	0.011x10^{-12}	0.006x10^{-12}
6-8 year	CDI	0.01x10^{-12}	0.01x10^{-12}	0.16x10^{-12}	0.17x10^{-12}	0.137x10^{-12}	0.212x10^{-12}	0.12x10^{-12}	0.004x10^{-12}	0.13x10^{-12}	0.38x10^{-12}	0.39x10^{-12}	0.25x10^{-12}	0.59x10^{-12}	0.34x10^{-12}
	DAD	0.0001x10^{-12}	0.0002x10^{-12}	0.002x10^{-12}	0.02x10^{-12}	0.001x10^{-12}	0.002x10^{-12}	0.001x10^{-12}	6.23x10^{-17}	0.001x10^{-12}	0.005x10^{-12}	0.005x10^{-12}	0.003x10^{-12}	0.0081x10^{-12}	0.004x10^{-12}
8-11year	CDI	0.011x10^{-12}	0.01x10^{-12}	0.13 x10^{-12}	0.14x10^{-12}	0.11x10^{-12}	0.17x10^{-12}	0.10x10^{-12}	0.003x10^{-12}	0.11x10^{-12}	0.32x10^{-12}	0.32x10^{-12}	0.20x10^{-12}	0.49x10^{-12}	0.29x10^{-12}
	DAD	0.0001x10^{-12}	0.0002x10^{-12}	0.001x10^{-12}	0.001x10^{-12}	0.001x10^{-12}	0.002x10^{-12}	0.001x10^{-12}	5.17x10^{-17}	0.001x10^{-12}	0.004x10^{-12}	0.004x10^{-12}	0.002x10^{-12}	0.006x10^{-12}	0.004x10^{-12}
12-14 year (girl	CDI	0.009x10^{-12}	0.01x10^{-12}	0.11x10^{-12}	0.12x10^{-12}	0.09x10^{-12}	0.15x10^{-12}	0.09x10^{-12}	0.003x10^{-12}	0.10x10^{-12}	0.27x10^{-12}	0.28x10^{-12}	0.18x10^{-12}	0.42x10^{-12}	0.25x10^{-12}
	DAD	0.0001x10^{-12}	0.0001x10^{-12}	0.001x10^{-12}	0.001x10^{-12}	0.001x10^{-12}	0.0021x10^{-12}	0.001x10^{-12}	4.48x10^{-17}	0.001x10^{-12}	0.003x10^{-12}	0.003x10^{-12}	0.002x10^{-12}	0.005x10^{-12}	0.003x10^{-12}
12-14 year (boy)	CDI	0.009x10^{-12}	0.011x10^{-12}	0.108x10^{-12}	0.11x10^{-12}	0.09x10^{-12}	0.14x10^{-12}	0.08x10^{-12}	0.003x10^{-12}	0.09x10^{-12}	0.26x10^{-12}	0.26x10^{-12}	0.17x10^{-12}	0.40x10^{-12}	0.23x10^{-12}
	DAD	0.0001x10^{-12}	0.0001x10^{-12}	0.001x10^{-12}	0.001x10^{-12}	0.001x10^{-12}	0.001x10^{-12}	0.001x10^{-12}	4.22x10^{-17}	0.001x10^{-12}	0.003x10^{-12}	0.003x10^{-12}	0.002x10^{-12}	0.005x10^{-12}	0.003x10^{-12}

Dosimetry through ICRP-Model

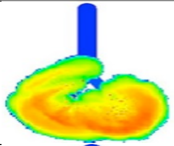
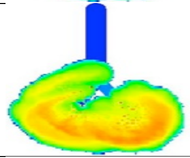
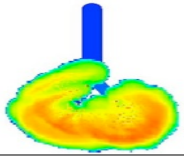
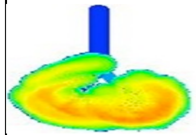
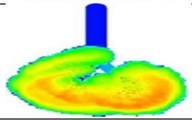
- International Committee of Radiological Protection Model [ICRP] has emerged as a promising tool for estimation of particulate matter deposition in lungs.
- It can estimate the deposition in the 3 segments of the lung namely, head airway, alveolar and tracheobronchial regions.
- Highest deposition for the smallest particle size was found in alveolar region.
- The total deposition is highest for PM2.5.

Particle size	IF	DF_{HA}	DF_{TB}	DF_{AL}	DF_{Total}
$PM_{1.0}$	1	0.2851	0.0271	0.7248	0.4204
$PM_{0.1}$	1	0.0211	0.0265	**2.0711**	0.2476
$PM_{0.25}$	1	0.0345	0.0060	0.0568	0.1348
$PM_{0.5}$	1	0.0994	0.0071	0.0819	0.1660
$PM_{2.5}$	1	0.4982	0.0012	0.1076	**0.8762**

Dosimetry via. MPPD Model version 3.0 (Multiple Path Particle Dosimetry)

Size / Age	$PM_{1.0-2.5}$	$PM_{0.5-1.0}$	$PM_{0.5-0.25}$	$PM_{<0.25}$
0-1yrs	 Deposition Color Key: 0.0 µg 3.573E-6 µg	 Deposition Color Key: 0.0 µg 6.397E-6 µg	 Deposition Color Key: 0.0 µg 7.972E-6 µg	 Deposition Color Key: 0.0 µg 1.351E-5 µg
1-3yrs	 Deposition Color Key: 0.0 µg 3.909E-6 µg	 Deposition Color Key: 0.0 µg 7.455E-6 µg	 Deposition Color Key: 0.0 µg 9.399E-6 µg	 Deposition Color Key: 0.0 µg 1.896E-5 µg
3-8yrs	 Deposition Color Key: 0.0 µg 8.883E-6 µg	 Deposition Color Key: 0.0 µg 1.625E-5 µg	 Deposition Color Key: 0.0 µg 2.022E-5 µg	 Deposition Color Key: 0.0 µg 3.640E-5 µg
8-9yrs	 Deposition Color Key: 0.0 µg 1.355E-5 µg	 Deposition Color Key: 0.0 µg 2.541E-5 µg	 Deposition Color Key: 0.0 µg 3.132E-5 µg	 Deposition Color Key: 0.0 µg 5.157E-5 µg
9-14yrs	 Deposition Color Key: 0.0 µg 1.605E-5 µg	 Deposition Color Key: 0.0 µg 3.149E-5 µg	 Deposition Color Key: 0.0 µg 3.894E-5 µg	 Deposition Color Key: 0.0 µg 6.187E-5 µg

Dose estimation in women

Geometry	
PM2.5	 Deposition Color Key: 0.0 µg 1.898E-4 µg
PM 1.0	 0.0 µg 4.494E-5 µg
PM0.1	 0.0 µg 1.111E-4 µg
PM 0.25	 Deposition Color Key: 0.0 1.837E-3
PM 0.5	 0.0 µg 5.761E-5 µg

Conclusion

- The study is first of it's kind in this part of the country.
- Indoor Concentration in residential areas were higher than outdoor whereas the trend was vice-versa in the case of commercial and industrial households.
- As the age of child increases the higher deposition of sub-micron PM can be found in the alveolar region.
- Women are exposed to highest concentration of pollutants as they are involved in household chores and even short term exposure may lead to very harmful effects
- The study is ongoing. We are still evaluating data for summer and rainy season for seasonal variation comparison which may help the decision makers .
- The results have provoked to not only monitor theses toxic and carcinogenic pollutants but also work on economic abatement techniques using industrial solid waste.

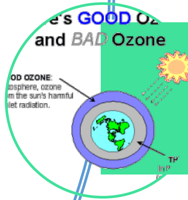
Tackling Household Air Pollution

- 21.9% Indians under poverty line'
- Two-thirds live on less than 5CHF per day.
- NO Indian Air Purifier removes PAHs & VOCs (at low cost)

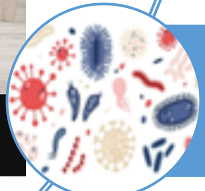
Can People afford air purifier which can cost over 20000?

Maintenance Overhead - indoor air purifiers do need maintenance, which can be erratically expensive

Under Performance- Some purifiers will remove smoke or odor and will fail at tackling microorganisms and allergens from your home. Another reason for their low efficiency is the age of air purifiers.



Ozone Emission- Air purifiers emit ozone gas as a byproduct, exposure to which will put your health at risk.



A multiplicity of Molds and Bacteria- HEPA filters can turn into a perfect breeding place for bacteria and microbes. The grouped microscopic organisms can quickly multiply themselves swiftly to bounce back into your room.

Importance/ Idea of Research Prospective

01

“Use Waste to Treat Waste”

Use of solid Industrial waste for air pollution mitigation

02

Cost effective

Globally millions of tons of waste is disposed every year which freely available for usage.

03

“Reuse-Reduce-Recycle”

An eco-friendly technique which will elevate the productive usage of waste.

Major Objective-

To prepare cost-effective and environment friendly adsorbent and fibrous mat from fly ash & Red mud obtained from <u>solid industrial waste</u> (bituminous coal and Lignite coal) for the mitigation of PAHs, particulate matter (PM) and VOCs in domestic indoor air.

- **Catalytic behaviour**
- **Adsorption towards Metals and gases**
- Environment Friendly technology & Fruitful utilizing of industrial waste
- It is low cost and it has maximum adsorption capacity from other industrial waste.

To prepare cost-effective adsorbent and fibrous mat from two types of fly ash industrial waste Bituminous coal and Lignite coal & Red Mud Pellets

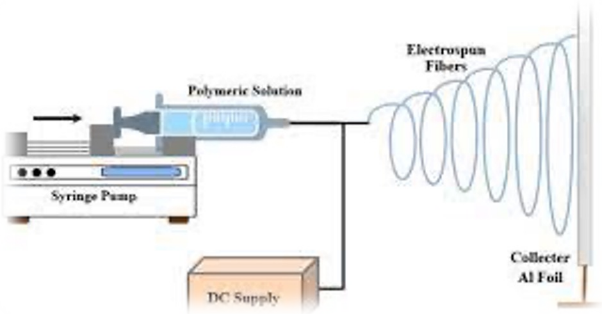
RED MUD

FLY ASH

Polymeric Solution

Pellets

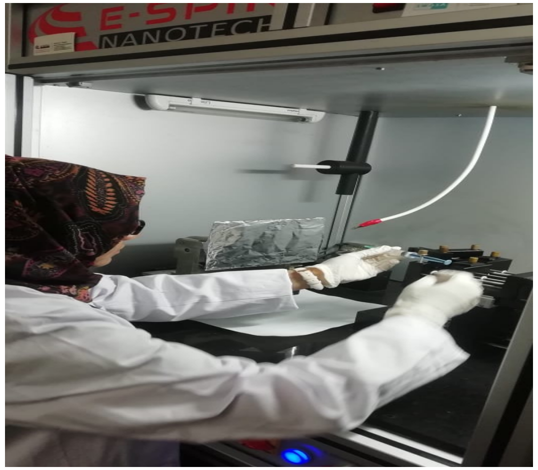
Fiber mat



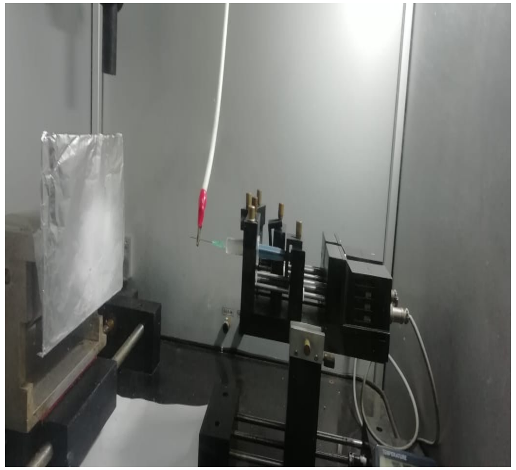
Electrospining Process

To prepare cost-effective adsorbent and fibrous mat from two types of fly ash industrial waste, bituminous coal and Lignite coal.(In Process)

Polymeric Solution



Electrospinning



Inject Solution

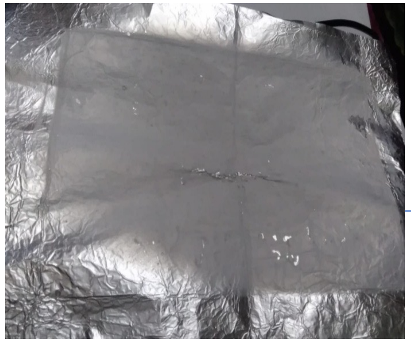
Fiber mat

Removal Mechanisms by Fly Ash Filters(My Lab Setup)-

FLY ASH

Outputs

Gaseous emissions

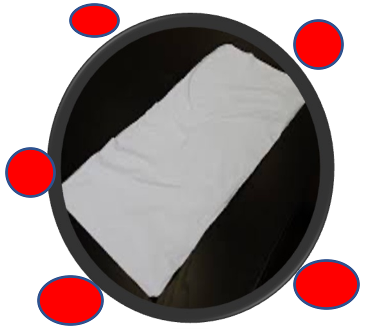


Fly ash based filter air systems

Clean Air

VOCs

SO2



NOx

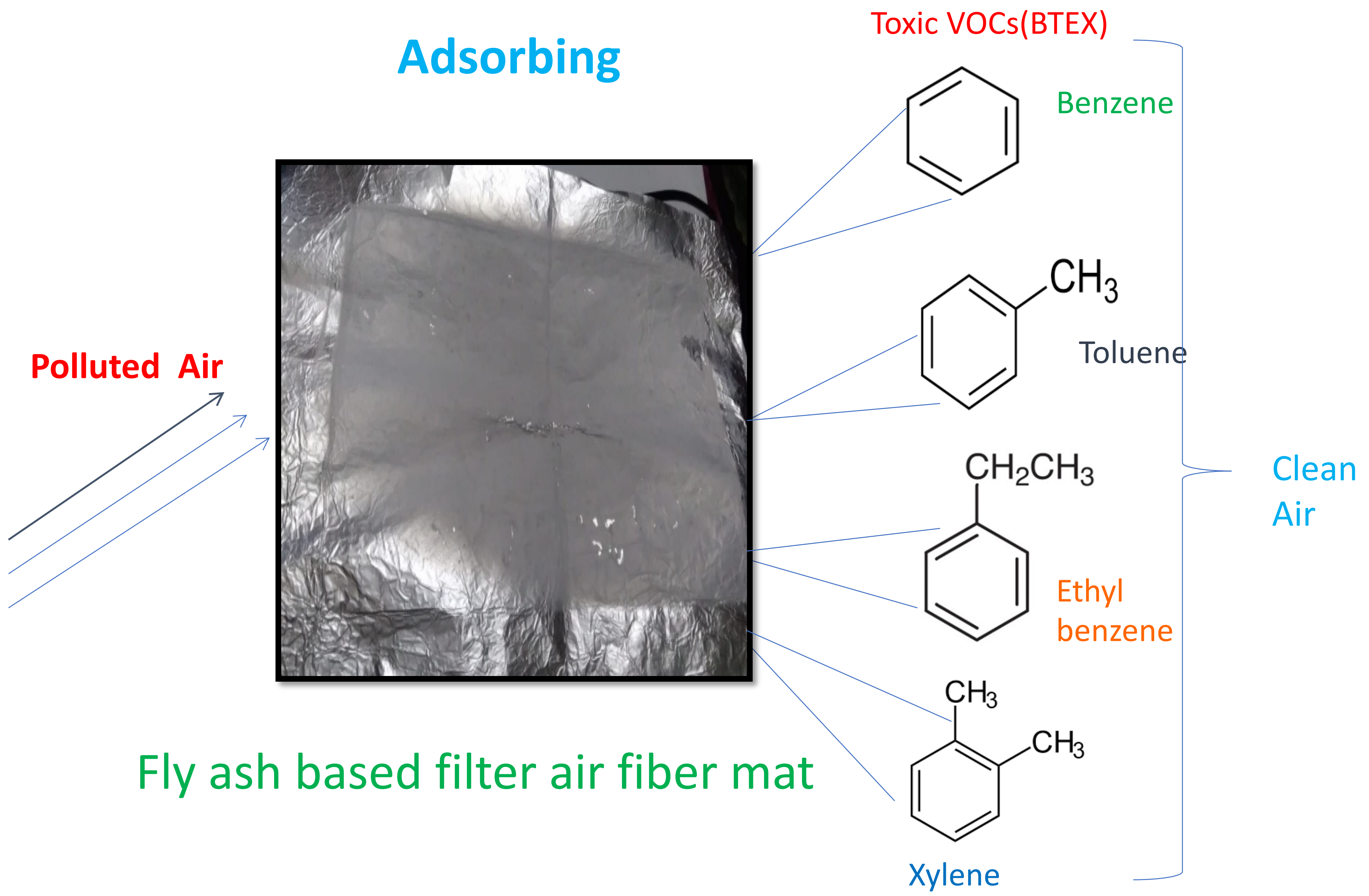
CO

CO2

Biomass/ Coal

- Economic Friendly
- Very budget friendly
- Saving life

No Study done for Chulha


Adsorbing
Toxic VOCs(BTEX)
Benzene
CH_3
Toluene
CH_2CH_3
Ethyl benzene
CH_3
CH_3
Xylene
Polluted Air
Clean Air
Fly ash based filter air fiber mat


Thank
You!

Health risk assessment modelling-

- Dermal adsorbed dose (DAD)- Dermal exposure assessment is a two-step process that considers the contact between contaminant and receptor as well as absorption of the contaminant into the body through the skin. The amount of contaminant absorbed represents what is available for interaction with target tissues or organs. The magnitude of exposure is a function of media-specific contaminant concentration, timeframe of exposure (e.g., acute, chronic), and other factors that affect dermal exposure such as skin surface area.

$$DA = Kp \times C \times t$$

Where:

DA = Absorbed dose (mg/cm2-event)

Kp = Permeability coefficient (cm/hr)

C = Concentration of chemical in vehicle contacting skin (mg/cm3)

t = Time of contact (hours/event)

❖**Chronic daily intake (CDI) –** Ingestion exposure can occur via consumption of contaminated food, water and other liquids. Food can contain chemical residues as a result.

- intentional application (e.g., pesticide use),
- deposition of particulate matter onto edible produce (e.g., from atmospheric pollutants), and/or
- biotic uptake and accumulation from contaminated soil or water (e.g., irrigation water, uptake of contaminants by fish or livestock).

Ingestion exposure can also occur via the intentional or inadvertent non-dietary ingestion of soil, dust, or chemical residues on surfaces or objects that are contacted via hand-to-mouth or object-to-mouth activity (especially for young children).

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

CW = Concentration

IR = Ingestion Rate (l/day)

EF = Exposure Frequency (days/yr)

ED = Exposure Duration (yr)

BW = Body Weight (kg)

AT = Averaging Time (period over which exposure is averaged) (days)

For noncarcinogens: AT = ED * 365 days per year and intake is called Chronic Daily Intake (CDI).

For carcinogens: AT = Lifetime (70 years) * 365 days per year and intake is called Lifetime Average Daily Dose (LADD).