

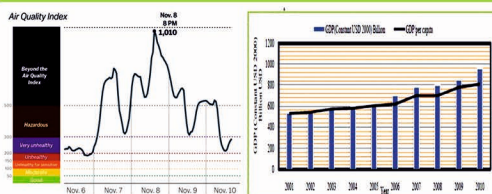
Indoor Air Quality Exploration- In Relation to Outdoor Pollution and House Characteristics in Urban Lucknow Houses

*Alfred J. Lawrence

*Department of Chemistry, Isabella Thoburn College, Lucknow, 226007, U.P., India



INTRODUCTION



- From 1978-2010, the average real rate of GDP growth is 5.8% in India
- A study published by the World Bank in 2016 revealed that air pollution cost India approximately 8% of its GDP or \$560 billion in 2013.



It is unquestionable that pollution has serious health and economic consequences

Air Pollution- A Democratizing force

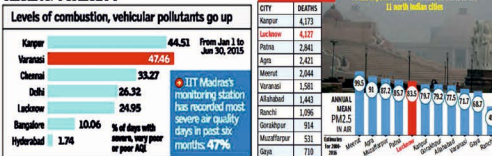


2017 State of Global Air Report

Government Initiatives

- The Union Ministry of Health & Family Welfare in 2014 constituted a Steering Committee of experts on air pollution.
- The Committee's Report outlined targeted actions to improve health outcomes.
- Pradhan Mantri Ujjwala Yojana
- Fast-tracking of newer fuel and emissions standards for vehicles.

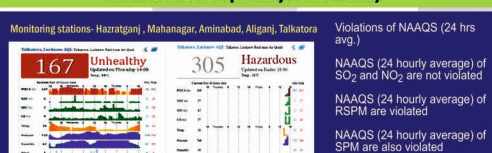
RISING TOXICITY



Material and Methods- Lucknow City

Geographical Position :	26°- 52' N Latitude 80°-56' E Longitude 128 m above Sea Level
Area :	310 sq. km.
Population :	28,15,033 as per 2011 Census
Projected Population:	45 lakhs as per Master Plan 2021
Climate :	Subtropical climate, cool dry winter (Dec. - Feb.) & summer (Mar - Jun.). Temperature about 45°C in summer to 3°C in winter. Average annual rainfall about 100 cm.
Total Vehicular Population in Lucknow city till October 2014 :	1552695
Growth of Vehicle over 2010-2011 :	8.68%
Total No. of Filling Stations : (Petrol/Diesel/CNG)	More than 100

Ambient Air quality in the city



AIR QUALITY WITH RESPECT TO SO₂, NO₂, SPM AND RSPM HAS BEEN DETERMINED IN TERMS OF LOW, MODERATE, HIGH AND CRITICAL LEVELS

Indoor Air Pollution- A direct consequence

- WHO has designated IAP as one of the **four most critical global environmental problems** in developing countries.
- According to the WHO, India accounts for **80% of the 600,000 premature deaths** occurring in south-east Asia annually due to indoor air pollution.
- Urban dwellers typically spend **90% of their time indoors**, and this has been linked to '**Sick Building Syndrome**' where dwellers exhibit a range of ill health effects related to breathing indoor air

Health impacts of exposure to air pollution

- Association between ambient air pollution and the prevalence of acute and chronic respiratory symptoms established
- Time-series analyses reported significant associations between increases in acute respiratory illness all-cause mortality and emergency visits for cardio-respiratory condition.
- Research studies published since 2010 have reported higher rates of mortality as a result of short-term exposure to PM and other pollutants.

OBJECTIVES OF THE STUDY

To present an overall indoor air quality status of Urban Lucknow city, the following objectives were designed-

- Questionnaire survey in medical colleges with respiratory patients to have an idea about impact of IAQ on respiratory health.
- Air quality was assessed through monitoring PM₁₀, PM_{2.5}, SO₂, NO₂, CO and CO₂ from November 2016- October 2017 covering summer, rainy winter seasons.
- Heavy metals (Fe, Cu, Pb, Zn, Ni, Mn and Cr) assessment associated with PM₁₀.
- Air Quality Index calculation
- Mortality rate prediction associated with inhaled particulate matter
- Establishment of a correlate between living standard and indoor air quality
- Assessment of health symptoms reported
- To study the correlation between indoor and outdoor pollutant concentrations

Methodology

Questionnaire survey with pulmonary patients in two hospitals

SGPGI

KGMU

Top 3 urban localities selected on the basis of health effects reported
Characterized under 1. Residential 2. Commercial 3. Roadside

Twelve urban houses selected for monitoring
SO₂, NO₂, CO, CO₂, PM_{2.5} and PM₁₀ (November-2016-October 2017)



Percentage distribution of patients from Urban Localities

Sampling Techniques

Contaminant	Principal	Instrument
CO	Non Dispersive Infra-Red (NDIR)	YES-205 multigas monitor, YES Environment Technologies Inc. Canada
CO ₂	Non Dispersive Infra-Red (NDIR)	YES-206 Falcon IAQ monitor, Geo Scientific Ltd., Canada
SO ₂	Improved West and Gaeke method	Impinger Technique, Handy Sampler Envirotech India
NO ₂	Jacob and Hochheiser modified (NaOH-NaAsO ₂) method	Impinger Technique, Handy Sampler Envirotech India
PM _{2.5} and PM ₁₀	Gravimetric	APM 550, Envirotech, India

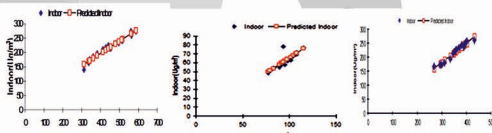
QAQC

Each instrument was calibrated before and after the end of monitoring. Instruments were positioned in the centre of the living area at a height of 1-1.5m above the ground to simulate breathing zone.

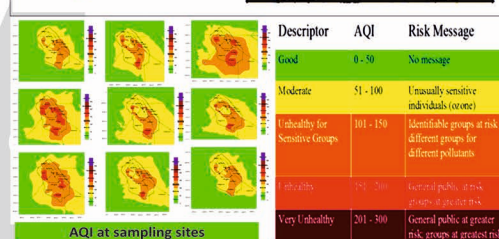
Results & Discussion

Indoor Average Concentrations (Commercial Site)

Pollutant	Summer	Rainy	Winter
CO	0.126±0.05	0.048±0.056	0.246±0.193
CO ₂	387±17.94	375±11.74	450±67.5
SO ₂	0.01224±0.004	0.027±0.015	0.030±0.006
NO ₂	0.0476±0.032	0.046±0.034	0.0163±0.004
PM ₁₀	172±18.56	95±26.82	287±36
PM _{2.5}	87±12	60±7	139±12

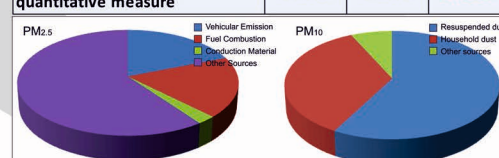


Positive correlation (71% (R²=0.714848), 96% (R²=0.960252) and 94% (R²=0.94642) indoor variation at residential commercial and roadside microenvironment was due to outdoors



Air Quality Index

Method	Summer	Rainy	Winter
Tiwari & Ali	524.2	311.8	642.6
Oak Ridge National Laboratory (ORNL), USA	341.1	199.9	412.1
Combined qualitative and quantitative measure	5.4513	3.1376	6.5615



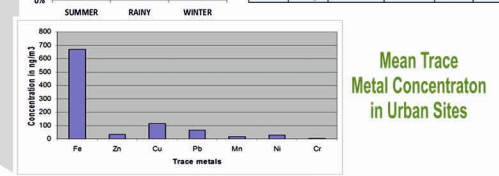
Source distribution of particle constituent at roadside microenvironment for PM showing high infiltration from outdoor as the major source

Probable exposure rate of PM₁₀ and trace metals and health risk in children and adult people of Lucknow city.

Pollutant/Metals	Concentration	Adults (70Kg) Intake ug/day	Children Intake ug/day	Standards
PM ₁₀	159 ug/m ³	3180	954	Adult=1000ug/day Child=300ug/day
Fe	669.08 ng/m ³	13.3	4.01	Calculation based on WHO indoor limits.
Zn	31.93 ng/m ³	0.64	0.19	---
Cu	113.16 ng/m ³	2.26	0.68	---
Pb	65.9 ng/m ³	1.3	0.39	****Intermediate-duration oral MRL (14-365 days) = 0.1 ug/(kg.day)
Mn	14.4 ng/m ³	0.29	0.086	***Tolerable daily intakes = 7.14 and 3.57 ug/(kg.d) for adults & children respectively
Ni	26.83 ng/m ³	0.54	0.16	***RfD for chronic inhalation and oral exposure = 0.014 and 10 ug/(kg.day) for adults & children respectively
Cr	3.3 ng/m ³	0.066	0.019	**RfD for chronic oral exposure=20 ug/(kg.day)

Worst Air Quality Index was found in Commercial Area during winters

Health Impact		Mortality Rate Prediction				
Category	Season	PM ₁₀ (µg/m ³)	WHO indoor limits(µg/m ³)	Relative difference	Mortality (%)	
Residential	Summer	13.7	75	56.7	5.67	
	Winter	286.3	75	171.3	17.1	
	Rainy	118.1	75	43.1	4.3	
Commercial	Summer	259.6	75	184.6	18.4	
	Winter	426.1	75	351.1	35.1	
	Rainy	155	75	80	8	
Roadside	Summer	265.8	75	190.8	19.5	
	Winter	223	75	148	14.8	
	Rainy	154.6	75	79.6	7.9	



Comparison of indoor PM₁₀ and PM_{2.5} with ITR ambient data at the sites of monitoring in different seasons

Conclusion

- Poor AQI values reported from roadside and commercial areas
- High particulate concentration was obtained indoors which was correlated primarily to outdoor sources.
- Highest mortality rate (35%) associated with PM was obtained from commercial area during winters.
- Poor health outcomes were linked with IAP
- Fe was the most abundant metal found indoors
- People were largely unaware about the gruesome effects of indoor air pollution.
- The study recommends public awareness programs, improved ventilation practices and immediate government initiatives to tackle the problem.
- Coordination between scientific bodies and administration for policy implementation

Acknowledgements

The author greatly acknowledges the University Grant Commission, New Delhi for the financial help and Dr. (Mrs.) V. Prakash, Principal, Isabella Thoburn College, Lucknow for her support.