Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 7 ~ Issue 1 (2021) pp: 90-95
ISSN(Online): 2348-2532
www.questjournals.org

Research Paper

Assessment of Indoor NO_2 Level in the Restaurants Located at Different Sites of Jammu City

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ABSTRACT: *The indoor air quality in terms of NO_2 levels was investigated in the restaurants located at different sites- on/near Highways, crossings, commercial and residential areas of Jammu City. The sampling of air for determination of NO_2 was done at each sub-site during the one-year study period. The study period was comprised of three seasons i.e. Rainy, Winter, and Summer. The sampling was done for a period of six hours using Handy Air Sampler Envirotech APM 821 within the range of 1.0-2.0 l/min. The results indicated that the Non-AC restaurants located at the Highway recorded the highest level of indoor NO_2 in the range of 38.87 $\mu g\ m^{-3}$ to 42.34 $\mu g\ m^{-3}$ with an average of 40.51±1.74 $\mu g\ m^{-3}$ during winter season whereas the lowest levels were observed in the AC restaurants located in the residential areas ranging from 5.96 $\mu g\ m^{-3}$ to 6.95 $\mu g\ m^{-3}$ with an average value of 6.41±0.49 $\mu g\ m^{-3}$ during the rainy season.*

KEYWORDS: *Environment, Air Pollution, Indoor Air Quality, NO_2.*

Received 01 Jan, 2021; Revised: 10 Jan, 2021; Accepted 12 Jan, 2021 © The author(s) 2021.
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I. INTRODUCTION

This Poor Indoor air quality (IAQ) is an important public health risk' worldwide. Indoor air pollution is the presence of one or more contaminants indoors that carry certain degree of threat. Prior to the 1970s, problems with Indoor air quality in residences and non-industrial workplaces were occasionally investigated but the level of interest in studying such problems was practically low but, in recent decades, emphasis has been given to the Quality of indoor air and has drawn attention by the researchers and governments (Abdul-Wahab et al., 2015).

The researches have established that most urban dwellers spend 16 hours a day and as much as more than 90 per cent of their time indoors (Kumar et al., 2005). Poor IAQ has been found to be particularly hazardous to children, the elderly, or those suffering from chronic respiratory and/or cardiovascular diseases (Cincinelli and Martellini, 2017). For that reason, in a society, the public health issues associated with Indoor air pollution are required to be studied and focused upon with urgency so that some resolutions could be catered to eliminate certain problems.

Spengler and Sexton (1983) emphasized that the "problems with indoor air were unquestionably much more apparent than they are today. Soot found on the ceilings of prehistoric caves provides ample evidence of high levels of pollution that was associated with inadequate ventilation of open fires". In addition, a comprehensive presentation of the history of understanding the health risks of indoor air is given by Sundell (2004). He argues that the quality of the environment within buildings is a topic of major importance for public health. The researches have established that most city dwellers spend 16 hours a day and as much as more than 90 per cent of their time indoors (Kumar et al., 2005). The principal factors responsible for poor indoor air quality are insufficient ventilation, contamination from inside as well as outside the building and microbiological contamination. Poor IAQ may cause workers, occupants and even the visiting public to experience a range of nonspecific symptoms that affect their comfort or health (Sundell, 2008). Workers in polluted atmosphere are supposed to be subjected to severe fatigue than the workers in normal environment.

There is an urgent need to improve the indoor air quality for better health. So, an attempt has been made to assess the indoor NO_2 levels in the restaurants of Jammu City. This preliminary study can serve as a basis for improving the conditions in these facilities. "Good indoor air quality in restaurants is essential for ensuring healthy and comfortable workplace environment and protecting the health of restaurant personnel and visiting customers from exposure to harmful air pollutants", El-Sharkawy and Javed, 2018.

The main outdoor source of nitrogen dioxide is the vehicular traffic whereas The maximum contribution from indoor sources include tobacco smoke and gas, wood, oil, kerosene and coal-burning appliances such as stoves, ovens, space and water heaters and fireplaces, particularly unflued or poorly maintained appliances. "Outdoor nitrogen dioxide from natural and anthropogenic sources also influences indoor levels", Jarvis et al. 2010.

Arbex et al. (2007) studied the relation between indoor NO_2 pollution and lung function of professional cooks and observed adverse effect of gas stove exposure on lung function. Nitrogen dioxide can irritate mucous membranes in the eyes, nose and throat and cause shortness of breath after exposure to high concentrations. People at particular risk from exposure to nitrogen dioxide include children and individuals with asthma and other respiratory diseases.

The International Society of Indoor Air Quality and Climate (ISIAQ) has been founded to support the creation of healthy, productive, and comfortable indoor environments (http://www.isiaq.org/). Several countries in the world have developed standards for air quality which they strive to attain by adopting suitable air pollution control measures. In India, National Ambient Air Quality Standards for major pollutants were notified by Central Pollution Control Board (CPCB) in November 2009 (www.cpcb.nic.in) (Table I).

Table I: National Ambient Air Quality Standards

Pollutant ($\mu g\ m^{-3}$)	**Time weighted Average**	**Industrial Area, Residential, Rural and other areas**	**Ecologically Sensitive Area (notified by central government)**
Sulphur dioxide (SO2)	*Annual **24-h	50 80	20 80
Nitrogen dioxide (NO2)	*Annual **24-h	40 80	30 80
Particulate matter (size less than 10 µm or PM_{10})	*Annual **24-h	60 100	60 100
Particulate matter (size less than 2.5 µm or $PM_{2.5}$)	*Annual **24-h	40 60	40 60

*Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

To prevent the illnesses resulting from indoor air pollution it is also necessary to educate the public, administrators and politicians to ensure their commitment for the improvement of public health and make strategies in accordance with the assessment.

II. STUDY AREA AND SITES

The present study was aimed at assessing seasonal variations in indoor levels of NO_2 in the restaurants located at different sites of Jammu City. Jammu is one of the fastest growing cities of India with a population of 15.264 lac with a total area of 3097 sq. Km at an elevation of 1,073 feet above the sea level. It is located between $74^o18'$ East longitude and $32^o50'$ and $33^o30'$ North latitude. Jammu lies on NH-1A and is situated on the bank of river Tawi. District Jammu falls in sub-mountainous region at the foothills of the Himalayas.

The study sites were the restaurants both AC and Non-AC located at/near the Highway, Crossings, in Commercial area and in Residential area.

Site SI Restaurants located in the Study Area
- **Site SIa** Restaurants located at/near Highway
  - **Subsite SIa (i)** AC Restaurant located at/near Highway
  - **Subsite SIa (ii)** Non-AC Restaurant located at/near Highway
- **Site SIb** Restaurants located near Crossing
  - **Subsite SIb (i)** AC Restaurant located near Crossing
  - **Subsite SIb (ii)** Non-AC Restaurant located near Crossing
- **Site SIc** Restaurants located in Commercial Area
  - **Subsite SIc (i)** AC Restaurant located in Commercial Area
  - **Subsite SIc (ii)** Non-AC Restaurant located in Commercial Area
- **Site SId** Restaurants located in Residential Area
  - **Subsite SId (i)** AC Restaurant located in Residential Area
  - **Subsite SId(ii)** Non-AC Restaurant located in Residential Area

III. COLLECTION OF SAMPLES

The sampling of air for determination of NO_2 was done at each sub-site during the one-year study period. The study period was comprised of three seasons i.e. Rainy, Winter, and Summer. The sampling was done for a period of six hours using Handy Air Sampler Envirotech APM 821 within the range of 1.0-2.0 l/min.

The sampling of air was done with the help of a Handy Air Sampler APM 821 having glass Impingers and rubber tubings. Air was made to flow through the glass impinger, holding 15 ml of sodium hydroxide as absorbing medium for nitrogen dioxide. In this process nitrogen dioxide from the air stream was absorbed in sodium hydroxide solution to form stable sodium nitrite. Interference from SO_2 was eliminated by converting any sulphur dioxide to sulphate by addition of hydrogen peroxide. After the sampling of nitrogen dioxide samples were brought to the laboratory for analysis. Analysis was done as per standard methods suggested by CPCB by using Spectrophotometer.

IV. CHEMICAL ANALYSIS

Materials Used:

a) Glassware: Conical flasks, Beakers, Pipettes, Burette, Burette stand, Reagent bottles (both transparent and dark coloured), Measuring Cylinders, Stirrer, Washing bottles, Glass funnels, and Cuvits.

b) Instruments: SPECTROPHOTOMETER: UV – VIS Double Beam Spectrophotometer – 2101 (Systronics).

c) Chemicals Used for NO_2: Sodium hydroxide, Sulphanilamide, Concentrated phosphoric acid, N(1-napthyl), Ethylenediamine dihydro-chloride (NEDA), 30% Hydrogen peroxide and Sodium nitrite (assay of 97% or above).

Calculation of NO_2 in Sampled Air:

Replaced any water lost by evaporation during sampling. A 10ml of the collected sample was pipetted into a test tube. 1.0 ml of hydrogen peroxide solution, 10.0 of sulphanilamide solution and 1.4 ml of NEDA solution was added with thorough mixing after adding the reagent. A blank was prepared in the same manner using 10ml of absorbing reagent. After 10 minutes of colour development interval, the absorbance was measured at 540 mm against the blank. The nitrogen dioxide (µg) per ml was read from the standard curve and finally NO_2 was calculated by using formula:

$$\mathbf{NO_2\ (\mu g/m^3) = \frac{NO_2\ (\mu g/ml) \times A \times 10^3}{V \times 0.82}}$$

Where, A = Absorbing medium taken for sampling

0.82 = Overall Average Efficiency

and $$V = \frac{F_1+F_2}{2} \times T$$

Where, V = Volume of air passed through absorbing reagent in litre

F_1 = Initial flow rate before sampling in 1pm

F_2 = Final flow rate after sampling in 1pm

T = Time of sampling in minutes

V. OBSERVATIONS

Table II represents the study data and followed by the following observations:

a Indoor NO_2 level in the Restaurants located at Highway of Jammu City.

a(i) Indoor NO_2 level in the Air Conditioned Restaurants located at Highway of Jammu City.

The AC Restaurants located at Highway of Jammu City exhibited indoor NO_2 in the range of 11.34 µg m^{-3} to 12.74 µg m^{-3} with an average value of 12.15±0.72 µg m^{-3} during rainy season
whereas, during winter season, it varied from 16.56 µg m^{-3} to 17.35 µg m^{-3} with an average value of 16.83±0.44 µg m^{-3}. The summer season exhibited indoor NO_2 in the range of 10.59 µg m^{-3} to 13.29 µg m^{-3} with an average value of 11.82±1.36 µg m^{-3}

a(ii) Indoor NO_2 level in the Non Air Conditioned Restaurants located at Highway of Jammu City.

The indoor NO_2 during rainy season varied from 19.59 µg m^{-3} to 24.26 µg m^{-3} with an average value of 21.71±2.36 µg m^{-3}, the winter season recorded indoor NO_2 in the range of 38.87 µg m^{-3} to 42.34 µg m^{-3} with an average of 40.51±1.74 µg m^{-3} and in summer, it was found to be in the range of 34.34 µg m^{-3} to 38.10 µg m^{-3} with an average of 36.34±1.89 µg m^{-3}

b Indoor NO_2 level in the Restaurants located at Crossings of Jammu City.

b(i) Indoor NO_2 level in the Air Conditioned Restaurants located at Crossings of Jammu City.

The indoor NO_2 during rainy season was observed to be in the range of 14.34 μg m^{-3} to 15.54 μg m^{-3} with an average of 14.82±0.63 μg m^{-3}, the winter season recorded indoor NO_2 in the range of 18.39 μg m^{-3} to 19.43 μg m^{-3} with an average of 18.80±0.55 μg m^{-3} and the summer season exhibited values in the range of 15.58 μg m^{-3} to 16.70 μg m^{-3} with an average of 16.17±0.56 μg m^{-3}

b(ii) Indoor NO_2 level in the Non Air Conditioned Restaurants located at Crossings of Jammu City.

The Non-AC Restaurants located at Crossings of Jammu City exhibited indoor NO_2 in the range of 17.59 μg m^{-3} to 21.17 μg m^{-3} with an average value of 19.03±1.88 μg m^{-3} during rainy season, winter season varied from 21.75 μg m^{-3} to 23.58 μg m^{-3} with an average value of 22.46±0.98 μg m^{-3} whereas the summer season exhibited indoor NO_2 in the range of 20.20 μg m^{-3} to 21.59 μg m^{-3} with an average value of 21.05±0.74 μg m^{-3}

Table II: Seasonal variations in Indoor NO_2 level μg m^{-3} in Restaurants at different sites (Site SI)

Sites		Indoor NO_2 μg m^{-3} during three seasons of the study period		
		Rainy Season	Winter Season	Summer Season
SIa	SIa (i)	12.15±0.72 (11.34-12.74)	16.83±0.44 (16.56-17.35)	11.82±1.36 (10.59-13.29)
	SIa (ii)	21.71±2.36 (19.59-24.26)	40.51±1.74 (38.87-42.34)	36.34±1.89 (34.34-38.10)
SIb	SIb (i)	14.82±0.63 (14.34-15.54)	18.80±0.55 (18.39-19.43)	16.17±0.56 (15.58-16.70)
	SIb (ii)	19.03±1.88 (17.59-21.17)	22.46±0.98 (21.75-23.58)	21.05±0.74 (20.20-21.59)
SIc	SIc (i)	12.12±0.54 (11.53-12.59)	15.28±0.59 (14.82-15.95)	13.07±0.68 (12.29-13.58)
	SIc (ii)	21.85±3.10 (19.58-25.40)	29.83±1.97 (27.59-31.33)	32.34±1.65 (30.58-33.87)
SId	SId (i)	6.41±0.49 (5.96-6.95)	9.95±0.86 (9.43-10.95)	8.33±0.65 (7.58-8.82)
	SId (ii)	9.83±0.65 (9.34-10.58)	12.40±0.83 (11.58-13.24)	7.56±0.80 (6.77-8.39)

SIa (i) – AC Restaurants located at/near Highway
SIa (ii) – Non-AC Restaurants located at/near Highway
SIb (i) – AC Restaurants located at/near Crossing
SIb (ii) – Non-AC Restaurants located at/near Crossing
SIc (i) – AC Restaurants located in Commercial area
SIc (ii) – Non-AC Restaurants located in Commercial area
SId (i) – AC Restaurants located in Residential area
SId (ii) – Non-AC Restaurants located in Residential area

c Indoor NO_2 level in the Restaurants located in the Commercial Areas of Jammu City.

c(i) Indoor NO_2 level in the Air Conditioned Restaurants located in the Commercial Areas of Jammu City.

The indoor NO_2 during the rainy season varied from 11.53 μg m^{-3} to 12.59 μg m^{-3} with an average value of 12.12±0.54 μg m^{-3}, winter season exhibited indoor NO_2 in the range of 14.82 μg m^{-3} to 15.95 μg m^{-3} with an average of 15.28±0.59 μg m^{-3}, while the summer season exhibited indoor NO_2 in the range of 12.29 μg m^{-3} to 13.58 μg m^{-3} with an average of 13.07±0.68 μg m^{-3}

c(ii) Indoor NO_2 level in the Non Air Conditioned Restaurants located in the Commercial Areas of Jammu City.

During the rainy season, indoor NO_2 in the Non-AC restaurants located in the commercial areas of Jammu City was found to vary from 19.58 μg m^{-3} to 25.40 μg m^{-3} with an average of 21.85±3.10 μg m^{-3}, in winter season, it was observed to be in the range of 27.59 μg m^{-3} to 31.33 μg m^{-3} with an average of 29.83±1.97 μg m^{-3} and the summer season recorded indoor NO_2 in the range of 30.58 μg m^{-3} to 33.87 μg m^{-3} with an average of 32.34±1.65 μg m^{-3}

d Indoor NO_2 level in the Restaurants located in the Residential Areas of Jammu City.

d(i) Indoor NO_2 level in the Air Conditioned Restaurants located in the Residential Areas of Jammu City.

The indoor NO_2 during rainy season varied from 5.96 μg m^{-3} to 6.95 μg m^{-3} with an average value of 6.41±0.49 μg m^{-3}, the winter season exhibited indoor NO_2 in the range of 9.43 μg m^{-3} to 10.95 μg m^{-3} with an average value of 9.95±0.86 μg m^{-3}, whereas the indoor NO_2 was observed to be in the range of 7.58 μg m^{-3} to 8.82 μg m^{-3} with an average value of 8.33±0.65 μg m^{-3} in the summer season.

d(ii) Indoor NO_2 level in the Non Air Conditioned Restaurants located in the Residential Areas of Jammu City.

The Non-AC Restaurants located in the residential areas of Jammu City exhibited indoor NO_2 in the range of 9.34 µg m^{-3} to 10.58 µg m^{-3} with an average value of 9.83±0.65 µg m^{-3} during rainy season, the winter season levels varied from 11.58 µg m^{-3} to 13.24 µg m^{-3} with an average value of 12.40±0.83 µg m^{-3} while the indoor NO_2 was observed to be in the range of 6.77 µg m^{-3} to 8.39 µg m^{-3} with an average value of 7.56±0.80 µg m^{-3} in the summer season.

Nitrogen dioxide is the most widely studied indoor air pollutant (Chauhan, 1999), which can be formed during high temperature combustion processes (Brunekreef, 2001). Melia et al., 1990 reported that the existence of a gas cooker was associated with significant increases in the levels of NO_2 and Dennekamp et al., (2001) has also reported that very high concentrations of oxides of nitrogen may also be produced by gas cooking.

VI. CONCLUSION

The study results have shown a pattern of increased NO_2 indoor levels during winter months in all the restaurants irrespective of their location in the study area. It suggests that apart from outdoor air and meteorological conditions, various other aspects like indoor activities, duration of human occupancy and insufficient ventilation effect indoor air quality during the winter (Baek et al., 1997). The results further indicated that the Non-AC restaurants located at the Highway recorded the highest level of indoor NO_2 in the range of 38.87 µg m^{-3} to 42.34 µg m^{-3} with an average of 40.51±1.74 µg m^{-3} during winter season whereas the lowest levels were observed in the AC restaurants located in the residential areas ranging from 5.96 µg m^{-3} to 6.95 µg m^{-3} with an average value of 6.41±0.49 µg m^{-3} during the rainy season. Education and awareness regarding poor indoor air quality and the associated health risks should be imparted to the general public. Measures like maintenance of combustion appliances and appropriate ventilation in the cooking area of the restaurants can aid in improving the indoor air quality.

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