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Correlation between Determinants of Indoor Air Quality and Respiratory Diseases In Lucknow City

Kaneez e Ibrahim

Department of Geography, Burhani College of Commerce and arts, India

ABSTRACT: It refers to the physical, chemical, and biological characteristics of air in the indoor environment within a home, building, or an institution or commercial facility. Indoor air pollution is a concern in the developed countries, where energy efficiency improvements sometimes make houses relatively airtight, reducing ventilation and raising pollutant levels. Indoor air problems can be subtle and do not always produce easily recognized impacts on health. Different conditions are responsible for indoor air pollution in the rural areas and the urban areas. For the analysis of the determinant of indoor air pollution and health impact some independent and dependent variables have been selected to examine the relationship between them. Standard statistical techniques with empirical observation have been used to analyze the degree of relations between dependent and independent variables. The analysis reveals positive correlation with varying degree of association. Among all the variable, it is discerned that the intensity of pollution is more pronounced in peripheral, industrial and central i.e. old part of the city .It is attributed to the high consumption of bio fuel by the slum dwellers, low living spacing, ill ventilation, smoke remain inside the houses as well as poor exit capacity of smoke from inside the house. To reduce the level of indoor air pollution and health impact suggestions and recommendations have been made for healthy living.

KEY WORDS: pollution, pollutant, respiratory, allergens, composite z-score, coefficient of correlation, bio fuel, Conjunctivitis, Rhinitis, Asthma.

I. DISCUSSION

It is general belief that air pollution is associated with the concentration of urban air from automobile exhaust and industrial effluent. However in developing countries, the problems of indoor air pollution is far out of weights, the ambient air pollution, and the indoor environment of houses often has a higher level of air pollution than the surrounding one in cities and towns.Unfortunately, indoor pollution has not been given much importance, while most people spent as much as 80-90 per cent of their time indoor.[1] In India, burning of unprocessed cooking fuels in home causes pollution, domestic cooking is one of the major activities of the average Indian house wife.

In view of the phenomenal change that is taking place in the cities and their environment. It is proposed to study the existing indoor air pollution in Lucknow city. Many scholars have studied on indoor air pollution in different cities of India pertaining to different attributes like, Armstrong (1991)[8], A.L. Singh and A. Rahman (1998)[9], Jayati Hazra (2000)[10], Mukesk and Gupta (2000)[11], Das Jayati (2004)[12], M. Haq (2006)[13], Ajay Taneja (2008)[14]. etc But no one has focused in a holistic view regarding the causes and consequences of indoor air pollutions in intensive manner, and proposed a diagnostic mechanism to reduce the level and its effects on health. The Present study is unique and different from aforesaid studies in the sense that it has analysed and evaluated the causes and consequences of indoor air pollution in holistic manner through spatio-temporal analysis and proposed a diagnostic approach to reduce the menace of indoor air pollutions affecting human health. For the present analysis the city has been divided into different zones and different sites have been marked out for collecting primary data through experiments and empirical observations.

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The independent variables of indoor air pollution includes, per head living space availability (x_1), non ventilated or ill ventilated house (x_2), biofuel (coal, wood, leaves, dust, cow dung), (x_3) Multiuse room House (x_4), kerosene as a fuel (x_5), smoking in house (x_6), smoke come from out side (x_7), smoke remain inside the house (x_8). The dependent variable pertaining to health includes diseases Conjunctivitis (y_1) Rhinitis (y_2), Sore throat (y_3), Allergy (y_4), Asthma (y_5), Bronchitis (y_6), Tuberculosis (y_7) and Pneumonia (y_8).

II. OBJECTIVES

The objective of the present analysis is to examine the correlation between determinants of indoor air pollution and diseases, and recommendations have been made to reduce the impact of indoor air pollution on health.

III. DATA BASE AND METHODOLOGY

To establish the relationship between indoor air pollution variables and the diseases, primary data have been generated through conducting field survey taking one per cent household from each wards of the city, i.e. 110 wards. The numbers of households are varied from wards towards depending upon their size. Therefore the number of house are selected variedly from each wards, thus the total number of houses have been selected based on purposive random sampling i.e. 3000 houses out of 298767 residential and residential cum commercial houses. Detailed questionnaire has been prepared for obtaining the information from the respondent. Different age group, men and women have been interviewed, basically children working women in the kitchen and old people, who spends their maximum time in their home. During the course of survey, affected and non affected people were interviewed. These information have been supplemented with the information regarding disease affected people, are taken from nearest private nursing home, govt. hospitals and medical colleges. The information obtained from primary sources has been organized, categorized, analyzed through standard statistical techniques i.e. correlation, regression, t- test in order to find out the level of significance of different variables related with different diseases. Moreover, the intensity of indoor air pollution and diseases have been analyzed using composite z-score besides pictorial presentation of analyzed data has been exhibited in the form of graphs, diagrams and maps using GIS techniques.

IV. STUDY AREA

Lucknow city formed the central part of the province of *Oudh* and capital of Uttar Pradesh occupies central position of the district. It is situated along both side of the river Gomti- a tributary of the river Ganga.

It lies in between $26^{o}30'$ to 27^{o} $10'$ North latitude an $80^{o}30'$ to 81^{o} $13'$ East longitude. It covers an area of 2544 sq. km and the area of city is 310.104 sq km excluding cantonment area. It has 2.207 million populations with the density of 7120.25 persons per sq. km. It is surrounded by the districts Sitapur in the North, Barabanki in the East, Raibareli in the South, Hardoi in the North West and Unnao in the South West.

Administratively the whole city has been divided into six zones. Each zone is divided into wards and ward is further divided into *mohallas*. Thus there are 6 zones and 110 wards in the study area.

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V. CORRELATION BETWEEN INDOOR AIR POLLUTION AND INCIDENCE OF RESPIRATORY DISEASES

To examine the causal association between the indoor air pollution and associated respiratory diseases, karl pearson,s technique of coefficient of correlation has been adopted the significance of their correlation has been tested with student 't' test technique 108 degree of freedom.

Table 1: Correlation (r)between indoor Air pollution and Occurrence of diseases

Table 1exhibit that all the variables of indoor air pollution are positively correlated to probable diseases. Their correlation is significant at 1 per cent level with exception of association between the independent variable per head living space availability and dependent variable tuberculosis, multipurpose room and tuberculosis and smoke come from outside and conjunctivitis which arte significant at 2 per cent level. It may be asserted from the analysis that the diseases which have been taken under study are4 supposed to be the consequences of indoor air pollution and former is increases as much as with the increase of indoor air pollution.

But it is important to note that though their relationship is significant at 1 per cent and 2 percent level, they arte correlated with varying degree of r value. It is observed that same correlations are significant at 1 per cent level. Though with very low degree of r value of unit of study (108 degree of freedom).

Causal factors (Indoor pollution) which highly affect diseases with value of correlation more than 60 per cent.

For the better clarification and convenience of study to understand the impact of indoor air pollution on occurrence of diseases at varying degree, they are grouped in to four categories on the basis of percentage of correlation (i.e. < 20 per cent, 20 per cent – 40 percent, 41 per cent – 60 percent, > 60 per cent)

Table 2 exhibited that the variable per head living space availability to the diseases rhinitis, sore throat, allergy, asthma, bronchitis and tuberculosis with r value 20- 40 per cent. However; it is correlated with rvalue 41-60 percent to the diseases conjunctivitis and pneumonia. Again it is observed that no one disease is neither very highly correlated nor very poorly with r value more than 60 per cent and less than 20 per cent.As far as the variable non ventilated houses are concerned, it is correlated to the diseases tuber culosis (r= 0.47) which fall under the category of rvalue ranging from 41-60 per cent, correlation of the diseases conjunctivitis, rhinitis, sore throat, allergy, asthma, bronchitis, pneumonia with r value more

Factors	Per Head Living Space Availability	Non ventilated Houses	multi porpuse room	(wood/coal/ saw/dust dung/cake/ dry leaves)	kerocien e/electric ity	smoki ng	smoke come from out side	Smoke Remains inside the rooms/house
Diseases								
Conjuncti vitis	0.41*	0.71*	0.35*	0.67*	0.46*	0.70*	0.26**	0.36*
Rhinitis	0.38*	0.85*	0.44*	0.80*	0.64*	0.86*	0.27*	0.38*
Sore throat	0.39*	0.85*	0.38*	0.77*	0.70*	0.85*	0.28*	0.41*
Allergy	0.32*	0.77*	0.41*	0.69*	0.58*	0.75*	0.46*	0.44*
Asthma	0.28*	0.86*	0.32*	0.72*	0.62*	0.80*	0.35*	0.27*
Bronchiti s	0.34*	0.74*	0.29*	0.61*	0.63*	0.72*	0.41*	0.42*
Tubercul osis	0.26**	0.47*	0.25**	0.49*	0.54*	0.53*	0.44*	0.44*
Pneumon ia	0.41*	0.73*	0.34*	0.63*	0.58*	0.79*	0.34*	0.41*

Source: Computed by researcher

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than 60 per cent.Same as the variable per head living space availability, multipurpose room is neither highly (more than 60 per cent) nor poorly (less than 20 per cent) correlated to any
diseases with r value ranging between 20-40 per cent, it is associated with the diseases conjunctivitis, sore throat, asthma, bronchitis and tuberculosis. The diseases like allergy and rhinitis are correlated with multipurpose room with r value ranging 41-60 per cent.

Table 2: degree of relationship between indoor air pollution and associated diseases
Source: Computed by Researcher

Again the table 2 reveals same association between biofuel and diseases as between non ventilated houses and diseases.

Value of correlation	**Per Head living space Availability**	**Non ventilated houses**	**Multi-purpose room**	**Bio-fuel**	**Kerosene/ electricity**	**Smoking in house**	**Smoke coming from outside**	**Smoke remain inside**
< 20	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
20-40	Rhinitis, Sore throat, Allergy, Asthma, Bronchitis, Tuberculosis	Nil	Sore throat, Asthma, BronchitisTuberculosis, Conjunctivitis and pneumonia	Nil	Nil	Nil	Rhinitis, Sore throat, Asthma, Conjunctivitis and pneumonia	Rhinitis, ConjunctivitiAsthma
41-60	Conjunctivitis and pneumonia.	Tuberculosis	Rhinitis, Allergy	Tuberculosis	Tuberculosis, Conjunctivitis Allergy and Pneumonia.	Tuberculosis	Allergy, Bronchitis, Tuberculosis	Tuberculosis, Sore throat, Bronchitis Allergy and pneumonia.
> 60	Nil	Rhinitis, Sore throat, Allergy, Asthma, Bronchitis,	Nil	Rhinitis, Allergy Sore throat, Asthma, Bronchitis, Conjunctivitis and pneumonia	Rhinitis,Sore throat, Asthma, Bronchitis,	Rhinitis, Sore throat, Asthma, Bronchitis Conjunctivitis Allergy and Pneumonia.	Nil	Nil

bio fuel is positively correlated to tuberculosis (r = 0.49 per cent), but it is correlated to rest of the diseases with r value

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more than 60 percent. Highest degree of correlation of it, is observed with the diseases rhinitis (r= 0.80). The positive association is observed between electricity and use of kerosene as cooking fuel and diseases like conjunctivitis, allergy, tuberculosis and pneumonia with r value ranging between 41-60 per cent. However it is correlated to rhinitis, sore throat, asthma and bronchitis with r value more than 60 percent. No one disease correlated with this factor neither to less than 20 percent and nor is 20 – 40 per cent. Same as non ventilated houses and bio fuel, the variable smoking in house is correlated to diseases tuberculosis (r= 0.53), while correlated to rest of the diseases with higher degree ofcorrelation more than 60 per cent. The highest of degree of correlation is observed with the disease rhinitis (r= 0.86 per cent). It also observed that not any disease poorly correlated with this independent variable i.e. less than 20 percent and again it observed that no one disease correlated with this factor r value 20-40 per cent. Variable smoke come from outside is correlated to the diseases of conjunctivitis, rhinitis, sore throat, asthma, and pneumonia with r value ranging between 20 -40 per cent however, it is associated with the diseases tuberculosis, bronchitis, and allergy with value of correlation ranging between 41-60 per cent. But the variable neither poorly nor strongly correlated to the diseases with lower or higher percentage of r value though they are significant they are significant at 1 per cent level except r value of 0.26 (smoke from outside vs conjunctivitis). Again, the variable smoke remains inside the house shows moderate correlation with the associated diseases with r value 20-60 per cent. Three diseases i.e, conjunctivitis, rhinitis and asthma are positively correlated to the dependent variable with r value ranging between 20-40 per cent. However, it is related to rest diseases with r value ranging between 41-60 per cent, are sore throat, allergy, bronchitis, tuberculosis and pneumonia. (Table 2)

VI. INTENSITY OF INDOOR AIR POLLUTION

The spatial analysis of intensity of indoor air pollution based on z- score clearly revels that under very high category of intensity indoor air pollution comes in between 0.43 to 1.12 holds 19.09 per cent wards of the city (table 3) consisiting of 21 wards such as Balakganj, Mallahitola, Daulatganj, Faizullahganj, Bazarkaliji, Qadamrasool, Shankarpurwa, Chinhatward etc. High intensity of indoor air pollution ranges from 0.11 to 0.43 spread over in 36 wards covers 32.73 per cent wards of the city like Kanhiyamadhopur, Haiderganj, kashmirimohalla, Bhawaniganj, Sarojininagar, Aishbagh, Jalsansthan, Daliganj, Rajabazar ward ets. Moderate intensity of indoor air pollution ranging in between -0.21 to 0.11 found in 19.09 per cent wards of the city which accounts 21 wards including ward Labourolony, Ambedkarnagar, Chowk Ibrahimpur, Lalbahadurshastri, Jankipuram Indiranagaretc. Low intensity of indoor air pollution ranges -0.38 to -0.21 accounts 17.27 per cent ward of the city prevail in 19 wars. Some of the important wards like Gurugovind singh, Hardeenrai, hazratganj, Aliganj, Murlinagar, Nishatganj etc. -0.93 to -0.38 comes under very low intensity of indoor air pollution occur in 11.81 per cent wards of the city counts 13 wards including ward Rajajipuram,Vikramadiya, Rafiahmadkidwainagar, gomtinagar, Niralanagaretc.

It has been clear from the spatial analysis of intensity of indoor air pollution, are mainly found in the central part of the city and peripheral zone of the city as well as in industrial areas. The central part of the city characterized by v. high population density and also old part of the city beside it this area unplanned residential areas have the narrow lane, street and ill ventilated houses. Some areas are as congested as there is no space for fresh air to replace the intensive room air.

Peripheral zone though covered large area and has high space and houses come under middle non ventilated houses. But there in use of fuel for cooking is bio fuel like leaves cow dung, wood and wood dust they contact with long time to smoke which release from these bio fuel. All the factor responsible for the high intensity of indoor air pollution where low and v. low indoor air pollution.These areas inhabited by spacious houses and most of the gentry in these areas belong to v. high to high income group low population density and access in these areas is very easy.

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Table 3: Intensity of Indoor Air Pollution Lucknow City 2010 (Based On Z- Score)

Category	Ranges	Total wards	per cent of Total wards
Very High	0.43-1.12	21	19.09
High	0.11-0.43	36	32.73
Medium	-0.21-0.12	21	19.09
Low	-0.38-0.20	19	17.27
Very Low	-0.93-0.37	13	11.81

VII. INTENSITY OF DISEASES

It is clear reveals from the (table 4) analysis of z- score the intensity of very high intensity of diseases ranges 0.56 to 1.96 found in the 17.27 per cent wards of the city that is 19 wards such as Balakganj, Jankipuram, Bazarkaliji, Tilaknagar, Ambedkarnagar, Ganeshganj, Chimhat etc. under high intensity of diseases prone households ranges from 0.18 to 0.56 found in 33.63 per cent wards of the city that is 37 wards such as ward, Kanhiyamadhopur, Haiderganj, Garhipeerkhan, Husainabad, Aishbagh, Jalsansthan, Daliganj, shankarpurwa, Mootilalnehru etc. Under medium intensity of disease prone households ranges from -0.25 to -0.18 found in 19.09 per cent wards of the city that is 21 wards such as ward Mallahitola, Daulatganj, Chowk, Kashmirimohallah, Bhawaniganj, golaganj, ismailganjetc. Under low intensity of disease prone households ranges from -0.72 to -0.25 found in the 12.72 per cent wards of the city that is 14 wards such as ward Rajajipuram, murlinagar, Hazratganj, Nishatganj, Mahanagar etc. Under very low intensity of disease prone households ranges -1.4 to -0.72 found in the 17.27 per cent wards of the city that is 19 wards such as ward Gurugovind singh, Niralanagar, Aliganj, Bajrangbali, Indiranagar, Gomtinagar etc.

After foregoing discussion it can say that the peripheral zone of the city and central part of the city is the diseases prone area of the city, due to its high intensity of indoor air pollution. Central part of the city is the commercial and traffic congested area also highest and RSPM and SPM beyond the prescribed limit, which discuss in previous chapter in air pollution combination of indoor air pollution factor supplemented without door air pollutant causes different respiratory diseases.

Table 4: Intensity of DiseasesLucknow City 2010 (Based On Z- Score)

Category	Ranges	Total wards	per cent of Total wards
Very High	0.57- 1.95	19	17.27
High	0.18- 0.56	37	33.63
Medium	-0.25 to -0.11	21	19.09
Low	-0.72 to -0.24	14	12.72
Very Low	-0.1.4 to -0.71	19	17.27

Source: Computed by Researcher

There is RSPM, SPM, SO_2 and NO_2 found There is positive correlation between the intensity of indoor. There is strong causal correlation between the intensity of indoor air pollution and occurrence of diseases. Air pollution and disease shows the (r= 0.58) 1 per cent level of significant at 108 degree of freedom explained 99.9 per cent significant.

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VIII. CORRELATION BETWEEN DETERMINANTS OF INDOOR AIR POLLUTION AND ASSOCIATED DISEASES (LUCNOW CITY 2010)

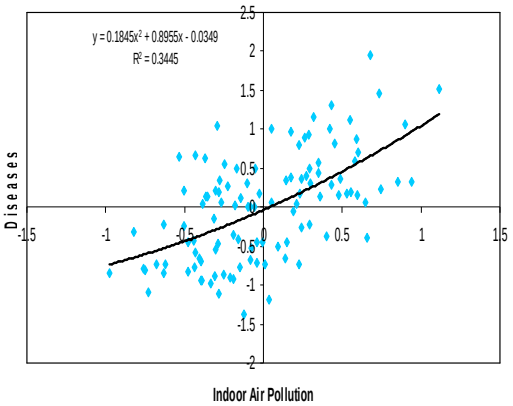

Fig 1

IX. CONCLUSIONS AND RECOMMENDATIONS

After foregoing analysis regarding variable of indoor pollution and their impact on health, it may be concluded that indoor air pollution and respiratory diseases are positively correlated. At 108 degree of freedom, 99 per cent significant are observed at 1 per cent level, among all the variables. It is commonly seen that intensity of pollution is more pronounced in peripheral, industrial and central i.e. old part of the city it is attributed to the high consumption of biofuel by the slum dwellers living in peripheral and along the *Nalas* and river Gomti, ill ventilation, low availability of spacing for living, smoke remains inside the houses are the common features of the central and old part of the city. The settlement in industrial area are exposed to emission of industrial smoke, in combustion of traffic fuel, indoor and outdoor smoking as well as poor exit capacity of smoke from inside the house.

X. RECOMMENDATIONS

In order to reduce the level of indoor air pollution and incidence of diseases following recommendations have been made:

- Mass awareness programme should be organized through mass media, television, radio, street drama, plays, stage drama, hoardings, handbills, depicted through caricature narrating the effects of indoor air pollution on health. The programme should be arranged time to time in proper manners.
- The housing plan with well ventilation should be proposed by the Housing development Corporation and it should be binding to every one. The housing plan should not be passed by legal authorities for the construction it is devoid of ventilation. Separate kitchen with full ventilation be allowed to prevail.
- The size of the room should be as per recommendation i.e. 50 sq feet need living space. Because over-crowding causes incidence of respiratory diseases.
- The use of biofuels kerosene should be replaced by LPG as far as possible, solar cooker, scientific stove, smokeless chullahas should be encouraged in place of traditional means of cooking. The government should offer maximum subsidies to the people living below poverty lines for the utensils and means used for cooking.
- The slums and squatter settlement should be provided laterine with flush systems, cooking gas, utensil and smokeless chullahs on very affordable prices.

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- Jhuggies and jhopdies should be replaced with one or two room sets with full ventilations in order to avoid indoor air pollution.

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