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Full Length Research Paper

Effects of indoor air pollution on human health: A micro-level study of Aligarh City-India

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Environmental pollution is one of the serious crisis to which we are facing today. It is fact that three basic elements air, water and land which constitute harmony of nature for proper and balance living of all organisms, it was fortunate enough that such hospitable and balance environment was the destiny of our predecessors. But it is contrary to living of the present environment. With the rapid growth of population, urbanization, industrialization, commercialization, consumerism, fast changing life style, unplanned development etc. have deteriorated the ecological balance day by day and now it went beyond its sustainable limit the craze of progress in agriculture, industry, transportation and technology is taken as the general criterion of development of any nation. Such activities of man have created adverse effects on all living organisms in the planet of the earth. The increasing population and poverty are also the cause of environmental pollution which compels the people for over exploitation of natural resources of the region. Besides poverty, illiteracy, unawareness, lack of knowledge, irrational and unplanned development etc. also contributes to pollution of the environment at regional scale. In the present work an attempt has been made to study impact of environmental pollution on human health, which is the home of approximately 0.67 million people, who are subject to sufferings. After foregoing analysis regarding variable of indoor air pollution and their impact on health, it may be concluded that the indoor air pollution is affected by the housing conditions and living conditions but to some extent it is also affected by the outdoor environment.

Keywords: Air Pollution, Wards, Households, Disease, Health

INTRODUCTION

Environmental pollution means lowering of environmental quality at local scale caused exclusively by human activities whereas environmental degradation means lowering of environmental quality at local, regional and global levels by both natural processes and human activities. Environmental pollution is very much close to the inside household environment. Urban health in proliferation of non-communicable diseases, triggered by urbanization and industrialization on the other. This dual developing countries has distinctive characteristic. There are communicable diseases on one hand and characteristic complicates the problem of health. Besides ill effects of the environment it generates promoting factors for the growth of many more diseases. Human health is also affected by the quality of the environment in the place of air, water noise and waste its improper disposal affects the environment adversely. Environmental degradation including the degradation of land and water is the most serious impact of pollution.

The environmental concern for air pollution has largely been focused on the question of pollution outdoors. However the attention of scientists has shifted to the quality of air indoors.

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The indoor air pollutants are nearly the same as that of the outdoor ones. However in some instances the concentration of household pollutants exceeds the standard set for the outdoors. These pollutants reach such a high level despite they are emitted in small volumes but they cannot escape easily from the buildings due to lack of proper ventilation. Indoor air pollution is more harmful and poses greater health hazards because on average a person spends nearly 16 to 18 hours indoors. Keeping these points in mind, it was thought worth studying the indoor air pollution and its impact on the health of the people in a medium size city of India, i.e. Aligarh with a population of nearly 0.6 million by the end of 2001 in Aligarh city. An attempt was made to see the income-wise household environmental pollution and its health impact on the sampled residents of Aligarh city. The study addresses the use of various fuels for cooking, place of cooking, indoor smoking, outside smoke coming inside the house, ventilation in the house and also the floor space per person in the sleeping rooms, the poor household environmental condition responsible for the occurrence of diseases.

Objectives of the study

The objectives of our study are as follows

- To know the physical and general characteristics particularly of sampled wards and Households of the study area, which provide necessary base framework for generation and utilization of resources.
- To analyze the nature and intensity of environmental pollution in the study area, i.e. air, water, and noise pollution.
- Finally to analyze the impact of environmental pollution on human health and measure to minimize its impact on the habitats of the city.

DATABASE AND METHODOLOGY

The data were collected mainly from primary and partially from secondary sources. This study is mainly based on primary sources of data which has been collected through field survey. Survey of the sampled households in the selected wards of the city was conducted on the basis of questionnaire / interviews. The field work was done by the authors during the year 2010. For getting the accurate information, the sampled wards and households were visited frequently.

Methodology

The following methods were used in this study:
(1) Preparation of questionnaire

(2) Sampling procedure

For the purpose of selecting the sample, multistage stratified sampling design was adopted. The selection of wards was purposeful one. Aligarh city is subdivided into 60 wards. Eleven wards were selected on the basis of their location (Core area, civil lines area and peripheral area).

To examine the degree of impact of household environmental pollution on human health of study area, some important independent variable of household pollution and dependent variables – disease affecting to human health have been analyzed using standard statistical techniques. Though physical housing conditions are documented across much of the world, little information is available on the quality of the built environment except for a broad classification of house type, the provision of environmental infrastructure and occasionally the levels of crowding.

An attempt has been made to establish the relationship between indoor air pollution with associated diseases. The following variables of indoor air pollution and diseases as related with indoor air pollution.

- Per head living space (room density) (X_1)
- Proper ventilation not exit (X_2)
- Multipurpose room (X_3)
- Smoking in house (X_4)
- Bio-fuel used for cooking (X_5)
- kerosene used for cooking (X_6)
- Smoke remain inside the house (X_7)
- Smoke coming from outside (X_8)

Whereas, eight types of diseases related with household air pollution.

- Conjunctivitis (Y_1)
- Rhinitis (Y_2)
- Sore throat (Y_3)
- Bronchitis (Y_4)
- Asthma (Y_5)
- Allergies (Y_6)
- Tuberculosis (Y_7)
- Pneumonia (Y_8)

The relationship between dependent and independent variables has been analyzed using Karl Pearson's technique of correlation of coefficient.

$$r = \frac{\Sigma xy - \frac{\Sigma x \Sigma y}{N}}{\sqrt{\Sigma x^2 - \frac{(\Sigma x)^2}{N}} \sqrt{\Sigma y^2 - \frac{(\Sigma N)^2}{N}}}$$

Where, r refers to coefficient of correlation
x and y are independent and dependent variables
N denotes number of observation
Significance test of coefficient of correlation

$$t = r \sqrt{\frac{N-2}{1-r^2}}$$

Where, t = Calculated't' value
r = Coefficient of correlation
n = Number of observation

Table 1. Diseases Associated with Indoor Air Pollution

Income Group	Diseases associated with Household air pollution							
	Conjunctivitis (Y_1)	Rhinitis (Y_2)	Sore throat (Y_3)	Bronchitis (Y_4)	Asthma (Y_5)	Allergies (Y_6)	Tuberculosis (Y_7)	Pneumonia (Y_8)
Very High	3.54	9.34	9.06	9.35	11.09	18.54	1.04	5.47
High	8.81	12.65	14.38	16.27	15.89	23.17	1.69	10.22
Medium	17.28	22.47	27.03	37.22	29.73	27.19	11.04	23.54
Low	37.41	32.35	38.94	38.01	37.21	37.11	21.38	42.18

Source: Based on field survey, 2010.

To find out the intensity of household air pollution has been examined by using Z-score or standard score technique.

$$Zi = \frac{x_i - \overline{X_1}}{\partial_1}$$

Where, Zi = denotes standard score of ith variable
Xi = original value of ith variable
$\overline{Xi}$ = Mean of ith variable
∂ = Standard deviation of ith variable
The model of composite Mean Z-score is thus

$$CS = \frac{\Sigma Zij}{N}$$

Where C.S refers to the composite Mean Z-score
Zij = standard score of ith variable at jth unit of study,
N = Number of variables.

DISCUSSION

From discussion regarding the impact of environmental pollution on human health of Aligarh city, it is concluded that, the Aligarh City was primarily clam and quite residential centre among the Indian cities. But, now days, it is one of the critically polluted cities among the Indian Cities. Rapid urbanization, industrialization, commercialization, consumerism and population explosion deteriorates the ambient air quality day by day by emitting SO_2 and NO_2 in the air. The analysis of three main gaseous pollutants (SO_2, NO_2 and SPM) and their average result that SPM is the major culprit of air pollution in the city and have gone to even beyond the permissible limit. Though the SO_2 and NO_2 are within the limit but their increment day by day bring close to the permissible limit, which may adversely affect the respiratory system causing respiratory diseases.

Table 1 depicts that all the selected disease namely, Conjunctivitis, Rhinitis, Sore Throat, Bronchitis, Asthma, Allergies, Tuberculosis and Pneumonia are positively correlated with the causes of indoor – outdoor air pollution. Their positive correlation generalized the fact that all the diseases are associated with the causes which have been taken for the present study.

Conjunctivitis

Spatial analysis of the Conjunctivitis is exhibited in Table 1 under very high and high income group household's percentage of Conjunctivitis affected households are 3.54 per cent and 8.81 per cent from selected wards of the city. The medium income group of Conjunctivitis affected household's is 17.28 per cent of the city. 37.41 per cent of the low income households Conjunctivitis affected households. The analysis reveals that very high occurrence of conjunctivitis disease is found in low income group of households who live in peripheral and central part of the city.

Rhinitis

Table 1 exhibits that 32.35 per cent households belong to low income group most affect by rhinitis. These areas are more prone to risk factor of the rhinitis like ill ventilation, per head livings space characterized with high pollution density and also very congested inhabitation in the houses. It is observed that 22.47 per cent of households affected by rhinitis come under medium category, very high 9.34 per cent and high 12.65 per cent households are affected by rhinitis respectively.

Sore throat

Table 1 reveals that very high and high income group households affected by sore throat are 9.06 per cent and 14.38 per cent respectively, 27.03 per cent affected belong to medium category and the highest affected category household belong to low income group household i.e. 38.94 per cent. It is observed that sore throat infection is very closely associated with ill ventilation, use of bio-fuel, high pollution density, traffic congestion, high frequency of automobiles, and emission of harmful gases such as NO_2, SO_2 and also SPM from automobiles. The affected people are the inhabitant of the peripheral of the city and industrial area where the risk factors are significant.

Bronchitis

Of the total sample, about 38.01 respondents reported of suffering from bronchitis infection belong to the low income households of the sampled household of the city. Under very high to high category of households affected by bronchitis are 9.35 per cent and 16.27 per cent respectively, under the medium category household affected by bronchitis disease 27.22 per cent of the sampled households of the city. The spatial analysis reveals that high percentage of occurrence of bronchitis is found mostly in the low income category household of the city. It is attributed to the high use of bio-fuel, ill ventilated house, low living space availability and high density of population, congested houses and high traffic flow. Besides, affected people are also reported from industrial area located in outer margin and central part of the city.

Asthma

Of the total sample, about 23.48 per cent of the respondents reported of suffering from asthma (37.21 per cent of low, 29.73 per cent of the medium 15.89 per cent of the high and 11.09 per cent of the very high income household). The analysis reveals that high percentage of asthma affected households are found mostly in low income households located in the central part and some in-peripheral area of the city. Central part of the city attributed to mainly very high density room (very low per head living space availability), ill ventilated and congested house, and some time some comes from outside peripheral area of the city closely associated with high use of bio fuel and emitting smoke industries.

Allergies

Of the total sample, about 26.5 per cent respondents reported of suffering from allergies (18.54 per cent very high, 23.17 per cent high, 27.19 per cent of medium and 37.11 per cent of low income households). Analysis reveals that high percentage of occurrence of allergies diseases is found the households are located in the central and southern peripheral area and industrial area also.

These areas are closely associated with very high to high use of bio-fuel, ill ventilation, per head low living space besides these area are also associated with more smoking, smoke come from outside and smoke remains inside the house.

Pneumonia

Of the total sample, about 20 per cent respondents reported of suffering from Pneumonia (5.47 per cent of very high, 10.22 per cent of high, 23.54 per cent of medium and 42.18 per cent of low income households). The low category income households are more Pneumonia affected household. The analysis reveals that high percentage occurrences of Pneumonia are found mostly in central and southern peripheral area of the city. The central part of the city characterized by high traffic congestion, ill ventilation, low living space availability and high population density. Old central parts of the city are having congested residential area associated with narrow lanes and streets.

Tuberculosis

Of the total sample, about 9 per cent respondent reported of suffering from tuberculosis (1.04 per cent very high, 1.69 per cent high, 11.04 per cent medium and 21.38 per cent of low income households). The analysis of the tuberculosis through its percent is not very high. It is attributed to the ill ventilation, congested inhabitation, high population density and low living space.

Impact of indoor air pollution on health

To analysis the impact of indoor air pollution on the health of habitant of Aligarh City, some significant diseases have been taken into consideration Karl Pearson's technique of coefficient of correlation has been adopted the significance of their correlation has been tested with student's' test technique at 108 degree of freedom. Table 2 exhibits that all the variables of household air pollution are positively correlated to the probable disease. The data analysis given in Table 2 depicts that all the selected disease namely, conjunctivitis, Sore throat, Bronchitis, Tuberculosis, Allergies, Asthma and Pneumonia are labeled as X_1, X_2 … … X_8 and causing factor namely, per head living space availability, non ventilated houses, multipurpose room, bio-fuel use for cooking, kerosene use as fuel for cooking, smoking in house, smoke coming from outside, smoke remains inside are labeled as Y_1, Y_2, ... … Y_8. Their correlation is significant at 1 per cent level with exception of association between the independent variable X_1…. X_8 and dependent variable Y_1…. Y_3, these are significant at 2 per cent level. It is clear from the above analysis that household air pollutions are the major causing factors for the respiratory diseases.

The study reveals that very high occurrences of conjunctivitis disease are found in peripheral and central part of the city. Having high correlation with per head living space availability (r=0.98) followed by smoking in house (r=0.96) and non ventilated Houses (r=0.94) respectively. Rest of the available are also moderately correlated with most severe disease conjunctivitis. The positive association is observed between Kerosene use

Table 2. Correlation Coefficient (R) Between Dependent (Disease) and Independent Variables (Causes of Household Air Pollution)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Y_1	0.98	0.94	0.98	0.88	0.97	0.95	0.96	0.94
Y_2	0.99	0.96	0.97	0.88	0.93	0.98	0.91	0.91
Y_3	0.97	0.89	0.90	0.95	0.80	0.92	0.89	0.92
Y_4	0.99	0.93	0.95	0.92	0.70	0.96	0.84	0.98
Y_5	0.90	0.78	0.96	0.74	0.98	0.95	0.98	0.84
Y_6	0.98	0.90	0.93	0.88	0.86	0.94	0.97	0.96
Y_7	0.98	0.97	0.97	0.92	0.95	0.97	0.84	0.99
Y_8	0.98	0.77	0.98	0.87	0.95	0.99	0.92	0.92

Source: Computed by researchers, 2010.

Table 3. Intensity of Indoor Air Pollution

Category	Ranges (CS)	Total Sampled Ward	Percent of Wards
High	0.5 Above	4	36.36
Medium	± 0.5	6	54.54
Low	Below -0.5	1	9.09

Source: Computed by Researchers, 2010.

as cooking fuel (r=0.97), smoke remain inside (r=0.94) with diseases conjunctivitis. The dependent variable (Y_2) Rhinitis closely associated with few independent variables. Table 2 exhibits that very high correlation occurs between Rhinitis and Y_1, Y_3 (multipurpose Room) and Y_8 (smoke remains inside). It is important to note that though their relationship in significant at 1 percent level but they are correlated with varying degree of r value, Although all the dependent variable (Y_1 … Y_8) positively correlated with independent variable X_3. Table 2 exhibits that the variable per head living space availability to the disease sore throat, allergy, Asthma, Bronchitis and Tuberculosis Rhinitis with varying r value are correlated. Again it is observed that note a single disease is either very highly correlated or very poorly with r value more than 60 per cent and less than 20 per cent. As far as the variable non ventilated houses and multiple purpose room is concerned, it has close association with Tuberculosis (r=0.96), per head living space availability have positive correlation with Tuberculosis.

The data presented in the Table 2 shows that all the cooking related factors or independent variables (Y_4, Y_5 and Y_6) are not highly correlated with al the associated diseases or dependent variable (X_1, X_2 … X_8) except for two cause factor that is multipurpose room is highly correlated (r=0.96), Allergies (r=0.93), Rhinitis (r=0.98), Asthma (r-0.97) except for conjunctivitis (r=0.82). Another variable use of kerosene oil as fuel are poorly correlated (r=0.80) sore throat, Bronchitis (r=0.72). Table 2 reveals some association between bio-fuel and associate disease Tuberculosis. Tuberculosis is positively correlated to (r=0.98) to bio-fuel used cooking. Improper ventilated houses and smoking in house is correlated with Tuberculosis with (r=0.78) and Pneumonia (r=0.77), while correlated to rest of disease with high degree of correlation. The highest degree of correlation is found with Rhinitis (r=0.97), it is also observed that not a single diseases is poorly correlated with the factors smoking in house.

Dependent variable (Y_7) smoke coming from outside is significantly correlated to the diseases i.e. conjunctivitis, Rhinitis, some throat, Asthma and Pneumonia with r values r=0.96, r=0.93, r=0.89, r=0.84 and r=0.94 respectively. It is highly associated with the diseases Tuberculosis (r=0.98). Bronchitis and Allergies, although they are significant at 1 percent level except r value 0.84 at 2 percent level

From the above discussion and Table 1 it may be generalized that the causing factors should be controlled and checked for the partial control over the spread of associate diseases up to some extent in the study area.

Intensity of air pollution

The analysis of intensity of household air pollution is calculated based on composite mean z-score (CS) which clearly reveals that under high category of intensity household air pollution lies in between above 0.5 CS values i.e. 36.36 per cent sampled wards of the city (Table 3) consisting of 4 wards such as Sarai Bala, Kala Mahal, Rasalganj, and Bhujpura. Moderate intensity of

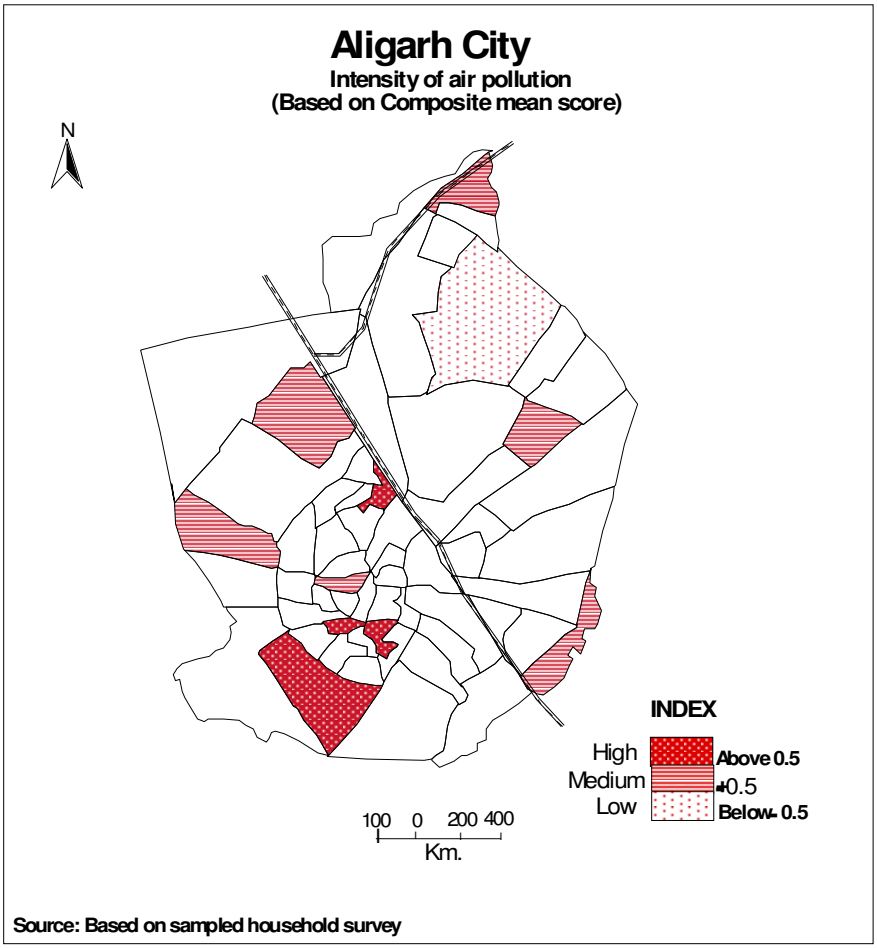

Figure 1. Intensity of air pollution (Based on composite mean score).

household air pollution ranging in between ±0.5 value of CS values are found in 54.54 per cent of the total sampled wards of the city, occupying six wards such as Tantanpara, Kishore Nagar, Begpur,Nagla Mehtab, Dori Nagar and Hamdard Nagar. Low intensity of household air pollution ranges below -0.5 value of CS, consisting of only 9.09 per cent of the sampled ward of the city i.e. Dodhpur. It has been clear from the spatial analysis of intensity of household air pollution are mainly found in the central part of the city and peripheral area of the city as well as industrial areas, the core area of the city characterized by very high population density, unplanned residential areas, narrow lane, street, and improper ventilated houses. Some areas are as congested as there is no space for fresh air to replace the room air. (Figure 1)

Intensity of diseases associated with indoor air pollution

Intensity of diseases is calculated based on composite mean z-score (CS) Table 4 reveals that high intensity of diseases are reported from Bhujpura, Sarai Bala, Rasalganj having the CS values 0.5 above occupying 27.27 per cent wards of the total sampled wards of the city. The medium intensity of diseases associated with household air pollution of the city having ±0.5 CS value, are found in 54.54per cent of the total sampled wards of the city occupying six wards such as Kala Mahal, Tantanpara, Baigpur, Nagla Mehtab, Hamdard Nagar and Dori Nagar. Under low intensity of diseases prone areas households range from below – 0.5 CS values. The low intensity of incidence of diseases associated with household air pollution is found in 18.18 per cent of sampled wards of the city i.e. Kishore Nagar and Dodhpur. The study reveals that highest intensity of diseases is mainly confined in the central and peripheral areas of the city. It is attributed that in additions to all the indoor air pollution factors, these areas are also facing the problem of high content of SPM, this is even beyond the prescribed limit due to number of household small industries located in these areas. (Figure 2)

The analysis reveals that the results showing poor nat-

Table 4. Intensity of incidence of diseases associated with indoor air pollution

Category	Ranges (CS)	Total Sampled Ward	Percent of Wards
High	0.5 Above	3	27.27
Medium	± 0.5	6	54.54
Low	Below -0.5	2	18.18

Source: Computed by Researchers, 2010.

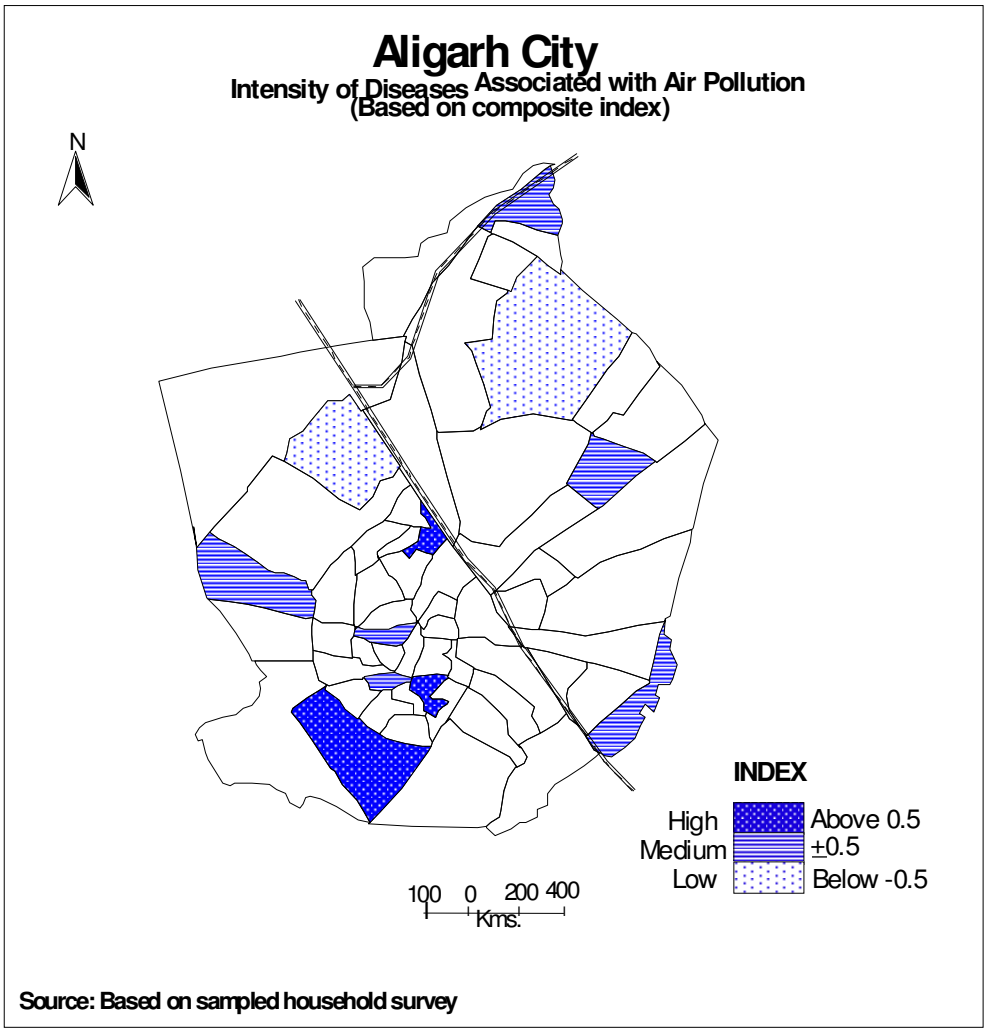

Figure 2. Intensity of diseases associated with air pollution (Based on cpmposite index)

ural environment were spread over two distinct areas, first is the older and central part of the city where concentration of population is maximum and the entire surface part is built upon and devoid of open space. This part of the city is very congested and has reported poor air and water quality. The second, although do not have high population concentration but also showed poor natural and households environment conditions. These area in the outer part of the city, which were earlier rural settlements but now they are within urban limit. The settlement became dense with time with no change in their rural character, thus have poor environment status. The very high and high income households observed lower concentration population and better implementation of urban planning norms. These households showed better status of land, air and water resources, and they have shown lesser mixing of land uses and better state of water, waste disposal and mobility. The analysis reveals

that the sampled households of selected wards of Aligarh city has found that lower income group was closely associated with lower level of economic activity, higher dependent population as well as their housing conditions were poor and these households were characterized by lack of education, health and recreational facilities. The main reason of poor environmental conditions is lower income and lack of education. The study suggests that the livability status in developing society is greatly dependent on social and cultural development of the population, which leads to better education and economic status. The better economic and educational status draws all the facilities to them. These people have better access and awareness to attract and utilize these facilities and maintain their household's environment. To achieve the goal of sustainability in a city as the reduction of city's use of natural resources and production of wastes while improving environment so that it can better placed in local, regional and global ecosystems.

CONCLUSION

The forgiving analysis and interpretation regarding the environmental pollution and its impact on the health, it may be concluded that the uneven growth of population in city together with overcrowding is primarily responsible for the poor environmental conditions. The ill effects of the environment invited many more diseases which adversely affect the public health. The city has grown up with time, with increase in population through natural growth and immigration, but the amenities, facilities and infrastructure remained the same. In many areas of the city economic or commercial growth with adequate environmental protection has resulted in wide spread environmental damage, creating new environmental problems.

Health and education starts from where we spend most of our time. So pollution indoor has a close hearing on our health. Indoor pollution is the contamination of all the pollutants which together forms the over all ambience of indoor environment. If we can not keep our houses free from pollution, how outdoor is expected to be safer.

- To reduce order to check indoor air pollution, well ventilated housing plan should be proposed by the housing development corporation. It should be binding to everyone.
- The housing plan should not be passed by legal authorities if it is devoid of ventilation. Separate kitchen with full ventilation should be allowed to prevail.
- The use of bio-fuels should be replaced by IPG or if possible by the solar cooks, scientific stove, smokeless *chulhas* be encouraged in place of traditional means of cooking. The government should offer maximum subsidies for the said purpose.
- More and more steps should be taken to improve the condition of the slums and squatter settlements. Govt. should take steps to replace *jhuggi jhopri* with one or two room sets on full ventilation basis under different *Awas Yojanas*.

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