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Quality of Indoor Air – An Indicator of Urban Environment

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Abstract:
Quality of indoor air is an important element of liveability as indoor environment may prove dangerous for the health of inhabitants. The quality of indoor environment can be judged through different techniques.
The quality of indoor environment in the present study is judged in terms of proper ventilation, quality of fuel used in houses and also appropriateness of fuel burning places within the houses.
The pollutants which are generally encountered in indoor air are carbon monoxide, nitrogen dioxide, sulphur dioxide and particulate matter.
Proper ventilation is required for cleaning the indoor air as burning of fuels generally takes place within houses in the city.

Keywords: *Indoor air, proper ventilation, quality of fuel, fuel burning place, pollutants.*

1. Introduction

Indoor environment or quality of indoor air is an important element of livability as a bad indoor environment may prove dangerous to the health of households especially women folk who live inside the house for most of the time. The quality of indoor environment can be judged through different mechanical and chemical techniques. However, in this study quality of indoor environment is judged in terms of proper Ventilation, quality of fuel used in houses and also appropriateness offuel burning places within the houses.

The Pollutants which are generally encountered in indoor air are carbon monoxide, nitrogen dioxide, Sulphur dioxide and particulate matter. The incomplete combustion is the reason for carbon monoxide emission. Presence of nitrogen dioxide in the indoor air is a result of complex reaction. Nitrogen from the air combines with oxygen at high temperatures and this forms various nitrogen oxides. This family of nitrogen oxides continuously changes its chemical composition and therefore, they are commonly referred to as unsuitable nitrogen dioxide. Particulate matter suspended in air can be mechanical or combustion generated. Combustion-generated particulates are of various sizes and chemical composition. Particulates less than 10 microns in diameter can be inhaled by humans and hence are known as respirable suspended particulates. At higher smoke temperatures more of particulates will be in vapour form, while at lower temperatures they remain suspended in the air. Smoke is a sign of incomplete combustion.

Obviously, proper ventilation is required for cleaning the indoor air as burning of fuels generally takes place within houses in the city. Its absence the concentration of harmful gases and particulate matter in the indoor air.Proper ventilation lowers the concentration of these pollutants as it leads to more frequent air exchange. Type of fuel used to be burnt in the house is also a determinant of concentration level of pollutants in the air of a house. Studies have shown that of concentration of respirable suspended particulates, carbon monoxide and other gases, decreases as the households climb up the energy ladder from the bio-fuels to the LPG. Fuel burning place also influence level of concentration of pollutants in the indoor air. For example, fuel burnt in open or properly ventilated kitchen pollutes less the indoor air than the fuel burnt in a room.

It needs not to mention that quality of air in the house is related to members of households, especially women who are directly exposed to the emissions from the burning of fuel and pass their entire time within the houses.

2. Study Area

The city of Saharanpur is situated in the Upper- Ganga Yamuna Doab in North India at 29 58 N and 77 37 E longitudes in Uttar Pradesh. The environment of the city is an undulating plain which is part of the Great Ganga plain. The climate of the city is moist and not very hot during the summer due to modifying effect of Siwaliks. The winters are of long duration as compared to the southern part of the Ganga valley. The city is densely populated and has a population of 2,896,863 persons.

Historically as the records reveal, Saharanpur originated during the reign of Mohammed-bin- Tughlaq. According to Hunter (18810 the township was founded about 1340 A.D. Since then the city has passed many phases of expansion and destruction. However, the city came into prominence during the British rule when they established cantonment in the Saharanpur city. Presently, it is one of the medium sized cities of the country.

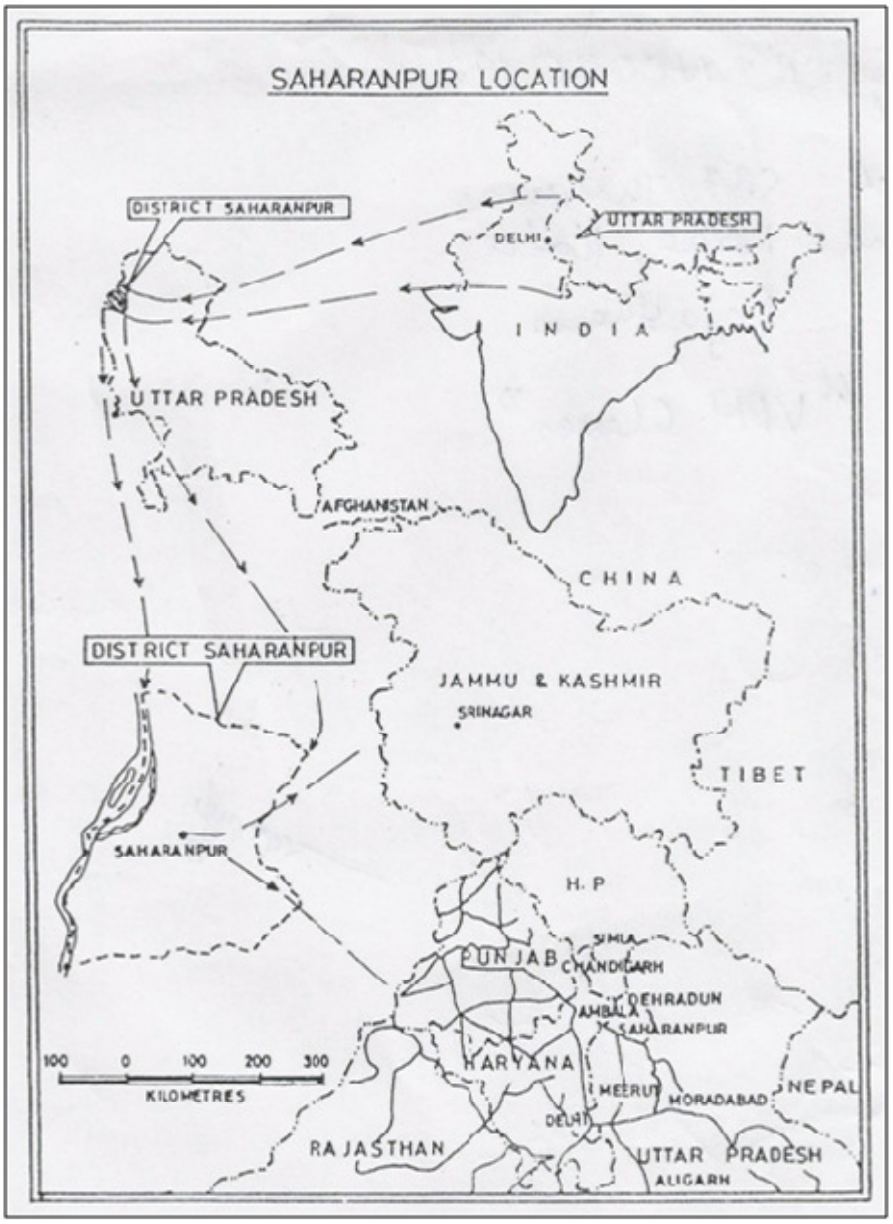

Figure 1

3. Objective

This paper is an attempt to assess the problem of indoor air pollution in a large developing city of India and to describe the quality of fuel and its impact on indoor air.

4. Database and Methodology

This analysis is based on the primary data collected through the fieldwork. This study is a part of a larger study carried out to assess environmental condition of life in Saharanpur city.

The study is empirical in its treatment of the theme of inquiry. The collected data and information is processed and compiled on the ward level which is taken as the unit of analysis. The wards of the city are classified into four categories of very high, high, low and very low ventilation, quality of fuel and appropriateness of fuel burning place. This has been achieved by applying nested means method and by preparing weighted index

The nested means method in the first instance involves arranging observations on a variable in ascending or descending order. In the second instance agrand mean is calculated taking all the observations into account. This grand mean divides the entire series of observations into two sub-sets: one containing observations smaller than the grand mean and other having observations larger than the grand mean. These three means provide limits for four classes. The value above the mean of the larger values are designated as very high and values falling between the grand mean and the mean of the larger values are designated as high whereas the values lying between the mean of smaller values and the grand mean are classified as low and values below the mean of smaller values are labeled as very low.

4.1. Ventilation

Sufficient ventilation is an important part of indoor house environment. It helps in cleaning door air polluted by breathing, burning of fuel and other sources. It is a necessary condition for health and hygiene of the people. The researcher has collected information on the ventilation in sample houses through observation and has classified houses into two categories: one which according to the researcher have adequate or sufficient ventilation to clean the indoor air, and the other in which ventilation is not sufficient. In order to examine spatial pattern of problem of ventilation, wards are classified into four categories of very high, high, low and very low proportion of houses having proper ventilation. The first category includes wards where proportion of houses with sufficient ventilation is very high, more than 73.68 per cent of the total surveyed houses. The number of such wards is sixteen and total population of these wards is 191,827. That is, 42.09 per cent of total population of the city enjoys sufficient ventilation in houses. Distribution pattern of these wards over the city space is sectoral. These wards are found in two major sectors. One sector lies north-east of the city –centre and of four wards extending from the city-centre towards the north- eastern periphery. The other sector south of the city-centre and has eight wards. There are also three isolated instances of the wards of this level of ventilation. Two of them are found in the north-west of the city centre consisting of one ward each, and one lies south-west of the city centre and consists of two wards. The majority of these wards are newly developed areas. Most of the population in these wards belongs to high and middle income groups. People living in these wards are generally aware of hygiene and need of proper ventilation in rooms and kitchens.

In the category of high proportion of houses with satisfactory ventilation are included twenty wards. In these wards sufficient ventilation is found in 47.43 to 73.68 per cent houses. Total population of these wards is 235,214 that is 51.61 per cent of total population that enjoys adequate ventilation. The spatial distribution of these wards is found zonal. They make an outer zone in the north-eastern part of the city. Both the old and new areas are included in this category. The majority of population of these wards belongs to medium and high income groups. Ventilation is found satisfactory in both old and new houses of these wards.

In the category of low proportion of houses with sufficient or adequate ventilation are included two wards.

These are randomly distributed over the city space. One ward lies north of the city centre and the other is found south of it. Total population of these wards is 16, 681.That is 3.66 per cent of total population of the city does not have sufficient ventilation in their houses. The proportion of houses with adequate ventilation in these wards varies from 45.51 to 47.43 per cent.

In the category of very low proportion of houses withproper ventilation is included only one ward in which proportion of such houses is less than 45.51 per cent. This ward is situated on the south-eastern periphery. This ward has a total proportion of 12,032 that is 2.64 per cent of the city's total population.

Proper ventilation in broad terms is not major problem in the city. It shows a spatial pattern whereby it is high in the outer zone and low in the central zone. The condition of ventilation is generally associated with the age of housing and income level of the households. New housing of the affluent class shows significantly high level of proper ventilation, while it decreases with the decrease in income level despite the young age of housing.

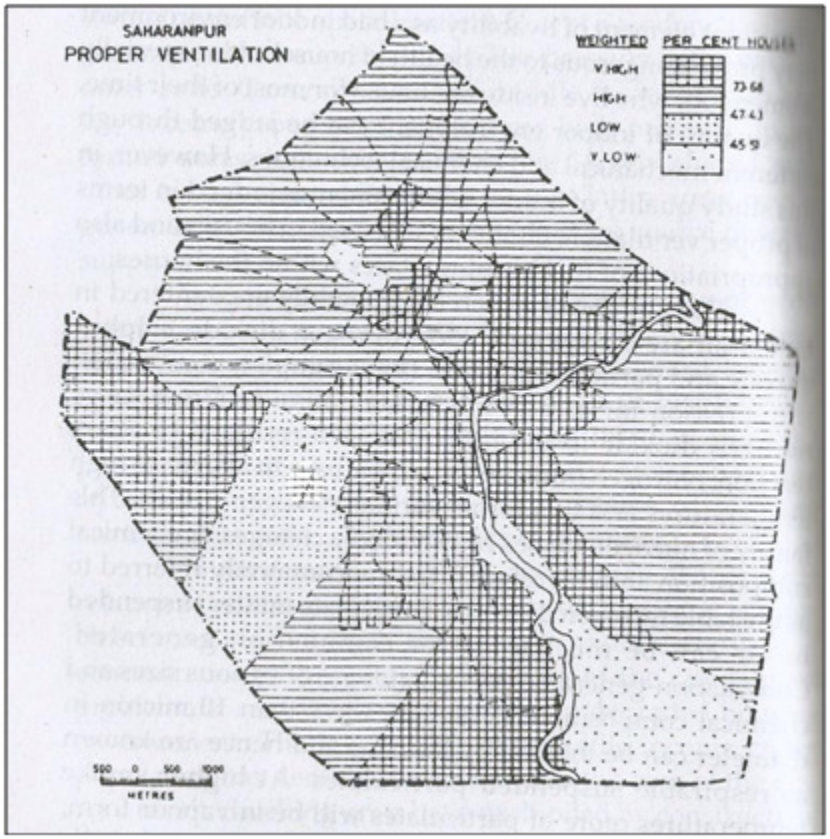

Figure 2

4.2. Quality of Fuel

Generally cooking of food involves burning of fuels of different types. The type of fuel used generally depends on the economic status of a household. This produces varying amount of gases including carbon monoxide and particulate matter. This pollutes not only the internal environment of a house but also adds to the obnoxious gases and particulate matter already present in the atmosphere of the settlement.

The various types of fuel used by the households in Saharanpur city include the LPG, Wood, Kerosene, sawdust, coal and Kanda (Cow- dung cake). In the city according to the households survey the proportion of households using these fuels is respectively 53.53, 29.06, 3.12 and 2.36 per cent.

To analyze the spatial pattern of the quality of fuel as a component of quality of Indoor environment in Saharanpur, a composite index is worked out. As discussed earlier there are five types of fuels used by the households in the city. These fuels differ in their potential to pollute environment. To calculate the composite index, the types of fuel are given ranks in descending order with their increasing potential to deteriorate livability. That is, the least polluting fuel is given the highest rank of five and the most polluting fuel is given the lowest rank of one. These ranks are multiplied by percentage proportions of households using respective fuels in a ward. Then these values are added together. These sums are divided by the largest sum and multiplied by 100. This gives the index of quality of fuels in a ward. Obviously, the ward having the lowest value of this index i.e., 100 has the best combination of fuels which is the least polluting and the ward having the lowest value has the worst composition of fuels which is the most polluting. Wards of the city are classified into four categories on the basis of this index of quality of fuel. These categories are very high, high, low and very low quality of fuel.

The very high quality of fuel or least polluting fuel is used in six wards. The index value in these wards is more than 82.24 points. Total population of these wards is 92,017 which is 20.19 per cent of total population of the city. That is, a sizable population of the city is secure from the ill effects of using bad quality fuel. Spatially these words show a sectoral pattern with reference to the city's core. Four of these wards make two major sectors in the north-west and north-east of the city-centre. The former includes one ward and latter has three wards. There is one such sector also south of the city-centre having two wards. These wards represent an outward sectoral expansion of the city and include newly developed areas. The population of these wards is mostly well-off and enjoys high standard of life. People are generally highly educated. Therefore, they not only can effect of traditional fuels on health.

The high quality of fuel or less injurious fuels are used in eleven wards. The value of index of quality of fuel varies between 72.34 and 82.24 units in these wards. These wards together have a population of 102,271 persons, that is 22.44 per cent of total population of the city. Again it is a sizable population which is relatively safe from the injurious effects of using low quality bio-fuels. It is interesting to note that like the former category of wards, these wards also show a sectoral tendency of distribution with few random instances. The major sector of these wards extends in south western direction, second sector extends in the north of the city centre. These wards in majority of cases extend over old part of the city which is mostly a residential area of middle class population and the descendants of the traditional elite of the city. However, as a whole fuel used in this part of the city is less harmful than the fuel used in other parts of the city.

The low quality fuel is used in eleven wards. The value of index of quality of fuel varies from 69.25 72.34 units. These wards have a population of 137,364 persons. Which is about 30.14 per cent of total population. These wards a zonal distribution in two segments in the outer parts of the city. Mainly peoples are belonging to medium and low income group.

The very poor quality of fuel used in thirteen wards. The index values are less than 69.25 units. The population of these wards is 124,102 that is 27.23 per cent of the population of the city. It means that more than one fourth population of the city is exposed to injurious diseases and infections caused by pollution of internal as well as external environment of houses.

Spatially, these wards show sectoral pattern of distribution. These areas are very congested and the problem of pollution is further exacerbated by this reason. These are peripheral areas and therefore a mixed population is found here, most of the population in this zone is rural and several villages are still intact in their morphological characteristics and behavioral pattern. Thus being of rural origin, this population still utilizes traditional sources of energy which are worst as far as their effect on environment is concerned.

5. Appropriateness of fuel Burning Place

Place of burning fuel or simply of cooking plays an important role in the indoor environment of a house. The level of concentration of various gases and particulate matter in the air of a house, depends greatly on the place fuel is burnt. A composite index is worked out to analyze the appropriateness of fuel burning place on the basis of reported places of cooking by the responding households. The cooking places are ranked, the highest rank of 4 is given to kitchen with proper ventilation and the lowest of 1 to cook in the rooms. The percentage of households in a ward using different places for cooking is multiplied by their respective ranks. The addition of these values gives acrude index of adequacy of fuel burning places. It is divided by the highest value of the index and multiplied by 100 for each ward.

On the basis of this index wards of the city divided into four categories of very good, good, bad and very bad combination of places of cooking from the viewpoint of indoor environment.

Seven wards of the city are included in the category of very good combination of cooking places these wards have an index value higher than 90.09 units. Total population of these wards is 80,258 i.e., 17.61 per cent of the city's total population. These wards are located in different directions from the city centre. Most of these wards are newly developed areas situated in the outer parts of the city, majority of people belongs to high and middle income group, so that they enjoy all the good household facilities.

The wards with index values vary between 84.86 and 90.09 units are placed in second category. They are thirteen in number, the population of these wards is 183,487 persons, that is 40.26 per cent of the city's population. Both new and old areas are included, the

majority of the population of these wards belongs to middle income group. A large segment of households is able to afford a suitable place for cooking.

In the category of bad combination of fuel burning places are included eleven wards. These wards have an index value that ranges between 79.63 and 84.86 units. Total population of these wards is 115,169 which is 25.27 per cent of the city's population. All these wards are found in outer zone except one that lies in the inner zone of the city. The majority of population of these wards belongs to low and middle income group. The literacy level of people is low in these areas. Courtyards and verandas are generally used as the cooking place as kitchens are rarely found in low income housing. Being uneducated people of these wards are unaware of the environmental hygiene and being poor they cannot afford proper place for cooking in terms of space and a separate facility.

The fourth category representing very bad combination of fuel burning places has wards where the index value is less than 79.63 units. These are nine wards in number. Total population of these wards is 76,840 that is, 16.86 per cent of total population of the city. All these wards have a low socio-economic base with the majority of population belonging to low income class. Therefore, their houses are lacking in kitchens like other housing facilities.

The indoor environment as a component of quality of housing reveals that more than 50 per cent population of the city of Saharanpur lives in conditions where risk of health hazard due to contamination of indoor air is considerably high. The quality of indoor environment is observed to co-vary with the quality of housing and economic status of the residents. The spatial pattern of this component of the quality of environment is a complex one as areas of good and bad quality co-exist in each of three zones of the city. In broad terms, average quality of indoor environment obtains largely in the inner zone that extends into the middle zone in the form of sectors. The quality of indoor environment is a little bad in a large part of the middle zone. The areas of both the best and worst indoor environment exist in the peripheral zone.

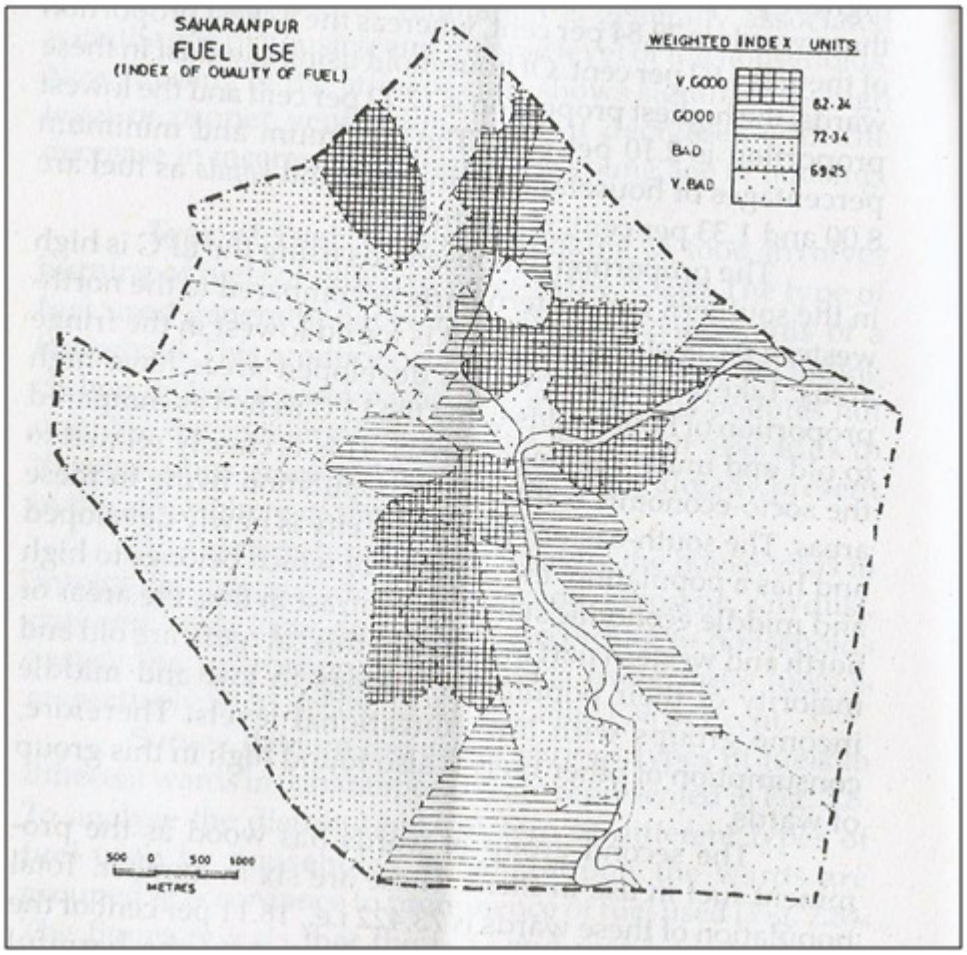

Figure 3

6. Conclusion

The above discussion shows that there is a direct relationship between the economic status of population and quality of indoor environment in the city of Saharanpur. The low income housing areas with high degree of crowding and congestion are more polluted than the high income spacious houses. The quality of indoor air is low in the old parts of the city as well as in the fringe areas where mixed population is living. Type of fuel and fuel burning place is also an important indicator of indoor environment, the houses where good quality fuel is used in the kitchen are less polluted than the houses where inferior quality fuel is used.

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