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INDOOR ENVIRONMENT IN URBAN AREAS: A CASE STUDY OF BIJNOR CITY, UTTAR PRADESH

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Abstract

Degradation of indoor environment is one of the several major issues which most of the urban population is facing today, especially in developing countries. The quality of indoor environment in any every part of the city should be such that it satisfies minimum health and living standards. Poor housing conditions (location, size and architecture) and consumption of polluting solid and liquid fuels are major factors in poor level of indoor urban environment in developing countries like India. People use different fuels and sources energy for activities like cooking, heating/cooling of living places and water. In India, generally it involves the use of LPG, cow dung cakes, woods, kerosene, dried grasses and leaves etc. which emit and create varying levels of indoor pollution in the ambient air. The nature, morphology, socioeconomic characteristics and processes of urbanisation in developing countries are different from that of the developed nations. In case of India these process are much more complex. Majority of urban areas in the country have actually emerged from the development of rural settlements. Therefore, these are unplanned, lack civic amenities and have grown haphazardly due to high growth and immigration of skilled and unskilled population mainly from rural areas. All these factors have provided a stimulus to make a case study of the quality of indoor environment of Bijnor, a city in the western Uttar Pradesh. Present study attempts to analyze indoor environment quality of the city on the basis of selected parameters of housing quality, ventilation and consumption of fuels which have statistically analysed using weighted method to determine different levels and spatial pattern of the quality indoor environment.

INTRODUCTION

The quality of a residential area not only reflects the city development, planning and allocation mechanisms between socioeconomic groups but also shows the quality of life of the urbanities. The realization of a decent home in a suitable living environment requires the availability of clean air, potable water, adequate shelter and other basic services. For the purpose of the study of level of quality, indoor environment may be broadly defined as the internal environment of

buildings in which people live and spend most of their time. It is a complex concept as it involves not only the consideration of air quality, sounds, odours, light and ventilation, dampness and moisture, microbial growth, but other factors also relating to size and architecture of the building which affect the level of ease and comfortability of occupants' life. The quality of these components of indoor environment or indoor environment quality (IEQ) which refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it is essential to study to determine quality of life in urban areas (NIOSH 2017). The problem of poor IEQ has emerged as a serious environmental hazard threatening health and wellbeing of urban population globally. A good level of IEQ depends on a variety of factors such as proper ventilation, design and architecture of houses, residential density, indoor/outdoor temperature and level of humidity etc. Households particularly women and young children who spend most of their time indoors have been found more vulnerable to indoor environment pollution (Almeida et al. 2015: 5-17, Bruce *et al.* 2000; Smith 1987: 1-21). In India, several parameters are used for assessing housing quality. In the past it has been the notion, that humans are safe indoors from exposure to outdoor pollutants from the exhaust of vehicles and poison emitting industries (Smith *et al.* 1994). However, new development in science and technology to evaluate the concentration of pollutants indoors has demolished this myth. Bijnor city is purely urban and has developed from small settlements (urbanised villages), as a result of extension of its municipal boundary towards surrounding rural settlements (Dangli 1981). In small city like Bijnor lack of proper ventilation and fuel burning within the houses is a major problem because concentrated pollutants cannot escape easily from the houses. In view of all these considerations, in the present study, indoor urban environment of Bijnor city has been judged on the basis of select parameters of three criteria which include housing quality, ventilation and fuel quality (Quazi 2017).

MATERIALS AND METHODS

Study Area

Bijnor city, located in the western central part of Bijnor is also the administrative head-quarter of the district. The district forms the north-western part of the Meerut Division of the State of Uttar Pradesh, India. The city lies at 29°2′ N latitude 78°0′ E longitude. Its elevation with reference to

the MSL is about 237.7 meters. The total area of the city is about 365 hectares. The city is built on the slightly undulating ground developed by the water of river Ganga. The city is about 4.8 km from the left bank of the river. The total population of the city is 93,297 persons as per Census of India 2011 (Census of India 2011: 6-69). Average annual temperature of the city is around 24.4 °C with a minimum of 13.7 °C in January and a maximum of 32.8 °C in June. Average annual rainfall is more than 70 cm with most of the rainfall being recorded during monsoon season only. Level of humidity varies between 69 percent in August to less than 20 percent in early May (India Water Portal 2018, World Weather Online 2018).

Methodology

The paper is based on primary data collected from 25 wards of city using stratified random sampling in 2013 and 2017. The study is intended to make a comparative analysis of the changes in IEQ in different wards of the city taking place in period of four years. For the purpose of collection of data a survey of sampled households in the selected wards of the city was conducted on the basis of detailed questionnaire/interview schedule. The IEQ has been statistically evaluated in terms of housing quality, fuel and ventilation of fuel burning places. The fuels used have been given ranks according to their perceived pollution potential. All fuels have been given subjective ranks for their types, e.g., LPG has been given the highest rank and cow dung cakes the lowest rank. The ranks of fuel types have been converted into weights by summing up the ranks and dividing the individual ranks by their sum. For example weight of a fuel is equal to:

$$W_i = \frac{R_i}{\sum_i^n R_i},$$

Where

W_i is weight of fuel of specific type i, R_i is rank of that fuel, $\sum_i^n R_i$ refers to sum of all ranks of fuel of different types that vary from 1 to n, and n being the highest rank. Percentages of different types of fuel have been multiplied by their respective weights and these weighted percentages of fuel have been added to obtain separate indexes of fuel quality for two periods of time.

In the same way, housing quality, ventilation in houses and kitchens has been evaluated from worst to the best on the basis of their qualitative assessment of removing pollutants and allowing flow of air. The highest rank has been assigned to the house having the best ventilation in both, rooms as well as kitchens and vice versa. As explained above, ranks have been converted into weights and these weights have been multiplied by the percentages of the respective houses of wards and added to develop indexes of ventilation.

The fuel types, index of housing materials and the ventilation status of houses have been made scale free or standardised by applying following formula:

$$V_i = \frac{O_i - O_{min}}{O_{max} - O_{min}};$$

Where,

V_i is new scale free variable, O_i is original variable, O_{max} and O_{min} are maximum and minimum values of original variable, O_i. Finally, these standardised variables have been added together to form composite indexes of indoor environment quality for the study periods (Quazi, S. 2017).

RESULT AND DISCUSSION

Age of housing unit has been taken as an indicator of housing quality as it affect IEQ by influencing health, wellbeing, ease and comfortability of households. In old houses, obsolete and outdated materials, moisture and dampness cause discomfort and attract many diseases directly or indirectly. Old houses are not only prone of dust mites; they are also having spaces for mouse and cockroaches. In these respects, old houses are unhealthy, unsafe and hazardous are

prone to collapse due to mild earthquake shock, intense wind, rain or flood (Wheeler 1986, Jiboye 2010, Kain and Quigley 1970).

In the present study, housing units have been divided into four classes viz. very new (< 20 years; new (20-30 years), old (30-40), and very old (>40 years) on the basis of average age of houses. Distribution of houses by age in different wards of Bijnor city is shown in Figure 1. According to the survey done in 2013 there were 38.75 percent of all sampled houses which were newly constructed. There share increased to 40.75 percent in 2017. Share of new houses has also increased from 30.75 to 32.25 percent (Figure 1). Categories of old and very old houses have recorded a decline in their share of total sampled houses. This is indication that new houses are built on vacant areas as well as old houses are also being replaced by new ones. As a whole, age of houses clearly indicates the process of expansion of the city over the surrounding areas. New houses have mostly located in the periphery which indicates that an expansion always occurs in the outer zone of the city. The entire central zone shows the dominance of the mixed age of houses. Old houses predominate in the southern zone. Thus, the core of the city has miserable housing conditions in terms of age of the house, whereas middle and outer zones have concentration of new houses which are relatively of better conditions.

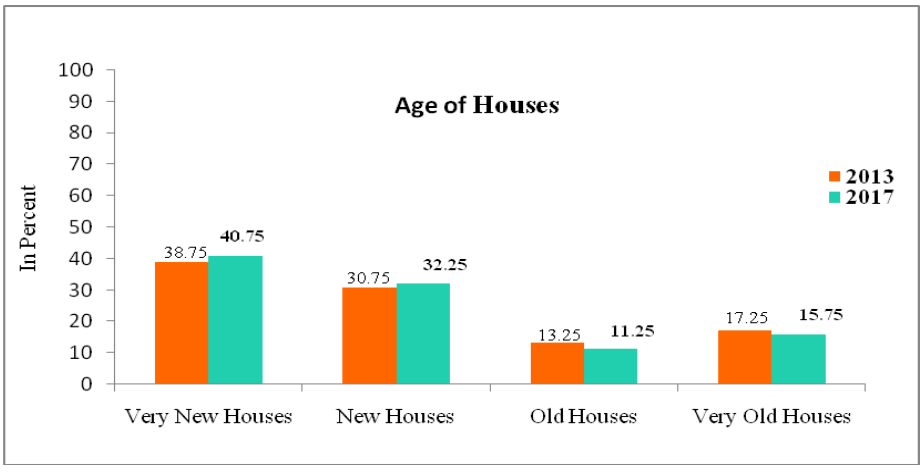

Figure 1: Age of housing units in Bijnor city

Material of housing is also a very important component of housing quality**.** Five types of houses have been recognized on the basis of building material in the study area. These are ferro-concrete, concrete-brick or *pucca* house, *kutcha-pucca* or mixed houses (built of bricks and

mud), *kutcha* houses (made of mud and sun- burnt bricks) and *jhuggis* and *jhopris* (made up of makeshift material).

The ferro-concrete houses include those residential buildings built of concrete reinforced with steel. In terms of material and durability these are very good quality houses. According to the survey they account for 14.75 percent of all sampled houses in 2013 and their share increased to 17.75 percent in 2017. Concrete-brick or *pucca* house, are also good quality house and they accounted for 59.5 percent of all sample houses in 2013. These houses also registered an increase in and covered 60.25 percent in 2017. Proportion of the *kutcha-pucca* or mixed houses, *kutcha* houses and *jhuggis/jhopris* which have low quality of materials have declined in the survey of 2017 (Figure 2).

In general it is an indication of improving socioeconomic condition of the people in all wards of city as they are increasingly choosing ferro-concrete and concrete-brick material to build their houses. However, in the case of low quality building material there is observed a strong tendency to locate in the centre or outer periphery of the city. In the central zone of the city old and dilapidated houses have still not been replaced as people prefer to out migrate to more open areas in the periphery of the city. The outer zone or periphery of the city is in developing stage and also a preferred location of rural immigrants who for time being reside in temporary houses of low quality of materials.

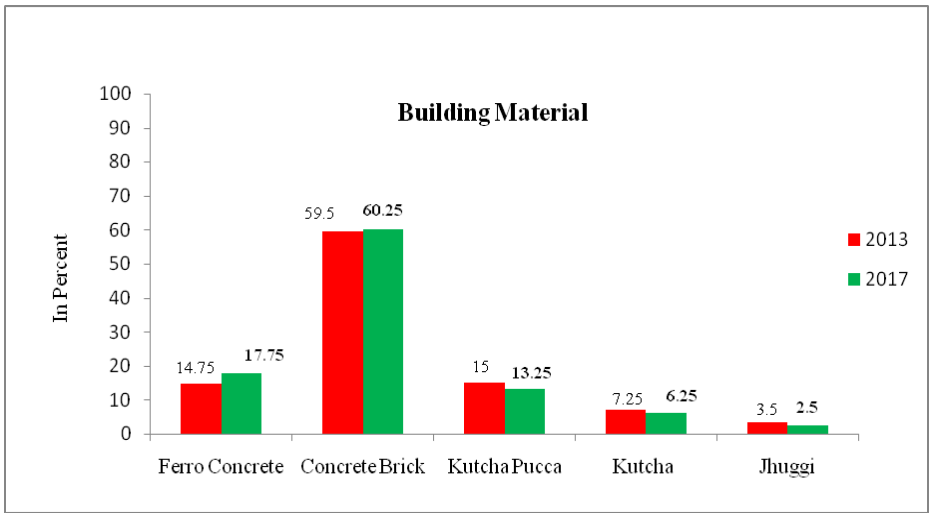

Figure 2: Use of different types of building materials in Bijnor city

Ventilation is also an important factor in determining the quality of indoor environment houses. Proper ventilation helps in cleaning indoor air polluted by breathing, burning of fuel, smoking and other sources. It is a necessary condition for health and wellbeing of the residents. It also allows sunlight in the houses which is necessary for hygiene and visibility. It suppresses the growth of fungus and many bacteria in the damp and dark areas.

To examine the spatial pattern of residences having ventilation in the city, they have been classified into four categories of very good (houses with open space and windows in all rooms and kitchen), good (windows in all rooms and kitchen), bad (houses with single source of ventilation) and very bad (absence of ventilation). The data of ventilation of sampled houses has been through observation. Distribution of residences having different levels of ventilation is shown in (Figure 3). In 2013, there were 7.5 percent of houses having very good level of ventilation which improved to 8.5 percent in 2017. Proportion houses having good level of ventilation condition has improved from 17 percent to 20 percent during the same period. More than 50 percent houses still have average ventilation level in 2017. Share of residences having poor level of ventilation has marginally come down but still it is more than that of good level of ventilated houses. On the basis of the analysis of these figures it may be safely concluded that in a majority of sampled houses ventilation level remains average and poor and has direct on low level of indoor environment.

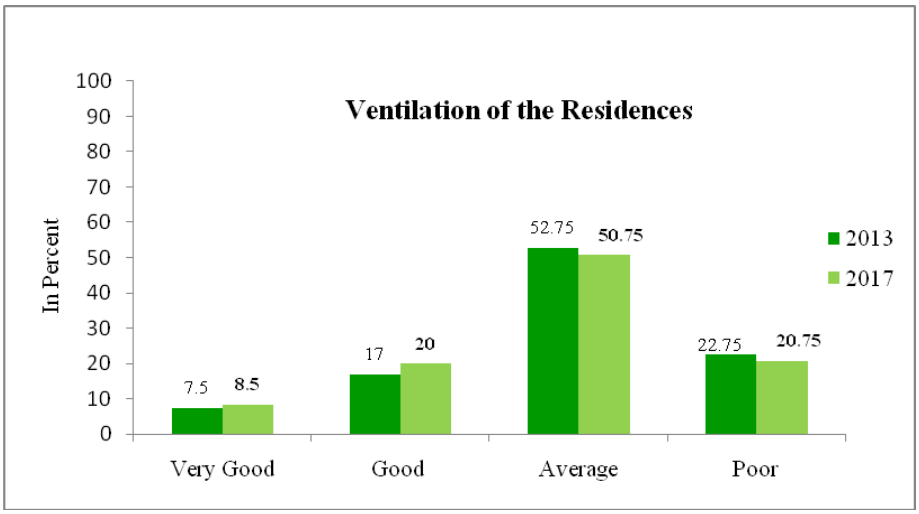

Figure 3: Level of ventilation in buildings in Bijnor city

Quality of indoor environment is also directly linked with the frequency of the use of fuels, quantity and duration of fuels use, types of fuels, and ventilation of pollution from the building (World Bank 2002). In the following paragraphs an assessment of these factors has been done to determine the quality of indoor environment in Bijnor city.

The various types of fuel used by the households in Bijnor city include the LPG, kerosene, coal, fuel wood and dung cakes. According to the data collected in 2013 from sample households, the percentage proportion of households using LPG was 47.6 percent which has fairly improved to 54.75 percent in 2017. Use of kerosene, coal, fuel wood and cow dung cakes has registered a declining trend due to preference given to the use of LPG as more clean and reliable source of energy. Households using cow dung cakes in outer and central wards of the city still constitute 13.75 percent of the sample houses. Overall trend of the use of fuels is an indication of improvement in indoor environment of the city. But, this indicator is subjected to other factors like housing density, location, size and architecture of the buildings and increasing population of the city.

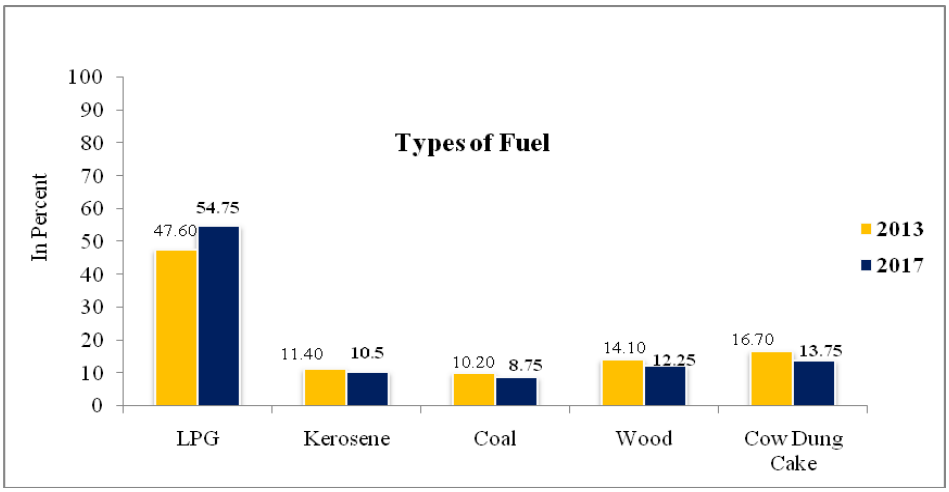

Figure 4: Use of different types of fuels in Bijnor city

Cooking place is significant component of the housing facilities like bathroom, bedroom and latrine etc. Availability and location of cooking place in a house is very important, as it involves burning of fuel, which produces fumes, ashes, odours and smell and directly affects the air

quality of the indoor environment (Koning *et al.* 1985). The data collected from Bijnor city in 2013 and 2017 reveal that kitchens do not exist in all houses. In many cases *aangan*, veranda and rooms are used as a cooking place. The percentage proportions of houses using different places for cooking are shown in Figure 5.

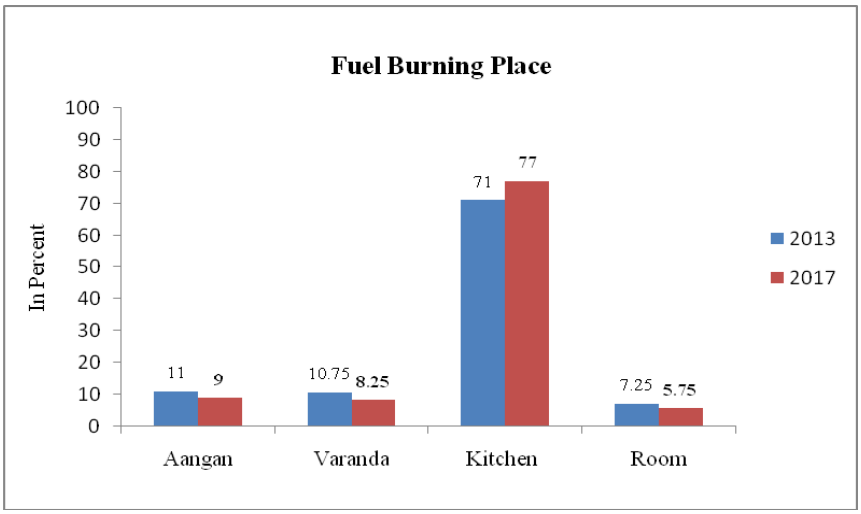

Figure 5: Fuels burning places in sample houses in Bijnor city

The sample data clearly shows that the large proportion of households (77 percent in 2017) are using kitchen for cooking purpose. *Aangan* has been found to be the second most important place for cooking. But, the proportion of households using *aangan* has also come down from 11 percent in 2013 to nine percent in 2017. In most of the Indian traditional families veranda has been the most prominent place for communication, especially in ladies, where they perform several types of household activities, and use this place for cooking food also. In Bijnor city 10.75 percent of households use veranda for cooking in 2013 and 8.25 percent in 2017. This declining trend may be due the fact that open space and veranda are vanishing from houses because of scarcity of space. Therefore, there are still some households in the city which are forced to use rooms as their cooking place but the percentage of this situation has also come declined from 7.25 percent in 2013 to 5.75 percent only in 2017.

Ventilation of fuel burning place: Aeration and ventilation of fuel burning places is an important parameter of indoor environment quality because it helps to remove the pollution and supply fresh air. The pollutants which are generally encountered in fuel burning place are carbon monoxide, sulphur dioxide and particulate matter. The reason for emission of carbon monoxide

is incomplete combustion. Presence of nitrogen dioxide in the fuel burning place is a result of complex reaction. Nitrogen from the air combines with oxygen at high temperatures and forms various oxides. This family of nitrogen oxides continuously changes its chemical composition and, therefore they are commonly referred to as unstable nitrogen dioxides. Particulates less than 10 micron in diameter can be inhaled by humans and hence are known as respirable suspended particulates. At higher temperatures in the smoke more of particulates will be in vapours form, while at lower temperatures they remain suspended in the air (WHO, 1999, WHO 2007, Quazi 2017). Only 22.25 percent kitchens have good quality of ventilation in 2017 in comparison to 21.5 percent in 2013. Kitchens having medium level of ventilation has also increased in 2017. But, what is worrisome is the fact that kitchens having poor level of ventilation has also increased from 16.25 percent to 18.75 percent and rooms which have poor ventilation in the city are also being used for cooking (Figure 6).

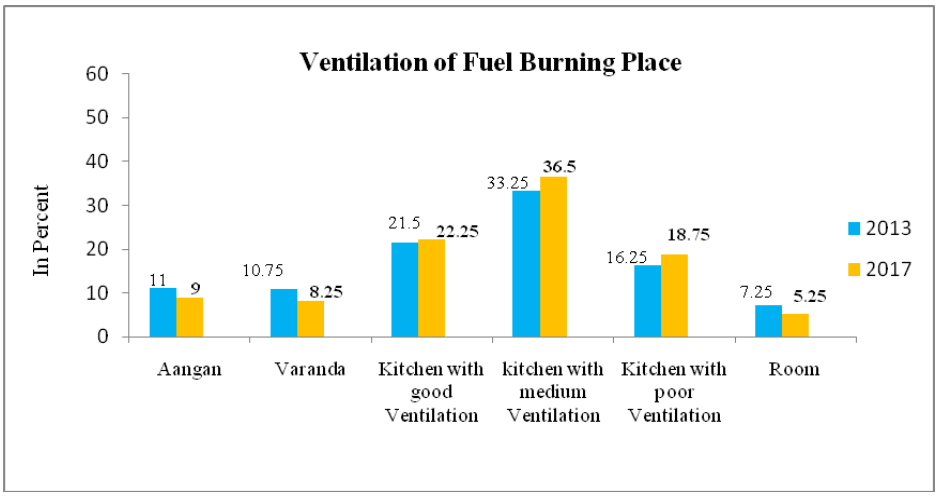

Figure 6: Ventilation of fuel burning places in Bijnor city

INDOOR URBAN ENVIRONMENT QUALTY STATUS

Indoor quality is not only a function of indoor activities and housing facilities, in many big towns more than half of indoor pollutants are contributed by outdoor pollution impairing indoor air quality. However, in small and medium cities where vehicular traffic flow is not at large scale and industrial sector is lowly developed, these are housing conditions and indoor activities which contribute most to the impairment of indoor air quality. The primary causes of poor indoor quality are those sources that release pollutants indoors, i.e. type of fuel burnt indoors, inadequate ventilation and place where fuel is burnt. Parikh *et al.* (2000) have found a strong correlation between the concentration of RPM in the indoor air and combustion of solid fuels traditional stoves. Another study carries out by Mishra *et al.* (1997) found a significant relationship between the excess use of solid fuels and partial or complete blindness. Lung cancer, chronic pulmonary diseases, asthma, etc. are associated with the quality of indoor air. Therefore, it's important to assess the indoor air quality in houses. In the present case, the quality of indoor environment is estimated using a surrogate measure on the basis of factors affecting it as mention above (WHO 1999, Quazi 2017).

All these factors analysed above if separately taken may give a wrong picture of the level and distribution of indoor environment quality. All these factors are interrelated and affected by the location and socioeconomic condition of the population (World Bank 1993). Therefore, two composite indices have been prepared to study the level and distribution of indoor environment quality in the city in 2013 and 2017. The values of these indices have been classified into four classes of very good, good, bad and very bad by applying nested mean method (Figure 7).

Very good quality: The value of composite quality index in these wards is more than 1.980. According to data collected in 2013 there were nine wards in the city where very high level of indoor environmental quality was recorded. In 2017 total number of these wards became 10. In these wards, the majority of households have been using LPG as fuel. Houses in these wards are mostly made of concrete-bricks and they have very good ventilation facilities. Some *kutcha-pucca* houses are also found in these wards, but they are in good condition. Very few *jhuggi/jhopdi* has been found in these wards which are mostly located in the outskirts of the city. An overwhelming number the houses in this category have separate kitchens with good level of

ventilation. People are generally highly educated and are able to afford better quality of life and aware of hygiene and health.

Good quality: The indoor air quality index of these wards varies between 1.474 and 1.980. In 2013 there were four wards in the study area where the quality of indoor environment was found to be good. In 2017 there was no change in the number of wards and same wards have been found falling under this category. All these wards are located in the southern part of the city. In these wards houses are mostly made of concrete-brick with sufficient ventilation. Some *kutcha-pucca* houses are also found in these wards, but they are in good condition. The LPG is used in most of the houses except in a few where kerosene is used as fuel. In these wards ventilation of fuel burning places has been found to be adequate.

Bad indoor quality: The bad quality indoor environment has been recorded in those wards wherein the indoor quality index ranges between 1.007-1.474. Seven wards of the city had this quality of indoor environment in 2013. In 2017 also same numbers of wards have been found under this category. The use of solid fuels and percentage of *kutcha* houses have been found to be the highest in one ward of this category. While, in two other wards, LPG is used in majority of houses, but kitchen ventilation is generally poor which leads to pollution and bad indoor environment quality. The concentration of concrete-brick houses in these wards has been found comparatively more than the *kutcha-pucca* houses. *jhuggis/jhopdis* are also found in these wards where the indoor air quality is found to be worst. These wards are found to be scattered throughout the city area.

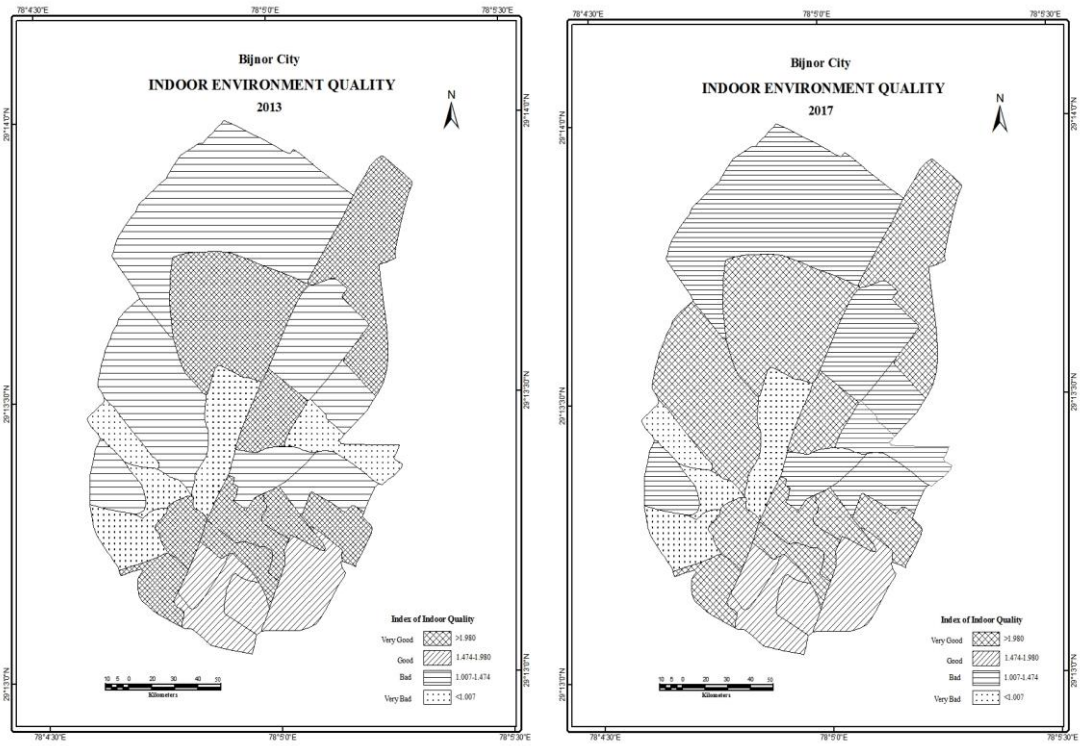

Figure 7: Indoor environment quality in Bijnor city

Very bad indoor quality: The index value of indoor environment quality in these wards is less than 1.007. The very low indoor air quality was observed in the five wards in 2013. In 2017, there were four wards found to be falling in this category. In these wards, majority of households use dung-cake and wood as fuel. All of these wards are now located in south eastern part of the city. The cooking places in these houses also have inadequate ventilation. Due to these factors these houses have high level of pollution concentration. Buildings/houses in these wards are mostly made of concrete-brick, but they don't have *aangan* and veranda. Some of the houses in these wards use rooms for cooking food. This makes the indoor quality worst in these houses. In these wards concentration of *jhuggis/jhopdis* is high which mostly without kitchen, ventilation, good quality of building material and cleanliness. All these factors contribute to very low level of indoor environment quality in these dwellings.

CONCLUSION

A comparative analysis of indoor environment quality in Bijnor city in 2013 and 2017 presents a miserable picture of the city. There have been recorded marginal improvements in many factors affecting indoor environment. But, on an aggregate level about fifty percent of the population is still living in sub-standard indoor environment. Indoor environment quality in the city shows some relation with the occupational structure and distribution of the population of the city, it is more closely associated with socioeconomic status and concentration of population. Other factors, closely associated with level and distribution of quality of indoor environment are location of the houses, concentration of buildings and size and architecture of the houses. The core of the city is more problematic. The low income and middle income groups have densely concentrated in the centre of the city. As a result, dwelling units have multiplied by construction, addition and partition of houses which generally are old. This has resulted, in the absence of proper ventilation, and other household facilities. Therefore, due to congestion and crowding in the central zone, high income people have also developed their residential enclave in the outer zone. Thus the outer zone is characterised by both substandard and high quality housing environments. It is suggested that more and more analytical researches of small cities should be conducted to extend this exploratory study.

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