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Research Article

Urban Residential Asthmatics Facing the Hazards of Indoor Carbon Dioxide (CO_2) Concentrations in Lahore, Pakistan

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Abstract | This study provides information about the indoor air quality (IAQ) of local asthmatics. Lahore, being a metropolitan city, is among the most polluted cities Pakistan. IAQ has been a matter of public concern in the country. Asthma is a common respiratory disorder. CO_2 is components of the air we breathe; type of house and room is directly linked with its concentration. CO_2 concentration is a surrogate indicator for the assessment of IAQ and ventilation efficacy. Average indoor CO_2 can be helpful to identify ventilation system performance. Data was gathered from 50 asthmatic homes with natural ventilation located throughout the nine administrative towns of Lahore, Pakistan. The levels of CO_2, the rate of air change, and the rate of ventilation per person per second were all closely observed in each home. Using CO_2, the ventilation rates were commuted using the tracer gas approach. The CO_2 monitor was used to measure the levels of CO_2 indoors. With SPSS (v.22), statistically significant correlations between open and closed windows of indoor CO_2 levels have been found. Every micro environment's lowest and highest air exchange rate per hour (ACH) was evaluated, and its effects on asthma were noted. Elevated symptoms of asthma have been linked to low ventilation rates. The findings indicated that the ambient air's CO_2 concentration above regulatory limits set by NEQS (National Environmental Quality Standards) and USEPA (United States Environmental Protection Agency), however observed elevated concentrations were in accordance with the given low occupancy (4 people/100 m^2). Other related characteristics included socioeconomic status, smoking, and cleanliness. According to the results, improved ventilation rates per person in a normal home can reduce symptoms by up to 80%. Correlation analysis and one-way ANOVA were used to assess relationships between indoor CO_2 concentration and ventilation rate. The high rates of CO_2 contamination in the homes under examination pose a major risk to the health of those who have asthma, especially and occupants of such houses normally. Curative steps are needed to safeguard the people at risk.

Novelty Statement | This study is unique in reporting the risk of high indoor carbon dioxide concentrations for asthmatic patients of people living the urban areas of Lahore Pakistan.

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INTRODUCTION

Pakistan is a heavily populous country, ranking sixth among other nations, with an estimation of 2.62% of 179 million total world's population (DESA UN, 2012). The average persons per household is 7.2 as estimated in a survey conducted in 2009-2010 by Pakistan Economic Survey, due to an increasing tendency in population dynamics; around 64% of the country's population lives in rural areas. Approximately 92% of people living in rural areas and 22% of people living in urban areas use solid

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fuels for cooking and other uses, like space heating, which contributes to indoor CO_2 rise (Satish *et al*., 2012).

Lahore is provincial capital of Pakistan, District Sheikhupura at north and Wagha border (Indo-Pak Border) at east and district Kasur on south. River Ravi passes from the north of Lahore. Lahore city contributes over 13.2% of the country's GDP, growing at an average annual rate of 5.6%. The city's dense transportation network and industries seriously harm both the urban environment and public health. Elevated air pollution is known to be associated with a higher risk of respiratory allergies, kidney damage, asthma, and other mental health issues (Butler *et al*., 2012). People, however, are not well informed about the risks and expenses to which they are exposed.

Indoor air pollution is a major concern especially in developing countries like Pakistan which is facing severe pollution problems. The air quality situation in urban areas is deplorable and the lack of information leads to an inability to understand the health risks. NEQS are set by the government to control a certain pollutant in limited range in the air. It is also recommended that indoor air pollution is also a potent health risk which must be addressed at the political level. No standards have been defined for determining range values of indoor pollution. Apart from a few studies, detailed information on monitoring CO_2 concentration in residential environments is lacking (Kulshreshtha and Khare, 2011).

The matter of discuss contamination are not recent ones rather they are known and emitted by cave men since ancient times when fire burning was explored which included up CO_2 interior these caves. This focuses out to the moo ventilation at that time but how much it must have influenced the tenants is still obscure (Satish *et al*., 2012). It gives an inspiration to understanding into the tall levels of toxins collection inside display residences. In 12^{th} century, few European houses began utilizing chimneys but the chimney stacks became common by 16^{th} century (Zhai *et al*., 2011). Initially primary IAQ issues were highlighted in early 19^{th} century and then amid vitality emergency in late 19^{th} century, IAQ issues became main focus (Sherbini and Pariggar, 2016). In arrange to avoid open air poisons from mixing with indoor environment, different precautions were made including covering buildings and making at that point discuss tight. In spite of the fact that these steps demonstrated valuable in avoiding invasion from the encompassing discuss, it too postured unused issues, expanded concentration of gasses like CO_2. The toxins concentration was found to be more in indoor air as compared to outdoor space. There is an assessment of sources within indoor environment which are supposed to be cause of next toxin level than the encompassing discuss (Wellenius *et al*., 2012).

Carbon dioxide is fundamental constituent of the soil environment. It is additionally a critical human metabolite. There are 350-400 ppm foundation levels of CO_2 in surrounding discuss. Its concentration in buildings can be as higher indeed coming to 4000-4500ppm (De Giuli *et al*., 2012). The main components which contributes to CO_2 level of indoor air includes the recurrence of discuss trade and human expiration due breathing. The strategies used to measure the ventilation rates in the interior of a building take account of the number of tenants, volume of the building and the ACH (Fischer-Mackey, 2013).

There are assortment of components within the indoor environment whose interaction can unequivocally decide the IAQ. These components incorporate the development of tenants coming about in resuspension of as of now stored tidy and contaminants; exercises of the tenants in this manner creating shifting sums of toxins; sources and sinks of poisons and development of discuss inside the distinctive parts of the building and from the outside influencing the evacuation as well as scattering of poisons (Satsangi *et al*., 2014). These sources change in nature such as outside, inner, organic or chemical in nature (Goyal and Khare, 2011). Discuss development is additionally an indispensably portion of IAQ. Discuss development in a building may be common or forced by a warming ventilation and discuss Conditioning (HVAC) setup. In essence, the ventilation system is a guarantee of invasion and exfiltration of the discussion in and out of the building. As a result, the toxins can move in and out of the indoor miniaturized scale situations (Fiorentini *et al*., 2015). Some of the different variables that have an effect on discussion streams in real ventilation buildings are location, shape and estimate of building close to wind direction as well as geology. It is also important to keep the temperature and humidity between indoors and outdoors consistent. The two driving forces that cause the wind flow from the exterior to the interior environment are the warm buoyancy and the weight of the wind. Also, it is important that the temperature and humidity of both indoors and outdoors are appropriate.

The two main drivers of the wind flow from the exterior to the interior environment are the warm buoyancy and the weight of the wind (ASHRAE, 2012). As ventilation is characterized by the supply of sufficient quantities of fresh air in an indoor atmosphere to allow people to breathe easily, and as a flood of air from inside can weaken or evacuate poisons that have been produced indoors. A constant supply of new discuss within the indoor small-scale situations is an imperative figure to preserve a solid environment. A higher rate of ventilation implies littler home time of the toxins inside. Ventilation may be characteristic, mechanical (fans or HVAC frameworks) and half breed (Fiorentini *et al*., 2015). On the other hand, when the external environment

is increasingly contaminated, more poisons will stream inside, weakening the toxins as they congregate inside the compartment. The HVAC systems may contain a variety of microorganisms that pose a risk to human health. However, if properly maintained, HVAC systems can be helpful in maintaining a high IAQ (Zhou and Chen, 2010). While natural ventilation is less expensive than mechanical ventilation, it is also more unpredictable because airflow is not always consistent under changing weather conditions. Furthermore, the opening and closing of windows and other similar openings affects the amount of open-air discussion that (Dong and Lam, 2014).

Individuals with asthma are more effortlessly influenced by the unfavorable wellbeing impacts of indoor toxins as compared to sound individuals (Samet *et al*., 2000). Numerous epidemiological considers of asthma and healing center confirmations are joined with indoor discuss contamination in North America and Europe (Galan *et al*., 2003; Dominci *et al*., 2006). However, limit contrasts within the occurrence of asthma among different age bunches like elderly, grown-ups and children have uncommon been tested appropriately (Peel *et al*., 2005; Atkinson *et al*., 2001). There aren't many epidemiological studies assessing how indoor CO_2 concentration affects asthma flare-ups (Tolbert *et al*., 2007).

Materials and Methods

Main purpose of the current ponder was to look into the features and parameters of CO_2 concentration air change rate and in naturally ventilated houses of asthma patients of Lahore.

Study area

Lahore is the chronicled city at (31˚15'-31˚45' N and 74˚01'-74˚39' E), 2nd greatest city of Pakistan located in territory of Punjab. Ravi waterway streams within the north-west. The city is amplified 1772 km^2 zone at 217m height over the ocean level. In 2001, Lahore was relegated the regulatory status of city Locale and is separated into 9 small and big towns and military organization cantonment zone. Being one of thickly populated cities around globe, populace of Lahore is around 9,086,000 tenants (Farhat *et al*., 2018). Lahore gets a hot climate with ordinary temperature ranging up to 24.3°C (Rasheed *et al*., 2015). The highest usual temperature during exceptionally hot summers is between 33 and 39°C, while the lowest normal temperature is between 22 and 28°C. The range of wintertime maximum temperatures is 17–22°C, while the range of minimum temperatures is 7–12°C (Alam *et al*., 2012). Lahore encounters yearly precipitation, 600-800 mm, for the most part amid the months of rainstorm period (Mid-July till September) (Pakistan Meteorology Division).

Site selection

Chosen destinations (n= 50) were inside the run of 02 km from main streets with overwhelming activity and different of urban environment regions. Among the chosen houses as it were twenty houses were chosen in urban, ten in semi urban, ten in absolutely commercial region and ten found in region of parks. These houses were of variety of floor area opted from each town. Three groups were formed on the basis of size of the houses large, 418.06 m^2, medium; 211-104 m^2 and small; 62.71 m^2. Since the number of people is also very significant contributor to the indoor air quality; three occupancy levels were also formed low with 03-05 occupants, medium with 06-09 occupants and high with 08-12 occupants.

Filling of survey questionnaire

Survey questionnaire was completed about every sampling site to get data regarding total number of residents, everyday routine activities, the time spent outdoors and indoors, smoking habits, fuel type for cooking and health status. The data thus collected was exceptionally valuable with a knowledge within the day by day schedule of the inhabitants and the conceivable exposures to the toxins at indoor and exterior as well.

Strategies of CO_2 checking

Dragerwerk AG, Germany and Drager suction pump (Accuro ® 2000, Dragerwerk AG, Germany) were utilized for estimating indoor level of CO_2. Data collected includes CO_2 concentrations (one reading) in parts per million (ppm) at each residence.

Estimation of ACH

Every one of the selected homes has regular, good ventilation. The rate of ventilation in each subject's living room was measured. In order to maintain the same CO_2 level, this procedure was finished while no one was in the room. When employing carbon dioxide as a tracer gas, the concentration rot technique was applied. The source of CO_2 was a fire quencher barrel, and the IAQ gas test (BW innovations) was used to measure the concentration of gas. With the help of fans, CO_2 was introduced into the room and allowed to evenly disperse across the famed foundation concentration. Gas concentration was measured every three minutes until it was within 200 parts per million of the recommended level. Plotting the normal log of CO_2 (ppm) over time (hours) yielded an ACH = inclination of the best fit line. The analysis of alter per hour (ACH) was performed to determine the ventilation rate at every site. The volume of discuss entering the desired rooms were too decided by utilizing the straightforward equation:

$$\text{Ventilation rate}\left(\frac{L}{sec}\right) = \frac{\text{ACH} \times \text{Volume of room } (m^3)}{3.6}$$

A constant blending and accessibility of new

discussions is not ensured by shared ventilation. Because of this, the volume of air shown per person in both miniaturised size scenarios was also determined using the formula Ventilation rate (L/s/person) = L/sec x number of people in the room (Fischer-Mackey, 2013).

Data analysis

Pearson's relationship between discuss change rate and CO_2 concentration was calculated to scrutinize the impact of ventilation rates of indoor discuss through SPSS (v.22.0).

Results

This study compares the CO_2 concentrations in 50 asthmatic patients' actual ventilated homes in Lahore, Pakistan, and offers the results of ACH as well as stream rate and CO_2 generation. The selected locations (n = 50) were located between 0.5 and 02 km away from areas of high surge activity in various metropolitan environments. Ten of the selected residences were set up in mechanical ranges; the remaining twenty were located in metropolitan areas, ten in semi-urban areas, and ten near parks. Other than winter, windows were typically left open due to Lahore's warm environment throughout the year.

Generally speaking, the majority of people living in households were work holders, house spouses, understudies, and house spouses. In all households, fossil fuel petrol was being used as a burning fuel. Table 1 shows that 50% of homes had a kitchen and a living room connected, 40% had a kitchen and a resting room slightly associated, and 10% had neither (Table 1). The floor plans of each place were set up to observe how the spaces were displayed for trade discussions and to gain insight into the living rooms of Lahore's asthmatics. The study determined that there was a coordinating association between ventilation rate and the measurements of rooms, living regions, entryways, windows, and removals from the street.

The housing estimate for the category-A locations under inspection was 418.1 m^2, with a floor zone spanning from 76.26 m^2 to 87.16 m^2. There were now between 8 and 12 residents, one of whom was a visitor smoker. 23–40°C in temperature and 17–39% mugginess. The selected locations A1–A10 were located between 0.5 and 1.75 kilometres from main streets, and in most cases, the adjacent streets were carpeted or cemented, while the streets outside the two destinations were clean, unpaved streets. Of the six locations shown, the dwellings' areas vary greatly in an urban and semi-urban setting. The inside CO_2 levels in the category-A testing locations were 558–754 ppm and 564–790 ppm with the entryway and windows closed, respectively.

The house size at the category-B testing locations was 211.4 m^2, with floor sizes ranging from 52.35 m^2 to 66.73 m^2. There were no longer six or eight tenants living there, and two of them were occasional smokers. Ranges of temperature are 26–41°C and 19–37% muggy. The selected locations B1–B10 were situated within a 0.5–02 km radius of main streets, with neighbouring streets that were typically carpeted or cemented. The streets outside of these three locations were clean, unpaved streets. In an urban or semi-urban setting, the housing area changes with four destinations. The inside CO_2 levels in the category-B inspection locations were 578–744 ppm and 641–781 ppm with the entryway and windows closed, respectively.

House estimates for category-C testing destinations ranged from 37.39 to 44.87 square meters, with a total floor area of 104.5 square meters. There were now six to nine tenants living there, two of whom were visit smokers. Ranges of temperature are 26–41°C and 17–41% muggy. The selected locations C1–C20 were situated within 0.5–02 kilometres of the majority of streets, with neighbouring streets that were typically carpeted or cemented, while the streets outside of the two locations were clean, unpaved streets. Six locations that are displayed in urban and semi-urban environments cause the dwellings' area to change. The inside CO_2 levels at category-C inspection sites were 687–796 ppm and 770–880 ppm with the entryway and windows closed, respectively.

Table 1: Houses data.

Study case	Size of house in m^2	Number of occupants	Town Location	Distance from road in km
A1- A10	418.1	8-12	Sabzazar, Iqbal town, Model town, Johar town, Gulberg, Wapda town, Valencia, Behria, Cantt, Gulshan ravi	0.5-1.75
B1-B10	211.4	6-8	Muslim town, Iqbal town, sabzazar, Green town, Model town, Faisal town, Johar town, Township, Link road, Shadman	0.5-2.0
C1-C20	104.5	6-9	Ichra, Samanabad, Yateem khana, Faisal town, Chouburgi, Sabzazar, Islam pura, Muslim town, Iqbal town, Samanabad, Green town, Township, Chouburgi, Mauzang, ShapurKanjraan, Badami bagh, Mughalpura, Railway station, U E T, Shadara	0.5-2.0
D1-D10	62.7	3-7	Anarkali, Baghbanpura, Mughalpura, Shalimar town, Shah Alam, Akbari, Gawal mandi, Shahi mohallah, Data darbar, Badami bagh	0.5-2.0

Table 2: Carbon dioxide monitoring open and close (doors and windows).

Study case	House size in m^2	Room size in m^2	Door size in m^2	Window size in m^2	Temperature °C	Humidity %	CO_2 Conc open door and window	Four times increase on CO_2 spray	Time Taken in minutes	CO_2 Conc closed door and window	Four times increase on CO_2 spray	Time taken in minutes
A1	418.1	87.16	2.61	2.31	31	37	752	3920	12	790	3682	42
A2	418.1	76.26	2.22	2.78	31	27	754	3013	12	775	3731	45
A3	418.1	87.16	1.93	2.31	31	30	650	2585	20	649	2041	39
A4	418.1	76.26	2.22	1.85	28	39	602	3040	22	564	2302	37
A5	418.1	87.16	2.27	3.34	34	22	558	2713	19	690	2915	41
A6	418.1	87.16	2.22	2.31	39	21	719	3183	9	790	3627	36
A7	418.1	87.16	2.08	2.78	40	17	592	2301	16	612	2501	36
A8	418.1	87.16	1.93	2.78	30	21	603	2617	12	670	2636	36
A9	418.1	76.26	2.22	3.34	39	19	584	2510	18	608	2526	41
A10	418.1	87.16	2.61	2.31	23	25	560	2140	19	630	2501	39
B1	211.4	52.35	1.93	1.11	35	36	741	3009	23	781	3138	29
B2	211.4	52.35	1.93	1.48	32	29	744	2976	11	771	3130	31
B3	211.4	57.19	1.93	1.85	34	37	676	2705	15	699	2541	28
B4	211.4	61.88	1.93	1.85	29	41	602	2408	16	660	2650	23
B5	211.4	57.19	1.93	1.48	33	20	578	2307	14	670	2715	31
B6	211.4	66.73	1.93	1.48	37	19	710	2872	16	780	3272	30
B7	211.4	61.08	1.93	1.85	41	19	692	2008	17	712	2802	28
B8	211.4	66.73	1.93	2.31	38	21	636	2610	17	693	2835	36
B9	211.4	52.35	1.93	2.31	38	22	684	2736	20	708	2860	35
B10	211.4	61.08	1.93	1.85	26	27	590	2360	19	641	2631	29
C1	104.5	44.87	1.66	1.48	31	37	790	3260	22	880	3550	32
C2	104.5	37.39	1.66	0.82	31	27	724	2906	23	825	3391	35
C3	104.5	41.07	1.95	0.82	31	30	776	3201	24	839	3350	36
C4	104.5	44.87	1.95	1.11	28	39	793	3200	21	864	3501	31
C5	104.5	41.07	1.95	1.48	34	22	780	3208	20	790	3200	41
C6	104.5	44.87	1.66	1.11	39	21	687	2744	25	812	3231	31
C7	104.5	44.87	1.66	2.31	40	17	732	2928	19	792	3180	33
C8	104.5	37.39	1.95	1.48	30	21	767	3050	21	770	3095	36
C9	104.5	41.07	1.66	1.48	39	19	784	3226	22	809	3327	41
C10	104.5	37.39	1.95	0.82	23	25	794	3190	23	830	3355	33
C11	104.5	44.87	1.66	0.82	35	36	760	3040	24	791	3184	29
C12	104.5	44.87	1.95	1.48	32	29	759	3050	21	799	3199	31
C13	104.5	41.07	1.66	0.82	34	37	703	2817	22	809	3210	28
C14	104.5	44.87	1.95	1.48	29	41	792	3201	19	866	3521	23
C15	104.5	37.39	1.95	1.48	33	20	766	3010	22	834	3350	31
C16	104.5	41.07	1.95	1.48	37	19	796	3199	12	798	3202	30
C17	104.5	37.39	1.95	1.48	41	19	788	3155	20	812	3220	28
C18	104.5	41.07	1.95	1.48	38	21	689	2809	17	873	3541	36
C19	104.5	44.87	1.95	1.48	38	22	767	3099	15	861	3494	35
C20	104.5	44.87	1.95	1.48	26	27	796	3211	18	842	3364	30
D1	62.7	28.37	1.66	--	31	37	819	3283	29	890	3588	51
D2	62.7	28.37	1.66	--	31	37	854	3420	27	855	3510	56
D3	62.7	22.69	1.66	0.55	31	27	892	3613	26	839	3350	48
D4	62.7	25.48	1.66	0.82	31	30	850	3435	25	874	3530	49
D5	62.7	28.37	1.66	--	28	39	880	3540	28	897	3580	57
D6	62.7	28.37	1.66	0.55	34	22	858	3413	23	891	3544	47
D7	62.7	25.48	1.66	0.55	39	21	839	3353	24	884	3489	46
D8	62.7	22.69	1.66	--	40	17	872	3482	27	879	3478	58
D9	62.7	28.37	1.66	0.55	30	21	864	30351	26	908	3602	46
D10	62.7	22.69	1.66	--	39	19	850	3505	28	930	3710	60

The house size in the category-D testing locations was 62.7 m^2, with floor areas ranging from 22.69 m^2 to 28.37 m^2. There were now three to seven people living there, two of whom were smokers on visits. Ranges for temperature are 28–40°C and 17–39% mugginess. The selected locations D1–D10 were discovered within a 0.5 km radius of basic streets, which were typically carpeted or cemented, while the streets outside of the three destinations were clean, unpaved streets. The area of the homes shifts with three destinations show in urban and semi-urban environment. Tables 1 and 2 gives with n diagram of each of the examining locales. Inspecting destinations of category-D had indoor level of CO_2 is 819-892 ppm and 839-930 ppm with open and closed (entryway and windows) separately.

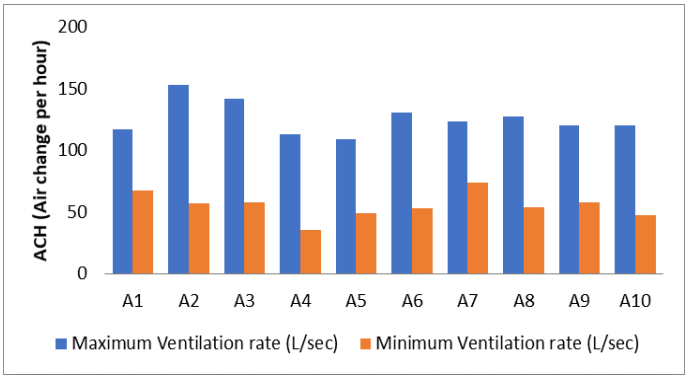

Figure 1: Maximum and minimum air change rate in the living rooms of the houses (liter/second/person) in the living rooms of the asthmatic patients (Category-A).

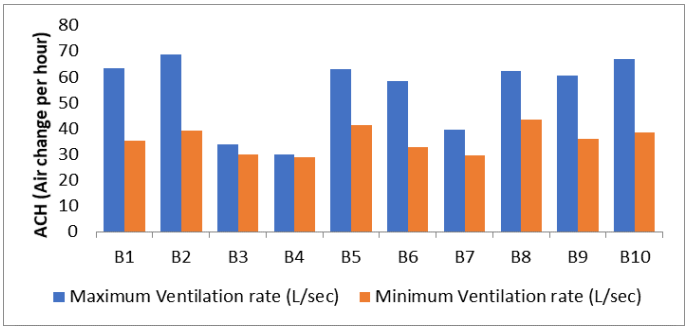

Figure 2: Maximum and minimum air change rate in the living rooms of the houses (liter/second/person) in the living rooms of the asthmatic patients (Category-B).

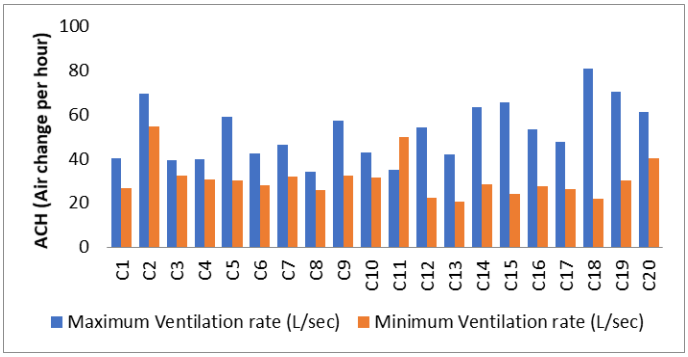

Figure 3: Maximum and minimum air change rate in the living rooms of the houses (liter/second/person) in the living rooms of the asthmatic patients (Category-C).

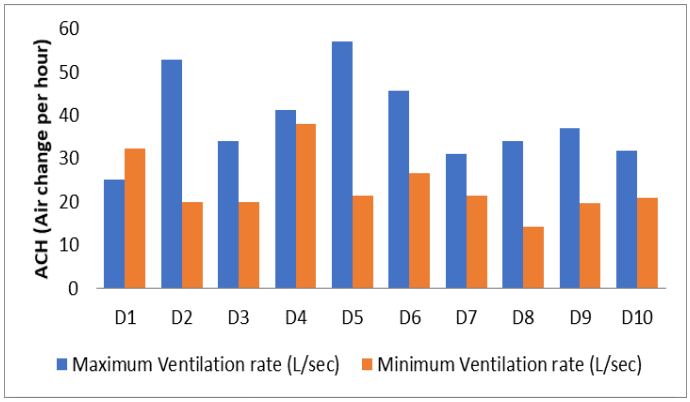

Figure 4: Maximum and minimum air change rate in the living rooms of the houses (liter/second/person) in the living rooms of the asthmatic patients (Category-D).

Talk about the exchange rate (ACH) The ventilation rates (L/sec) and (L/s/person) of the most extreme and least (open and closed windows and doors) were measured. Maximum ACH 4.4-7.2, ventilation rate (L/sec) 108.63-153.05, and ventilation rate (L/s/person) 325.89-306.11 are the observed values for the selected destinations A1-A10. Ventilation rate (L/sec) 35.78-73.94, minimum ACH 1.6-3.0, and ventilation rate (L/s/person) 143.13-295.76. Maximum ACH 1.7-4.7, ventilation rate (L/sec) 29.95-68.68, and ventilation rate (L/s/person) 119.82-206.06 are the observed values for the selected destinations B1-B10. Ventilation rate (L/sec) 29.03-41.32, minimum ACH 1.6-2.6, and ventilation rate (L/s/person) 116.14-123.0. Max ACH 2.7-12.5, ventilation rate (L/sec) 34.78-143.63, and ventilation rate (L/s/person) 139.14-430.90 are the values obtained for the selected destinations C1-C20 that were examined. Ventilation rate (L/sec) 20.37-54.59, minimum ACH 1.7-5.2, and ventilation rate (L/s/person) 81.48-163.48. The maximum ACH 3.1-79.1, the minimum ACH 2.2-5.3, the maximum ventilation rate (L/sec) 14.18-38.03, and the maximum ventilation rate (L/s/person) 70.92-15214 are the ventilation rates for the selected localities D1-D10 that were verified (Table 3). Of all these gas levels that were associated, more than 70% of the dwellings had CO_2 levels that were higher than the recommended amount (ppm).

Carbon dioxide concentration and discuss alter rate appeared negative pearson relationship (Table 4). One way ANOVA appeared noteworthiness of Max and Min ACH (0.007 and 0.079).

Discussion

CO_2 could be a natural constituent of the environment. Its degree within the encompassing discuss is as a rule 380ppm or more noteworthy based on the nearby circumstances like vehicular thickness, combustion sources including mechanical, climatic conditions, wind

Table 3: Comparison between maximum and minimum ventilation rate.

Case No.	Maximum ventilation with open doors and windows					Minimum ventilation with closed doors and windows			
	CO_2 concentration	Persons in a room	ACH	Ventilation rate (L/sec)	Ventilation rate (L/s/person)	CO_2 concentration	ACH	Ventilation rate (L/sec)	Ventilation rate (L/s/person)
A1	465	3	4.8	116.97	350.92	522	2.7	67.15	201.46
A2	470	2	7.2	153.05	306.11	511	2.6	56.86	113.72
A3	449	3	5.8	142.12	426.38	493	2.3	57.41	172.24
A4	446	4	5.3	112.70	450.83	488	1.6	35.78	143.13
A5	429	3	4.4	108.63	325.89	486	2.0	49.12	147.38
A6	469	3	5.3	130.25	390.76	599	2.1	53.23	159.70
A7	499	4	5.1	123.51	494.07	513	3.0	73.94	295.76
A8	439	4	5.2	127.29	509.17	473	2.2	53.97	215.91
A9	433	4	5.6	120.53	482.14	476	2.7	57.67	230.71
A10	430	3	4.9	120.26	360.80	501	1.9	47.43	142.31
B1	590	2	4.3	63.47	126.95	671	2.4	35.29	70.59
B2	685	3	4.7	68.68	206.06	773	2.6	39.04	117.12
B3	836	3	2.1	33.78	101.35	896	1.8	29.96	89.89
B4	892	4	1.7	29.95	119.82	913	1.6	29.03	116.14
B5	595	3	3.9	63.02	189.08	702	2.6	41.32	123.96
B6	578	2	3.1	58.36	116.73	690	1.7	32.63	65.26
B7	701	2	2.3	39.52	79.058	799	1.7	29.55	59.10
B8	760	2	3.3	62.14	124.29	865	2.3	43.57	87.15
B9	684	3	4.1	60.36	181.08	728	2.4	36.10	108.30
B10	839	2	3.9	66.77	133.54	929	2.2	38.40	76.81
C1	669	2	3.2	40.22	80.45	982	2.1	26.59	53.18
C2	584	3	6.6	69.26	207.80	691	5.2	54.49	163.48
C3	601	3	3.4	39.20	117.60	712	2.8	32.56	97.70
C4	581	2	3.1	39.68	79.36	650	2.4	30.81	61.62
C5	819	2	5.1	59.16	118.32	923	2.6	30.02	60.05
C6	758	2	3.3	42.23	84.47	833	2.2	27.78	55.56
C7	709	2	3.7	46.16	92.32	781	2.5	31.94	63.89
C8	901	3	3.2	34.26	102.79	944	2.4	25.62	76.87
C9	834	3	5.0	57.20	171.60	913	2.8	32.24	96.74
C10	792	4	4.1	42.77	171.08	866	3.0	31.30	125.20
C11	752	4	2.7	34.78	139.14	790	3.9	49.70	198.82
C12	754	4	4.3	54.13	216.53	775	1.7	22.34	89.37
C13	650	4	3.6	42.00	168.01	649	1.7	20.37	81.48
C14	602	4	5.0	63.27	253.10	564	2.2	28.48	113.92
C15	558	4	6.2	65.36	261.47	690	2.3	24.05	96.21
C16	719	3	12.5	143.63	430.90	790	2.4	27.42	82.28
C17	592	2	4.5	47.763	95.52	612	2.5	26.04	52.09
C18	603	4	7.0	80.65	322.62	670	1.9	21.94	87.77
C19	584	4	5.6	70.27	281.10	608	2.4	30.39	121.56
C20	560	4	4.9	61.08	244.34	630	3.2	40.39	161.57
D1	741	3	3.1	25.14	75.44	781	4.1	32.40	97.22
D2	744	4	9.1	72.16	288.64	771	2.5	19.83	79.32
D3	676	3	5.4	34.04	102.14	699	3.1	19.92	59.78
D4	602	4	5.8	41.09	164.39	660	5.3	38.03	152.14
D5	578	4	7.2	56.96	227.86	670	2.6	21.26	85.07
D6	710	4	5.8	45.74	182.98	780	3.3	26.51	106.05
D7	692	4	4.3	31.00	124.03	712	3.0	21.33	85.33
D8	636	5	5.3	33.90	169.52	693	2.2	14.18	70.92
D9	684	5	4.6	36.88	184.41	708	2.5	19.76	98.83
D10	590	4	5.0	31.90	127.62	641	3.3	20.84	83.38

Table 4: Table correlation.

Correlations		Max CO_2 concentration	ACH	Ventilation rate	Ventilationrate (L/s/person)
Max CO_2 concentration	Pearson correlation	1	-0.499**	-0.744**	-0.738**
	Sig. (2-tailed)		0	0	0
	N	50	50	50	50
ACH	Pearson correlation	-0.499**	1	.487**	0.548**
	Sig. (2-tailed)	0		0	0
	N	50	50	50	50
Ventilation rate	Pearson correlation	-0.744**	0.487**	1	0.883**
	Sig. (2-tailed)	0	0		0
	N	50	50	50	50
Ventilationrate (L/s/person)	Pearson correlation	-0.738**	0.548**	.883**	1
	Sig. (2-tailed)	0	0	0	
	N	50	50	50	50

**, correlation is significant at the 0.01 level (2-tailed).

development and temperature (Butler *et al*., 2012). Indoor CO_2 level for category-A was 558-754ppm, category-B was 578-744ppm, category-C was 687-796ppm, category-D was 819-892ppm with 8-12, 6-8, 6-9 and 3-7occupants individually. An exalted indoor CO_2 concentration is connected with check of tenants within the room (Kukee and Dovjak, 2014), ventilation rate and CO_2 level within the surrounding discuss of room. When ventilation is insufficient to remove or reduce the amount of CO_2 that room occupants consistently produce, indoor CO_2 levels can build up (ASHRAE, 2012). The upper limit of acceptable CO_2 concentrations is between 250 and 350 ppm, while the present monitoring levels are between 558 and 892 ppm for open windows and doors and between 564 and 930 ppm for closed windows and doors. ASHRAE (2012) ventilation guidelines make it very evident that the indoor CO_2 concentration cannot be higher than 650 ppm above the ambient concentration. People who live in areas with higher CO_2 concentrations may be executed if they become fatigued and inactive (Satish *et al*., 2012). Concurring to WHO (World Wellbeing Organization), sufficient ventilation is essential for dodging airborne diseases and it is highly recommendable to maintain a strategic distance from spread of TB and asthma (WHO, 2009). The encompassing discuss quality depends upon the concentrations of vaporous contaminants and its ventilation framework to debase these gasses. It is found essential to check surrounding discuss quality (IAQ) for tenant aspiratory wellbeing and consolation (ASHRAE, 2012). In display consider, category A, B, C, D have max ACH 4.4-7.2, 1.7-4.7, 2.7-12.5 and 3.1-79.1 separately. Prove appeared that diminished ventilation rates are related with high disease rates though; tall ventilation rate can diminish airborne contamination rates by bringing down the concentration of bead cores by decreasing the hazard of inhaled infections (WHO, 2009; NVPAC, 2007). The breathing of tenants is the main source of indoor CO_2. CO_2 for the most part ranges from 350-2500ppm (Satish *et al*., 2012).

For the most part indoor CO_2 rise up is expected to be a surrogate pointer for other inhabitants, particularly bio effluents and for ventilation rate per inhabitant. The limit run of CO_2 is 5000 ppm for eight hours weighted normal exposures (Akkas *et al*., 2015). ASHRAE (2012) recommended 10 Ls-1 per individual most reduced ventilation rate for workplaces, to a nearly steady circumstance of indoor concentration of 870ppm (ASHRAE, 2012), based on supposition that open air CO_2 are 350ppm and generation rate is 0.31 L/min- individual (Apte *et al*., 2000).

CO_2 levels in inside are utilized to get to IAQ and the ventilation rate. The CO_2 concentration in a living space appears in case the building's ACH adjust is satisfactory. CO_2 is produced when individuals breathe out and each breathed out breath have 35,000 to 50,000ppm of CO_2 and on normal is around 100 times more prominent than is regularly found in encompassing discuss. Greatest admissible CO_2 level in a mechanical working environment is 5,000ppm. Surrounding CO_2 levels are generally about 380- 500ppm. Indoor CO2 levels ought to not surpass by more than 650ppm (ASHRAE, 2012). Analysts conducted by the US-EPA approximately human presentation to toxins delineated that levels of most toxins are two to five times more noteworthy than surrounding levels. These levels of indoor discuss poisons are of uncommon connection since it is concluded that most individuals particularly children spend 90% of their time inside (Bronsema *et al*., 2004). A parcel of connection was suggested among indoor CO_2 concentration and IAQ and unfavorable wellbeing results of improved CO_2, IAQ, CO_2 concentration and surrounding discuss (ASHRAE, 2012; Hoskins, 2003). Carbon Dioxide concentration could be

exceptionally vital parameter for analyzing indoor discuss quality and efficient ventilation (Godish, 2000).

Although typical ventilation isn't expensive, it has the drawback of requiring windows and doors to be opened, which isn't possible because of temperature restrictions, precipitation patterns, safety concerns, and security concerns. There are two possible methods to screen ventilation rate: first, using space volume (i.e., talking about alter per hour or ACH) instead of the total number of occupants in the living area (i.e., liters/second/person). Approximations based on occupancy emphasise the fact that every person in the designated area needs a specific amount of fresh information (WHO, 2007).

DOSH (2005) detailed IAQ provided discuss and ventilation estimation were diverse in ancient and modern buildings. In ancient buildings moo IAQ was recorded (18.60cfm/person) compared in comparison to least (20cfm/person) prescribed ASHRAE Standard-62 (Common Ventilation). Indoor environment recorded lower IAQ level of ASHRAE Standard-62 prescribed may deliver certain warm inconvenience like eye bothering, cerebral pains and discombobulation on delayed presentation. Irtishad (2001) detailed the convenience of discuss dealing with unit (HVAC framework), its upkeep, cleaning handle and time by time review can way better the ventilation and advancement of IAQ. By and large, CDC suggests ventilation in a wellbeing care office must be in between 6-12 air changes per hour (ACH). This is equal to 80 l/s/person for a room of $24m^3$. Rooms for asthmatics and irresistible TB patients, at slightest 12 ACH are emphatically prescribed (WHO, 2009; CDC, 2005). Though, in our consider Category A, B, C, D have Max ACH 4.4-7.2, 1.7-4.7, 2.7-12.5 and 3.1-79.1 individually which were underneath the prescribed levels. Apte *et al.* (2000) and Erdman *et al.* (2002) considered affiliations of SBS (debilitated building disorder symptoms) and indoor-outdoor CO_2 concentration deviation as surrogates for per individual ventilation rates. The highest indoor and outdoor CO_2 concentrations in our study are 418 and 716 ppm, respectively. Tenant stack patterns were recorded and related to building utilization (Wong and Mui, 2006). Control of IAQ and the vitality related were appeared to be inhabitant stack design related (Mui *et al.*, 2007; Wong *et al.*, 2008). In regularly particular Hong Kong workplaces, inhabitance ranges are nearly steady around working hours but for a drop at lunch-time. In actuality, all IAQ measures must take into account the viability of ventilation rate, commencement rate, vacillation, and weakening of indoor CO_2 concentration, as these factors contribute to the amounts' weaknesses (Hui *et al.*, 2008).

In our study most of the buildings were old and similar results were watched by (Kukee and Dovjak, 2014), expressed that the SBS may happen due to unseemly ventilation and more noteworthy levels of temperature and stickiness and temperature. Clear affiliation in between upgraded of indoor CO_2 levels increments in certain SBS indications (Norhidayah *et al.*, 2013). Greatest decreases in indication prevalence are generally up to 70-85% related with CO_2 concentration. The lessening of CO_2 may come by massive increase in ventilation rates, viability in providing new discuss of breathing zone of tenants (Syazwan *et al.*, 2009). A high level of CO_2 in a particular area of the living room may be caused by an improper and limited sum of fresh discuss admissions (Wagocki *et al.*, 2005). The ventilation rates (L/sec) at the selected destinations A1–A10 observed are 108.63–153.05 and 325.89–306.11, respectively. The ventilation rates (L/sec) in the selected sites B1–B10 that were examined are 29.95–68.68 and 119.82–206.06. The selected destinations C1–C20 that were evaluated had ventilation rates ranging from 34.78–143.63 (L/sec) and 139.14–430.90 (L/s/person). Insufficiency of indoor discuss quality can increment long term and brief term wellbeing results (Norback *et al.*, 2000; Simoni *et al.*, 2006; Tillet, 2010; Simoni *et al.*, 2010) that affect execution (Gilliland *et al.*, 2001; Shaughnessy *et al.*, 2006; Mohai *et al.*, 2011) and bring positive alter in wellbeing disintegration (Lohbeck, 2008). The outcomes of this ponder portray a solid affiliation in between higher indoor CO_2 levels and individual increment in SBS indications. Examinations conducted utilizing normal and greatest indoor CO_2 had comparable discoveries. These discoveries are clear in relapse models and were confirmed through alteration for a number of potential perplex (Apte *et al.*, 2000).

The basic source of CO_2 in any house is respiration of the individuals living in it (Zhang *et al.*, 2017). The concentrations in most indoor situations like CO_2 buildup is thought to be a pointer of toxins created by tenants, particularly bio effluents and per inhabitant ventilation rate (Bonfiglioli *et al.*, 2013). In spite of the more regrettable conditions of the indoor situations especially in urban ranges, arrangement producers are still insensible of the dangers to which lion's share of the populace is uncovered. It could be a much-needed step to recognize indoor discuss contamination at approach level so that moderation measures can be started.

Conclusions and Recommendations

The levels of CO_2 as a gaseous poison display within the houses were more noteworthy than typical and this may be respected as a potential health danger to the asthmatic patients at large. It can be hurtful to all tenants of these houses in specific. Few preparatory measures are required to escort securely individuals at hazard. These comes about propose that extra ventilation rates per individual among commonplace house will on normal significantly diminish the prevalence of numerous side effects up to 80%.

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Conflict of interest

The authors have declared no conflict of interest.

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