Increase in outdoor carbon dioxide and its effects on the environment and human health in Kuje FCT Nigeria

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Abstract: Globally there are concerns about outdoor air pollution and its effects on the environment and human health. Researchers are concerned with the negative effects of and best mitigation strategies for air pollution. Climate change and human health are a common phenomenon associated with air pollution, as carbon dioxide (CO₂) is absorbed and emitted naturally as part of the carbon cycle. This study was aimed at assessing the emission level of CO₂ in Kuje Area Council in the Federal Capital Territory, Nigeria and its effect on the environment and human health. Fifty specific residential and commercial locations were considered, and over 1200 observations of CO₂ field data were collected and analysed during two seasons—dry and wet. The land-use settlement pattern was taken into consideration. The data were collected weekly at different time bands (2-, 4-, 6-, and 8-hour time intervals) using the AMPROBE CO₂-100, CO₂ meter gas detection instrument with self-calibration capability of ± 30 parts per million (ppm), $\pm 5\%$ reading (0–5000) accuracy. A Garmin CX60 global positioning system was used to obtain the point locations Universal Transvers Mercator coordinates. The results showed higher mean CO₂ emission values of >541 ppm and <713 ppm during the dry and wet seasons, respectively. It was also observed that these values were contrary to and exceeded the American Society of Heating, Refrigerating and Air-Conditioning Engineers and Occupational Safety and Health Administration normal outdoor level standards of 350–450 ppm. These higher CO₂ values were found in the residential and commercial districts, and if not monitored and controlled they will have adverse effects on human health and climate change effects. Quick interventions would be to plant trees to sequester the CO₂ and to regulate the transportation system within the area due to continuous carbon emission.

Key words: carbon dioxide, climate change, human health, emission levels.

Introduction

There have been continuous discussions on climate change and the role of air pollution globally. This has stimulated many global studies, articles, and publications on climate change and its effect on economy, human health, and the environment. The discussions are skewed in the direction of greenhouse gas (GHG) emissions, most importantly that the GHGs directly emitted by humans, such as methane (CH₄), nitrous oxide (N₂O), carbon dioxide (CO₂), and several others. GHG emissions are often measured in a CO₂ equivalent according to United States Environmental Protection Agency (USEPA, 2016). Transportation is the second largest source of CO₂ emissions, accounting for about 31% of total U.S. CO₂ emissions and 26% of total US GHG emissions in 2011 (Thind, 2013). Carbon dioxide also enters the atmosphere through burning of fossil fuels, municipal solid waste, trees and wood products, and because of certain chemical reactions. It is also removed from the atmosphere or “sequestered” when it is

absorbed by plants as part of the biological carbon cycle (USEPA, 2016). The increase in GHG emissions is generating more data-informed research on several causes of the change in climatic conditions and the resultant effects on the environment. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and Occupational Safety and Health Administration (OSHA) normal standards for the outdoor levels of CO₂ is 350–450 parts per million (ppm), which is used for the purpose of this study. In August 2016, the Mauna Loa Observatory in Hawaii noted that the mean monthly average measurement of CO₂ increased from 398.93 ppm in 2015 to 402.25 ppm a year later (United States Earth System Research Laboratory (ESRL) and National Oceanic and Atmospheric Administration (NOAA), 2016). If this increases more in the atmosphere and displaces oxygen (O₂) significantly, it will contribute to toxicity (Rice, 2004) and will clearly contribute to poor indoor air quality (Miller et al., 2010), because the changes in the CO₂ level impacts fungal growth medium to induce allergies (Lang-Yona et al., 2013). For every 1 degree rise in temperature caused by CO₂, cancers may increase by 20%–30% (Kalaugher, 2008). When the body

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Deforestation is an environmental challenge that contributes to increased weather conditions and climate change effects. Between 2008 and 2016, trees removed from the Kuje Area Council Federal Capital Territory (FCT) resulted in an arithmetic difference of 0.0283 km² (40.67%). This translates to an equivalent of over 9.6 tons of CO₂ that was not sequestered due to deforestation. An increase in tree cover provides more resistance to extreme weather and improves photosynthesis; therefore, a decrease in trees to sequester CO₂ presents a challenge (Badaru et al., 2016). High concentrations of CO₂ in residential settlements or commercial workplaces can cause adverse health effects such as, but not limited to, dizziness, suffocation, disorientation, and under certain circumstances, death. (Farrar et al., 1999; IVHHN, 2005; Nelson, 2000; NIOSH, 1976, 1996). Owing to the observed environmental CO₂ issues, behavioural toxicity levels are inevitable; however, re-evaluation of existing standards for the maximum allowable concentrations is considered (Vercruyssen et al., 2007). In the FCT, increased anthropogenic activities contribute immensely to the outdoor pollution (Abdullahi et al., 2012; Okobia, 2012), it is of utmost necessity that the outdoor CO₂ level is quickly assessed in the FCT.

We assumed that CO₂ outdoor emission levels are normal in residential districts and high in commercial districts of Kuje Area council. This research covers residential and commercial areas in Kuje Area Council within the FCT of Nigeria, to provide a basis for extensive and comparative analysis.

Kuje Area Council is located between latitude 8°40' and 9°00' north of the equator and longitude 7°00' and 7°40' east of the Greenwich meridian. It is bordered on the north by Abuja Municipal Area Council, to the east by Nasarawa state, and to the west by Kwali Area council. It has a population of 97 367 according to the 2006 Nigerian census report (Federal Government of Nigeria Official Gazette, 2007). Kuje Area Council is among the most developed of the six area councils; it falls within the semi-urban settlement location of the FCT. The bulk of the built-up areas are Kuchiyako, Lowcost estate, Pasali, etc., Figure 1 gives the boundary locations of the study area.

Climate

The climate of the FCT is hot, humid, and tropical. It is such that its major elements have regimes that are transitional from those of the southern and the northern parts of the country.

From the information extrapolated from adjacent weather stations, the study area has a total annual rainfall of approximately 1650 mm. About 60% of the annual rains fall during the months of July, August, and September (NIMET, 2010). A crucial climatic characteristic of this area is the frequent occurrence of squall lines heralded by thunder storms, lightening, strong winds, and high-intensity rainfall.

The temperature is highest and greatest during the dry season months from December to March, when the maximum temperature ranges between 30°C and 35°C. During the wet season months from May to September the maximum temperature ranges between 25°C and 30°C (NIMET, 2010).

Methods and materials

The land-use patterns and population density were studied using purposive sampling techniques to guide in data acquisition. The primary CO₂ field data were acquired directly from 50 specific residential and commercial locations in the study area at 2-hour intervals (from 0600 h to 2200 h GMT) with over 1200 observations. We used an AMPROBE CO₂-100, CO₂ gas detection instrument with a self-calibration capability of ± 30 ppm $\pm 5\%$ reading (0–5000) accuracy (which meets

European, American, Australian, and Nigerian standards), combined with a Garmin CX60 global positioning system to obtain the point location Universal Transvers Mercator coordinates.

The field observations were done in compliance with local and global regulations. Spatial point CO₂ data value readings were collected (morning, afternoon, and evening), separately in 2-, 4-, 6-, and 8-hour time bands in the residential and commercial areas during the wet and dry seasons.

Results

Dry season mean CO₂ data for the residential district in Kuje Area Council

The mean dry season CO₂ results for the residential district in Kuje Area Council are presented in Figure 2. The details of each point in the residential district are shown in Table 1.

The mean dry season CO₂ data from the residential district showed a minimum value of 574 ppm at point 17 (P17 (by a housing development)), whereas the highest CO₂ mean value was 694 ppm at P3 (by an event centre). The lowest value was observed at 0600 h at the 2-hour time band, and the highest value was obtained at 2200 h at the 8-hour time band. The graph in Figure 2 shows a distinct trend of CO₂ emissions with higher values during the 4-hour time band and the 8-hour time band as tabulated in Table 1. However, the overall trend from morning to evening shows little fluctuation in the CO₂ emissions (diurnal range).

Figure 2. Graph showing mean CO₂ dry season residential data for Kuje, F.C.T. Nigeria.

Table 1. Mean dry season residential field CO₂ data in Kuje Area Council in the Federal Capital Territory.

S/N	Residential areas	Location		Mean CO ₂ emission (ppm)			
		Coordinates N	Coordinates E	0600 h	1200 h	1800 h	2200 h
	Kuje Low-cost Housing Estate						
P1	Dr. Ekpendo Road junction	0981794	0306423	601	671	607	676
P2	Dr. Ekpendo Road I	0981848	0306430	598	646	621	669
P3	Dr. Ekpendo Road by FCTA Event Centre	0981997	0306458	594	663	609	694
P4	Kuje Lowcost housing estate junction	0981812	0306325	596	623	609	614
P5	Kuje Lowcost housing estate road	0981871	0306390	591	615	613	614
P6	Kuje Lowcost by RONNAWINS Fashion	0981893	0306238	587	645	606	616
P7	Kuje Lowcost by CHISCO rentals	0981955	0306253	587	645	605	614
P8	Kuje Lowcost Road by mosque	0982057	0306182	587	636	601	611
P9	Kuje Lowcost Road by mosque junction	0982049	0306103	586	628	600	609
P10	Settlement Road II off Wuru Street	0982016	0305853	589	611	602	614
P11	Settlement Road III off Wuru Street	0981974	0305866	590	614	601	615
P12	Wuru Street by Fine Touch Salon	0981975	0305731	588	615	604	615
	Kuchiyako District						
P13	Union Homes Crescent I	0980426	0306038	590	646	603	672
P14	Road 4 by Electricity transformer	0980445	0305974	582	631	600	642
P15	House B29 Road 4 Union Homes Est.	0980408	0305954	581	623	601	632
P16	House B29B Road 4 Union Homes Est.	0980370	0305932	580	625	601	637
P17	Road 4 by Abu Sidqu	0980311	0305901	574	617	599	624
P18	House B37 Road 4 Union Homes Est.	0980162	0305837	577	627	587	612
P19	House B38 Road 4 Union Homes Est.	0980117	0305822	578	617	593	611
P20	House D15A Road 3 Union Homes Est.	0980091	0305869	578	642	592	650
P21	House D13A Road 3 Union Homes Est.	0980124	0305882	577	637	593	652
P22	House D11 Road 3 by Water Reservoir	0980166	0305900	579	630	593	646
P23	House D9D Road 3 Union Homes Est.	0980204	0305915	579	623	591	638
P24	House D7D Road 3 Union Homes Est.	0980257	0305937	580	627	591	647
P25	House D5D Road 3 Union Homes Est.	0980293	0305955	576	626	590	647

Dry season mean CO₂ data for the commercial district in Kuje Area Council

The mean dry season CO₂ results for the commercial district in Kuje Area Council are presented in Figure 3. The details of each point in the commercial district are shown in Table 2.

The mean field data of CO₂ in the commercial district showed a different trend in emissions, with a minimum value of 612 ppm at P6 (by a shopping district) at 0600 h for the 2-hour time band, but a higher CO₂ emission of 708 ppm was obtained at P23 (by a plaza). However, the highest values of 708 ppm, 711 ppm, and 714 ppm were recorded at 1800 h for the 6-hour time band at P4 (by a fuel station), P5 (inside the fuel station), and P22 (by a fast food establishment), respectively. At 1400 h for the 4-hour time band the highest CO₂ value was at P3 by the fuel station, and the lowest CO₂ value was at P8 by the supermarket. The lowest CO₂ value at the 4-hour time band was above 600 ppm. Therefore, this implies

that human activities contribute greatly to gas emissions (Table 2).

Wet season mean CO₂ data for the residential district in Kuje Area Council

The mean CO₂ results for the wet season in the residential district in Kuje Area Council are presented in Figure 4. The details of each point in the residential district are shown in Table 3.

The lowest mean CO₂ data from field values was 541 ppm at P18 at the 8-hour time band. At 1800 h, the 6-hour time band was lowest at 579 ppm at P23–P25 and was highest at 597 ppm at P2 (Table 3). At 1400 h, the lowest value of the 4-hour mean data was 598 ppm at P23 (Table 3) and the highest value was 611 ppm at P2. At 0600 h, the 2-hour mean CO₂ data had the highest value of 673 ppm at P18 and the lowest value of 589 ppm at P18 (Table 3).

Figure 3. Graph showing mean CO₂ dry season commercial data for Kuje, F.C.T. Nigeria.

Table 2. Mean dry season commercial field CO₂ data in Kuje Area Council in the Federal Capital Territory.

S/N	Commercial areas	Location		Mean carbon dioxide emission (ppm)			
		Coordinates N	Coordinates E	0600 h	1200 h	1800 h	2200 h
	Kuje/Pasali Road						
P1	Kuje/Pasali Road by Anyi Chuks Inv.	0981897	0305989	678	652	667	648
P2	Kuje/Pasali Road by MARYAM house	0981885	0306013	673	653	701	648
P3	Kuje/Pasali Road by A.A RANO fuel station	0981888	0305989	684	692	708	693
P4	Kuje/Pasali Road inside A.A RANO	0981879	0306013	681	689	714	687
P5	Gomo Street by Unique Fast Food	0981867	0305989	695	698	711	690
P6	Kwakwara Street by Shoppers Corner	0981766	0305989	612	634	635	638
P7	Kwakwara Street by Future Hope Kiddies	0981805	0306013	616	635	628	637
P8	Kwakwara Street by Godwin supermarket	0981856	0305989	622	629	631	634
P9	Kuje/Gwags Road by GFU fuel station	0981933	0306013	633	658	686	657
P10	Kuje/Gwags Road by Four Square junction	0981995	0305989	641	669	682	665
	Wowo Street						
P11	Wowo Street in front of City Plaza	0982006	0305017	656	673	662	662
P12	Wowo Street inside City Plaza	0982004	0305041	654	651	675	657
P13	Wowo Street I	0982056	0304997	639	656	672	668
P14	Wowo Street by grinding machine	0982090	0304982	631	656	661	669
P15	Wowo Street by Tailor shop	0982119	0304978	629	650	669	669
P16	Kuje Zonal Education Office	0982397	0304983	626	646	642	662
P17	Kuje Junior Secondary School I	0982421	0304951	623	632	640	638
P18	Kuje junior Secondary school II	0982438	0304836	621	631	637	636
P19	Kuje Junior Secondary School III	0982435	0304898	615	631	635	634
P20	NUT Street junction	0982373	0305156	613	630	629	632
P21	Secretariat Road by God's Time Plaza	0982076	0305398	614	632	626	626
P22	Secretariat Road by Kuje/Gwags junction	0981927	0305370	636	631	704	630
P23	Secretariat Road by Dana Plaza	0981883	0305667	708	681	681	679
P24	Secretariat Road by FCMB	0981873	0305854	676	667	677	649
P25	Secretariat Road by Police Station	0981860	0305978	669	663	677	656

Figure 4. Graph showing mean CO₂ wet season residential data for Kuje, F.C.T. Nigeria.

Table 3. Mean wet season residential field CO₂ data in Kuje Area Council in the Federal Capital Territory.

S/N	Residential districts	Location		Mean carbon dioxide emission (ppm)			
		Coordinates N	Coordinates E	0600 h	1200 h	1800 h	2200 h
	Kuje Low-Cost Housing Estate						
P1	Dr. Ekpendo Road junction	0981794	0306423	603	608	595	618
P2	Dr. Ekpendo Road I	0981848	0306430	600	611	597	625
P3	Dr. Ekpendo Road by FCTA Event Centre	0981997	0306458	601	599	598	637
P4	Kuje Low-cost Housing Estate junction	0981812	0306325	622	605	593	615
P5	Kuje Low-cost Housing Estate Road	0981871	0306390	660	605	593	615
P6	Kuje Low-cost by RONNAWINS Fashion	0981893	0306238	626	604	588	609
P7	Kuje Low-cost by CHISCO rentals	0981955	0306253	624	602	586	607
P8	Kuje Low-cost Road by mosque	0982057	0306182	642	602	587	608
P9	Kuje Lowcost Road by mosque junction	0982049	0306103	632	601	585	607
P10	Settlement Road II off Wuru street	0982016	0305853	631	602	587	607
P11	Settlement Road III off Wuru street	0981974	0305866	650	602	588	607
P12	Wuru Street by Fine Touch Salon	0981975	0305731	620	602	587	606
	Kuchiyako District						
P13	Union Homes Crescent I	0980426	0306038	664	603	587	620
P14	Road 4 by Electricity transformer	0980445	0305974	628	598	582	619
P15	House B29 Road 4 Union Homes Est.	0980408	0305954	645	599	583	620
P16	House B29B Road 4 Union Homes Est.	0980370	0305932	650	600	584	625
P17	Road 4 by Abu Sidqu	0980311	0305901	673	600	585	622
P18	House B37 Road 4 Union Homes Est.	0980162	0305837	589	600	583	541
P19	House B38 Road 4 Union Homes Est.	0980117	0305822	593	599	582	616
P20	House D15A Road 3 Union Homes Est.	0980091	0305869	590	600	583	617
P21	House D13A Road 3 Union Homes Est.	0980124	0305882	593	600	582	619
P22	House D11 Road 3 by Water Reservoir	0980166	0305900	605	599	581	613
P23	House D9D Road 3 Union Homes Est.	0980204	0305915	600	598	579	611
P24	House D7D Road 3 Union Homes Est.	0980257	0305937	597	599	579	613
P25	House D5D Road 3 Union Homes Est.	0980293	0305955	594	600	579	612

Wet season mean CO₂ data for the commercial district in Kuje Area Council

The mean CO₂ wet season results for the commercial district in Kuje Area Council are presented in Figure 5. The details of each point in the commercial district are shown in Table 4.

The lowest mean CO₂ data were at 0600 h; the 2-hour time band value of 600 ppm was at P10, whereas the highest value of 686 ppm was at P23. At 1400 h, at the 4-hour time band the highest mean CO₂ value of 709 ppm was at P23, and the lowest value of 620 ppm was at P21. At 1800 h and 2200 h, the 6- and 8-hour time bands had mean CO₂ data of 713 ppm and 705 ppm, respectively, and were highest at P23, whereas the lowest mean CO₂ data for the 6-hour time band were 615 ppm at P21 and for the 8-hour time band were 629 ppm at P20 and P21 (Table 4).

Discussion

The results showed that in the residential district during the dry season for the mean 2-hour time band, the lowest atmospheric CO₂ emission value was 574 ppm at P17 (Table 1). This value was observed during an off-peak period at 0600 h in the morning, whereas the highest CO₂ mean value was 694 ppm at P3, obtained during an 8-hour time band at 2200 h at night (Table 1). During the wet season in the residential district, the lowest CO₂ mean data value of 541 ppm was obtained at P18 during the 8-hour time band at 2200 h at night (Table 3). The 2-hour mean CO₂ data had the highest value of 673 ppm at P18 at 0600 h in the morning (Table 3).

In the commercial districts, the lowest mean atmospheric CO₂ value for the dry season was 612 ppm during the 2-hour off-peak time band at 0600 h in the morning at P6, whereas the highest value of 714 ppm was obtained during the 6-hour peak time band at 1800 h at P4 (Table 2). The mean atmospheric CO₂ data for the commercial district in the wet season were lowest at 600 ppm during the 2-hour time band of 0600 h at P10 and highest at 713 ppm during the 6-hour time band at 1800 h at P23 (Table 4).

The results showed that our assumption that outdoor emission levels are normal in residential districts and high in commercial districts of Kuje Area council is wrong. CO₂ is high in the commercial and residential districts in Kuje, Nigeria, during both dry and wet seasons; however, the diurnal range is higher around the commercial areas compared with the residential areas. This further collaborated the fact that anthropogenic activities are contributing factors of increasing CO₂ emission in Kuje, as indicated by the mean lowest and highest values in geospatial sample locations at Union Homes Estate during peak (1000 h to 1800 h) and off-peak (0600 h in the morning and 2200 h) periods. The high CO₂ mean emission values were prevalent in the commercial districts and in the mean data obtained and analyzed. The dry and wet season mean CO₂ data have shown high CO₂ emissions of >541 ppm and <713 ppm collaborating the ESRL and NOAA research publication of mean monthly average measurement increase of CO₂ from 398.93 ppm to 402.25 ppm over 365 days. These mean geospatial location CO₂ data emission values from Kuje-Nigeria were higher than ASHRAE and OSHA outdoor standards of 350–450 ppm, which were used as standards for this research.

Figure 5. Graph showing mean CO₂ wet season commercial data for Kuje, F.C.T. Nigeria.

Table 4. Mean wet season commercial field CO₂ data in Kuje Area Council in the Federal Capital Territory.

S/N	Commercial districts	Location		Mean carbon dioxide emission (ppm)			
		Coordinates N	Coordinates E	0600 h	1200 h	1800 h	2200 h
	Kuje/Pasali Road						
P1	Kuje/Pasali Road by Anyi Chuks Inv.	0981897	0305989	650	638	631	645
P2	Kuje/Pasali Road by MARYAM house	0981885	0306013	657	641	634	650
P3	Kuje/Pasali Road by A.A RANO fuel station	0981888	0305989	661	641	638	649
P4	Kuje/Pasali Road inside A.A RANO	0981879	0306013	667	642	638	648
P5	Gomo Street by Unique Fast Food	0981867	0305989	668	673	677	648
P6	Kwakwara Street by Shoppers Corner	0981766	0305989	616	648	632	649
P7	Kwakwara Street by Future Hope Kiddies	0981805	0306013	625	636	629	633
P8	Kwakwara Street by Godwin supermarket	0981856	0305989	615	633	625	630
P9	Kuje/Gwags Road by GFU fuel station	0981933	0306013	621	640	636	633
P10	Kuje/Gwags Road by Four Square junction	0981995	0305989	600	659	660	647
	Wowo Street						
P11	Wowo Street in front of City Plaza	0982006	0305017	639	659	660	646
P12	Wowo Street inside City Plaza	0982004	0305041	656	651	647	644
P13	Wowo Street I	0982056	0304997	645	648	642	642
P14	Wowo Street by grinding machine	0982090	0304982	646	638	631	637
P15	Wowo Street by Tailor shop	0982119	0304978	639	632	625	634
P16	Kuje Zonal Education Office	0982397	0304983	650	633	625	638
P17	Kuje Junior Secondary School I	0982421	0304951	647	631	624	636
P18	Kuje Junior Secondary school II	0982438	0304836	630	629	623	635
P19	Kuje Junior Secondary School III	0982435	0304898	629	627	621	633
P20	NUT Street junction	0982373	0305156	619	624	620	629
P21	Secretariat Road by God's Time Plaza	0982076	0305398	612	620	615	629
P22	Secretariat Road by Kuje/Gwags junction	0981927	0305370	620	623	616	630
P23	Secretariat Road by Dana Plaza	0981883	0305667	686	709	713	705
P24	Secretariat Road by FCMB	0981873	0305854	655	666	666	664
P25	Secretariat Road by Police Station	0981860	0305978	645	662	653	653

These high CO₂ data emission values have affected the environment as an increasing atmospheric temperature is prevalent in Kuje, and it warms the environment and causes fewer plants to provide less evaporative cooling; this may require a comprehensive research study. There are also issues of stress on residents, therefore reducing ability to work maximally. Tolerance limits of some plants are receded, resulting in low productivity.

There are several scientific and epidemiological studies on effects of high and increasing CO₂ emissions in the global environment. Humans and mammals do not adapt to prolonged intake of toxic materials (Robertson, 2006). The increasing CO₂ emission will adversely affect human health, causing cardiorespiratory issues and psychological reactions such as impaired vision, slowed reactions and responses,

disorientation, or reduced attentional capacities that may jeopardize a worker's health and safety. (Kalaugher, 2008; Thind, 2013; Vercruyssen et al., 2007). The climate change effects due to sequestration of CO₂ from the deforestation data of Kuje forest during an 8-year period grew by 40.67% (Badaru et al., 2016).

The high emission of CO₂ values of >541 ppm and <714 ppm obtained in Kuje-Nigeria will pose serious health risks to the residents in the near future if the anthropogenic activities leading to the high CO₂ emissions are not controlled or reduced. This should be done through advocacy, policy, and legislative framework. "If the atmospheric concentration of carbon dioxide reaches 600 ppm, the planet will have a permanent outdoor atmosphere exactly like that of a stuffy room" (Sarmiento et al., 2010).

Conclusion

The results showed that the mean outdoor CO₂ emission levels in Kuje were higher than the normal outdoor ASHRAE and OSHA standards of 350–450 ppm. The implication of the higher outdoor values of mean CO₂ obtained is worrisome because as temperatures rise, increased toxicity levels and environmental effects are inevitable.

The quick implementation of strategic interventions such as planning, monitoring, and controlled mitigation of tree planting; transport regulations; education/awareness campaigns, etc., to reducing CO₂ emissions is of utmost importance. The continuous rise in CO₂ will adversely affect air quality and indoor pollution levels, which could lead to respiratory issues, fatigue, stress, and more.

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