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Contribution of fast food outlets proliferation to regional co_2 concentration in southern Nigeria

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Abstract
Carbon dioxide (CO_2) is a salient constituent of the atmosphere, averaging about 0.036% or 360 ppm by volume. It is also a normal end-product of human and animal metabolism. Unfortunately, carbon dioxide is one of the most frequently under estimated and inappropriately overlooked component of all toxic gases. A minor reference to CO_2 as a toxic gas is a surprise to many health and safety professionals. The toxicity of CO_2 for breathing has been well defined for high concentrations but it remains unknown what level will compromise human health when individuals are perpetually exposed for a lifetime. This research investigated the level of carbon dioxide in fast food outlets in Obior Akpor Local Government Area (LGA), Rivers State, Nigeria as a case study. To achieve this objective, carbon dioxide readings were taken in fast food outlets in the LGA. The fast food outlets were selected using the systematic random sampling technique. Analysis of Variance (ANOVA) and the Chi-square test was used to test the hypotheses. The results and research findings showed that there is a difference in the level of carbon dioxide emitted across the fast food outlets as such, people who patronize these fast food outlets as well as their workers are susceptible to a certain level carbon dioxide poisoning without them being aware. Recommendations involving the use of potted house plants were made in other to alleviate or ameliorate the effect of increased carbon dioxides on human health.

Keywords: Rivers State; Urban Health; Work Place Safety; Perceived Indoor Air Quality; Carbon Dioxide Toxicity

1. Introduction

Carbon dioxide (CO_2) is nonflammable, colorless, and odorless in the gaseous and liquid states. Carbon dioxide is a minor but important constituent of the atmosphere, averaging about 0.036% or 360ppm by volume. It is also a normal end-product of human and animal metabolism (Beerling and Royer 2011; Eggleton 2013) [2, 9]. Since about 1820, CO_2 levels have increased rapidly and are now above 400ppm. This is potentially a catastrophic problem for many species of animals, including humans, for a number of reasons. The most well publicized issue is that of climate change. The mechanisms and history of global warming associated with CO_2 increase are well understood and the increase in atmospheric energy gradients will produce more extreme temperatures and weather events. To many people, climate change itself may not appear to be catastrophic – for example, it might be possible to escape the effects of even a 5 degree increase in this century by moving to a cooler and safer geographic location. However, it is possible that humans have overlooked the more direct and immediate toxicity aspect of increasing atmospheric CO_2. The earth's atmosphere has already reached CO_2 levels that are outside the range breathed by humans throughout their evolution. As well, in earlier pre-primate epochs, elevated atmospheric CO_2 has been found to be a cause of mass extinction events (Knoll *et al*. 1996). Breathing CO_2 is toxic to humans when levels are high with numerous deaths reported based on occupational exposure (Scott *et al.*, 2009). Although the CO_2 exposure limit for an 8 hour working day has been set at 5,000 ppm (OSHA, 2012) [16], this limit was decided in 1946 and based on relatively short term observations of fit and healthy submariners (Scott *et al*, 2009). The safe level for lifetime exposure may be significantly lower than this and a number of researchers suggest there could be toxicity effects at CO_2 levels predicted in the near future with ongoing anthropogenic emissions (Portner *et al*,. 2004; Robertson 2006; Ezraty *et al*. 2011; Antic, 2012; McNeil and Sasse 2016) [18, 10].

An axiom of modern science, as quoted from TS Huxley, is "Do not pretend that conclusions are certain which are not demonstrated or demonstrable". Carbon dioxide is one of the most frequently overlooked of all toxic gases. Even to refer to CO_2 as a toxic gas is a surprise to many health and safety professionals (Henderson, 2006). In indoor environments CO_2 concentration is often elevated relative to ambient outdoor levels due to the fact that the exhaled breath from humans contains high CO_2 (about 4%) and ventilation may not be adequate to prevent the resulting increase in CO_2 (Liu, Zhong, & Wargocki, 2017) [14]. Despite the possible adverse effects on health where many people occupy buildings or vehicles, there is very little awareness of this issue in the general community. At present the average ambient concentration of CO_2 (in fresh air) is about 400 ppm (Carbon Dioxide Information Analysis Center, 2015). There is now strong scientific evidence of a rapid, persistent and uncontrolled increase in atmospheric carbon dioxide (CO_2) due to humanity's activities, largely resulting from the burning of fossil fuels. The background level of CO_2 in ambient air is now about 400 ppm and it has been gradually increasing due to industrialization and the consequent release of CO_2 from the combustion of fossil fuels; over the last half century it has increased by nearly 80 ppm.

An outdoor level of 350 ppm has generally been used when determining ventilation requirement in terms of acceptable CO_2 levels (e.g., Fanger and Berg-Munch, 1983). The concentration of CO_2 in buildings can be one order of magnitude higher than outdoors, typically being below 2,000-2,500 ppm, but in some cases reaching 4,000-4,500 ppm or even higher (e.g., Myhrvold *et al.*, 1996; Stricker *et al.*, 1997; Shaughnessy *et al*., 2006; Bekö *et al*., 2010; Menå and Larsen, 2010) [15, 22, 21, 3] In the non-industrial indoor environments (e.g., offices, schools and homes), CO_2 is not a dominant pollutant such as in occupational settings (e.g., breweries and beverage bottling plants), and the effects of CO_2 can be modified by many other pollutants present at low concentrations. The occupational limits may not therefore be directly applicable in non-industrial indoor environments due to potential additive or synergistic effects between different pollutants. In non-industrial settings, the major source of CO_2 is human metabolism. The concentration of CO_2 in exhaled air is two orders of magnitude higher than in the ambient air and usually between 40,000 and 55,000 ppm (Liu, Zhong, & Wargocki, 2017) [25].

The levels of CO_2 that occur indoors thus depend predominantly on human occupancy and on the rate of exchange with outdoor is achieved by natural or mechanical means (Zhang, Wargocki, Lian, & Thyregod (2017) [25]. As articulated by Pettenkofer, *'The corruption of the air is not caused by the carbon dioxide content; we simply use this as a benchmark from which we can then also estimate a higher or lower content of other (pollutant) substances.'* Recent work by Ramalho *et al.*, (2015) [19] provides some support to the view that CO_2 is a good indicator of other pollutants. It has generally been accepted that indoor CO2 levels at or below 1,000 ppm indicate that the indoor air quality is acceptable (outdoor level of CO_2 is then assumed to be 350 ppm). CO_2 has been used quite successfully as an indicator of the required outdoor air supply rate in rooms with occupants present, especially when there is high and variable occupancy, as in theatres and lecture halls (e.g., Emmerich and Persily, 2001) [7]. CO_2 is used as a control variable in demand-controlled ventilation (DCV) installations, whose main purpose is to reduce the energy consumed by building ventilation (Cable *et al*., 2014) [4]. Because humans produce and exhale carbon dioxide (CO_2), concentrations of CO_2 in occupied indoor spaces are higher than concentrations outdoors. As the ventilation rate (i.e., rate of outdoor air supply to the indoors) per person decreases, the magnitude of the indoor-outdoor difference in CO_2 concentration increases. Consequently, peak indoor CO_2 concentrations, or the peak elevations of the indoor concentrations above those in outdoor air, have often been used as rough indicators for outdoor-air ventilation rate per occupant (Persily and Dols 1990) [17]. The need to reduce energy consumption provides an incentive for low rates of ventilation, leading to higher indoor concentrations. Prior research has documented direct health effects of CO_2 on humans, but only at concentrations much higher than found in normal indoor settings. CO_2 concentrations greater than 20,000 ppm cause deepened breathing; 40,000 ppm increases respiration markedly; 100,000 ppm causes visual disturbances and tremors and has been associated with loss of consciousness; and 250,000 ppm (25%) CO_2 can cause death (Lipsett *et al*. 1994).

According to the National Institutes of Health (NIH), fast foods are characterized as quick, easily accessible and cheap alternatives to home- cooked meal. The implication of this is that more and more people now patronize fast food outlets on a daily basis with this population expected to grow even further with the rest of the world expected to become more urbanized ad the years go by. In Nigeria and the particularly the upwardly mobile urban areas in southern region of Nigeria, the proliferation of fast food chains without adequate safety and regulatory standards being met possess a potent and immediate danger to the health and wellbeing of workers and fast food patrons alike.

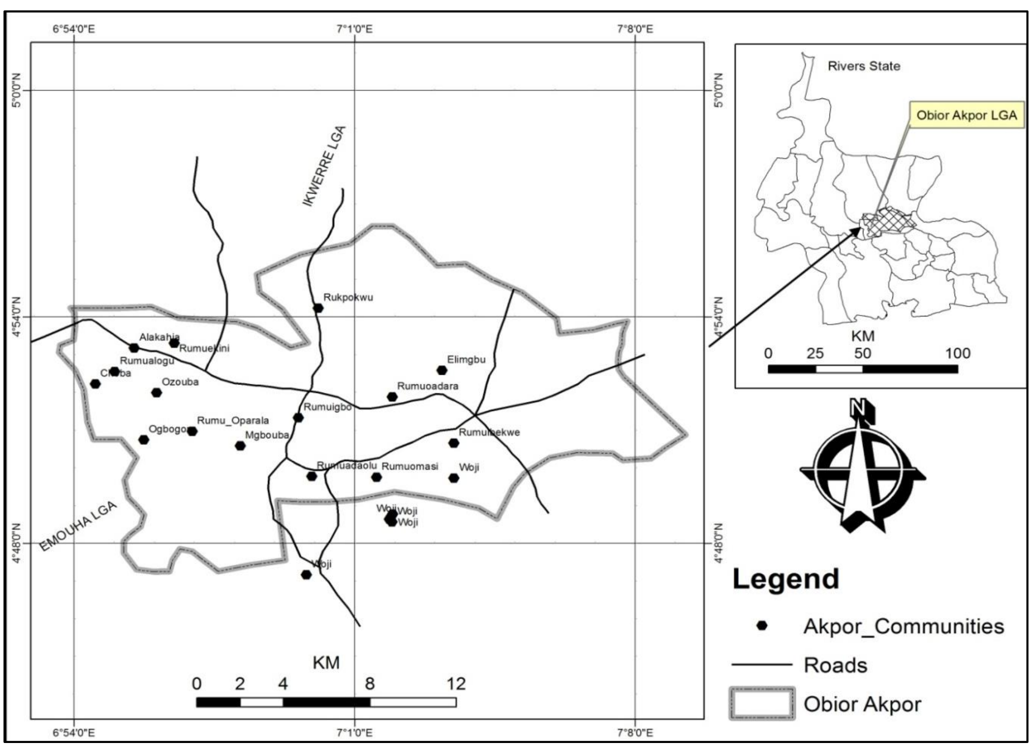

Fig 1: Study Area (Obior Akpor Local Government Area of Rivers State, Nigeria).

2.2. *Data*

Data for this research were obtained from both primary and secondary sources. The primary data were sourced from direct field measurements and observations). The data were obtained in a randomly selected fast food outlet in Obio-Akpor LGA of Rivers state. The Geographic Positioning System (GPS) was used in locating the coordinate of the fast food outlet in the area. Carbon dioxide meter (Aeroqual 500 series) was used to obtain on the spot measurement of CO_2 concentrations within the sampled outlets. The stop watch was used to keep accurate time when the meter is switched on and when it is stopped. These readings were taken at intervals of 5 minutes after which the stop watch will trip off. The carbon dioxide meter are used in measuring the level or the amount of carbon dioxide emitted by the fast food outlet, the stop watch was used as the time keeper when the measurement is carried out, and after which the reading is recorded. In other words, the sources include personal observation, measurement and reading the amount of carbon dioxide emitted with the use of carbon dioxide meter. The secondary data are the reviews of relevant literature to be made by the researcher (that is, review of already documented facts), the source include academic journals, textbook, the internet, and the previous works, etc.

Table 1: Sampled fast food locations and ancillary information

s/n	Names of fast food	Locations	Average daily Patronage	Area of Operations
1	Big Treat	Rukpokwu	4,500	Nation wide
2	City Crown	Iwofe	1,625	Local
3	Dacota	Rumuigbo	2,925	Regional
4	Genesis	Iwofe	6,740	Nation wide
5	Happy Bite	Eliozu	4,654	Nation wide
6	Kilimanjaro	Choba	4,445	Nation wide
7	Mr. Biggs	Rumigbo	3,343	Nation wide
8	Old Spice	Rumuekini	2,010	Local
9	Pepperoni	Wimpy	3,210	Nation wide
10	Shining Light	Rukpoku	1,321	Local

***Source*:** Research Effort, 2018.

A simple random sampling technique was used for the study. This usually requires listing of elements in alphabetical order. Every n^{th} element in the total list is then choosing for inclusion in the sample with the aid of a convenient sampling interval. All the fast food outlets in Obio-Akpor were randomly selected since all the Population could not be sampled.

3. Results

A total of 40 Fast Food was sample, out of which 10 was selected for analysis using systematic random sampling techniques.

Table 2: Average morning and evening fast food outlets measured CO_2 concentrations (in and out) and coordinates.

S/N	Name of fast food Outlet	Location	Morning (In)	(out)	Evening(in)	(out)	N	E
1	Kilimanjao	Choba	1591.6	675.3	2222.3	730.3	4.89841	6.90652
2	Old Spice	Rumuekini	1478.2	762.9	2015.3	774.2	4.8893	6.94072
3	Pepperoni	Wimpey	1648.9	702.7	1840.9	671.2	4.82951	6.97636
4	City Crown	Iwofe	920.4	695.6	1199	616.4	4.82962	6.97622
5	The Promise	Rumuigbo	1514.4	723.8	1246.7	583.9	4.8467	6.9911
6	Big Treat	Rukpoku	848.4	799.2	1122.9	721.6	4.89538	7.00205
7	Genesis	Choba	1699.8	853.2	2009.6	692.8	4.89559	6.90704
8	Happy Bite	Air force	1042.8	766.6	1389.3	742.3	4.89868	7.00127
9	Dacota	Rumuigbo	1157	676	1352.8	653.5	4.86493	6.98183
10	Shining Light	Rukpoku	1352.2	737.3	971.7	695.1	4.89866	7.00134

Table 3

S/N	Name of fast food outlet	Location	Morning(In)	(out)	Evening (in)	(out)	
1	Kilimanjaro	Choba	1591.6	675.3	2222.3	730.3	5219.5
2	Old Spice	Rumuekini	1478.2	762.9	2015.3	774.2	5030.6
3	Pepperoni	Wimpey	1648.9	702.7	1840.9	671.2	4863.7
4	City Crown	Iwofe	920.4	695.6	1199	616.4	3431.4
5	The Promise	Rumuigbo	1514.4	723.8	1246.7	583.9	4068.8
6	Big Treat	Rukpoku	848.4	799.2	1122.9	721.6	3492.1
7	Genesis	Choba	1699.8	853.2	2009.6	692.8	5255.4
8	Happy Bite	Air force	1042.8	766.6	1389.3	742.3	3941
9	Dacota	Rumuigbo	1157	676	1352.8	653.5	3839.3
10	Shining Light	Rukpoku	1352.2	737.3	971.7	695.1	3756.3
			1323.7	7392.6	15370.5	6881.3	42898.1

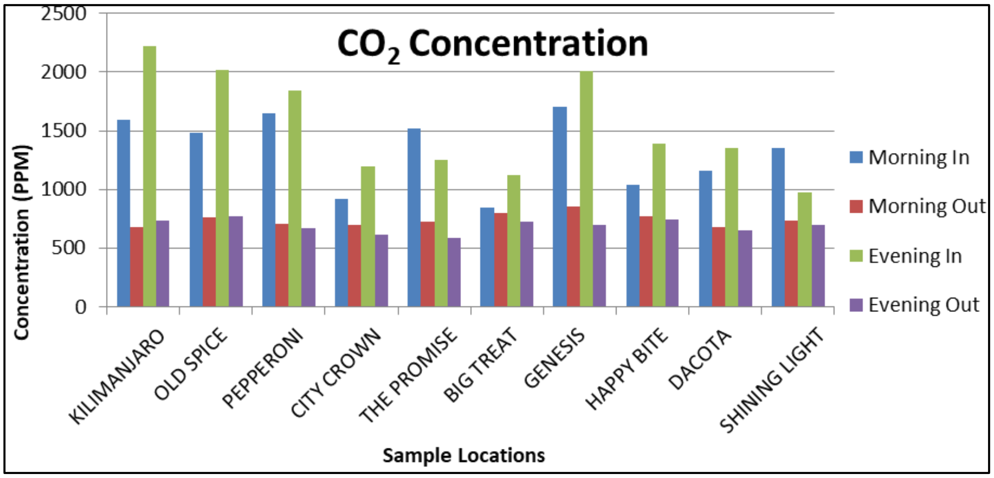

Fig 2: Temporal Concentration of CO_2 in fastfast outlets in Obior Akpor

3.1 Discussion

Table 4: CO_2 Concentration in Fast Food Chains in Obior Akpor

S/N	Name of Fast Food	Location	Morning (In)	(out)	Evening(in)	(out)
1	Kilimanjaro	Choba	1591.6	675.3	2222.3	730.3
2	Old Spice	Rumuekini	1478.2	762.9	2015.3	774.2
3	Pepperoni	Wimpey	1648.9	702.7	1840.9	671.2
4	City Crown	Iwofe	920.4	695.6	1199.0	616.4
5	The Promise	Rumuigbo	1514.4	723.8	1246.7	583.9
6	Big Treat	Rukpoku	848.4	799.2	1122.9	721.6
7	Genesis	Choba	1699.8	853.2	2009.6	692.8
8	Happy Bite	Airforce	1042.8	766.6	1389.3	742.3
9	Dacota	Rumuigbo	115.07	676.0	1352.8	653.5
10	Shining Light	Rukpoku	1352.2	737.3	971.7	695.1

Table 3, shows the average level of carbon dioxide emitted by the fast food outlets in Obio Akpor LGA. From the result obtained, Genesis emits highest in the morning hours, followed by pepperoni, Kilimanjaro, The promise, Old Spice, Shining Light, Dacota, Happy bite, City Crown and Big Treat, which emit the lowest. In the evening hours, Kilimanjaro emits the highest, followed by Old Spice, Genesis, Pepperoni, Happy Bite, Dacota, The promise, City Crown, Big Treat and Shining Light, which emits the lowest in the evening hour.

CO_2 emissions from human activity arise from a number of different sources, mainly from the combustion of fossil fuels used in power generation, transportation, industrial processes, and residential and commercial buildings. Carbon dioxide comes from many sources, including the wood, grass and dung burned by poor families around the world; the fermentation processes of bread and beer; natural sources such as animals, volcanoes and deep sea vents; and many others. The major sources of carbon dioxide in the fast food outlet across the sample area is the use of cooking gas and the number of persons found in the fast food outlets (both customers and the workers). The higher the population of humans, the higher the carbon dioxide level and the lower the oxygen found in the fast food outlet. Note, some of the fast food outlets are more populated, for example Big Treat, Happy Bite, pepperoni, but due to natural ventilation, the amount or level of carbon dioxide was significantly lower compared to other measured locations. In terms of worker safety, the US Occupational Safety and Health Administration has set a permissible exposure limit (PEL) for CO_2 of 5,000 parts per million (ppm) (or 0.5 %) over an 8-hour work day (OSHA 2012) [16]. They report that exposure to levels of CO_2 above this can cause problems with concentration, an increased heart rate, breathing issues, headaches and dizziness.

Breathing too much CO_2 results in high levels of CO_2 in the blood (hypercapnia) associated with a decrease in blood pH (increased acidity) resulting in a condition known as acidosis. This implies that people who patronize or work in fast food outlets in the study area are exposed to CO_2 levels that may not be healthy for them without them realizing this. The decreases in blood and tissue pH produce effects on the respiratory, cardiovascular, and central nervous systems (CNS) (Eckenhoff and Longnecker 1995) [8]. Changes in pH act directly and indirectly on those systems producing effects such as tremor, headache, hyperventilation, visual impairment, and CNS impairment. Exposures to 1-5 % CO_2 for short-term periods have been documented to produce symptoms on humans and animals such as dyspnea (shortness of breath), modified breathing, acidosis, tremor, intercostal pain, headaches, visual impairment, lung damage, increased blood pressure, bone degradation, reduced fertlity, alterations to urine and blood chemistry as well as erratic behaviour (Halperin 2007; Rice 2004; Guais *et al*. 2011; Schaefer *et al*. 1963; Yang *et al*. 1997) [13, 12, 23]. These levels of CO_2 also induce panic attacks, interrupt the processes of metabolic enzymes and disrupt normal cell division processes (Colasanti *et al*. 2008; Guais *et al*. 2011; Abolhassani *et al*. 2009) [6, 12, 1]. Health risks continue to escalate, with progressively higher CO_2 concentrations causing more severe reactions and faster responses. Lack of concentration was associated with CO_2 levels above 1000 ppm. Gaihre *et al*. (2014) [11] found that CO_2 concentrations exceeding 1000 ppm is associated with reduced school attendance. Teachers also report neuro-physiologic symptoms (i.e., headache, fatigue, difficulty concentrating) at CO_2 levels greater than 1000 ppm (Muscatiello *et al.*, 2015). The impacts on students including sickness, reduced attendance and reduced learning abilities should be a concern for society. Moreover, the relatively high levels of CO_2 in vehicles associated with declining concentration and fatigue has serious implications for the safety of drivers and their passengers. This is an issue that does not appear to have been raised in research on driver fatigue illustrating the general lack of awareness about CO_2 effects. Most of the problems associated with elevated indoor CO_2 levels greater than about 800 ppm, can be alleviated by spending time in fresh air. The indoor environments can be restored to acceptable CO_2 levels with effective ventilation although this is often not being achieved in Nigeria, due to poor legislation, weak enforcement and endemic corruption on the part of regulatory agencies such as the National Agency for Food and Drug Control (NAFDAC).

Table 3: Documented effects of breathing CO_2

CO2 Level	Health effect	Exposure Duration	Source
800 ppm	Level associated with Sick Building Syndrome - Headaches, dizziness, fatigue, respiratory tract, eye, Nasal irritations.	Short-term	Seppanen *et al.*, 1999; Lu *et al.* 2015.
950-1000ppm	Moderate impairment of cognitive function	2.5 to 8 Hours	Allen *et al.*, 2015
1000 ppm	Level associated with respiratory diseases, headache, fatigue, difficulty concentrating in classrooms	Short-term	Carreiro-Martins *et al.*, 2014; Ferreira and Cardoso 2014.
1400-3000ppm	Significant impairment of cognitive function including fatigue.	2.5 to 8 Hours	Satish *et al* 2012; Allen *et al* 2015; Kajtar & Herczeg 2012
5000 ppm	Permissible exposure limit (PEL) for a work day	8 hours	OSHA 2012 [16]
8500 ppm	Increased lung dead space volume	20 days	Rice 2004
5000-6600 Ppm	Headaches, lethargy, moodiness, mental slowness, emotional irritation, sleep disruption	Short-term	Chronin *et al*. 2012; Law *et al*. 2010

Documented effects of breathing CO_2 at different exposure levels
The indoor carbon dioxide Concentration is generally higher than the outdoor concentration. Figure 1, shows the variations among the various sample fast food outlet across the sample location. This variation is due to the difference in the sitting capacity of the outlet and the population

Found in the fast food outlets varies significantly as well. In other words, the higher the population the higher the carbon dioxide emitted. From the result obtained, Genesis emits highest in the morning hours in the indoor concentration (1699.7), followed by pepperoni(1648.9), Kilimanjaro (1591.6), The promise(1514.4) Old Spice (1478.2), Shining Light (1352.2), Dacota (1157.0), Happy bite (1042.8), City Crown (920.4) and Big Treat (848.4), which emit the lowest. While in the outdoor, Genesis emits the highest (853.2), followed by Big Treat (799.2), Happy Bite (766.6), Old Spice (762.9), Shining Light (737.3),The promise (723.8), Pepperoni (702), City Crown (695.6), Dacota (675.8), Kilimanjaro (675.3), which emits the lowest in the outdoor.

Temporal variation of carbon dioxide levels across the study area.

The evening readings or concentration indoor are higher than the morning concentrations. Table 3, shows the different concentration of carbon dioxide emitted in the morning and in the evening across the study area. In the outdoor, the morning concentration is higher than the evening readings. Based on the finding, there are more patrons (customers) in the evening hours than the morning hours.

Recommendations and Policy Implementation

This section will attempt to give appropriate recommendations to solving and alleviating the problems created by carbon dioxide CO_2 concentration in Fast Food outlets in Obio Akpor L.G.A of Rivers State. The following are the recommendations;

It is recommended that the Fast Food outlets should be constructed in a way that they will receive natural ventilation so as to reduce the high concentration of carbon dioxide and replace them with natural air. This work also commend that, there should be a regular check or monitoring of the CO_2 level in the fast food outlets by the management. This will help in taking a quick action when it has exceeded the acceptable limit on human health. Those who use the Fast Food regularly should fine out time to go for medical checkup, because of the health implications of exposure to high concentration of carbon dioxide. This will help to alleviate the health effects before it escalate. The employee and the customer should be educated on the need of the dangers of increase CO_2 level on human health.

Potted house plants (flower) that has no allergic effect, should be planted around the fast food outlets so as to reduce or absorb the level of carbon dioxide emitted and replace it with oxygen. Finally, this research recommends that further research on the potential effect of CO_2 on fast food users should be explored.

Recommendation for Further Studies

There is need for further research in other Local Government Area to ascertain the concentration of CO_2 in their fast food outlets. Also there is need to monitor the CO_2 level in the following areas; Banks, taxi, offices, churches and also in the kitchen where the food are prepared.

Conclusions

The main aim of this work was to assess the level or concentration of carbon dioxide in fast food outlets. For humans, breathing is paramount before finding water, food and shelter. From the evidence presented here, there appears to be current health impacts of rising CO_2 levels and a significant risk of serious health issues arising in the human population at some time in this century. Current impacts of elevated and increasing CO_2 in indoor environments include respiratory diseases, headaches, fatigue and other symptoms at levels above 800 ppm. Other ongoing impacts may include the exacerbation by CO_2 of cellular oxidative stress resulting in an increase in cancers, neurological diseases, viruses and many other conditions. Studies of health effects at higher levels of CO_2 at around 2,000-5,000 ppm demonstrate the impact of persistent attempts by the body to compensate for increased acidity in the blood. These effects include kidney calcification, bone degradation and cerebral blood flow disorders.

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