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Spatial analysis of air pollution inside residential units in the city of Kufa

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Abstract

In this study, the concentration of carbon dioxide and volatile organic compounds was measured. Three residential neighborhoods were chosen in the city of Kufa, which were mentioned in the study area section, where 1% of the number of houses was chosen, results of (carbon dioxide, volatile organic Maysan residential neighborhood. the CO₂ concentration (ppm) varies between 367 ppm and 2450 ppm, with an average value of 1,064±59 ppm. In addition, the VOC concentration (ppb) ranges from 44 ppb to 888 ppb, with an average value of 182±21 ppb. The results (CO₂, voc) Al-Sayray residential neighborhood from 367 ppm to 1850 ppm with an average value of 1,083±111 ppm. VOC concentration (ppb) ranged from 28 ppb to 870 ppb, with an average of 352 ±65ppb.and show the results (CO₂, VOC) from 435 ppm to 1950 ppm in the residential area of Altamar, Kufa, with an average value of 957.1 ± 97.479 ppm. The VOC concentration (ppb) ranged from 38 ppb to 788 ppb with an average value of 262.7 ± 224.48 ppb. Unfortunately, most of the results obtained in these were higher than the permissible limits set by the World Health Organization.

Keywords: Spatial analysis, CO₂, VOCs, in the door, city of Kufa, wave pulse

Introduction

Pollution of air is an environmental issue that is critical and has considerable effects on the health of human beings, as well as their quality of life. In urban areas such as Kufa City, the distribution in space of indoor CO₂ and volatile organic compounds (VOCs) are pollutants which are notably given serious concern. From this particular research work essay an understanding on how spatial analysis affects air pollution at residential levels is fundamental since this contributes significantly towards strategies development in mitigating issues related to quality of indoor air. The aim of this research paper is to examine the spatial distribution among CO₂ and VOCs levels; study different zones within Kufa based on their variability in air pollution; investigate factors influencing indoor air quality; and talk about impact for health due to VOC exposure in homes. The evaluation of indoor air quality through the spatial distribution of CO₂ levels in living spaces is a critical consideration. Lu *et al.*'s work unveiled an innovative approach to deducing space air change rates and CO₂ generation rates by occupants, underscoring the essence behind comprehending CO₂ concentrations within enclosed settings [2]. In Figure 1, stark disparities in where CO₂ is concentrated across different spots within a classroom are depicted this underscores the call for elaborate spatial scrutiny that pinpoints specific areas requiring attention [1]. Findings relayed by reports from the Air Quality Expert Group echo loud repercussions resulting from CO₂ levels on indoor air quality dynamics demanding due attention through continuous monitoring and remedial action towards this pollutant [3]. Toxicity of VOCs is largely dependent on their spatial distribution within residential units which underscores the importance of this factor in indoor pollution assessment. VOCs have significant sources from building and furniture materials that determine their long-term indoor levels. The industrial VOC emission sources have attracted attention as a result of the rapid growth in emissions; this emphasizes the need for spatial analysis to identify the distribution of VOCs. Despite being highly toxic, comprehensive studies on spatial distribution are not available from any particular location about VOCs. Which indicates a knowledge gap that should be dealt with. In Kufa, the spatial difference of air pollution between various regions worsens the situation within enclosed spaces. Studies that have been made to characterize urban air pollutants have shown notable differences in their spatial and temporal variations which implies the need for detailed assessments [7].

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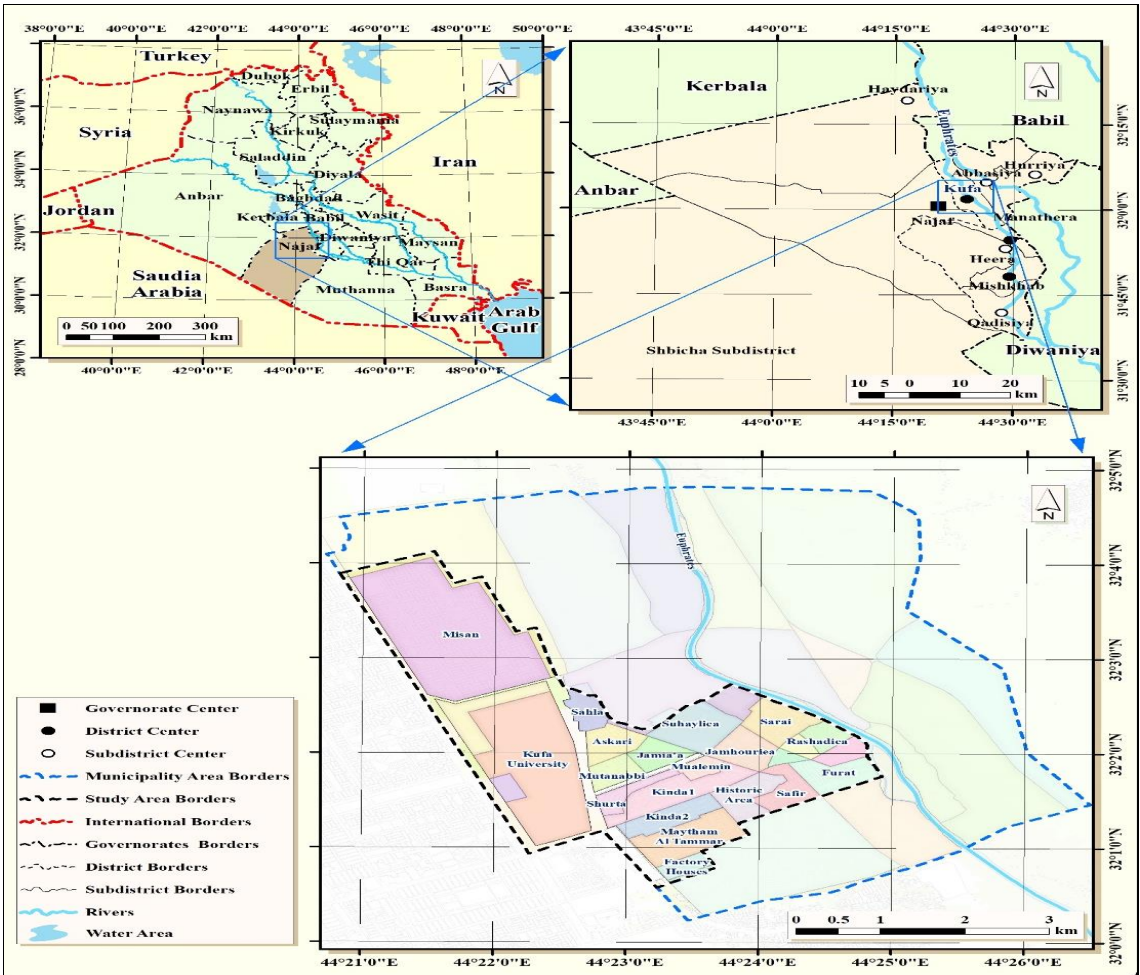
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The levels of urban air pollution exhibit a convoluted relationship between spatial variability and indoor exposure on top of outdoor sources; this calls for an all-round air quality management approach [8]. When the level of air pollutants is not very high uniformly across different areas, it implies that simple models will not work; fine resolution models are needed for better evaluation of indoor pollution levels [7]. Indoor air quality is an issue that has a large impact on human health. The consequences of household air pollution reach far into respiratory implications, hindering the growth of children's lungs and

elevating cases of lower respiratory tract infections [11]. When exposed to high levels for short periods, air pollution can have various adverse effects on the body's lung function and general respiratory wellness [12]. Chronic exposure to such pollution leads to noncommunicable diseases like stroke or heart disease: Hence, effective management strategies are vital in addressing this silent menace [8].

Study area

Location of the city of Kufa in Najaf Governorate, Iraq



Source: (General Authority for Survey, Kufa Administrative City Map, 2023)

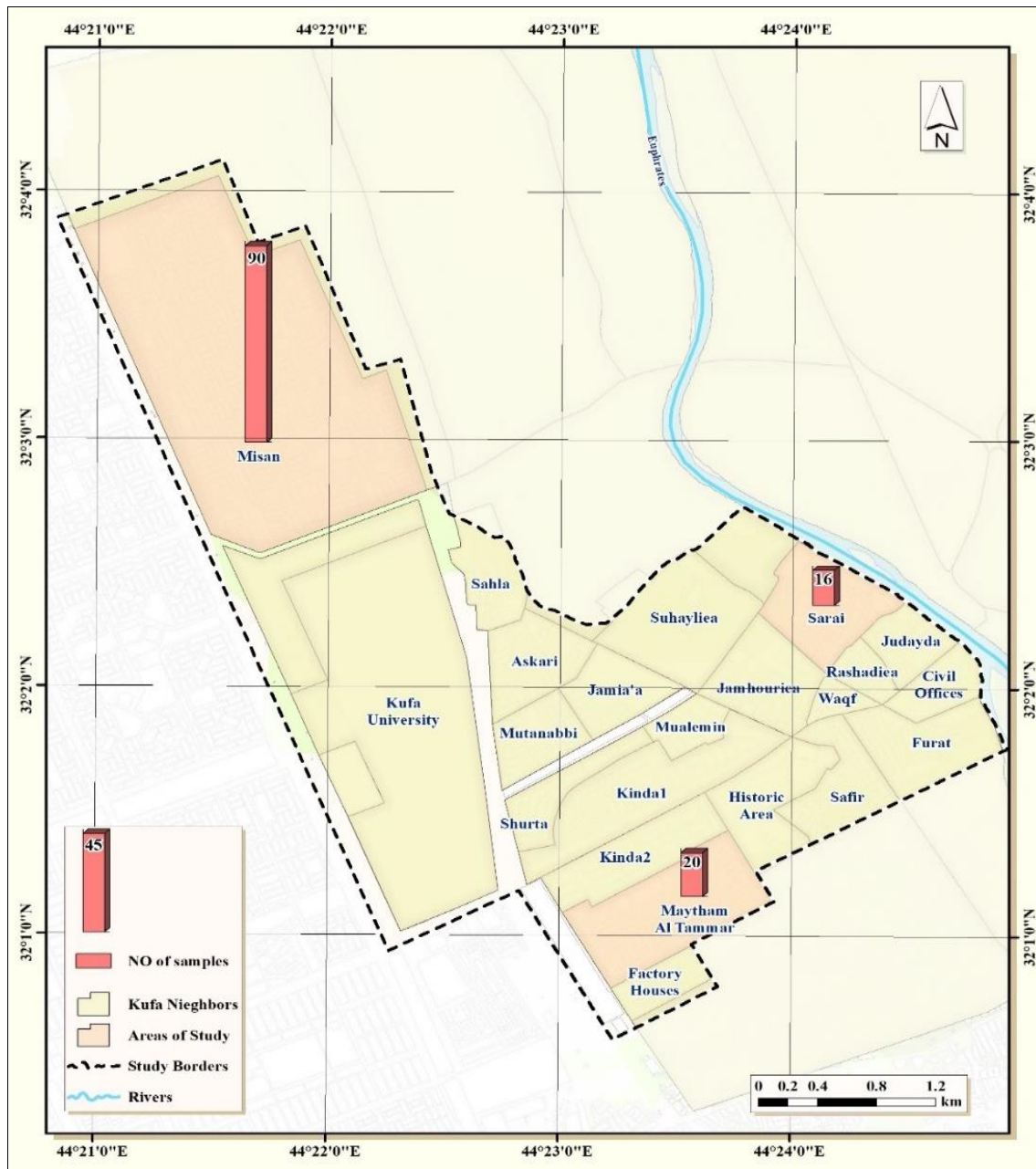
The city of Kufa was chosen, which is an Iraqi city and district center administratively affiliated with the Najaf Governorate in the Middle Euphrates region, south of the capital, Baghdad, and is about 156 km away from it and 10 km northeast of Najaf. Its population is estimated at about 230 thousand people, according to 2014 estimates. Three residential neighborhoods were selected from them. Three residential neighborhoods were chosen in the city of Kufa, which were mentioned in the study area section, where 1% of the number of houses was chosen, as shown in Table No. 1, during the time period from September 2023 to

May 2024.

Table 1: The measurement process was carried out using a radon device. Smart

Neighborhood	Number of houses
Maysan	90
Altamar	20
Al-Sayray	16

(Spatial distribution of air pollution samples in residential units in the city of Kufa)



Source: General Authority for Survey, Kufa Administrative City Map for the year 2023

Measurement System

Placing the Wave Plus device at breathing height is ideal. It should be placed in rooms where people spend most of their time to get accurate readings on CO₂ and VOC levels an effective way of monitoring indoor air quality. Avoid placing it near ventilation points such as vents, fans, windows or doors if you want precise readings all through. The Airthings View Plus device keeps track of various parameters related to indoor air quality, making it easier for users to access this information. When we compare different methods used in measuring CO₂ and VOCs with the Wave Plus Device, we are able to see what each method has to offer including its limitations: for example, traditional lab-based analytical equipment might be expensive but would provide detailed data analysis while real-time monitoring methods like what is used by the Wave Plus Device give immediate results plus continuous tracking of VOC concentrations in breath [9]. In order to evaluate risks of VOCs, it is essential to have a good understanding of the concentrations present in the atmosphere. The Wave Plus

Device has the ability to detect and measure VOCs in real-time; this means that it can pick up volatile profiles quickly and accurately. These profiles can be used for assessment of air quality and environmental risks. As such, when one is sensitive to CO₂ as well as VOCs, using deep-learning methods for data analysis helps in coming up with complex data patterns which lead towards enhancement of measurement precision a positive approach even toward urban emissions of VOCs and CO₂ micrometeorological techniques plus fast-response sensors can be used in real time. Measuring ultra-low concentrations of VOCs is not straightforward yet when considering technologies like the Wave Plus Device that are furnished with PID detectors, the light shines on their potential to actualize precise separation and quantification of VOCs. It marks an accomplishment for air quality monitoring; an innovation that could revolutionize how we control pollutants (number 8 and 9). An evaluation that compares different methods used in measuring Carbon Dioxide (CO₂) and Volatile Organic Compounds (VOCs) provides a revelation about what each

approach brings on board as well as what it lacks. Such studies have shown that real-time monitoring techniques (similar to what the Wave Plus Device uses) can deliver immediate results on continuous tracking of VOC levels in breath information vital for determining air quality and efficacy of pollutant controls. Although it may be said that traditional lab-based analytical equipment offers elaborate data analysis, remember: the accessibility plus efficiency offered by these real-time monitoring technologies paint a promising picture for improving practices related to air quality surveillance. Yet difficulties still loom in accurately measuring ultra-low concentrations of VOCs which act as a major impediment to achieving exact quantification. However, despite these challenges, emerging technologies such as the Wave Plus Device that feature PID detectors signal hope towards surmounting these obstacles. The innovation in turn augments the separation and quantification of VOCs thus underscoring the potential contribution advanced monitoring devices can make in the field of air quality monitoring and pollutant control. In light of this, it is recommended that future research should focus on addressing limitations encountered when measuring VOCs at ultra-low concentrations; seeking more applications for real-time monitoring technologies and improving the effectiveness of air quality monitoring systems. These identified shortcomings are areas for improvement: through recognizing them and acting upon it

within the research community we can continue promoting knowledge generation and adoption on innovations related to environmental monitoring issues.

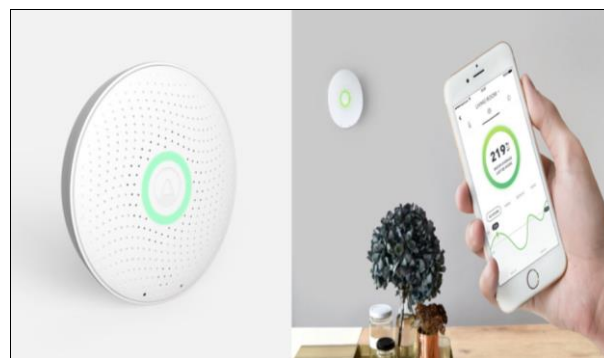


Fig 1: Wave Plus device

Results

Table 2. Shows the results of (carbon dioxide, volatile organic Maysan residential neighborhood in the city of Kufa. The data and Figures (2) show that the CO₂ concentration (ppm) varies between 367ppm and 2450 ppm, with an average value of $1,064 \pm 59$ ppm. In addition, the VOC concentration (ppb) ranges from 44 ppb to 888 ppb, with an average value of 182 ± 21 ppb.

Table 2: Results of analysis of Maysan neighborhood samples.

No. House	CO ₂ (ppm)	Voc (ppb)	No. House	CO ₂ (ppm)	Voc (ppb)	No. House	CO ₂ (ppm)	Voc (ppb)
1.	900	455	31	901	97	61	413	79
2.	1120	788	32	1111	64	62	577	26
3.	2500	120	33	2450	31	63	899	36
4.	670	112	34	677	71	64	466	85
5.	500	144	35	555	82	65	1200	78
6.	794	155	36	974	93	66	1490	300
7.	666	166	37	888	75	67	2494	320
8.	1800	250	38	1700	35	68	2333	444
9.	1333	744	39	1322	95	69	478	510
10.	1450	560	40	1870	15	70	951	24
11.	1780	111	41	1990	85	71	753	180
12.	790	888	42	633	52	72	987	143
13.	784	796	43	277	46	73	435	124
14.	2466	130	44	803	79	74	618	144
15.	801	78	45	855	13	75	792	178
16.	896	49	46	687	67	76	487	198
17.	640	55	47	460	91	77	349	156
18.	1222	17	48	1034	73	78	825	137
19.	1120	88	49	1777	91	79	782	158
20.	2130	44	50	559	82	80	1460	194
21.	955	123	51	557	789	81	1790	122
22.	788	100	52	885	258	82	367	178
23.	633	98	53	667	133	83	467	165
24.	2000	75	54	1992	155	84	824	149
25.	1400	64	55	1380	478	85	1570	134
26.	1666	14	56	1688	125	86	963	178
27.	1040	71	57	1030	270	87	951	222
28.	1164	82	58	1790	266	88	753	44
29.	755	93	59	554	480	89	498	57
30.	644	31	60	791	756	90	547	83
Average							1,064±59	182±21

Source: The researcher based on the field study and the results of sample analysis

Neighborhood in Kufa from 367 ppm to 1850 ppm with an average value of $1,083 \pm 111$ ppm. VOC concentration (ppb)

ranged from 28 ppb to 870 ppb, with an average of 352 ± 65 appb.

Table 3: show the results (cO₂,voc)Al-Sayray residential

No. House	CO ₂ (ppm)	Voc (ppb)
1.	879	360
2.	800	870
3.	1670	569
4.	1850	45
5.	1474	28
6.	1378	99
7.	1465	260
8.	894	255
9.	985	234
10.	678	798
11.	479	164
12.	367	258
13.	889	498
14.	1600	689
15.	1344	55
16.	578	456
average	1,083±111	352 ±65

Source: The researcher based on the field study and the results of sample analysis

Table 4: Results of analysis of samples from the Maitham Al-Tamar neighborhood.

No. House	CO ₂ (ppm)	Voc (ppb)
1.	835	320
2.	820	670
3.	1170	269
4.	1950	55
5.	1357	38
6.	1456	109
7.	1798	160
8.	987	225
9.	684	244
10.	678	788
11.	479	194
12.	654	218
13.	889	448
14.	1580	639
15.	630	155
16.	879	156
17.	485	140
18.	697	126
19.	679	187
20.	435	113
Average	957.1 ±97.479	262.7 ±224.48

Source: The researcher based on the field study and the results of sample analysis

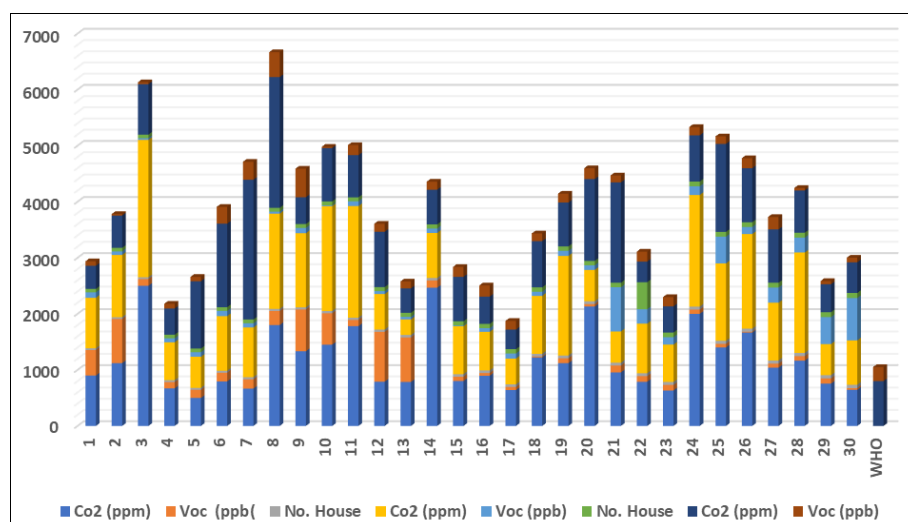
**Fig 2:** (CO₂, Voc₂) concentration is the in the In the Maysan residential neighborhood in the city of Kufa. with world average by WHO

Table 4. Table (4) and Figure (4) show the results (CO₂, VOC) from 435 ppm to 1950 ppm in the residential area of Altamar, Kufa, with an average value of 957.1 ± 97.479

ppm. The VOC concentration (ppb) ranged from 38 ppb to 788 ppb with an average value of 262.7 ± 224.48 ppb.

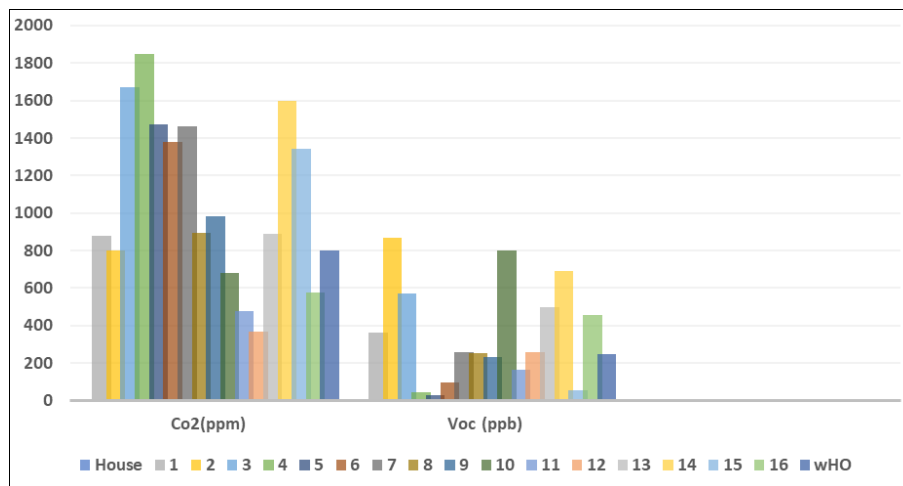


Fig 3: (CO₂, Voc2) concentration is the in the In the Al-Sayray residential neighborhood in Kufa. With world average by WHO.

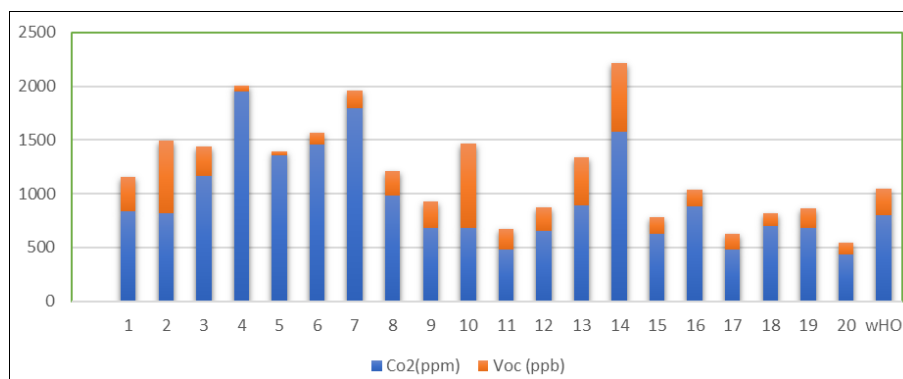


Fig 4: (CO₂, Voc2) concentration is the in the In the Altamar residential neighborhood in Kufa. With world average by WHO.

Discussion

The results from Table No. (2, 3, and 4) depicted significant variations in carbon dioxide and volatile organic compounds concentrations among the three residential neighborhoods in Kufa city. The disparity is largely due to differing indoor air quality, which can be heavily influenced by various factors with a notable impact coming from artificial air fresheners that affect concentrations of specific VOCs in residential settings. Volatile organic compounds (VOCs) have primary indoor sources contributing to their composition along with certain distinct compounds such as limonene or hexanal: emission sources like ventilation rates coupled with indoor oxidative environment further determine levels of VOCs indoors. Observations show that levels of volatile organic compounds (VOCs) indoors are typically higher than those outdoors; elevated benzene concentrations in colder seasons can be attributed to reduced ventilation as well as the use of oil and gas heaters leading to increased VOC emissions [10]. On another note, indoor levels of formaldehyde, toluene, and ammonia show significant dependence on temperature variability which points towards a seasonal impact on indoor air quality dynamics [11]. Similarly, parameters such as air temperature, relative humidity, and even age of the flat contribute distinctly to indoor formaldehyde levels underlining the intricate interplay of factors governing indoor air quality considerations [12]. Our findings exceeded WHO limits. There are several other factors that play roles

in determining these concentrations: household appliances, building characteristics.. etc., suggesting a more holistic approach is needed when addressing indoor air quality management [13]. The presence of ventilation is crucial in altering indoor air quality situation through stalling the accumulation of impurities such as CO₂ and VOCs, which can endanger health over time [14]. Hence, an investigation and control of the carbon dioxide and VOC sources should be prioritized in residential settings since it fosters better indoor air quality as well as decreasing adverse health risks due to long-term contact with high levels of pollutants [15].

Conclusion

In the research, a study was conducted to measure the carbon dioxide concentration of three residential neighborhoods in the city of Kufa. Unfortunately, most of the results obtained in these were higher than the permissible limits set by the World Health Organization.

Recommendations

Enhancing the quality of air inside can be done by removing volatile organic compounds (VOCs) which are contained in a lot of everyday household items including air fresheners. Choosing products that are low-VOC or VOC-free is an easy way to cut down on the amount of these harmful pollutants being introduced into your indoor space. Think green: potted plants and bio-filtration systems serve as

natural purifiers for indoor air at minimal cost by eliminating pollutants organically. In fact, looking at phytoremediation pathways could give us more ideas about reducing indoor pollution through plant-microbe systems. Apart from biodiversity patterns, such integrations with plant-based solutions would allow other co-benefits like creating a conducive work environment for remote workers. More study should refine plant selection optimization coupled with different synergies explored toward other strategies on improving air quality indoors.

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