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Assessment of indoor air quality in some coffee shops in Kalar District, Sulaymaniyah, Iraq

Sara Yousif Mohammed[1], Abdulmutalib Raafat Sarhat[2], Shagul Abubaker Ali[3]

1- Chemistry Department, College of Education, Garmian University, Kurdistan Region – Iraq

2- Chemistry Department, College of Science, Garmian University, Kurdistan Region – Iraq

3- Kurdistan Institution for Strategic Studies and Scientific Research, Natural Engineering and Agricultural Sciences Engineering, Kurdistan - Iraq

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Corresponding Author

abdulmutalib.raafat@garmian.edu.krd

Abstract :

Despite the fact that the majority of people spend most of their time indoors, no studies have been conducted to assess indoor air quality IAQ, particularly in cafés or coffee shops in the study area. The causes of air pollution in indoor places have many factors and differ from place to place; in this study, one of the causes was identified, which was that in most of the selected indoor places, an excessive number of smokers predominated, particularly among those who spent their leisure time inside coffee shops. As a result, indoor air quality in particular locations is vulnerable to pollution. This research focuses on the inner environment of different coffee shops in Kalar City and measured the air quality in each café during business hours for one week. Although there are several indices for assessing indoor air quality, only seven were monitored in this study: Carbon Monoxide CO, Carbon Dioxide CO_2, Total Volatile Organic Compounds TVOCs, Formaldehyde HCHO, Temperature, Particle Matters PM2.5 and PM10. The mean values of toxicity potential in all the coffee shops were greater than 1, indicating that PM2.5 and PM10 pose a health risk to the customers. In most of the coffee shops, average concentrations of these contaminants surpassed World Health Organization WHO standards. The concentrations of the contaminants investigated were directly influenced by occupant density, cigarette smoking, and hookah smoking. Controlling the concentrations of CO2 and other pollutants through optimal ventilation and adjusting coffee shop temperature can be used to ensure the quality of indoor air.

Introduction:

Air pollution is described as an unacceptable change in the qualities of the air that can affect human health. Unhealthy air is one of the biggest causes of respiratory disorders, including asthma, as well as irritation[1][2][3][4]. Indoor air pollution poses larger health risks than outdoor pollution, especially for susceptible groups such as children, young people, the elderly, and those who struggling with chronic respiratory or cardiovascular medical conditions[5]. There are so many sources of air pollution for both indoor and outdoor. In this study the IAQ was observed, in addition to the fact that most individuals throughout the world spend more than 80% of their time in various indoor areas such as houses, workplaces, restaurants, or cafes [1]. Beside that in indoor places like café or

restaurant, there are many potential hazards, such as; Cookware, open fires, appliances, refrigeration units, and cleaning agents [6]. In other study in North America found that the adults spend 87% of their time inside the indoors[2][7]. Also, there are no previous study conducted to measure the IAQ and majority of young people try to spend most of their time in fleshpots such as; coffee shops, most of young people consider the coffee shops as an alternative place of their homes and they do not concern or aware about their IAQ. In this study, coffee shops selected among the indoor places as the most popular indoor places where young people spend their time smoking hookah, electronic cigarettes, shisha (water pipe), drinking, and eating sweets, as a result affects the indoor air quality, for that purpose the quality of indoor air must be addressed as it impacts peoples' health [8][9]. There are many factors affecting the quality of air in enclosed places, including: lack of ventilation, poor air distribution, and improper design of the buildings and the filter systems, pollutants from indoor sources such as; combustion gases releasing gaseous, contaminants that emitted by cooking appliances, formaldehyde, and other toxic chemicals, including: tobacco, pesticides, and cleaning products [10].Those sources can emit lots of indoor pollutants such as CO_2, p-PAHs and VOCs [11][12]. The majority of studies track comfort, ventilation, and regulated contaminants. Pollutants that are commonly monitored include gaseous chemicals CO, CO_2, NO_x and organic compounds with carcinogenic potential[13]. Concern over the effects of VOCs from food production on our environment and health is growing, VOCs in food are generated and released throughout most phases of the food production chain, from the farm to the table[14].The pollutants and gases that are presented in the indoor environment air directly affect the air quality, physical, mental and the well-being conditions of the workers and the visitors of a given area in the long term[15][16]. The Particle Matters PM are related directly to the health problems. The particles size with less than 10 µm in diameter can be cause of many health issues, as they can enter into the bloodstream and penetrate into lungs easily[17][18]. Exposure to these particles especially PM2.5 can harm the heart and lungs. Many studies have revealed the relationship between particle exposure and some health issues, including death in people with lung or heart disease, irregular heartbeat, heart attacks, asthma, increased respiratory symptoms, decreased lung functions, difficulty breathing and some others[19].

The VOC, HCHO, CO, CO_2, PM2.5, PM10 and temperature are indoor air pollutants that are the main cause of some severe health issues for young and adults [20]. Among Iraqi youth, the hookah smoking phenomenon is widespread nowadays in many places including cafes and public roads. This phenomenon poses a significant threat to public health. The importance of proper ventilation system in coffee shops is a necessary tools to ensure a healthy indoor environment[21]. Due to indoor exposure to smoke, which typically comprises a variety of health-damaging contaminants such as; fine particles and carbon monoxide, more than 1 million individuals worldwide per year pass away from Chronic Obstructive Pulmonary Disease COPD[14].

The IAQ in cafes and other enclosed areas are influenced by the lack of clean air and low regulations. The investigation of the emission rates from indoor pollutant sources is very important to assess IAQ [22][23]. Since there are no previous study been conducted for assessing the quality of air in indoor places so far in Kurdistan Region of Iraq, make such a study significant. The aim of this paper is to assess the potential indoor air pollution in cafes in Kalar City, Northeastern of Iraq, in order to develop necessary measures to reduce the indoor air pollution and its impact on health. The outcomes of this paper will be useful for cafe managers and the customers to understand the potential health risks associated with indoor air pollution.

Material and Methods

Study Area

Kalar city is located in the northeastern part of Iraq, and the selected sampling stations include (12) coffee shops area. The indoor activities included tobacco smoking, cooking, Hookah and some other activities that may change the air quality.

Instruments

The Air Quality Detector JSM-131 SC, Air Quality Monitor w/ PM2.5, PM10, TVOC, HCHO, and 317-3 Portable Ambient CO Monitor have been used for IAQ monitoring.

Sampling

The sample collections were extensively conducted within three months from December 2022 to March 2023. Each coffee shop was monitored on daily basis from Friday to Saturday. The monitoring and collecting data were continuously conducted during the night business hours in each coffee shop in four different times (19:00-20:00; 20:00-21:00 and 21:00-22:00; 22:00-00:00). The sampling point was fixed and not changed in order to reduce the interferences of other factors. Then, the mean values of the pollutants in each coffee shop were compared to the standard of CO, CO_2, TVOC and HCHO, as mentioned in Table 1.

Table 1. The permissible levels of studied pollutants [10][24][25]

Pollutants	Standards (ppm)	Units
HCHO	0.1	mg/m^3
TVOC	0.5	mg/l
CO_2	750	mg/l
CO	5	mg/l
PM2.5	35	$\mu g/m^3$
PM10	50	$\mu g/m^3$
Temperature	20-30	^oC

Toxicity potential TP

It is defined as the ratio of evaluated PM concentration to its permissible limit[19]. It is considered as a significant factor in determining the pollutants harmful effects on the human health[26]. It can be calculated by Equation (1):

… (1)

Where:

MPM is the examined PM, and SPM is the permissible value set for both PM2.5 and PM10.

Results and Discussion

In this study, seven variables have been studied in twelve different coffee shops located in various places in Kalar city. The average value of each (CO, CO_2, TVOCs, HCHO, Temperature, Particle Matters PM2.5 and PM10) per hour were monitored for the duration of one week in four different times to assess the quality of air based on EPA and WHO regulations, as shown in Table 1.

Carbon monoxide CO is one of the variables, it is a toxic gas that formed from incomplete combustion of fuels[27][28]. It is connected to a lot of heart diseases in different ages. Also, there is a strong link between CO and CO_2 gases, as both of them have a severe impact on increasing respiratory infection [29].The concentrations of CO and CO_2 are varied from (5.25 to 7.5) ppm and (1202 to 2903.25) ppm in all the coffee shops, respectively. As shown in the Table 2, based on the maximum permissible levels, the IAQ was poor in all the coffee shops for the CO_2 and CO concentrations [30]. While most of the time the coffee shops are enclosed also they are the most crowded areas with many activities which negatively affect the quality of air, the poor IAQ was obtained at all the coffee shops [8]; for those reasons, these places are thought to be inadequate in terms of comfort standards.

The temperature during the occupancy periods were almost high and ranging between 23.5 and 24.75 ^oC, which is higher than the proposed indoor temperatures (ASHRAE Standard 55–2004)[10].

Table 2. The mean value of the studies pollutants with the standard deviation St.D value for each coffee shop

Coffee Shop	CO2		CO		TVOC		HCHO		PM2.5		PM10		Temp.	
	Mean	St.D	Mean	St.D	Mean	St.D	Mean	St.D	Mean	St.D	Mean	St.D	Mean	St.D
CS1	1263.5	84.054	5.25	0.957	0.3875	0.23	0.0208	0.020	47.5	2.88	53.25	2.06	24	0.81
CS2	1444.75	7.805	5.75	1.258	3.515	0.0376	0.486	0.0038	47.25	4.99	53.25	4.99	24.75	0.5
CS3	1399.5	13.23	5.75	1.708	3.336	0.0599	0.468	0.0045	48.75	4.03	54	3.65	23.5	1.29
CS4	2456.5	103.5	5.5	0.577	10.947	1.764	1.975	0.1346	48.75	3.5	53.75	3.5	23.5	1.29
CS5	1672	194.34	6.5	1.291	1.373	0.0057	0.188	0.00096	47.25	6.45	52.5	6.25	24	0.82
CS6	1268.25	286.94	5.75	0.5	1.425	0.045	0.2	0.00359	46	3.56	51.25	3.30	23.5	0.58
CS7	1202	3.916	6.25	2.217	2.567	0.0213	0.356	0.0019	46.5	2.64	52.5	2.65	24	0.82
CS8	1735.5	11.091	7.5	2.38	4.545	0.059	0.636	0.00619	48.5	6.24	54	6.63	23.5	1.29
CS9	2698.75	24.309	6	1.826	10.25	1.708	2.019	0.0388	48.5	4.20	54	4.69	23.75	0.96
CS10	2628.75	314.37	6.5	1.291	10.89	1.827	1.971	0.061	48.25	4.42	53.5	4.65	24	0.82
CS11	1316.5	8.813	6.75	2.061	2.976	0.036	0.416	0.0023	48.25	5.91	53.5	5.44	24	0.81
CS12	2903.25	43.44	6.25	1.258	10.75	1.708	1.976	0.06	52	3.16	57.5	3.32	24.25	0.95
Min.	1202	-	5.25	-	0.3875	-	0.0208	-	46	-	51.25	-	23.5	-
Max.	2903.25	-	7.5	-	10.947	-	2.01875	-	52	-	57.5	-	24.75	-
Ave.	1832.44	-	6.1458	-	5.2468	-	0.8927	-	48.13	-	53.58	-	23.9	-

Indoor VOCs are mainly emitted from various sources such as; paints, carpets, disinfectants, solvents detergents, from the cooking appliances for example ; environmental emissions come from meat grills, smoking, incomplete combustion, and some unburned fuel[31][2].

The results showed that; the levels of TVOCs in the studied areas were ranged between 0.3875 and 10.947 ppm. This indicates that the levels of VOCs in 91.67% of the coffee shops were exceeded the acceptable value[24][32], this could be the result of heavy uses of detergent and the intensive smoke of cigarette and hookah as well as the poor ventilation systems in the coffee shops. However, in only one coffee shop shows low level of VOCs. The most significant indicator for the high level of VOCs in the studied area first was the occupant density and second was the design of all the coffee shops, which was the open-kitchen style; in which there is no segregation between cooking and dining areas. While the VOCs are among the main causes of possible human carcinogens and toxicants[14][33].

Regarding the HCHO concentration in indoor places, exposure to HCHO is higher in indoors if it compared to outdoors environment, which is related to the presence of more sources of HCHO and low ventilation rates in the indoor environments[34][35]. HCHO is classified as carcinogenic gas, and has the major damages on the air quality of indoor environment[31]. The sources of indoor HCHO are extensive such as; melamine resin, paint, smoking, and cooking fumes are the most common sources [7][27][28]. The standard values of HCHO in indoor environment is 0.10 ppm [24]; while, the excessive levels can cause increasing in the incidence rate of some types of carcinoma such as Nasopharyngeal Carcinoma[36][37]. The results show that the levels of HCHO in the studied area were ranged between (0.0208-2.018) ppm. This indicates that the levels of HCHO in 91.67% of the coffee shops were exceeded the acceptable value; while, there was only one coffee shop showed low level of HCHO.

The PM2.5 averages of coffee shops were ranged between (46-52) $\mu g/m^3$, which exceeded the WHO and EAP IAQ standard which is (35 $\mu g/m^{3)}$[25][32]. Also, the PM10 averages of all examined coffee shops were ranged between (51.25-57.5) $\mu g/m^3$, which exceeded the EPA and WHO guidelines of 24-h average, (45 $\mu g/m^3$). The high values of both PM are belonged to some anthropogenic activities within the coffee shops, including; the generator fumes, cocking, cigarette smoke, hookah smoking and using perfumes by the customers.

The mean occupant density of all the coffee shops were ranged between (25-43) occupants/100 m2, and were higher than the American Society of Heating, Refrigerating, and Air-Conditioning Engineers which recommendation 20 occupants/100 m2 for coffee stations[10].

As shown below in the Table 3, very strong correlation has been noticed between TOVC and HCHO with a value of 0.996, as well as between PM2.5 and PM10 with a value of 0.977. Also, strong correlations have been shown between CO_2 and each of TVOC and HCHO. However, nonlinear correlations have been illustrated between temperature and most of the pollutants.

Table 3. Correlation coefficient among the pollutants

	CO_2	CO	TVOC	HCHO	PM2.5	PM10	Temp.
CO_2	1						
CO	0.081296	1					
TVOC	0.949713	0.052716	1				
HCHO	0.96084	0.013403	0.996078	1			
PM2.5	0.710856	0.155282	0.66295	0.648082	1		
PM10	0.658557	0.141648	0.610863	0.595679	0.977841	1	
Temp.	-0.00173	-0.07551	-0.04661	-0.04993	0.074845	0.211648	1

The average of toxicity potential TP of PM2.5 and PM10 were ranged between (1.314 to 1.486) and (1.025 to 1.150) respectively. The value of TP with greater than 1 in a location indicates that PM2.5 and PM10 pose a health risk to people. However, TP values with lesser than 1 indicates that there are no health risk associated with PMs. As shown below in the Table 4.

Table 4. Values of Toxicity Potentials (TP) for PM2.5 and PM10

Coffee Shop	TP (PM2.5)	TP (PM10)
CS1	1.357	1.065
CS2	1.350	1.065
CS3	1.393	1.08
CS4	1.393	1.075
CS5	1.350	1.05
CS6	1.314	1.025
CS7	1.329	1.05
CS8	1.386	1.08
CS9	1.386	1.08
CS10	1.379	1.07
CS11	1.379	1.07
CS12	1.486	1.15
Min	1.314	1.025
Max	1.486	1.150
Ave.	1.375	1.072

Conclusion

This study's objective was to evaluate the indoor air quality in 12 coffee shops in Kalar City. All of the studied pollutants, including CO, CO_2, VOCs, HCHO, PM2.5, and PM10 were significantly over the acceptable limits, which pointed to the existence of several indoor sources. The mean values of toxicity potential in all the coffee shops were greater than 1, indicating that PM2.5 and PM10 pose a health risk to the customers. Therefore, to protect the health of coffee shop employees and customers, some potential strategies should be utilized to control or minimize the rate of indoor pollutants emissions within the coffee shops, such as separating the cooking area and installing effective smoke exhaust systems in the kitchens. Additionally, air purification systems and suitable ventilation must be implemented.

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