Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

Assessment of indoor air quality for closed cafés in Baghdad City, Iraq

Mohammed Abdul Bari Fezea*, Maha A. Gathwan

Department of Biology, College of Education for Pure Sciences (Ibn Al-Haitham), University of Baghdad, Iraq

** Corresponding author's Email: mohammed.a@ihcoedu.uobaghdad.edu.iq*

ABSTRACT

The phenomenon of young people frequenting closed cafes spread in Baghdad to smoke hookahs and cigarettes has increased. This phenomenon is associated with unemployment, an increase in leisure time and the deterioration of economic conditions. This phenomenon has an impact on indoor air quality and exposes workers to the risk of exposure to various pollutants, including particulate matter, therefore, we examined some indicators ($PM_{2.5}$, PM_{10}) IAQ for a month in summer and another month in winter in six different locations in the Rusafa district. $PM_{2.5}$ and PM_{10} concentrations, relative humidity (RH) and temperatures were measured using (Multifunction Air Quality Detector BENETECH -China). The results showed an increase in temperatures inside closed cafes, exceeding the recommended limits, and regardless of the seasonal fluctuations, the average concentrations of both $PM_{2.5}$ and PM_{10} inside closed cafes for the months of August and December exceeded the daily and annually PM standards recommended by World Health Organization for both $PM_{2.5}$ and PM_{10} concentrations were higher in summer than in winter were the most of young people enjoy a long holiday. The peak of $PM_{2.5}$ and PM_{10} concentrations also occurred during evening rush hour, more than the highest readings in the morning periods.

Keywords: Indoor Air Quality, $PM_{2.5}$, PM_{10}.
Article type: Research Article.

INTRODUCTION

Indoor air quality is essential for human health and well-being. The air we breathe inside our homes and other indoor spaces can contain a range of pollutants, including volatile organic compounds (VOCs), particulate matter, and allergens (Al-Easawi *et al*. 2015; Lin *et al*. 2022). These pollutants can cause a range of health problems (Thamie 2017; Al-Azzawy *et al*. 2017; Mahmmod 2019; Masoudi *et al.* 2019; Farivar Ghaziani *et al.* 2021; Idris *et al*. 2022; Semin *et al.* 2023), including respiratory issues, headaches, allergies, and infections (Ibraheem, 2017; Singh & Tripathi 2021). Additionally, poor indoor air quality can also impact our comfort, leading to symptoms such as fatigue, irritability, and difficulty concentrating (Langiano *et al*. 2008). There are several key factors that can influence indoor air quality (Bettaieb *et al*. 2020). The most important include:

Ventilation. Mahdi *et al*. (2020) and Francisco *et al*. (2017) pointed out that the proper ventilation is crucial for maintaining healthy indoor air quality. It helps to dilute indoor air pollutants and remove them from the indoor environment. Wolkoff (2018) and Hassan & Al-Waeli (2022) found that indoor humidity levels can have a significant impact on indoor air quality. High humidity levels can promote the growth of mold and other allergens, which can become airborne and contribute to indoor air pollution. They also mentioned that high indoor temperatures can increase the levels of particulate matter in the air by promoting the evaporation of volatile organic compounds. Low indoor temperatures can increase indoor humidity levels, leading to a higher risk of mold growth and other indoor air quality problems.

Building materials. The materials used in construction and furnishings can release VOCs into the indoor environment, contributing to indoor air pollution.

Caspian Journal of Environmental Sciences, Vol. 21 No. 5 pp. 1279-1287 Received: April 20, 2023 Revised: July 04, 2023 Accepted: Sep. 25, 2023
DOI: 10.22124/CJES.2023.7430

Publisher: University of Guilan,

Pests. Pests such as cockroaches, mice, and dust mites can release allergens into the indoor environment, contributing to indoor air pollution.

Household cleaning products. The use of household cleaning products can release VOCs into the indoor environment, contributing to indoor air pollution.

Particulate matter defined as a complex mixture of solid and/or liquid particles suspended in the air. It is often referred to as particulate matter or particulate pollution. The content, size, and form of these particles can all vary (Yang *et al*. 2018; Arias-Pérez *et al*. 2020; Philip *et al*. 2017). Particles of a diameter of 10 micrometers or less are of special concern to the EPA since they can be inhaled. The particles, when inhaled, have the potential to have major health consequences, including impacts on the heart and lungs (Perry *et al*. 2023; Zhang *et al*. 2019). Fine particle matter's negative effects on human health are well known, and they are used to set health standards for outdoor air (National Ambient Air Quality Standards, NAAQS). Additionally, PM is present in all indoor settings. The NAAQS and outdoor particle matter thresholds could be exceeded by indoor particulate matter levels. Unfortunately less is understood, regarding the precise effects of indoor PM on health (Humadi 2016; Zaman *et al*. 2021). $PM_{2.5}$ (particulate matter with a diameter of 2.5 micrometers or less) can come from a variety of sources, including:

1. Combustion sources: $PM_{2.5}$ can be generated by the combustion of fossil fuels, such as coal, oil, and natural gas, in power plants, industrial processes, and vehicles (Hassoon 2019).
2. Agricultural sources: $PM_{2.5}$ can be generated by agricultural practices, such as plowing fields, harvesting crops, and raising livestock (Al-Taay *et al*. 2018).
3. Wildfires: $PM_{2.5}$ can be generated by wildfires, which can release large amounts of smoke and soot into the air (Aguilera *et al*. 2021).
4. Construction and demolition activities: $PM_{2.5}$ can be generated by construction and demolition activities, such as sanding, cutting, and grinding building materials (Cheng *et al*. 2020).
5. Industrial processes: $PM_{2.5}$ can be generated by various industrial processes, such as mining, smelting, and manufacturing (Karagulian *et al*. 2015).
6. Residential sources: $PM_{2.5}$ can be generated by residential sources, such as cooking, burning cigarette tobacco, wood or other biomass for heating, and using candles or incense (Camilleri *et al*. 2022).
7. Natural sources: $PM_{2.5}$ can be generated by natural sources, such as dust storms, volcanic eruptions, and sea spray (Achilleos *et al.* 2022).

While particulate matter with a diameter of 10 micrometers or less (PM_{10}) can come from a variety of sources, including:

1. Natural sources: PM_{10} can be generated by natural sources, such as windblown dust, wildfires, and pollen (Evagelopoulos *et al*. 2022).
2. Construction and demolition activities: PM_{10} can be generated by construction and demolition activities, such as sanding, cutting, and grinding building materials (Azarmi *et al*. 2014).
3. Agricultural sources: PM_{10} can be generated by agricultural practices, such as tilling soil and harvesting crops (Arslan & Aybek, 2012; Chen *et al*. 2017).
4. Industrial processes: PM_{10} can be generated by various industrial processes, such as mining, smelting, and manufacturing (Larionov *et al*. 2022).
5. Transportation: PM_{10} can be generated by vehicle emissions, including exhaust from diesel engines and brake and tire wear (Timmers & Achten 2016).
6. Residential sources: PM_{10} can be generated by residential sources, such as burning wood or other biomass for heating and cooking (Lachowicz *et al*. 2022).
7. Fossil fuel combustion: PM_{10} can be generated by the combustion of fossil fuels, such as coal and oil, in power plants, industrial processes, and vehicles (Maciejczyk *et al*. 2021).

MATERIALS AND METHODS

A total of 6 public places of one type (closed cafe) in Al-Rusafa district in Baghdad City were chosen in this study; indoor $PM_{2.5}$ and PM_{10} were monitored by Multifunction Air Quality Detector BENETECH. Data under varying conditions were collected and analyzed, such as doors or windows or mechanical ventilation devices being opened, rooms cramped with people and smoking.

RESULTS AND DISCUSSION

The highest mean temperature for the morning peak was recorded in the sixth station in August at 36.35 °C, while the highest mean for the evening peak temperature was 31.65 °C for the same station, and the highest mean relative humidity was recorded in the morning peak at 53.95% in the second station, while the humidity reached 62.7% in the fifth station at its evening peak (Table 1; Fig. 1).

Table 1. The monthly average of temperature and humidity in the study sites – August.

Stations	Average T- AM	Average T- PM	Average H- AM	Average H- PM
St.1 A	28.85	31.15	44.65	51.9
St. 2 A	28.7	30.35	53.95	43.5
St. 3 A	28.95	30.35	42.65	49.25
St.4 s.c	32.5	29.75	50	56.15
St. 5s.c	33.35	28.85	50	62.7
St. 6F.S	36.35	31.65	44.75	47.15

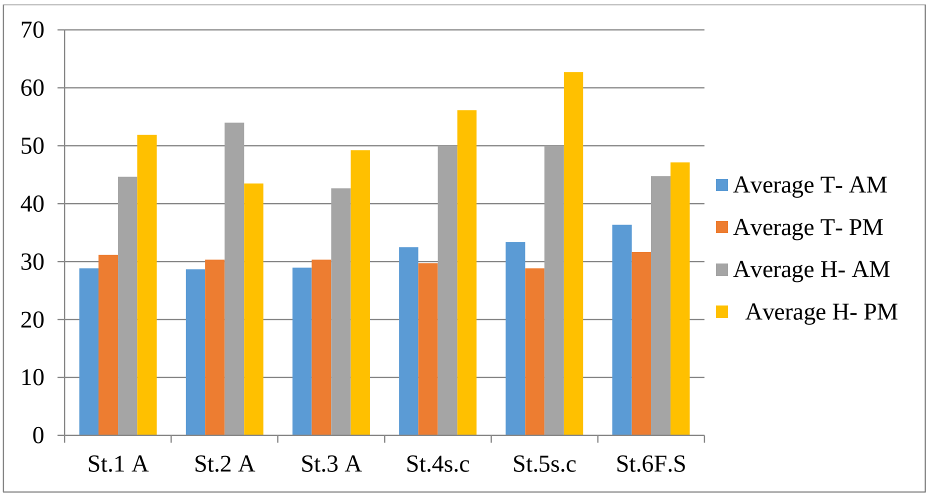

Fig. 1. The monthly mean temperature and humidity in the study sites – August.

The highest average concentration of $PM_{2.5}$ was recorded at the second station and for the morning peak, amounting to 541.5 µg m^{-3}, while the highest rate at the first station during the evening peak, amounting to 1247.5 µg m^{-3}. The highest concentration for PM_{10} was recorded for the peak morning and reached 650.5 µg m^{-3} at the second station, while 1605 µg m^{-3} at the first station and at its evening peak (Table 2; Fig. 2).

Table 2. The monthly average concentration of particulate matter in the air (µg m^{-3}) during August.

Stations	Average-$PM_{2.5}$- AM	Average-$PM_{2.5}$- PM	Average-PM_{10}- AM	Average-PM_{10}- PM
St.1 A	437.5	1247.5	466.5	1605
St.2 A	541.5	798	650.5	1025.5
St.3 A	194.5	490.5	379	575
St.4s.c	168.5	274	222	324
St.5s.c	220	306.5	255.5	387
St.6F.S	250	376.5	297.5	441

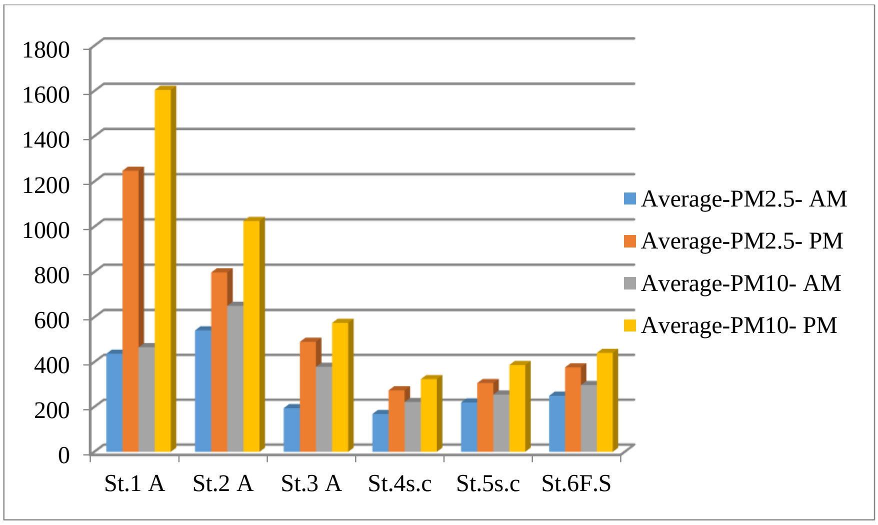

Fig. 2. Monthly average concentration of particulate matter in the air (µg m^{-3}) during August.

The highest average temperature was recorded at the fifth station and in the morning and evening peaks during December, reaching 24 and 23.45 °C, while the highest average relative humidity and in the morning peak was 51.5% in the sixth station, whereas in the evening peak it reached 57.8% in the fifth station (Table 3; Fig. 3). The highest average concentration of $PM_{2.5}$ and PM_{10} in the morning and evening peaks were recorded in the sixth station, which amounted to 271.5, 514, 386.5 and 666.5 respectively (Table 4; Fig. 4).

Table 3. Monthly average of temperature and humidity in the study sites, during December.

Items	Average T-AM	Average T-PM	Average AM-RH	Average PM-RH
St.1 A	22.95	23.3	48.9	52.6
St.2 A	23.15	22.6	49.6	52.8
St.3 A	23.4	23.45	48.8	51.4
St.4s.c	23.25	22.9	51.35	53.9
St.5s.c	24	23.45	50.25	57.8
St.6F.S	23.35	23.25	51.5	54.4

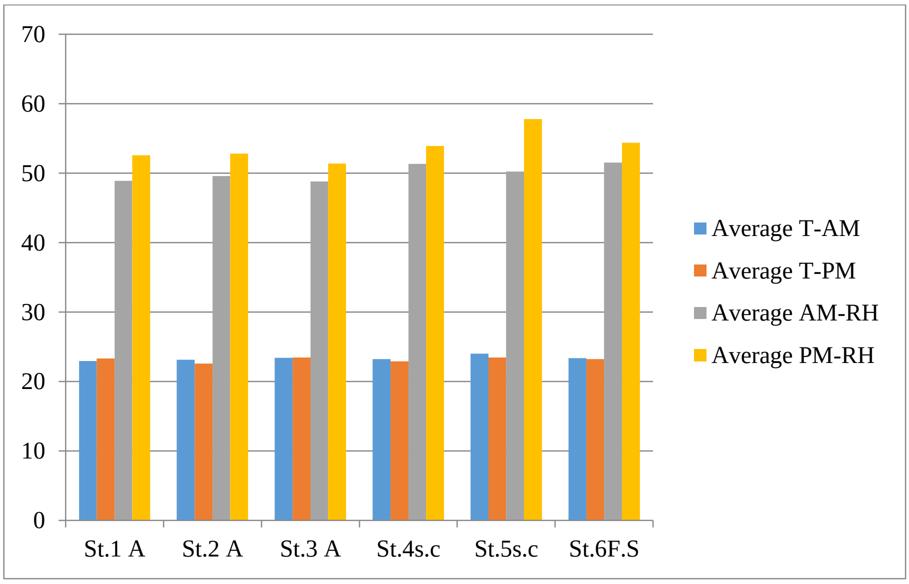

Fig. 3. Monthly average of temperature and humidity in the study sites, during December.

Table 4. Monthly average concentrations of particulate matters in the air (µg m^{-3}) during December.

Items	Average $PM_{2.5}$-AM	Average $PM_{2.5}$-PM	Average PM_{10}-AM	Average PM_{10}-PM
St. 1 A	231.5	395	258.5	455.5
St. 2 A	131	295.5	153.5	339.5
St. 3 A	105	164	115	184
St. 4s.c	132.5	225	152	251.5
St. 5s.c	155.5	260.5	188.5	311.5
St. 6F.S	271.5	514	386.5	666.5

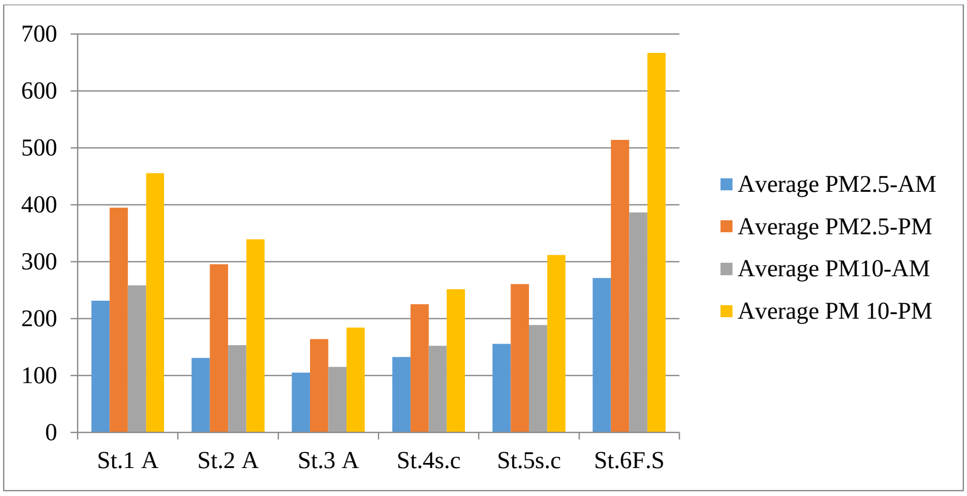

Fig. 4. The monthly average concentration of particulate matter in the air (µg m^{-3}) during December.

The average temperatures inside closed cafes for the months of August and December exceeded the limits recommended by the Environmental Protection Agency, considered that the comfortable room temperatures were about 68-76 degrees Fahrenheit (20-24 °C). The unstable air temperatures contribute to heat stress for both workers and customers (Hajizadeh *et al*. 2016). The exposure to excessive heat has wide ranging physiological impacts for all humans, often amplifying existing conditions and resulting in premature death and disability (Bobb *et al*. 2014; Al-Kaabie 2019; Shindell *et al*. 2020; de Schrijver *et al*. 2022), while humidity was within the recommended percentages (30% and 60%; WHO 2021). The human body can suffer from high humidity levels. It can make the person feel tired with lack of energy since the air feels warmer than the recommended measured temperature. In addition, in environments with high humidity, hyperthermia, or overheating as a result of body's inability to adequately release heat, can have a detrimental influence on health. Overexposure to humidity (hyperthermia) poses a number of health hazards, including: Dehydration, weariness, cramping muscles, heat exhaustion, fainting, and heat stroke (Razjouyan *et al*. 2020), regardless of seasonal fluctuations temperature and humidity can play a role in elevate stress for the workers who spent the majority of their time at the office in bad conditions (Turunen *et al*. 2014; Al horr *et al*. 2016). The average concentrations of both $PM_{2.5}$ and PM_{10} inside closed cafes for the months of August and December exceeded the daily and annually PM standards recommended by World Health Organization (2011, 2021). Both $PM_{2.5}$ and PM_{10} concentrations were higher in summer than in winter, where the most of young people enjoy a long holiday. The peaks of $PM_{2.5}$ and PM10 concentrations also occurred during evening rush hour, more than the highest readings in the morning periods, cause of the significant indoor sources of PM (2.5 and 10) like burning of coal for hookah (Wei & Semple 2022), burning of sticky mixture of tobacco (maassel; Milner *et al*. 2011; Loffredo *et al*. 2016), regular cigarette smoking (Fernandez *et al*. 2015), electronic cigarettes (Li *et al*. 2020), poor ventilation depend mainly on mechanical ventilation to recirculate indoor air with a very low amount of outdoor air dilution leading to the accumulation of pollutants indoors (Chen & Zhao 2011), and due to the increased number of visitors to these cafes (Cobb *et al*. 2012), as well as out-door particles that infiltrate indoors and remain suspended (Matthaios *et al*. 2021) mostly from unpaved streets where the cafes are located (Amato *et al*. 2014; Chithra & Shiva Nagendra 2014).

CONCLUSION

The PM (2.5 and 10) concentrations observed among the cafés sampled indicated a bad air quality, the concentrations exceed national and international air quality standards, potentially putting both staff and customers' health at risk. Smoke-free laws that cover all combusted tobacco products, including the waterpipe, are required to safeguard the public from the risks of secondhand smoke and to alter social norms regarding tobacco use.

REFERENCES

Achilleos, S, Michanikou, A, Kouis, P, Papatheodorou, S I, Panayiotou, A G, Kinni, P, Mihalopoulos, N, Kalivitis, N, Kouvarakis, G, Galanakis, E, Michailidi, E, Tymvios, F, Chrysanthou, A, Neophytou, M, Mouzourides, P, Savvides, C, Vasiliadou, E, Papasavvas, I, Christophides, T, Nicolaou, R, Yiallouros, P K 2023, Improved indoor air quality during desert dust storms: The impact of the MEDEA exposure-reduction strategies. *The Science of the Total Environment*, 863, 160973. https://doi.org/10.1016/j.scitotenv.2022.160973

Aguilera, R, Corringham, T, Gershunov, A & Benmarhnia, T 2021, Wildfire smoke impacts respiratory health more than fine particles from other sources: observational evidence from Southern California. *Nature Communications*, 12(1), DOI: 10.1038/s41467-021-21708-0

Al-Azzawy, LHA & Al-Qaicy, AGS 2017, Astudy About Some Physiological Parameters in Smokers. *Ibn AL-Haitham Journal for Pure and Applied Sciences*, 24(3). Retrieved from https://jih.uobaghdad.edu.iq/ index.php/j/article/view/734

Al-Easawi, NAF, Al-Azzawi, MNA & Afaj, AH 2015, Indoor air concentrations of heavy metals in two Shisha smoke cafés in Baghdad. *Iraqi Journal of Science*, 56: 1359-1365.

Al horr Y, Arif, M, Katafygiotou, M, Mazroei, A, Kaushik, A & Elsarrag, E 2016, Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature. *International Journal of Sustainable Built Environment*, 5: 1–11, DOI: 10.1016/j.ijsbe.2016.03.006

Al-Kaabie, SJ 2019, Smoking and social behavior. *Journal of the College of Education for Women*, 20(1). Retrieved from https://jcoeduw.uobaghdad.edu.iq/index.php/journal/article/view/279

Al-Taay MSA, AHA Al-Assie and R ORasheed 2018, Impact of Bazian cement factory on air, water, soil, and some green plants in Sulaimani City, Iraq. *The Iraqi Journal of Agricultural Sciences*, 49: 463-477.

Amato, F, Rivas, I, Viana, M, Moreno, T, Bouso, L, Reche, C, Querol, X 2014, Sources of indoor and outdoor PM2.5 concentrations in primary schools. *Science of The Total Environment*, 490: 757-765. DOI:10. 1016/j.scitotenv.2014.05

Arias-Pérez, RD, Taborda, NA, Gómez, DM; Narvaez, JF, Porras, J, Hernandez, JC 2020, Inflammatory effects of particulate matter air pollution. *Environmental Science and Pollution Research*, 27: 42390-42404.

Arslan, S & Aybek, A 2012, Particulate matter exposure in agriculture. Air Pollution, A Comprehensive Perspective. DOI: 10.5772/50084

Azarmi, K, Kumar, P, Mulheron & M 2014, The exposure to coarse, fine and ultrafine particle emissions from concrete mixing, drilling and cutting activities. *Journal of Hazardous Materials*, 279: 268-279, Online link: http://dx.doi.org/10.1016/j.jhazmat.2014.07.003

Bettaieb, J, Toumi, A, Leffondre, K, Chlif, S & Ben Salah, A 2020, High temperature effect on daily all-cause mortality in Tunis 2005-2007. *Revue d'Epidemiologie et de Sante Publique*, 68: 37-43. https://doi.org/10.1016/j.respe.2019.09.007

Bobb JF, Peng RD, Bell ML & Dominici F 2014, Heat-related mortality and adaptation to heat in the United States. Environ Health Perspect 122: 811-816, http://dx.doi.org/10.1289/ehp.1307392

Camilleri, R, Vella, A J, Harrison, R, & Aquilina, N J 2022, Source apportionment of indoor $PM_{2.5}$ at a residential urban background site in Malta. *Atmospheric Environment*, 278: 119093, https://doi.org/10.1016/ j.atmosenv.2022.119093

Chen, C & Zhao, B 2011, Review of relationship between indoor and outdoor particles: I/O ratio, infiltration factor and penetration factor. *Atmospheric Environment*, 45: 275-288, DOI: 10.1016/j.atmosenv.2010.09.04

Chen, W, Tong, DQ, Zhang, S, Zhang, X & Zhao, H 2017, Local PM_{10} and $PM_{2.5}$ emission inventories from agricultural tillage and harvest in northeastern China. *Journal of Environmental Sciences*, 57: 15-23, DOI: 10. 1016/j.jes.2016.02.024

Cheng, C-W, Sheu, G-T, Chou, J-S, Wang, P-H, Cheng, Y-C, & Lai, C-Y 2020, Fine particulate matter $PM_{2.5}$ generated by building demolition increases the malignancy of breast cancer MDA-MB-231 cells. *Chemosphere*, 129028. doi: 10.1016/j.chemosphere.2020.12

Cobb, CO, Vansickel, AR, Blank, MD, Jentink, K, Travers, MJ & Eissenberg, T 2012, Indoor air quality in Virginia waterpipe cafés. *Tobacco Control*, 22: 338-343, DOI: 10.1136/tobaccocontrol-2011-050350

Chithra, VS & Shiva Nagendra, SM 2014, Impact of outdoor meteorology on indoor PM10, PM2.5 and PM1 concentrations in a naturally ventilated classroom. *Urban Climate*, 10: 77-91, DOI: 10.1016/j.uclim.2014. 10.001

de Schrijver E, Bundo M, Ragettli M, Sera F, Gasparrini A, Franco O & Vicedo-Cabrera A 2022, Nationwide analysis of the heat- and cold-related mortality trends in Switzerland between 1969 and 2017: The role of population aging. *Environmental Health Perspectives*, 130:3

Evagelopoulos, V, Begou, P & Zoras, S 2022, In-depth study of $PM_{2.5}$ and PM_{10} concentrations over a 12-year period and their elemental composition in the lignite center of Western Macedonia, Greece. Atmosphere, 13, 1900. https://doi.org/10.3390/atmos13111900

Farivar Ghaziani, S, Ahmadi Orkomi, A, Rajabi, M 2021, Gaseous air pollutants dispersion emitted from point and line sources by coupling WRF-AERMOD models (Case study: Lowshan, Guilan Province, Iran). *Caspian Journal of Environmental Sciences*, 19: 649-660

Fernandez, EM, Ballbe, X Sureda, MFuE, Salto & JM, Martinez-Sanchez 2015, Particulate matter from electronic cigarettes and conventional cigarettes: A systematic review and observational study. *Current Environmental Health Reports*, 2: 423–429

Francisco, PW, Jacobs, DE, Targos, L, Dixon, SL, Breysse, J, Rose, W & Cali, S 2017, Ventilation, indoor air quality, and health in homes undergoing weatherization. *Indoor Air*, 27: 463-477. https://doi.org/10.1111/ina.12325

Hajizadeh, R, Golbabaei, F, Farhang Dehghan, S, Beheshti, M H, Jafari, SM & Taheri, F 2016, Validating the heat stress indices for using in heavy work activities in hot and dry climates. *Journal of research in health sciences*, 16: 90-95.

Hassan, AWAA & Al-Waeli, AA-Z 2022, The spatial and temporal variation of the concentration of gaseous pollutants in the air of the Al-karaduh area. *Al-Adab Journal*, 3(143): 249–262. https://doi.org/10.31973/aj. v1i116.470

Hassoon HA 2019, Measurement of carbon monoxide emissions from vehicles exhaust pipe using portable gas detector. *The Iraqi Journal of Agricultural Sciences*, 50: 936-942

Humadi, AF 2016, Smoking Behavior Among School Students At Al-Doura/Al- Kurkh/Baghdad Year 2014, *AL-Kindy College Medical Journal*, 12: 22-28, https://doi.org/10.47723/kcmj.v12i2.293

Ibraheem, QA 2017, Effect of Smoking on Serum Level of Some Mineral. *Ibn AL-Haitham Journal For Pure and Applied Sciences*, 23: 305-310, Retrieved from https://jih.uobaghdad.edu.iq/index.php/j/article/view/961

Idris, AAA, Mohammed, HI & Osman, MI 2022, Impact of tobacco use in the etiology of chronic renal failure among sudanese patients: Tobacco and renal failure among sudanese patients. *AL-Kindy College Medical Journal*, 18: 13–17, https://doi.org/10.47723/kcmj.v18i1.786

Karagulian, F, Belis, CA, Dora, CFC, Prüss-Ustün, AM, Bonjour, S, Adair-Rohani, H & Amann, M 2015, Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level. *Atmospheric Environment*, 120: 475-483, DOI: 10.1016/j.atmosenv.2015.08

Razjouyan, J, Lee, H, Gilligan, B, Lindberg, C, Nguyen, H, Canada, K, Burton, A, Sharafkhaneh, A, Srinivasan, K, Currim, F, Ram, S, Mehl, M R, Goebel, N, Lunden, M, Bhangar, S, Heerwagen, J, Kampschroer, K, Sternberg, E M, & Najafi, B 2020, Wellbuilt for wellbeing: Controlling relative humidity in the workplace matters for our health. *Indoor Air*, 30: 167-179, https://doi.org/10.1111/ina.12618

Langiano, E, Lanni, L, Atrei, P, Ferrara, M, La Torre, G, Capelli, G & De Vito, E 2008, Air quality in ad hoc designed school buildings and repurposed residential buildings (Indoor air quality in school facilities in Cassino (Italy). *Igiene e sanita pubblica*, 64: 53-66.

Larionov, A, Volobaev, V, Zverev, A, Vdovina, E, Bach, S, Schetnikova, E, Leshukov, T, Legoshchin, K & Eremeeva, G 2022, Chemical composition and toxicity of PM_{10} and $PM_{0.1}$ samples near open-pit mines and coal power stations. *Life (Basel, Switzerland)*, 12(7): 1047. https://doi.org/10.3390/life12071047

Lecca, LI 2022, Cooking particulate matter: A systematic review on nanoparticle exposure in the indoor cooking environment. *Atmosphere*, 14(1): 12. https://doi.org/10.3390/atmos14010012

Li, L, Lin, Y, Xia, T & Zhu, Y 2020, Effects of electronic cigarettes on indoor air quality and health. *Annual Review of Public Health*, *41*, 363–380. https://doi.org/10.1146/annurev-publhealth-040119-094043

Lin, YW, Tang, CS, Liu, HC *et al.* 2022, Ranking the environmental factors of indoor air quality of metropolitan independent coffee shops by Random Forests model. *Scientific Reports,* 12: 16057, https://doi.org/10.1038/ s41598-022-20421-2

Loffredo, CA, Tang, Y, Momen, M, Makambi, K, Radwan, GN & Aboul-Foutoh, A 2016, $PM_{2.5}$ as a marker of exposure to tobacco smoke and other sources of particulate matter in Cairo, Egypt. *The International Journal of Tuberculosis and Lung Disease*, 20: 417-422, https://doi.org/10.5588/ijtld.15.0316

Maciejczyk, P, Chen, L-C, & Thurston, G 2021, The role of fossil fuel combustion metals in $PM_{2.5}$ air pollution health associations. *Atmosphere*, 12(9), 1086. https://doi.org/10.3390/atmos12091086

Mahdi, BH, Yousif, KM, & Dosky, LMS 2020, Influence of meteorological parameters on air quality and other pollutants in Duhok City, Iraq. *The Iraqi Journal of Agricultural Sciences*, 51: 1160-1172. https://doi.org/10.36103/ijas.v51i4.1095

Mahmmod, MT 2019, The phenomenon of air pollution and health effects on man. *Al-Adab Journal*, 1(116): 549-583. https://doi.org/10.31973/aj.v1i116.470

Masoudi, M, Behzadi, F, Sakhaei, M 2019, Assessment of NO_2 levels as an air pollutant and its statistical modeling using meteorological parameters in Tehran, Iran. *Caspian Journal of Environmental Sciences*, 17: 227-236.

Matthaios, VN, Liu, M, Li, L, Kang, C-M, Vieira, CLZ, Gold, DR & Koutrakis, P 2021, Sources of indoor PM2.5 gross α and β activities measured in 340 homes. *Environmental Research*, 197, 111114. doi:10.1016/j. envres.2021.11111

Milner, J, Vardoulakis, S, Chalabi, Z & Wilkinson, P 2011, Modelling inhalation exposure to combustion-related air pollutants in residential buildings: Application to health impact assessment. *Environment International,* 37: 268-279, DOI: 10.1016/j.envint.2010.08.015

Perry, T, Obolski, U & Peretz, C 2023, The association between high ambient temperature and mortality in the Mediterranean Basin: a systematic review and meta-analysis. *Current environmental health reports*, 10: 61-71. https://doi.org/10.1007/s40572-022-00386-0

Philip, S, Martin, RV, Snider, G, Weagle, CL, Van Donkelaar, A; Brauer, M, Henze, DK, Klimont, Z, Venkataraman, C, Guttikunda, S, *et al.* 2017, Anthropogenic fugitive, combustion and industrial dust is a significant, underrepresented fine particulate matter source in global atmospheric models. Environmental Research Letters, 12: 044018.

Singh, K & Tripathi, D 2022, Particulate matter, and human health. In: Environmental Health; IntechOpen: London, UK, 2021; Available online: https://www.intechopen.com/chapters/79308 (accessed on 24 August 2022). [CrossRef].

Semin, AN, Faminskaya, MV, Ponkratov, VV, Mikhayluk, ON, Shapoval, GN 2023, Risk assessment and its management for environmental pollution in oil refinery using FMEA approach. *Caspian Journal of Environmental Sciences*, 21: 603-622.

Shindell, D, Zhang, Y, Scott, M, Ru, M, Stark, K, & Ebi, K L 2020, The effects of heat exposure on human mortality throughout the United States. *GeoHealth*, 4(4), e2019GH000234. https://doi.org/10.1029/2019GH 000234.

Thamie, SH 2017, The use of factor analysis to identify the leading factors to high blood pressure."A field study in Baghdad hospitals. *Journal of Economics and Administrative Sciences*, 23(99), 417. ,https://doi.org/10.33095/ jeas.v23i99.263

Timmers, VRJH & Achten, PAJ 2016, *Non-exhaust PM emissions from electric vehicles. Atmospheric Environment*, 134: 10-17, DOI: 10.1016/j.atmosenv.2016.03.

Turunen, M, Toyinbo, O, Putus, T, Nevalainen, A, Shaughnessy, R & Haverinen-Shaughnessy, U 2014, Indoor environmental quality in school buildings, and the health and wellbeing of students. *International Journal of Hygiene and Environmental Health*, 217: 733-739, DOI: 10.1016/j.ijheh.2014.03.002 10.1016/j.ijheh.2014.03. 002

Wei, S & Semple, S 2022, Exposure to fine particulate matter ($PM_{2.5}$) from non-tobacco sources in homes within high-income countries: a systematic review. *Air Quality, Atmosphere, & Health*, 1–14. *Advance Online Publication.* https://doi.org/10.1007/s11869-022-01288-8

Wolkoff, P 2018, Indoor air humidity, air quality, and health - An overview. *International journal of hygiene and environmental health*, 221: 376-390, https://doi.org/10.1016/j.ijheh.2018.01.015

World Health Organization 2021, WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10})ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide: executive summary. , World Health Organizationhttps://apps.who.int/iris/handle/10665/345334

Yang, X, Feng, L, Zhang, Y, Hu, H, Shi, Y, Liang, S, Zhao, T, Fu, Y, Duan, J, Sun, Z 2018, Cytotoxicity induced by fine particulate matter ($PM_{2.5}$) via mitochondria-mediated apoptosis pathway in human cardiomyocytes. *Ecotoxicology and Environmental Safety*, 161: 198-207.

Zaman, SU, Yesmin, M, Pavel, MRS, Jeba, F & Salam, A 2021, Indoor air quality indicators and toxicity potential at the hospitals' environment in Dhaka, Bangladesh. *Environmental science and pollution research international*, 28(28): 37727–37740. https://doi.org/10.1007/s11356-021-13162-8.

Zhang, L, Yang, Y, Li, Y, Qian, Z M, Xiao, W, Wang, X, Rolling, C A, Liu, E, Xiao, J, Zeng, W, Liu, T, Li, X, Yao, Z, Wang, H, Ma, W & Lin, H 2019, Short-term and long-term effects of $PM_{2.5}$ on acute nasopharyngitis in 10 communities of Guangdong, China. *The Science of the total environment*, *688*, 136-142, https://doi.org/ 10.1016/j.scitotenv.2019.05.470.

Bibliographic information of this paper for citing:

Bari Fezea, MA, Gathwan, MA 2023, Assessment of indoor air quality for closed cafés in Baghdad City, Iraq. Caspian Journal of Environmental Sciences, 21: 1279-1287.