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Effect of PM2.5 and PM10 on the Hematopoietic System of Cafés Workers in Baghdad

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Abstract

The aim of our current study was to identify the effect of particulate matter of both types (PM2.5 and PM10) resulting from hookah smoking on the hemopoietic system of workers (smokers) in closed cafes. This study included six stations (cafes) on the Rusafa side of Baghdad city and conducted a blood test that included a complete blood count (CBC). A multifunctional air quality detector measured both types of particulate matter in the morning and evening. The study included 30 men (workers and smokers) and 30 men (non-smokers), whose ages ranged from 20 to 40 years. The study found that smokers had an increase in white blood cells and red blood cells, as well as an increase in the percentage of hemoglobin (HGB), hematocrit (HCT), the mean corpuscular volume (MCV), and the number of platelets (PLT), while also showing a decrease in the mean corpuscular hemoglobin concentration (MCHC). There was a significant difference between PM2.5 in the morning and hemoglobin, and platelets, in smokers. Additionally, smokers showed a significant difference between PM2.5 in the evening, PLT, and MCV. In the case of PM10, a significant difference was found between it and the blood platelets of smokers in the morning, while PM10 in the evening was found to have a significant difference with PLT and MCV among the smokers group.

Keywords: Indoor Air Quality, air pollution, particulate matter, hemopoietic system, smokers, non-smokers**.**

1. Introduction

In recent years, Indoor Air Quality (IAQ) has been a focus of attention for scientists, society, and environmental organizations [1]. It is a term that refers to the quality of air inside buildings, homes, and facilities, particularly those related to the health and comfort of the building's residents [2]. It is known that humans spend more than 90% of their time in the internal environment, and that the rates we observe are often higher than those recorded in the external environment [3].The health risks associated with indoor air pollution are much greater than those associated with outdoor pollution. The lack of indoor air quality can be harmful to a large group of people, such as the elderly, children, youth, or those who suffer from chronic diseases such as heart and vascular diseases [4]. The indoor air quality of the workplace is also very important because workers are

regularly exposed to various pollutants that potentially affect health, work-related problems, and absences due to disease and productivity [5, 6].

Restaurants and cafes not only suffer from the threats of poor indoor air quality, but also include many pollutants that result from open flames, materials used to remove grease, strong cleaning materials, or some pollutants resulting from gaseous compounds such as PM10, PM2.5, NO_x, CO_2, and CO_2 [7, 8].Particulate matter is one of the air pollutants that spreads effectively around the world. Combustion processes like industrial activities, vehicles, and forest fires primarily generate particulate matter [9]. This substance differs in its concentration and composition in all parts of the world, but it greatly affects the health level in most countries. This particulate matter is classified according to its particle size (PM100, PM10, PM2.5, and PM0.1). The most widespread and harmful to human health and the environment is PM2.5 [10]. PM10 and PM2.5 also pose a serious health challenge (a set of adverse effects), increase morbidity and mortality rates, and are major contributors to the global disease burden [11]. PM10 and PM2.5 also play an important role in cardiovascular disease and atherosclerosis [12]. These particles disturb some blood parameters, such as Hb, WBC, RBC, PLT, PCV, HCT, MCH, and Lymphocyte Count [13, 14]. Exposure to second-hand smoke from all sources can be responsible for the premature deaths of more than 600,000 people every year [15]. Because hookah smoke contains toxic substances, this habitual practice could be responsible for nearly 6 million deaths each year. Despite the abundance of evidence of a health risk, addiction to hookah smoking has become a global epidemic for many people, reaching levels that indicate danger [16]. Iraq, like some Middle Eastern countries, uses tobacco in the form of hookahs and cigarettes [17]. Hookah is the most common tobacco smoking habit, and it contributes to indoor air pollution. This phenomenon has become more common among young people in Iraqi society over the past few years. Previous research has indicated that it has more serious health effects than regular smoking of cigarettes [18]. Previous studies have shown that water pipe smoking is associated with the development of varying degrees of reduction in lung function [19]. Numerous chronic diseases, such as respiratory, vascular, and heart diseases, have proven smoking to be a risk factor. This is due to the numerous compounds released during tobacco smoke inhalation [20].

2. Materials and Methods

This study included 30 people working in cafes (smokers) and 30 non-smokers from Baghdad, Al-Rusafa district, and was divided into 3 regional groups that included 10 workers (smokers) and 10 non-smokers from AL-Amen Second (a), 10 workers (smokers) and 10 non-smokers from Sadr City (b), and 10 workers (smokers) and 10 non-smokers from Palestine Street (c). The age range of the study groups was between 20 and 40 years, and we measured particulate matter (2.5 and 10) during two peaks, the morning peak and the evening peak, on two days per week. The device (Multifunction Air Quality Detector) was used to measure particulate matter of both types.

2.1. Instruments and Equipment

The following scientific devices were used to measure the indicators used in the study **Table 1**.

Table 1. Scientific equipment used in the study.

No.	Equipment	Company	Country
1.	Multifunction Air Quality Detector	BENETECH	CHINA
2.	Automated CBC Analyzer	DIAGON	HUNGARY
3.	Refrigerator	CONCORD	FRANCE

2.2. Tools and Laboratory Apparatus

The following laboratory materials and supplies were used when collecting blood samples and transporting them to the laboratory, as shown in **Table 2**.

Table 2. Tools and Laboratory Apparatus.

No.	Tools and Laboratory Apparatus	Company	Country
1.	Cool box	VB	CHINA
2.	Sterile medical syringes (10 ml)	MEDECO	UAE
3.	K3-EDTA tubes (2.5 ml)	AFCO	JORDAN
4.	EDTA tubes rack	AFCO	JORDAN
5.	Surgical silk plaster	CANSIN	TURKEY
6.	Graduate tubes for measuring E.S.R.	AFCO	JORDAN

2.3. Study Sites

The current study was conducted from January 1 to January 31, 2023, to study the effect of indoor air quality in a group of closed cafes and the people working in them on the Rusafa side. The study sites were six stations, according to **Table 3**.

1. First station: Al-Amen Second (in the middle of the street that connects between Al-Mohsen mosque's square and Al-Rasoul mosque's square).
2. Second station: Al-Amen Second (in the middle of the Al-Mohsen mosque's square).
3. Third station: Al-Amen Second (at the beginning of the street that connects between Al-Mohsen mosque's square and Al-Rasoul mosque's square).
4. Fourth station: Al-Sadr City (Al-Kayara, the street separating sectors 62 and 63).
5. Fifth station: Al-Sadr City (Al-Kayara, Sector 63's main street).
6. Sixth station: Palestine Street, near Beirut Square.

Table 3. Study sites with a brief description**.**

The site	Coordinates	Description of the study site
ST.1	33°18'93,48"North 44°29'32,57"East	Rusafa district / AL-Amen Second
ST.2	33°18'85,48"North 44°30'22,3"East	Rusafa district / AL-Amen Second
ST.3	33°18'59,49"North 44°30'43,0"East	Rusafa district / AL-Amen Second
ST.4	33°23'19,19"North 44°26'03,27"East	Rusafa district, Sadr City / Sector 62
ST.5	33°23'27,13"North 44°26'05,20"East	Rusafa district, Sadr City / Sector 63
ST.6	33°21'90,7"North 44°25'62,34"Eaast	Rusafa district / Beirut Square

2.4. Collection of Blood Samples

60 random blood samples were collected during the study period, including two groups: workers in closed cafes, and the control group, who are non-smokers from the same areas outside the cafes that were studied. The individuals were male, their ages ranged from 20 to 40 years, and they spent 6–12 hours working in cafes.

Table 4. Division of the groups from which blood samples were taken.

Study groups	Number of samples
Staff group (smokers)	30
Non-smoking group	30
The total number	60

2.5. Treatment of Blood Sample

5 ml of blood was taken intravenously from the workers included in the study in closed cafes by means of sterile plastic syringes 10 ml. The samples were divided according to the type of test. In order to perform a complete blood count on the studied samples, we placed three milliliters of blood into glass tubes containing anticoagulant (EDTA), gently shook the tubes to mix the blood with the anticoagulant, and then performed a complete blood count (CBC test) using the Automated CBC Analyzer in one of the private laboratories.

2.6. Measuring of Particulate Matter

2.6.1 Multifunction Air Quality Detector:

To measure the concentration of particulate matter of two types, PM 2.5 and PM 10, this device features two static sensors that provide direct results for PM 2.5 and PM 10. It is possible to obtain the highest value and the lowest value for the concentration of each of them, and by combining them and dividing by two; we get the exact concentrations of PM2.5 and 10 PM. As per the manufacturer's instructions, we position the device one meter above ground level. This device is characterized by reading the temperature (°C) and relative humidity (%RH) at the same time. The maximum concentration of 2.5 PM and 10 PM measured in this device is 5000 ug/ m^3.

2.7. Statistical Analyses

The data was tabulated in a datasheet of IBM SPSS version 25.0, which was utilized to do the statistical analysis. The mean and standard errors of continuous variables were reported, and significant differences were tested using the analysis of variance (ANOVA) test, followed by the least significant difference (LSD) test. The Pearson's correlation coefficient was utilized to determine the correlation between the different parameters under study. Statistical significance was defined as a probability value ($p \leq 0.05$).

3. Results

As in **Tables 3-1**, the results showed an increase in the rate of PM2.5 and PM10 above the permissible limits (by the World Health Organization and the US Environmental Protection Agency), which are (75ug/m3) (150ug/m3) respectively [21, 22]. Where PM2.5 in the morning reached [(358.1111±48.59508)a, (341.0556±45.06588)b, (508.6667±48.57955)c]. As for the evening [(515.6667±48.74322)a, (433.6111±44.89183(b, (626.5556±45.63871)c]. The results appeared in the morning. There was no significant difference between a and b. However, there were significant differences between a and c, as well as between b and c. Overall, there was a significant difference across all regions. In the evening, there were significant differences between b and c, but no significant differences between a and b or a and c. In terms of the regions as a whole, there were significant differences. While the results of PM10 in the morning showed [(416.1852±58.80587)a, (402.7778±55.78282)b, (640.7778±67.39493)c]. However, in the evening, the results were [(625.4815±75.26472)a, (520.7222±62.76810)b, (750.3333±65.92399)c]. In the morning, the results showed that there is a significant difference between a and c, as well as between b and c. There was no significant difference between a and b. Overall, there were significant differences between the regions. While the evening results showed

a significant difference between b and c, there was no significant difference between a and b, between a and c, or between the three regions.

Table 5. Shows the significant differences between PM2.5 and PM10 for the groups under study.

Particulate Matter	Location	Mean ±S.E.	P-value
pm2.5 morning	AL-Amen Second [a]	358.1111±48.59508	[a,b] 0.802No [a,c] 0.034*
	Al-Sadr City [b]	341.0556±45.06588	[b,c] 0.020*
	Palestine Street [c]	508.6667±48.57955	[a,b,c] 0.037*
pm2.5 evening	AL-Amen Second [a]	515.6667±48.74322	[a,b] 0.224No [a,c] 0.104No
	Al-Sadr City [b]	433.6111±44.89183	[b,c] 0.007*
	Palestine Street [c]	626.5556±45.63871	[a,b,c] 0.025*
pm10 morning	AL-Amen Second [a]	416.1852±58.80587	[a,b] 0. 878No [a,c] 0.015*
	Al-Sadr City [b]	402.7778±55.78282	[b,c] 0.011*
	Palestine Street [c]	640.7778±67.39493	[a,b,c] 0.017*
pm10 evening	AL-Amen Second [a]	625.4815±75.26472	[a,b] 0.288No [a,c] 0.208No
	Al-Sadr City [b]	520.7222±62.76810	[b,c] 0.026**
	Palestine Street [c]	750.3333±65.92399	[a,b,c] 0.078No

***Significant at p≤0.05**

No non-significant at p>0.05

3.1 Blood Parameters

As shown in **Table 6** , the results showed that the percentage of hemoglobin among workers (smokers) was higher than the normal rate, reaching 16.6593±0.49454 g/dL compared to non-smokers, which reached 12.2148±0.25294 g/dL. Also, the percentage of white blood cells among workers (smokers) was higher than normal, reaching 11.4519±0.69893 10^9 /L when compared to non-smokers, which reached 4.9370±0.46916 10^9 /L. While the red blood cells were high in the workers (smokers), they did not exceed the normal limit 5.4133±0.30433 10^{12}/L. While in the non-smokers it was also within the normal range and less than the workers 4.1681±0.16474 10^{12} /L. Likewise, the hematocrit (HCT) was high in workers (smokers), but it was close to the upper limits of normal 52.2778±1.83689 %. While its levels were close to the normal lower limits for non-smokers 39.0630±0.28096 %.With regards to the mean corpuscular volume (MCV), a significant increase was recorded in workers (smokers) 101.0407±2.41219 fL. However, its percentage was normal among non-smokers 90.3074±3.34836 fL. The results of the mean corpuscular hemoglobin (MCH) for workers (smokers) were 32.8704±0.42521 pg and for non-smokers 28.2556±0.40992 pg, and in both cases it was within the normal range. Also, the results showed that the mean corpuscular hemoglobin concentration (MCHC) in workers (smokers) was lower than the normal rate, which amounted to 30.9481±0.34337 g/dL, compared to non-smokers, reaching 33.3185±1.22262 g/dL. It is noteworthy that the percentage of blood platelets increased among workers (smokers), as it recorded (306.6296±6.39675)10^9/L, when compared to non-smokers, as it recorded 159.0000±11.16893 10^9 /L. Finally, the percentage of E.S.R. tests among workers (smokers) was low, reaching (2.9630±0.43978) MM/1hr. Either in smokers or non-smokers, the percentage was normal, reaching 10.1111±1.37508.

Table 6. Descriptive statistics of blood parameters for workers (smokers) and non-smokers.

Parameters	Mean± Std. Error
HGB smoke	16.6593±0.49454
HGB non	12.2148±0.25294
HCT smoke	52.2778±1.83689
HCT non	39.0630±0.28096
MCV smoke	101.0407±2.41219
MCV non	90.3074±3.34836
MCH smoke	32.8704±0.42521
MCH non	28.2556±0.40992
MCHC smoke	30.9481±0.34337
MCHC non	33.3185±1.22262
RBC smoke	5.4133±0.30433
RBC non	4.1681±0.16474
WBC smoke	11.4519±0.69893
WBC non	4.9370±0.46916
PLT smoke	306.6296±6.39675
PLT non	159.0000±11.16893
E.S.R .smoke	2.9630±0.43978
E.S.R. non	10.1111±1.37508

3.2 Correlation and Significant Differences

Figure 1 illustrates the significant correlation and difference between PM2.5 in the morning and HGB and PLT, where we recorded HGB smoke 16.6593 and PLT smoke 306.6296 (P≤0.05). There is also a significant correlation and difference between PM2.5 in the evening and MCV and PLT, where MCV smoke (101.0407) and PLT smoke (306.6296) were recorded at the level of probability P≤0.05.In the case of PM10 in the morning, the blood parameters did not record any correlation or significant differences, except for PLT smoke, which was 306.6296 (P≤0.05). In the case of PM10 in the evening, it recorded a correlation and a significant difference for each of MCV smoke 101.0407, PLT smoke 306.6296 at the level of probability P≤0.05.

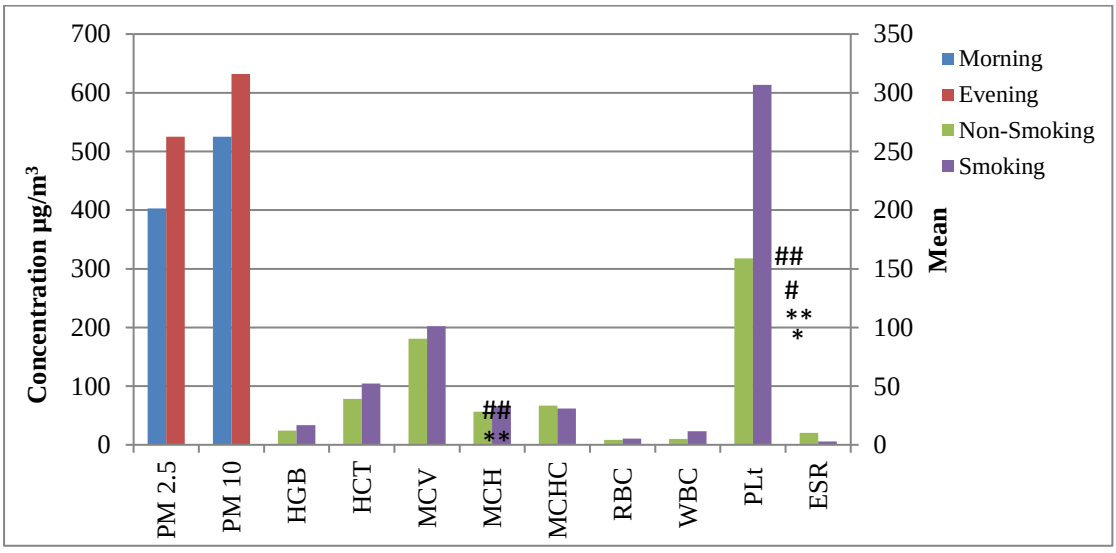

Figure 1. Correlation and a significant difference.

***There is a significant correlation with PM2.5 in the morning**

****There is a significant correlation with PM2.5 in the evening**

 # There is a significant correlation with PM10 in the morning

There is a significant correlation with PM10 in the evening

4. Discussion

Our study found a higher level of HGB, WBC, RBC, HCT, MCV, and PLT in smokers compared to non-smokers for the samples under study, as it recorded a clear and significant difference. This study was in agreement with other studies [14, 23]. The results of these studies showed that smoking cigarettes was a major environmental factor that changed blood parameters in a healthy person who did not have any clinical signs. These parameters included more white and red blood cells, HCT, MCH, MCV, and PLT. The body's need to increase oxygen carrying capacity is responsible for the high percentage of hemoglobin, red blood cells, and hematocrit, leading to an increase in red blood cell production to offset the decrease in oxygen levels. These results were in agreement with the results of another study [24]. The study analyzed the percentage of hemoglobin concentration and its correlation with vascular and heart diseases, as well as all other causes of death. Furthermore, the nicotine present in tobacco explains the rise in WBC in smokers, as it activates most white blood cells, especially neutrophils, leading to an increase in inflammation in the body. This result aligns with the findings of another study [25]. The study examined the impact of smoking on blood parameters within a healthy population group, revealing a noteworthy rise in white blood cell levels as a result of cigarette smoking. Moreover, the body's lack of iron and folic acid, along with the presence of larger or smaller red cells in the blood, contribute to the high MCV level, indicating severe or hemolytic anemia. These results are consistent with the results of previous studies [14, 26]. These studies demonstrated the dangerous and often fatal effects of cigarette smoking on human health, as well as the significant harm it causes to blood biochemical properties. Alternatively, smoking triggers an inflammatory response in the body, leading to a rise in platelets due to their fibrinogen receptors. This decreases coagulation and damages the inner lining of cells. This study's findings coincided with those of another study in this field [27]. The study found that smokers had a lot more platelets than nonsmokers. The study also suggested that fibrinogen binds to platelet receptors, essential for platelets to clump together. This causes blood to clot and damages the inner lining of cells. Smoking causes harm, necessitating an increase in the number and effectiveness of PLTs [28]. Additionally, the study found no significant difference in MCH between smokers and non-smokers. The results of the study [29] confirmed this. The study explicitly examined the effects of tobacco and cigarette smoking on blood parameters and made a comparison between male smokers and non-smokers. On the other hand, MCHC denotes the amount of hemoglobin in a given packed volume of erythrocytes. Smokers recorded a clearly low percentage of MCHC, indicating deficient anemia, folic acid scarcity, thyroid problems, or vitamin B12 deficiency. These results obtained in the current study agreed well with many previous studies [30, 31]. These studies aimed to determine the effectiveness of blood parameters in identifying iron deficiency anemia, folic acid deficiency, and thyroid problems, given the low levels of MCHC recorded. Regarding PM10 and PM2.5 levels in the morning, the same number of café visitors did not result in any significant differences between areas a and b. The presence of more café occupants in the c area led to a significant difference between areas a and c, as well as b and c. In the case of PM2.5 and PM10 in the evening, significant differences appeared between areas b and c due to the large number of people in the c area's café. However, when there are no significant differences between areas a and b or a and c, it's likely due to inadequate ventilation in the cafes located in the a area during the evening hours. In general, coffeehouse occupants were more numerous in area c, then fewer in area a, and then slightly less in area a.

5. Conclusion

Our current study concluded that the percentage of particulate matter (2.5 and 10) exceeds permissible levels in areas where hookah smoking is common. Additionally, conducting a CBC count on people working in cafes revealed a significant increase in blood standards. These results revealed a direct impact of hookah smoking on human blood parameters.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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References

1. Abdul-Wahab S.A.; En, S.C.F.; Elkamel, A.,;Ahmadi, L.; Yetilmezsoy, K. A review of standards and guidelines set by international bodies for the parameters of indoor air quality Atmos. *Pollution Research* **2015**, *6*, 751-767. https://doi.org/10.5094/APR.2015.084.
2. AL-Alali, I.A.R. Indoor air pollution and its impact on habitants health. *Journal of the Planner and Development*, **2016**, *21(2)*, 266-288.
3. Al-Kindi, G.Y.; Al-Haidri, H.A. Indoor Air Quality, Health Effects Resulting from Coffee Shops Smoke–Review. *Ecological Engineering & Environmental Technology*, **2023**, *24(2)*, 67-78. DOI: https://doi.org/10.12912/27197050/156975.
4. Cincinelli, A.; Martellini, T. Indoor air quality and health. *International journal of environmental research and public health*, **2017**, *14*(11), 1286. https://doi.org/10.3390/ijerph14111286.
5. Talib, A.H.; Abdulateef, Z.N.; Ali, Z.A. Measurement of some Air Pollutants in Printing Units and Copy Centers Within Baghdad City. *Baghdad Science Journal* **2021**, *30(18)*, 1. https://doi.org/10.21123/bsj.2021.18.1(Suppl.).0687.
6. Carrer, P.; Wolkoff, P. Assessment of indoor air quality problems in office-like environments: Role of occupational health services. *International journal of environmental research and public health*, **2018**, *15*(4), 741. https://doi.org/10.3390%2Fijerph15040741.
7. 7.Sahoo, G.; Wani, A.M.; Swamy, S.L.; Rout, S.; Gupta, S. Indoor pollution and human health. In *AIP Conference Proceedings*., 2022, *2385(1)*, 030001. https://doi.org/10.1063/5.0070902.
8. Marć, M.; Śmiełowska, M.; Namieśnik, J.; Zabiegała, B. Indoor air quality of everyday use spaces dedicated to specific purposes—A review. *Environmental Science and Pollution Research*, **2018**, *25*, 2065-2082. https://doi.org/10.1007/s11356-017-0839-8.
9. Al–Dulaimi, S.H.; Rabee, A.M. Measurement of Pollution Level with Particulate Matter in Babylon Concrete Plant and Evaluation of Oxidative Stress and Hematological Profile of Plant Workers. *Iraqi Journal of Science*, **2021**, 3834-3841. https://doi.org/10.24996/ijs.2021.62.11.4.
10. Abulude, F. O. Particulate matter: an approach to air pollution.Science and Education Development Institute, Akure, Ondo State, Nigeria, **2016**, 2-4. https://doi.org/10.20944/PREPRINTS201607.0057.V1.
11. Collaborators, G.B.D.; Ärnlöv, J. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, **2020**, *396(10258)*, 1223-1249. https://doi.org/10.1016/s0140-6736(20)30752-2.

12. Ain, N.U.; Qamar, S.U.R. Particulate matter-induced cardiovascular dysfunction: a mechanistic insight. *Cardiovascular Toxicology*, **2021**, *21(7)*,505-516. https://doi.org/10.1007/s12012-021-09652-3
13. Jaafar, N.S. The effect of cigarette smoking on blood and biochemical parameters: A comparative study among male smokers and non-smokers in Baghdad City. *Iraqi Journal of Science*, **2020**, 727-731. https://doi.org/10.24996/ijs.2020.61.4.3.
14. Mohammed, Z.J.; Sharba, M.M.; Mohammed, A.A. The effect of cigarette smoking on haematological parameters in healthy college students in the capital, Baghdad. *European Journal of Molecular & Clinical Medicine*, **2022**, 9(3), 11013-11022.
15. Al-Mulla, A.; Fanous, N.; Seidenberg, A.B.; Rees, V.W. Secondhand smoke emission levels in waterpipe cafes in Doha, Qatar. *Tobacco control*, **2015**, *24(e3)*, e227-e231. https://doi.org/10.1136/tobaccocontrol-2014-051717.
16. Al-Dabbous, A.N.; Khan, A.R.; Al-Tamimi, S.A.; Shalash, M.; Bajoga, A.D.; Malek, M.J. Oxides of carbon, particulate matters and volatile organic compounds impact on indoor air quality during water pipe smoking. *International Journal of Environmental Science and Technology*, **2019**, *16*, 2849-2854. https://doi.org/10.1007/s13762-018-1870-0.
17. Humadi, A.F. Smoking Behavior Among School Students At Al-Doura/Al-Kurkh/Baghdad Year 2014. *Al-Kindy College Medical Journal*, **2016**, *12(2)*, 22-28. https://doi.org/10.47723/kcmj.v12i2.293.
18. Al-Easawi, N.A.F. The exposure effect of water pipe smoke (wps) on the respiratory tract of swiss mice. *Iraqi Journal of Science*, **2010**, *51*(4), 543-549.
19. Mohammed, N.H. Lung Diffusing Capacity for Carbon Monoxide (DLco-SB): the Influence of Cigarette Smoking. *Iraqi Postgrad Med J*, **2010**, *9*(3), 328-34.
20. Al-Azzawy, L.H.A.; Al-Qaicy, A.G.S. A study About Some Physiological Parameters In Smokers. *Ibn AL-Haitham Journal For Pure and Applied Science*, **2017**, *24(3).* https://jih.uobaghdad.edu.iq/index.php/j/article/view/734.
21. World Health Organization. *WHO global air quality guidelines: particulate matter (PM2. 5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization, **2021**.
22. Mannan, M.; Al-Ghamdi, S.G. Indoor air quality in buildings: a comprehensive review on the factors influencing air pollution in residential and commercial structure. *International Journal of Environmental Research and Public Health*, **2021**, *18*(6), 3276. https://doi.org/10.3390/ijerph18063276.
23. Hussain, M.S.; Hamid, N.M.; Al-Ani, M.Q.; Muden, B.K.; Hamad-Allah, M.J.; Sweed, O.H.; Sabbar, S.S. Hematological Changes in Blood of Smokers of Cigarettes and Nargyle. *Indian Journal of Forensic Medicine & Toxicology*, **2020**, *14(2)*, 1771-1776. https://doi.org/10.37506/ijfmt.v14i2.3193.
24. Lee, G.; Choi, S.; Kim, K.; Yun, J.M.; Son, J.S.; Jeong, S.M.; Park, S.M. Association of hemoglobin concentration and its change with cardiovascular and all-cause mortality. *Journal of the American Heart Association*, **2018**, *7(3)*, e007723. https://doi.org/10.1161/JAHA.117.007723.
25. Malenica, M.; Prnjavorac, B.; Bego, T.; Dujic, T.; Semiz, S.; Skrbo, S.; Causevic, A. Effect of cigarette smoking on haematological parameters in healthy population. *Medical Archives*, **2017**, *71*(2), 132. https://doi.org/10.5455/medarh.2017.71.132-136.
26. Asif, M.; Karim, S.; Umar, Z.; Malik, A.; Ismail, T.; Chaudhary, A.; Rasool, M. Effect of cigarette smoking based on hematological parameters: comparison between male smokers and non-smokers. *Turkish Journal of Biochemistry/Turk Biyokimya Dergisi*, **2013**, *38(1)*, 75-80. doi: https://doi.org/10.5505/tjb.2013.49369.
27. Nádia, M.M.; Shamseldein, H.A.; Sara, A.S. Effects of Cigarette and Shisha Smoking on Hematological Parameters: An analytic case-control study. *IMJH*, **2015**, *10*, 44-51.
28. Al-Awadhi, A.M.; AlFadhli, S.M.; Mustafa, N.Y.; Sharma, P.N. Effects of cigarette smoking on hematological parameters and von Willebrand factor functional activity levels in asymptomatic male

and female Arab smokers. *Medical principles and practice*, **2008**, *17(2)*, 149-153. https://doi.org/10.1159/000112970.

29. Pankaj, J.; Reena, J.; Mal, K.L.; Ketan, M. Effect of cigarette smoking on haematological parameters: comparison between male smokers and non-smokers. *IJSN*, **2014**, *5(4)*, 740-473.
30. Ghosh, A.; Chowdhury, S. D.; Ghosh, T. Under nutrition in Nepalese children: a biochemical and haematological study. *Acta Paediatrica*, **2012**, *101(6)*, 671-676. https://doi.org/10.1111/j.1651-2227.2012.02613.x.
31. Ceylan, C.; Miskioğlu, M.; Colak, H.; Kiliççioğlu, B.; Özdemir, E. Evaluation of reticulocyte parameters in iron deficiency, vitamin B12 deficiency and β-thalassemia minor patients. *International Journal of Laboratory Hematology*, **2007**, *29(5)*, 327-334. https://doi.org/10.1111/j.1365-2257.2006.00872.x.