

EVALUATION AND PARAMETERIZATION OF AIR POLLUTANTS AS A FUNCTION OF METEOROLOGICAL PARAMETERS IN ZAKHO CITY, KURDISTAN REGION -IRAQ

Dilsouz D. Hassan ^{a,*}, Kamil M. Yousif ^a, Amin K. Qasim ^a

^a Dept. of Environmental Sciences, Faculty of Science, University of Zakho, Kurdistan Region, Iraq.

(Dilsouz.hassan@staff.uoz.edu.krd, Kamil.yousif@uoz.edu.krd, Amin.qasim@uoz.edu.krd)

Received: 11 Apr., 2022 / **Accepted:** 08 Jun., 2022 / **Published:** 01 Jul., 2022

<https://doi.org/10.25271/sjuoz.2022.10.3.919>

ABSTRACT:

Many cities in Iraq are facing environmental issues, such as air, and noise pollution, due to huge increases in population, vehicles density, heavy traffic congestion, as well as petroleum extraction. Therefore, the quality of the air has deteriorated and has threatened citizens' health. In this research, the concentration of gaseous pollutants like carbon monoxide (CO), carbon dioxide (CO₂), ozone (O₃), methane (CH₄), and hydrogen sulfide (H₂S) were measured at five locations near heavy traffic jams in Zakho City, (north of Iraq) during autumn and winter 2021-2022. In addition, the relationship between these pollutants and the meteorological parameter was investigated such as temperature (T, °C), relative humidity (RH, %), atmospheric pressure (AP, mbar), wind speed (WS, m/s), and wind direction (WD). Methane (CH₄), and hydrogen sulfide (H₂S) gases were not detected at all locations. In autumn, carbon monoxide (CO), carbon dioxide (CO₂), and ozone (O₃) concentrations ranged from 0.0468-8.852 ppm, 0.0497-0.071%, and 0.0012-0.145 ppm, respectively, and 0.056-8.667 ppm, 0.0417-0.06 Vol%, and 0.0006-0.0571ppm respectively during winter. The results show that concentrations of recorded gases and meteorological parameters were weakly correlated.

KEYWORDS: Air pollution, Meteorological parameters (MP), Gaseous pollutants, Linear regression analysis, Zakho city.

1. INTRODUCTION

Air pollution has been the most dangerous type of pollution that harms people, plants, animals, and the environment (Rai, 2015). Air pollution is the introduction of substances into the air which is harmful to human health, plant, animal, and the environment in general. Air pollutants are either pollutants that are emitted into the air directly from a source (named primary pollutants) or created into the air during primary pollutants' reactions and in the presence of sunlight (secondary or often named precursors) (Manisalidis et al., 2020). These pollutants such as particulate matter (smoke, soot, dust, and mist), gases (methane (CH₄), carbon dioxide (CO₂), ozone (O₃), and radioactive materials (Mahdi, Yousif, & Dosky, 2020; Mahdi, 2021; Mahdi, Yousif, & Dosky, 2018). Air pollutants can be emitted from natural sources such as dust from roads, emissions from volcanoes and wildfires, and manmade sources including domestic heating emissions, fuel combustion, factories, and electrical generators. The burning of different kinds of fuels is the primary source of anthropogenic air pollution (Mohamed et al., 2021).

However, air pollution primarily affects people who live in big cities, where road emissions are the most responsible for the deterioration of air quality. Numerous potentially harmful chemicals are emitted when gasoline and petroleum diesel are burned in car engines (Holnicki, Nahorski, & Kałuszko, 2021). In urban sites, the prime cause of increasing gas levels from car exhaust is heavy traffic congestion (Hassoon, 2019). In addition, the major sources of air pollutants are mobile sources. As the number of automobiles increases, traffic moves more slowly, resulting in longer times stuck in congestion and, as a result, increased use of fossil fuel and release of more pollutants (Habermann, Medeiros, & Gouveiai, 2011). In most cities, the major air pollutants include particulate matter (PM_{2.5} and PM₁₀), carbon monoxide, and sulfur oxide. Such pollutants are spread in high concentrations throughout the world's atmosphere, which is enough to cause severe health issues progressively (Mahdi, 2021; Mahdi, Yousif, & Dosky, 2018; Al-Sultan, 2015).

Furthermore, air pollution becomes a serious risk agent for a variety of illnesses such as heart disease, cancer of the lung, and respiratory inflammations, according to the World Health Organization (WHO). The health impacts that are produced by air pollution can include breathing difficulties, asthma, allergies, wheezing, coughing, and worsening of existing respiratory as well as heart conditions (Choudhary & Garg, 2013). Therefore, air contamination has been connected to millions of deaths worldwide every year (Kan et al., 2010). Roughly 3.7 million individuals die as a result of ambient air pollution plus 4.3 million as a result of household air pollution, most of them live in Asia (2.6 and 3.3 million, respectively) (Ghorani-Azam, Riahi-Zanjani, & Balali-Mood, 2016).

Air pollution is influenced by various factors such as pollutant emissions, weather elements, pollutant transfer, and transformation. In addition to emission control, meteorological parameters have substantial effects on air quality because they determine dispersion conditions and also atmospheric environmental ability. Local meteorological conditions are responsible for the distribution and dispersion of pollutants, including wind speed and direction. In addition to that, some meteorological parameters, such as humidity and temperature, play a significant role in chemical reactions, changing the concentrations of reacted pollutants (Zhou et al., 2020; R. Li et al., 2019).

Herein, the main object of this study is to investigate the relationship between meteorological parameters and air pollutants and how weather conditions impact the concentration of gases that come out of vehicles in traffic in Zakho city, Iraq. Therefore, the present research will increase knowledge of air pollution in Zakho city, Iraq, as well as help the people inhabitants become more aware of the seriousness of the rise in those emissions and pollution's impacts on the health and environment.

* Corresponding author

This is an open access under a CC BY-NC-SA 4.0 license (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

2. MATERIALS AND METHODS

2.1 Description of the study area

This study was conducted in Zakho city (ZC), Iraq, located between 37°22' to 37°14' N and 43°11' to 42°74' E, with an altitude of 440m in the northwest of Duhok governorate, Kurdistan Region of Iraq (Figure1). Zakho city is just 8 kilometers away from the Ibrahim-Khalil point on the border with Turkey (Jindy, Qasim, & Mohamad, 2020). The climate of the Zakho district is quite hot and dry in summer, wet and cold in winter, and moderate temperature in both autumn and spring.



Figure 1. Map of Zakho city (ZC) showing the positions of measurements at traffic (Tr1-Tr5).

2.2 Measurements of CO, CO₂, O₃, CH₄, and H₂S concentrations

This study was performed in autumn and winter seasons from September 2021 to February 2022. The daily average concentrations of air pollutants (CO, CO₂, O₃, CH₄, and H₂S) were measured and recorded by Dräger multi-gas detector X-am 5600 (Figure 2) at five different positions of traffic (Tr₁, Tr₂, Tr₃, Tr₄, and Tr₅). Dräger multi-gas detector X-am 5600 is a small, portable, and reliable instrument that is used for the detection of flammable gases in tough environments and works at optimal functionality even under harsh conditions for a broad variety of toxic gases that need to be measured simultaneously and require regular calibration for accuracy. The location was selected close to heavy traffic (see Figure 1). However, Gases (CO, CO₂, O₃, CH₄, and H₂S) were measured daily for six hours, three hours in the morning from 7:30 to 10:30 am, and three hours in the afternoon between 3:00 and 6:00 pm. To study the influence of meteorological parameters such as temperature (T, °C), relative humidity (RH, %), atmospheric pressure (AP, mbar), wind speed (WS, m/s), and wind direction (WD) on these air pollutants, their daily average was taken for the same period from the Environmental Directorate of Zakho city.



Figure 2. Dräger multi-gas detector X-am 5600.

2.3 Statistical analysis

Minitab software (17.1), a statistical program, was used for the analysis of the data. It was used for statistical description as maximum, minimum, mean, median, and standard deviation, drawing the relationship between variables and also finding regression equations, regression linear, and correlation coefficients (R) between concentrations of gaseous pollutants

CO, CO₂, O₃, CH₄, and H₂S (dependent variables) and meteorological parameters T, RH, AP, WS, and WD (independent variables).

3. RESULTS AND DISCUSSION

3.1 Measurement of the concentrations CO, O₃, CO₂, CH₄, and H₂S with Meteorological Parameters

Wind direction assists in understanding this influence on the diffusion of atmospheric pollutants. Hence, as shown in Figure 3, the wind rose diagram for the study period of Zakho city using daily mean values of WD is shown. WRPLOT view TM (wind rose program) was used to prepare it. However, sixteen cardinal directions (south S, north N, and so forth) and six wind speed categories were used to show the wind-rose.

In autumn, it was clear that the wind came more frequently from the west (W), the east (E), and south (S) directions. The WS average for this period is 0.61 m/s, with 200 degrees being the most common WD at 25% (south-southwest (SSW)). The wind speed frequencies in the categories 0.10-0.50, 0.50-1.00, and 1.00-1.50 are 5.6%, 90.1%, and 4.2%, respectively.

In winter the wind came more frequently from the east (E), south (S), and the directions. The WS average for this period is 0.81 m/s, with 137 degrees being the most common WD at 54% (southeast (SE)). The wind speed frequencies in the categories 0.10-0.50, 0.50-1.00, 1.00-1.50, 1.50-2.00, and 2.00-2.50 are 8.2%, 64.4%, 19.2%, 6.8%, and 1.4% respectively.

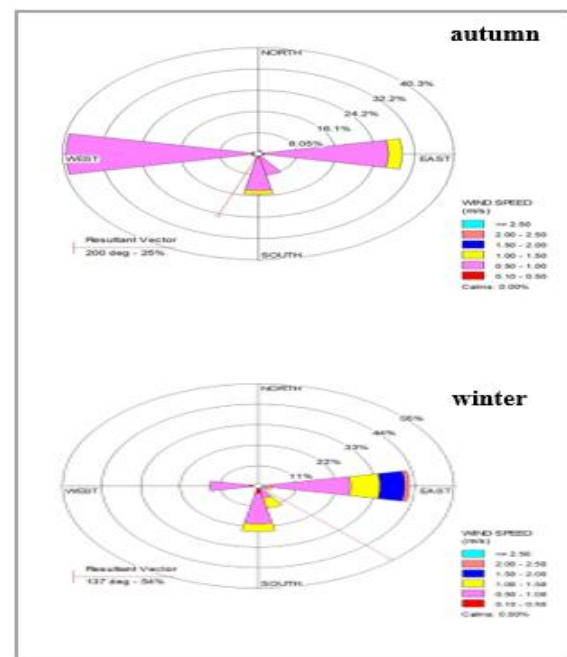


Figure 3. Wind rose plots for ZC during study period 2021-2022.

The maximum (Max), minimum (Min), mean, median, and standard deviation (StDev) for concentrations of CO, CO₂, and O₃ as well as weather parameters (T, RH, AP, and WS) for study period have been shown in table 1. It is indicated in table 1 that the seasonal average T, RH, AP, and WS are 22.1°C, 35.52 %, 1014.8 mbar, and 0.61 m/s respectively during autumn 2021 and 10.28°C, 57.99 %, 1019.9 mbar, and 0.81 m/s respectively during winter 2021-2022. The concentrations CH₄ and H₂S gases were not detected at all locations, because the sources of these gases like fossil fuel, biomass burning and biofuel are not existent in the district of collections of data to be more exact in Zakho city.

Table 1 illustrates that the greater levels of gaseous air pollutants are linked to the type of climate and/or various atmospheric conditions in a certain period. Their levels are also related to the

variable case of the climate on any given day, as well as anthropogenic activities, such as fuel gases emitted from car exhausts and gases emitted from burning green areas, or may be due to petroleum extraction in the Zakho region. The maximum allowable values for the CO and O₃ concentrations in Iraqi Kurdistan region are 9 ppm and 0.075 ppm for 8 hours

respectively(Mahdi, Yousif, & Dosky, 2020). Even so, the concentrations recorded for both air pollutants were less than those permissible values, while CO₂ concentrations in the autumn and winter seasons ranged from 0.0497 to 0.071 Vol% and 0.0417-0.06%, respectively, this was higher than the normal atmospheric concentration rate (0.03%).

Table 1. The minimum, maximum, mean, median, and standard deviations (StDev) of CO, CO₂, and O₃, and MP for the study period.

	Min	Max	Mean	Median	StDev
Autumn					
CO concentration (ppm)	0.114	8.852	2.981	2.6452	2.198
CO ₂ concentration (Vol%)	0.0497	0.071	0.0553	0.0544	0.0044
O ₃ concentration (ppm)	0.0012	0.0468	0.0166	0.0128	0.0218
Temperature (°C)	12.15	30.45	22.101	22.3	4.891
Relative humidity (%)	18	65	35.52	32.5	12.21
Atmospheric pressure (mbar)	1002.9	1023.7	1014.8	1016.1	5.19
Wind speed (m/s)	0.29	1.37	0.61	0.59	0.1524
Winter					
CO concentration (ppm)	0.056	8.667	2.733	2.286	2.529
CO ₂ concentration (Vol%)	0.0417	0.06	0.052148	0.0514	0.004485
O ₃ concentration (ppm)	0.0006	0.0571	0.02503	0.02785	0.01167
Temperature (°C)	0.05	17.4	10.286	10.95	3.573
Relative humidity (%)	24	87.5	57.99	58.5	13.02
Atmospheric pressure (mbar)	1008.8	1027.6	1019.9	1020.4	4.41
Wind speed (m/s)	0.2	2.18	0.8114	0.65	0.3849

The connection between the quality of surrounding air data and weather parameters for autumn 2021 was estimated using linear regression analysis to predict the impacts of Meteorological Parameters (MP) on the air quality of the city. Table 2 shows the correlation coefficients (R) as well as regression equations for the daily mean concentrations of CO₂, CO, and O₃ with the daily mean of MPs (T, RH, AP, and WS). In Figures 4 and 5, the concentrations of CO, O₃, and CO₂ based on T have been plotted for the autumn of 2021 and winter 2021-2022.

In autumn period, based on Table 2 and Figure 4, the concentrations of CO and CO₂ are in an extremely weak and negative correlation with T, the main reason is the contribution of household heating emissions because of temperature drop in the autumn. But O₃ is a weak and positive association with T, due to O₃ production accelerates at high temperatures, and emissions of the natural components of ozone increase. O₃ increases with the increase in T but CO and CO₂ decrease with an increase in T, which agrees with the findings of other researchers(Ocak & Turalioglu, 2008; Duo et al., 2018; Vtoryi et al., 2016; Lewicki et al., 2010). The concentration of both O₃ and CO₂ are very weak and negatively correlated with RH, but CO is positively correlated to the RH, as presented in Table 2. Similar findings have been seen in other researches(Ocak & Turalioglu, 2008; Elminir, 2005; Pathakoti et al., 2018). The positive correlation and high CO concentration with high RH are because of high vehicular emissions at traffic(R. Li et al., 2019; Ocak & Turalioglu, 2008). The negative correlation or correlation of low CO₂ and O₃ with high RH are attributed to the effects of pure tropospheric air masses, which agree with the results by (Elminir, 2005; Seinfeld, Pandis, & Noone, 1998). CO and CO₂ concentrations are weak and positively associated with the AP. The findings are in agreement with those found in the researches(Duo et al., 2018; Lewicki et al., 2010). O₃ amounts negatively correlated with the AP. Another research (Duo et al., 2018) has reported the same results. The complicated relations

were probably explained by changing AP anomalies during the autumn (Duo et al., 2018). CO and O₃ are weak and negatively associated with WS, representing that WS have a significant role in pollution spread, on the other hand, the concentration of CO₂ has a very weak and positively increased with WS. Studies (Lewicki et al., 2010; Duo et al., 2018; Afonso & Pires, 2017)have reported the same results.

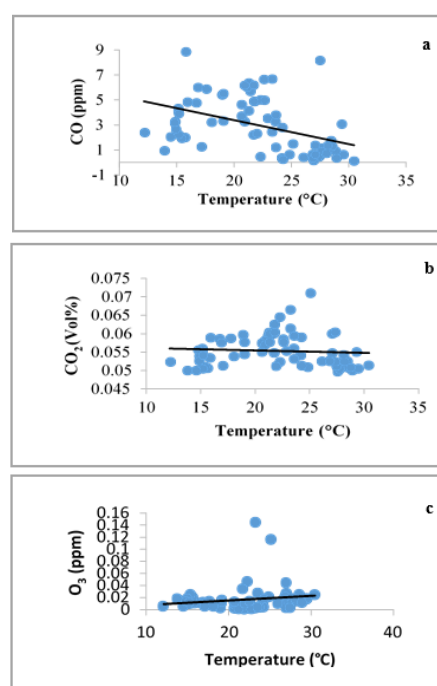


Figure 4. The daily average concentrations of gases (a) CO, (b) CO₂, and (c) O₃ versus Temperature for the autumn period in ZC.

In winter, from Table 2 and Figure 5, the concentrations of CO and CO₂ are in an extremely weak and negative correlation with T and decrease with the increase of T. These are in agreement with discussions of studies(Ocak & Turalioglu, 2008; Lewicki et al., 2010; Ma’rufatin & Kusnoputranto, 2018). But O₃ has a weak and positive association with T and increased with an increase in T, meaning that the photochemical reaction of ozone seemed to be important in the formation of O₃ during the cold season(Duo et al., 2018). The concentration of both CO and CO₂ are very weak and have a positive correlation with RH, but O₃ is negatively correlated to the RH, which means RH is correlated inversely to the concentration of pollutants since it controls the amount of absorption of pollutants. Similar findings have been seen in other studies(Metya et al., 2021; M. Li et al., 2021). As shown in Table 2, the concentrations of Co and CO₂ gases are very weak and positively associated with the AP, while O₃ emission is weak and negatively associated with AP. The findings are in agreement with those found in the researches (Duo et al., 2018; Lewicki et al., 2010). CO and CO₂ have a weak and positive connection with WS, on the other hand, the concentration of O₃ was very weak and positively correlated with WS, WS become the most important weather element that influences the diffusion of pollutants. Studies (Zhou et al., 2020; Lewicki et al., 2010; Afonso & Pires, 2017)have also reported the same results.

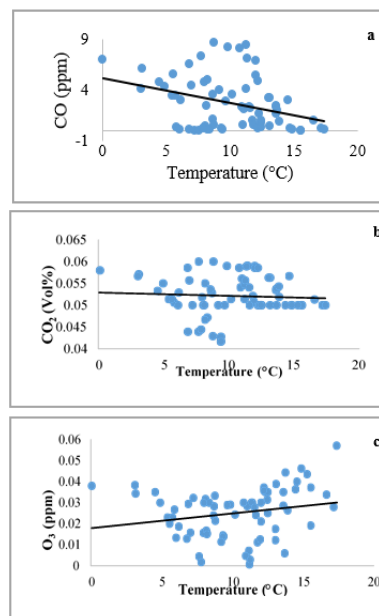


Figure 5. The daily average concentrations of gases (a) CO, (b) CO₂, and (c) O₃ versus Temperature for the winter period in ZC.

Table 2. The regression equation and the correlation coefficient (R) for CO, CO₂, and O₃ with meteorological parameters.

Pollutant	Reg.equ.	R
Autumn		
CO	= 7.211-0.1914*[T]	0.169
	= 1.345+0.0461*[RH]	0.052
	= 3.498-0.842*[WS]	0
	= -196.1+0.1962*[AP]	0.203
CO ₂	= 0.0568-0.00007*[T]	0
	= 0.05599-0.00002*[RH]	0
	= 0.05496+0.0006*[WS]	0
	= -0.1149+0.0002*[AP]	0.026
O ₃	= -0.00002+0.00075*[T]	0.014
	= 0.0336-0.0005*[RH]	0.058
	= 0.0266-0.01637*[WS]	0
	= 0.8225-0.0008*[AP]	0.022
Winter		
CO	= 5.230 - 0.2537 * [T]	0.1156
	= 0.036 + 0.04457 * [RH]	0.039
	= 2.010 + 0.7529 * [WS]	0
	= - 87.02 + 0.08789 * [AP]	0.0096
CO ₂	= 0.05291 - 0.000074 * [T]	0
	= 0.04965 + 0.000043 * [RH]	0.0018
	= 0.05050 + 0.002029 * [WS]	0.0167
	= - 0.0981 + 0.000147 * [AP]	0.0072
O ₃	= 0.01885 + 0.000568 * [T]	0.0152
	= 0.02969 - 0.000086 * [RH]	0
	= 0.01567 + 0.01112 * [WS]	0.116
	= 0.4489 - 0.000416 * [AP]	0.0098

4. CONCLUSION

Air pollution levels depend on two important factors, which are source emissions and weather conditions. In this study, the relationship between meteorological parameters such as T, AP, RH, WS, and WD and concentrations of O₃, CO, CH₄, H₂S, and CO₂ was investigated. The concentrations of both CO and CO₂ were negatively decreased with an increase in T. The mean values of CO during autumn and winter are 2.981 ppm and 2.733 ppm, respectively, and the mean values of CO₂ are 0.055 Vol% and 0.052 Vol% respectively. While O₃ concentration increased

with increasing T, and mean value of O₃ is 0.0166 ppm and 0.025 ppm during both seasons respectively. As well as CH₄ and H₂S gases were not detected over the study period. From the results, concentrations of all gases and meteorological parameters were weakly correlated. the released gases from vehicle exhausts are a significant source of air contaminants, particularly in crowded traffic intersections in ZC. Finally, our study concluded that the air quality of ZC is moderately polluted.

REFERENCE

- Afonso, N. F., & Pires, J. (2017). Characterization of surface ozone behavior at different regimes. *Applied Sciences*, 7(9), 944.
- Al-Sultan, A. A. (2015). Evaluation Of Gases Emissions From Automobiles Exhaust In Baghdad City. In *The 2 nd International Conference of Buildings, Construction and Environmental Engineering (BCEE2)* (p. 203).
- Choudhary, M. P., & Garg, V. (2013, August). Causes, consequences and control of air pollution. In *All India Seminar on Methodologies for Air Pollution Control*, held at MNIT.
- Duo, B., Cui, L., Wang, Z., Li, R., Zhang, L., Fu, H., ... & Qiong, A. (2018). Observations of atmospheric pollutants at Lhasa during 2014–2015: pollution status and the influence of meteorological factors. *Journal of Environmental Sciences*, 63, 28-42.
- Elminir, H. K. (2005). Dependence of urban air pollutants on meteorology. *Science of the Total Environment*, 350(1-3), 225-237.
- Ghorani-Azam, A., Riahi-Zanjani, B., & Balali-Mood, M. (2016). Effects of air pollution on human health and practical measures for prevention in Iran. *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences*, 21,65.
- Habermann, M., Medeiros, A. P. P., & Gouveiai, N. (2011). Vehicular traffic as a method to evaluate air pollution in large cities [Trafego veicular como metodo de avaliacao da exposicao a poluicao atmosferica nas grandes metropoles]. *Revista Brasileira de Epidemiologia*.
- Hassoon, H. A. (2019). Measurement of carbon monoxide emissions from vehicles exhaust pipe using portable gas detector. *Iraqi Journal of Agricultural Sciences*, 50(3).
- Holnicki, P., Nahorski, Z., & Kafuszko, A. (2021). Impact of Vehicle Fleet Modernization on the Traffic-Originated Air Pollution in an Urban Area—A Case Study. *Atmosphere*, 12(12), 1581.
- Jindy, J. M., Qasim, A. K., & Mohamad, S. A. (2020). Evaluation of Soil Pollution by Some Heavy Metals Via Atomic Absorption Spectrophotometer (AAS) Technique in Zakho District, Kurdistan Region-Iraq. *Science Journal of University of Zakho*, 8(4), 145-148.
- Kan, H., Chen, B., Zhao, N., London, S. J., Song, G., Chen, G., ... & Jiang, L. (2010). Part 1. A time-series study of ambient air pollution and daily mortality in Shanghai, China. *Research report (Health Effects Institute)*, (154), 17-78.
- Lewicki, J. L., Hillel, G. E., Dobeck, L., & Spangler, L. (2010). Dynamics of CO₂ fluxes and concentrations during a shallow subsurface CO₂ release. *Environmental Earth Sciences*, 60(2), 285-297.
- Li, M., Yu, S., Chen, X., Li, Z., Zhang, Y., Wang, L., ... & Seinfeld, J. H. (2021). Large scale control of surface ozone by relative humidity observed during warm seasons in China. *Environmental Chemistry Letters*, 19(6), 3981-3989.
- Li, R., Wang, Z., Cui, L., Fu, H., Zhang, L., Kong, L., ... & Chen, J. (2019). Air pollution characteristics in China during 2015–2016: Spatiotemporal variations and key meteorological factors. *Science of the total environment*, 648, 902-915.
- Ma'rufatin, A., & Kusnopranto, H. (2018). Investigating the relationship between variation of greenhouse gases concentrations and humidex. In *E3S Web of Conferences (Vol. 74, p. 11004)*. EDP Sciences.
- Mahdi, B. H., Yousif, K. M., & Dosky, L. S. (2020). Influence of meteorological parameters on air quality and other pollutants in Duhok city, Iraq. *The Iraqi Journal of Agricultural Science*, 51(4), 1160-1172.
- Mahdi, B. H., Yousif, K. M., & Dosky, L. S. (2018, December). Characterization of airborne particles collected in Duhok city (in Iraq), by using various techniques. In *IOP Conference Series: Materials Science and Engineering (Vol. 454, No. 1, p. 012073)*. IOP Publishing.
- Mahdi, B. H. (2021, March). Measurement of Fall Rate and Analysis of Atmospheric Falling Dust in Duhok Governorate of Iraq by Using Atomic Absorption Spectrometry and X-ray Diffraction. In *Journal of Physics: Conference Series (Vol. 1829, No. 1, p. 012001)*. IOP Publishing.
- Manisalidis, I., Stavropoulou, E., Stavropoulos, A., & Bezirtzoglou, E. (2020). Environmental and health impacts of air pollution: a review. *Frontiers in public health*, 14.
- Metya, A., Datye, A., Chakraborty, S., Tiwari, Y. K., Sarma, D., Bora, A., & Gogoi, N. (2021). Diurnal and seasonal variability of CO₂ and CH₄ concentration in a semi-urban environment of western India. *Scientific reports*, 11(1), 1-13.
- Mohamed, A. M. O., Maraqa, M. A., Howari, F. M., & Paleologos, E. K. (2021). Outdoor air pollutants: sources, characteristics, and impact on human health and the environment. In *Pollution Assessment for Sustainable Practices in Applied Sciences and Engineering* (pp. 491-554).
- Ocak, S., & Turalioglu, F. S. (2008). Effect of meteorology on the atmospheric concentrations of traffic-related pollutants in Erzurum, Turkey. *J. Int. Environmental Application & Science*, 3(5), 325-335.
- Pathakoti, M., Gaddamidi, S., Gharai, B., Sudhakaran Syamala, P., Rao, P. V. N., Choudhury, S. B., ... & Dadhwal, V. K. (2018). Influence of meteorological parameters on atmospheric CO₂ at Bharati, the Indian Antarctic research station. *Polar Research*, 37(1), 1442072.
- Rai, P. (2015). *Biomagnetic monitoring of particulate matter: in the Indo-Burma hotspot region*. Elsevier.
- Steinfeld, J. I. (1998). *Atmospheric chemistry and physics: from air pollution to climate change*. *Environment: Science and Policy for Sustainable Development*, 40(7), 26-26.
- Vtoryi, V., Vtoryi, S., Lantsova, E., & Gordeev, V. (2016, May). Effect of weather conditions on content of carbon dioxide in barns. In *Proceedings 15th International Scientific Conference «Engineering for rural development* (pp. 437-441).
- Zhou, H., Yu, Y., Gu, X., X., Wu, Y., Wang, M., Yue, H., ... & Ge, X. (2020). Characteristics of Air Pollution and Their Relationship with Meteorological Parameters: Northern versus Southern Cities of China. *Atmosphere*, 11 (3), 253.