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Air Quality and Bioclimatic Conditions in the Touristic City Centre of Rhodes from June to November 2022

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Abstract **–** The air quality is considered a hot-issue for the scientific community because it is responsible for health problems and premature deaths. Additionally, the discomfort sense of population due to the alternation of climate conditions is of great importance as it increases the health risk for people. This study investigates the air quality and bioclimatic conditions in the centre of Rhodes city in the south-eastern Mediterranean during the period from 9th June to 14th November 2022. For the analysis, timeseries of the recordings from a mobile air quality monitoring system are used. In order to investigate the air quality and the variation of pollution levels, the concentration of pollutants CO, NO, NO2, PM10, SO2 and sound are analyzed. Additionally, the discomfort index (DI) and the wet bulb globe temperature (WGBT) are calculated to study the discomfort sense and heat stress for the people in Rhodes city. The positive correlation among the concentration of pollutants and the bioclimatic indices provide an evidence that the air quality degradation and the increased values of bioclimatic indices possibly increase human health risk. Results show that the period with higher tourist activities presents an increase of the concentration of PM10 and a downgrade of the climatic sense of population. However, these findings do not show exceedances regarding the danger limits for people's health. Moreover, the strong wind speed during summer of 2022 possibly increases the dispersion of pollutants. Finally, this study emphasizes the improvement of knowledge regarding the air quality and human discomfort sense in the tourist region of Rhodes contributing to the formation of the green strategic plan over the south-eastern Aegean Sea.

Keywords**:** air quality, Rhodes, eastern Mediterranean, Aegean Sea, bioclimatic index, discomfort index (DI), wet bulb globe temperature (WBGT)

1. Introduction

The study of air pollution is a dominant concern for public authorities and scientific community due to its adverse human and environmental health effects [1,2]. The traffic emissions and anthropogenic activities such as industry, vehicles and high tourist density are some of the main drivers for the air quality degradation increasing the harmful effects for human health. There are a number of previous studies that provide elements regarding the association between air pollution and health problems such as cancer, respiratory diseases, lung function, cardiovascular problems, pregnancy disorders, cognitive decline e.t.c. [1,3,4]. According to the World Health Organization (WHO) [5] about 90% of citizens in urban regions are exposed to high pollution levels and the 92% of world population is living in poor ambient air quality conditions with harmful results for their health. IPCC [6] highlights that the global warming is related to the emissions due to the anthropogenic activities (and vice versa) [5,7]. The Paris Agreement and the goal of 1.5°C pathways could lead to about 110 to 190 million fewer premature deaths compared to 2°C pathways [8]. This climate strategy also provides various benefits for the socioeconomic sectors. In particular, the adaptation of novel carbon capture and storage technologies (CCS) as well as the development of other green – negative emission technologies in industry, marine activities, vehicle and traffic sectors could provide the context for a sustainable and growing future economy [9].

The bio-climatological conditions affect the discomfort condition of population. Under the global warming, there is an association among the human comfort level, air pollution and imminent health risk [10]. It is of great interest the synergy effect of bioclimatic conditions and air pollution on human health [11]. Tan et al. [12] have shown that the urban heat island (UHI) is related to increased air quality degradation. There are previous studies that provide elements regarding the negative impact of the combined effect of discomfort condition and poor air quality on human health [13-16]. Wati and Nasution

[13] have shown that the increased concentration of total suspended particles is related to increased DI in Jakarta. For the Greek region, Poupkou et al. [14] have found a strong synergy between poor air quality and discomfort human sense in an urban environment (Thessaloniki city) during the summer period. Over the Thriassio plan in Attica, Mavrakis et al. [15] have shown that thermal discomfort was found to be positively related with increased pollution levels (studied from March to May, 2020). Moreover, Logothetis et al. [16] have shown that the DI and the concentration of PM2.5, and NOx show positive regression values in the city of Rhodes during the summer of 2021. These analyses provide evidence that the discomfort sense of people is related with poor air quality.

The climate vulnerable region of Mediterranean is a hot tourist destination with a special dynamic for further economic sustainable development. This study is conducted in the context of "ELEKTRON" project (https://elektron-project.gr/) and follows up our previous works where the air quality, climate conditions and discomfort index in the Rhodes city are investigated during the summer of 2021 [17]. In our current work, the analysis of an extended number of pollutants and bioclimatic indices during the period from 9^{th} June to 14^{th} November of 2022 are studied. In order to investigate the bioclimatic condition for the city of Rhodes, the discomfort index (DI) and wet bulb globe temperature (WGBT) are calculated. The calculation of DI and WGBT is examined in combination with the recordings of concentration of pollutants in order to investigate their synergy on human health risk.

This study aims to further investigate and understand the variability of air quality and bioclimatic condition in the city of Rhodes in southeastern Aegean. Additionally, the analysis tries to provide more elements regarding the main features of pollution in the city of Rhodes following up our previous works [16,17]. Finally, this work, as a part of the project "ELEKTRON" which promotes electro-mobility and green technology, aims to raise awareness regarding the air quality and environment.

2. Data and Methodology

The analysis employs hourly recordings from a mobile air quality monitoring system (AQMS; Haz@Scanner™ model HIM-6000, [18]) located in the centre of Rhodes city, near the "Cyprus" square (Fig. 1). The recordings of AQMS include the **(a)** concentration of CO (ppm), NO (ppb), NO2 (ppb), PM10 (μg/m3) and SO2 (ppb), **(b)** sound (Snd; db) and **(c)** the meteorological factors, relative humidity (HR; %) and temperature (T; ºC). The campaign is conducted during the period from 9 June 2022 to 14 November 2022 (159 days).

(A)

(B)

Fig. 1: The location of the **(A)** AQMS in Rhodes city and **(B)** the AQMS (in the red cycle in upper right corner) near the "Cyprus" square in Rhodes city center.

In order to investigate the impact of climate conditions on human sense, the discomfort index (DI) and the Wet Bulb Globe Temperature (WGBT) are calculated. Discomfort index is considered as the most common bioclimatic index to express human experience under modified meteorological conditions [14]. The DI was proposed in 1959 by Thom (Thom's discomfort Index; DI). It is calculated using a combination of temperature and relative humidity fraction reflecting the impact of these climate parameters to human comfort sense [19]. DI is calculated using the following equation (1):

$$DI(°C) = T_h - 0.55 \cdot (1 - 0.01 \cdot RH_h) \cdot (T_h - 14.5) \quad (1)$$

where, T_h is the air temperature in degrees Celsius and RH_h is the relative humidity as a percentage [14,15,19,20]. The classes with the discomfort conditions of the DI index are presented in Table 1.

Table 1: Classes of Discomfort Index.

Class number	DI (°C)	Discomfort Conditions
1	DI <21	No discomfort
2	21≤DI<24	Less than half of population feels discomfort
3	24≤DI<27	More than half of population feels discomfort
4	27≤DI<29	Most of population suffers discomfort
5	22≤DI<32	Everyone feels severe stress
6	DI≥32	State of medical emergency

The wet bulb globe temperature (WGBT) is an index that quantifies the heat stress of population and it is considered as an appropriate index to express heat stress in a workplace [21]. For the calculation of WGBT index, we follow the methodology of Lemke and Kjellstrom, [21] using the following equation (2):

$$WGBT(°C) = 0.567 \cdot T_h + 0.393 \cdot \frac{RH_h}{100} \cdot 6.105 \cdot e^{17.27 \cdot T_h / (237.7 + T_h)} + 3.94 \quad (2)$$

As in equation (1), T_h is the air temperature in degrees Celsius and RH_h is the relative humidity as a percentage. The classes with the comfort conditions of the WGBT index are presented in Table 2.

Table 2: Classes of Wet Bulb Globe Temperature index.

Risk	WGBT (°C)		Suggested Actions and Impact Prevention	
	min	max	Effects	Precautionary Actions
Low	<26.6	26.6	-	-
Medium	26.7	29.4	Working or exercising in direct sunlight will stress your body after 45 minutes.	Take at least 15 minutes of breaks each hour if working or exercising in direct sunlight
High	29.5	31.1	Working or exercising in direct sunlight will stress your body after 30 minutes.	Take at least 30 minutes of breaks each hour if working or exercising in direct sunlight
Very High	31.2	32.2	Working or exercising in direct sunlight will stress your body after 20 minutes.	Take at least 40 minutes of breaks each hour if working or exercising in direct sunlight
Extreme	32.3	>32.3	Working or exercising in direct sunlight will stress your body after 15 minutes	Take at least 45 minutes of breaks each hour if working or exercising in direct sunlight

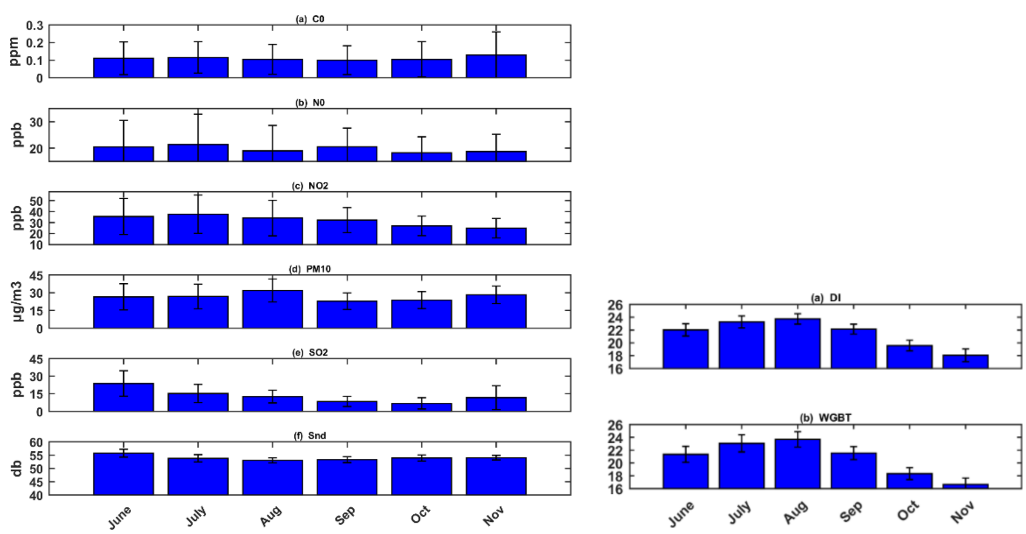
The bar-chart of the monthly mean concentration of CO, NO, NO2, PM10, SO2, sound as well as the DI and WGBT indices are calculated for each month from June to November in order to investigate the monthly mean level and the variation of these parameters. In this analysis, June includes recordings from 9th to 31st June and the November from 1st to 14th November, respectively. The other months of the studied period include all the hourly recordings. In order to investigate the diurnal variability of pollutants and bioclimatic indices, the hourly mean variation of concentration of pollutants, sound and bioclimatic indices are also calculated. Additionally, the differences of mean diurnal variability of each month are calculated with reference to the mean diurnal variability of the whole period (from 9th June to 14th November). Finally, the Spearman correlation among concentration of pollutants, sound and bioclimatic indices are calculated in order to study the possible relation among these parameters [22].

3. Results

The analysis shows that the concentration of CO mainly changes in September and November compared to the period mean value (Fig. 2A). In particular, the mean concentration of CO decreases, with respect to (hereafter wrt) the period mean (from 9 June to 14 November) concentration about 5%, 10% and 6% for August, September and October, respectively. For

November, the mean concentration presents an increase about 17% (Fig. 2A-a). The reduced values of concentration from August to October are possibly explained by the wind field that blow in southern eastern Mediterranean during this period. The mean concentration of NO shows (wrt the mean period value) an increase in July (about 9%) and decrease for October and November about 7% and 5%, respectively (Fig. 2A-b). In addition, the mean concentration of NO2 shows an increase of the monthly mean concentration about 11%, 18% and 7% for June, July and August and a decrease about 15% and 22% for October and November, respectively (Fig. 2A-c). The monthly mean variability of the concentration of NO and NO2 are possibly explained by the traffic emissions (vehicles, tourist and shipping activities) [16]. In general, the anthropogenic activities are increased during the summer period [16, 17]. Other parameters that affect the monthly variation of pollutants are the seasonal solar cycle as well as photochemistry of the lower atmosphere [16]. Additionally, it is possible that the variation of concentration of these pollutants to be affected by pollutants that are transferred from continental to southeastern regions and possibly these pollutants participate to the formation of secondary pollutants via chemical reactions [23,24]. The monthly mean concentration of PM10 increases (wft the mean period value) about 19% and 6% in August and November, respectively (Fig. 2A-d). September and October show a decrease about 15% and 10%, respectively (Fig. 2A-d). The mean concentration of SO2 (wrt the mean period) shows an increase about 81% and 16% in June and July and a decrease about 36%, 47% and 11% for September, October and November, respectively (Fig. 2A-e). The high traffic activity, wind speed variation and the long range transport of SO2 during the studied period possibly explain the monthly mean variability SO2 [16,17,24]. Additionally, the marine traffic and shipping activities in the Rhodes possibly affect the concentration of SO2. The sound does not present a significant change during the monthly mean values as compared to the mean period value. The main reason for this insignificant change is that the AQMS is located in a central location of Rhodes city, near a central commercial road, that is affected by a traffic activity over the seasons.

The bar-charts of the monthly mean values of DI and WGBT indices are presented in Fig. 2B. Both the DI and WGBT increase during the summer months with a peak in August. This variability is related to the climate conditions (RH and T of ambient air) that affects the discomfort sense and heat stress of people. The analysis shows that DI, wrt the mean period DI, increases about 8% and 11% in July and August and decreases about 9% and 16% in October and November (Fig. 2B-a). The monthly mean DI value from June to September is about 22 to 24 (°C) which means that less than half of the population feels discomfort. During October and November, the people feel no discomfort (Fig. 2B-a). The analysis of WGBT shows that the higher values are shown in August (about 24°C) (Fig. 2B-b). The monthly mean WGBT values from June to November suggest normal activity and no need for specific activity guidelines.



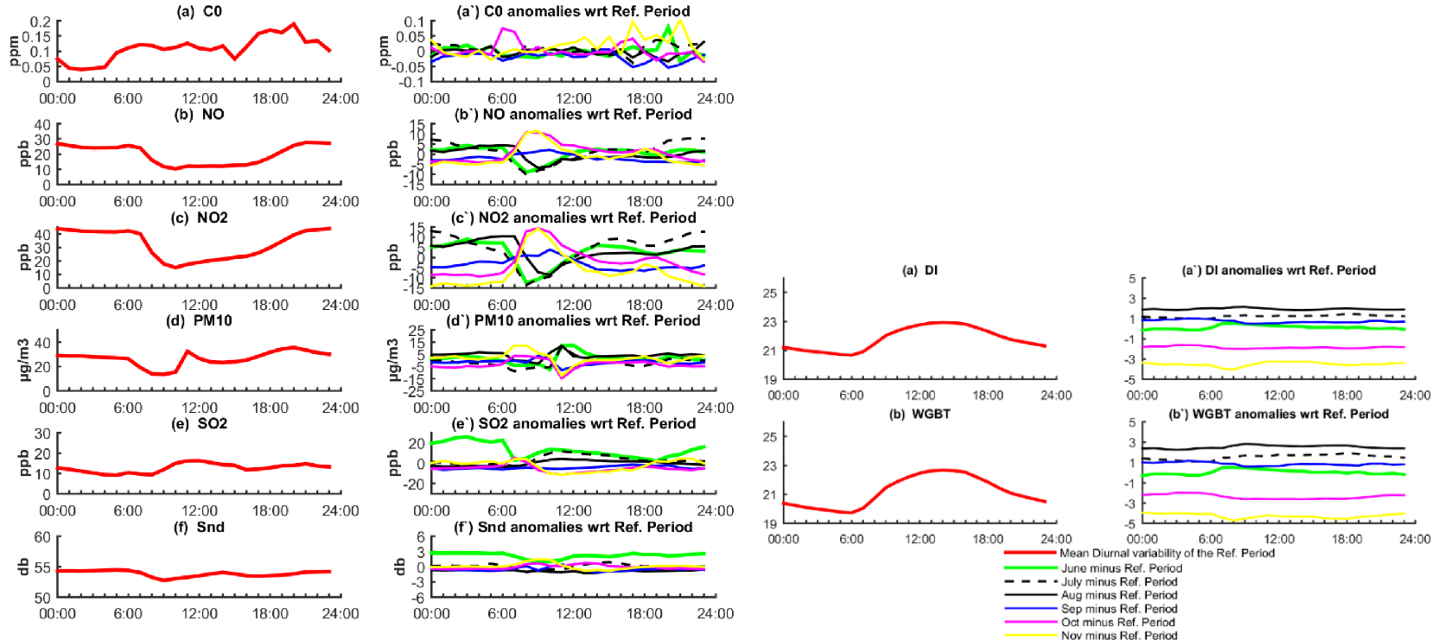
(A) **(B)**

Fig. 2: Bar chart **(A)** of the mean concentration of pollutants and sound and **(B)** of DI and WGBT for each month. The whiskers show mean value plus/minus one standard deviation.

In order to investigate the hourly mean evolution of pollution level in the Rhodes city centre, the mean diurnal variability variability of the concentration of pollutants and sound are calculated. Fig. 3A shows the mean diurnal variability of concentration of pollutants and sound for the whole studied period and the monthly mean anomalies of each month wrt the the whole studied period (from 90 June to 14 November). The mean concentration of CO shows maximum values at the hours from 17:00 to 22:00 (Fig. 3A-a). The CO concentration shows positive hourly anomalies during the high traffic period for the hours from 15:00 to 23:00 (Fig. 3A-a'). Additionally, this is indicative for the hours with higher traffic activity during a common day. The hourly mean variability of NO during the whole period shows lower hourly mean concentration during the morning (about 10:00) (Fig. 3A-b). For October and November the analysis shows positive anomalies indicating that during these months the mean NO concentration is increased about 10ppb wrt the whole period (Fig. 3A-b'). The hourly mean concentration of NO2 during the whole period is minimized during the hours from 7:00 to 10:00 (Fig. 3A-c). The analysis of anomalies shows that June and July show reduced values of hourly mean concentration about 15ppb at 8:00-9:00 and October - November show increased values about 15ppb at the same hours (Fig. 3A-4c'). The diurnal variability and the hourly mean anomalies for each month (wrt the whole period for the concentration of NO and NO2) are possibly explained by the impact of wind speed pattern over the Rhodes city (the Etesian winds system during summer period [17]), the traffic emissions and the human activities in the centre of Rhodes city. Possibly the wind speed is a dominant factor that explains the variability of NO and NO2. Additionally, the solar activity and photochemical reactions affect the diurnal variability of the concentration of NO and NO2. All these elements seem to affect the variation of concentration of these pollutants in a complex way. The period mean hourly variability of the concentration of PM10 shows a peak at 11:00 and does not change significantly during the hours from 12:00 to 24:00 (Fig. 3A-d). The maximum mean concentration of PM10 for the whole period is about 32ppb (Fig. 3A-d). June and August show positive anomalies at 11:00 about 12ppb. Generally, August shows the most positive mean hourly anomaly values compared to the other months (Fig. 3A-d'). The hourly mean concentration of SO2 is maximized after 8:00 following the human and traffic activities of the city (Fig. 3A-e). The anomalies of each month (wrt the whole period) do not present a significant difference except for June at 00:00 to 7:00 (an increase about 20ppb; Fig. 3A-e'). The sound does not variate significantly during the day (Fig. 3A-f). Additionally, the analysis shows that sound does not change significantly for each month as compared to the mean hourly values of sound for the whole period (Fig. 3A-f'). For the further investigation of the sound in the centre of the location of AQMS, the position of AQMS will be changed in order to further investigate the pollution and sound variability in the city. Finally, the common mean diurnal variability of CO, PM10 and SO2 possibly is evidence for a common origin of these pollutants (maybe the shipping, traffic activity and transport could be the main components that explain a significant percentage of their variability).

To study the diurnal variation of the human sense under modified climate conditions, the bioclimatic indices DI and WGBT are calculated (Fig. 3B). Both bioclimatic indices are maximized at 13:00 – 16:00. The mean maximum value of DI and WGBT for the whole period are about 23, respectively (Fig. 3B-a&b). This result shows that the midday hours are the time with the maximum health risk for population (in terms of discomfort sense) (Fig. 3B-a&b). The hourly mean anomalies (wrt the whole studied period) show that July and August are the months with the most significant positive anomalies (about 2°C and 3°C for DI and WGBT, respectively) (Fig. 3B-a'&b'). During these months, at the hours from 13:00 to 16:00, DI values are classified in the "more than half of population feels discomfort" class. The WGBT, during the common period, shows low health risk. This analysis shows that the population should be aware mainly during the hours between 13:00 and 16:00 for the warmest summer months.

Fig. 4 shows the correlation coefficients among the concentration of pollutants, sound and bioclimatic indices DI and WGBT. This analysis possibly indicates the relation between the pollutants and bioclimatic indices. The majority of pollutants shows positive, from low to moderate, correlation coefficients (0.2 to 0.7). Sound shows no correlation with the concentration of the majority of pollutants except the SO2 where a low positive correlation value (about 0.2) is presented. The bioclimatic indices DI and WGBT show (low to moderate) positive correlation (about 0.2 to 0.4) with the concentration of NO2, PM10 and SO2. This positive relation possibly indicates that a synergy between the concentration of pollutants and discomfort scene could increase the health risk of people.



(A) **(B)**

Fig. 3**: (A) (a-f)** Mean diurnal variability of concentration of pollutants and sound for the whole studied period and **(a'-f')** Difference between diurnal variability of concentration of pollutants and sound for each month and the whole studied period (Ref. Period from 9/7 to 14/11). **(B) (a-b)** Mean diurnal variability of DI (°C) and WGBT (°C) for the whole studied period and **(a'-b')** Difference between diurnal variability of DI and WGBT for each month and the whole studied period.

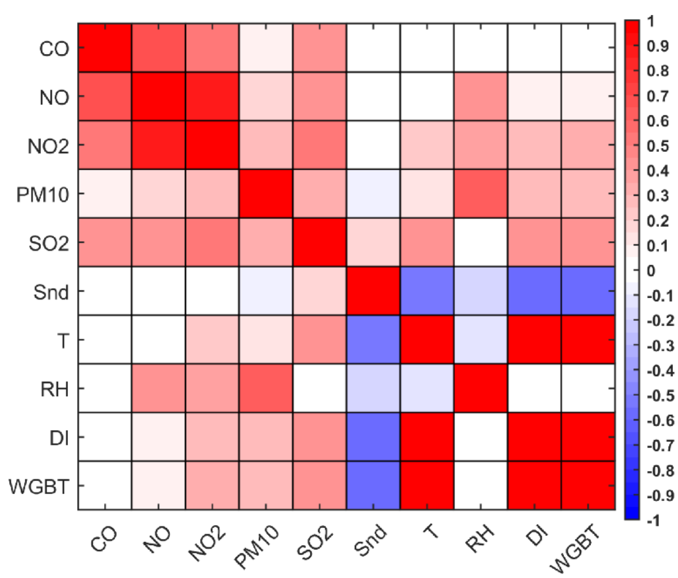


Fig. 4: Spearman correlation among concentration of pollutants, sound and bioclimatic indices.

4. Conclusion

This work investigates the air quality and bioclimatic conditions in the centre of Rhodes city during 9th June to 14th November 2022. Findings show that the monthly mean variation of concentration of pollutants shows that traffic emissions from tourist activities, vehicles and shipping as well as the possible long range transport of pollutants affect the variation of pollutants. The period with maximum concentration of pollutants seems to be the summer months (June to August). Additionally, during summer, the diurnal variation of pollutants concentration is possibly affected by the Etesian wind pattern. The common mean diurnal variability for the majority of pollutants concentration may indicate their common source (for instance traffic, shipping etc.). Both DI and WGBT increase during midday hours. The bioclimatic indices values are not significantly increased to be a danger for the population but the synergy between increased values of concentration of pollutants and bioclimatic indices should be taken under consideration for the health risk of people in Rhodes. Finally, this study emphasizes the investigation of the pollution levels over an extended period in order to shed more light to the specific reasons that affect the air quality in Rhodes city.

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References

[1] P.T. Nastos. Weather, Ambient Air Pollution and Bronchial Asthma in Athens, Greece. In: Thomson, M.C., Garcia-Herrera, R., Beniston, M. (eds) Seasonal Forecasts, Climatic Change and Human Health. Advances in Global Change Research, 2008, vol 30. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-6877-5_11

[2] P. Monforte, M.A. Ragusa, Evaluation of the air pollution in a Mediterranean region by the air quality index. Environ Monit Assess 190, 625, 2018. https://doi.org/10.1007/s10661-018-7006-7

[3] P. Orellano, N. Quaranta, J. Reynoso, B. Balbi, J. Vasquez, Effect of outdoor air pollution on asthma exacerbations in children and adults: systematic review and multilevel meta-analysis. PLoS One. 2017;12(3):e0174050.

[4] W.M. Sweileh, S.W. Al-Jabi, S.H. Zyoud, Sawalha A.F., Outdoor air pollution and respiratory health: a bibliometric analysis of publications in peer-reviewed journals (1900 – 2017). Multidiscip Respir Med 2018, 13, 15, https://doi.org/10.1186/s40248-018-0128-5

[5] World Health Organization. "Ambient air pollution: A global assessment of exposure and burden of disease." (2016).

[6] IPCC, 2018: Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

[7] I. Manisalidis, E. Stavropoulou, A. Stavropoulos and E. Bezirtzoglou, Environmental and Health Impacts of Air Pollution: A Review. Front. Public Health, 2020, 8:14. doi: 10.3389/fpubh.2020.00014 D.T.

[8] Shindell, G. Faluvegi, K. Seltzer, and C. Shindell, Quantified, localized health benefits of accelerated carbon dioxide emissions reductions. Nature Climate Change, 2018, 8(4), 291–295, doi:10.1038/s41558-018-0108-y.

[9] P. Ekins, P. Drummond, D. Scamman, L. Paroussos, I. Keppo, The 1.5°C climate and energy scenarios: impacts on economic growth, Oxford Open Energy, Volume 1, 2022, oiac005, https://doi.org/10.1093/ooenergy/oiac005

[10] S. Tong, H. Bambrick, P. J. Beggs, L. Chen, Y. Hu, W. Ma, W. Steffen, J. Tan, Current and future threats to human health in the Anthropocene, Environment International, Volume 158, 2022, 106892, ISSN 0160-4120,https://doi.org/10.1016/j.envint.2021.106892.

[11] D. Zha, D. Zhou, P. Zhou, Driving forces of residential CO2 emissions in urban and rural China: an index decomposition analysis Energy Pol., 2010), 38, pp. 3377-3383

[12] J. Tan, Y. Zheng, X. Tang, C. Guo, L. Li, G. Song, X. Zhen, D. Yuan, A.J. Kalkstein, F. Li, The urban heat island and its impact on heat waves and human health in Shanghai Int. J. Biometeorol., 2010, 54 , pp. 75-84

[13] T. Wati and R. I. Nasution, Evaluation of urban pollution and bio-climate using total suspended particles and discomfort index in Jakarta City, IOP Conf. Ser.: Earth Environ. Sci., 2018, 203 012003
[14] A. Poupkou, P. Nastos, D. Melas, C. Zerefos, Climatology of Discomfort Index and Air Quality Index in a Large Urban Mediterranean Agglomeration. Water Air Soil Pollut. 2011, 222, 163–183. https://doi.org/10.1007/s11270-011-0814-9
[15] A. Mavrakis, A. Kapsali, I.X. Tsiros, K. Pantavou, Air quality and meteorological patterns of an early spring heatwave event in an industrialized area of Attica, Greece. EuroMediterr J Environ Integr. 2021; 6(1): 25. Published online 2021 Jan 25. doi: 10.1007/s41207-020-00237-0
[16] I. Logothetis, C. Antonopoulou, G. Zisopoulos, A. Mitsotakis, P. Grammelis, Air Quality and Climate Comfort INDICES over the Eastern Mediterranean: The Case of Rhodes City during the Summer of 2021. Environ. Sci. Proc. 2022, 19, 1. https://doi.org/10.3390/ecas2022-12833
[17] I. Logothetis, C. Antonopoulou, G. Zisopoulos, A. Mitsotakis, P. Grammelis, The Impact of Climate Conditions and Traffic Emissions on the Pms Variations in Rhodes City during the Summer of 2021. Proceedings of the 7th World Congress on Civil, Structural, and Environmental Engineering (CSEE'22) Lisbon, Portugal Virtual Conference – April 10 – 12, 2022 Paper No. ICEPTP 181 DOI: 10.11159/iceptp22.181
[18] S. S. K. Ko, R. Jindal, K. Tantrakarnapa, N. Surinkul and W. Trivitayanurak, Investigations of Baseline Air Quality around the Proposed Yangon Outer Ring Road Construction (Eastern Section) Area in Myanmar, Engineering Access, 2022, vol. 8, No. 1
[19] EC Thom. The discomfort index. Weatherwise. 1959;12:57–60. doi: 10.1080/00431672.1959.9926960.
[20] B.D. Giles, C.H. Balafoutis, & P. Maheras, Too hot for comfort: the heatwaves in Greece in 1987 and 1988. International Journal of Biometeorology, 1990, 34, 98–104.
[21] Lemke and Kjellstrom, (2012). Calculating Workplace WBGT from Meteorological Data: A Tool for Climate Change Assessment, Industrial Health 2012, 50, 267–278
[22] I. Logothetis, C. Antonopoulou, K. Sfetsioris, A. Mitsotakis, P. Grammelis, Comparison Analysis of the Effect of High and Low Port Activity Seasons on Air Quality in the Port of Heraklion. Environ. Sci. Proc. 2021, 8, 3. https://doi.org/10.3390/ecas2021-10329
[23] Rizos K., Logothetis I., Koukouli M.E., Meleti C., Melas D. The influence of the summer tropospheric circulation on the observed ozone mixing ratios at a coastal site in the Eastern Mediterranean, Atmospheric Pollution Research, Volume 13, Issue 4, 2022, https://doi.org/10.1016/j.apr.2022.101381
[24] G. Kouvarakis, H. Bardouki, N. Mihalopoulos,Sulfur budget above the Eastern Mediterranean: relative contribution of anthropogenic and biogenic sources, Tellus B: Chemical and Physical Meteorology, 2002, 201, 212,54, 3. https://doi.org/10.3402/tellusb.v54i3.16661