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Examination of air pollutants and their risk for human health in urban and suburban environments for two Romanian cities: Brasov and Iasi☆

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ABSTRACT

To detect the spatial differences of atmospheric pollutants in urban and suburban areas is important for observing their aspects on regional air quality, climate, and human health. This study is focused on the evolution of $PM_{2.5}$, PM_{10}, NO_x and SO_2, concentrations, and meteorological parameters from 2010 to 2022, at urban and suburban area in the two Romanian city: Brasov and Iasi. The daily patterns of most pollutants in urban and suburban areas, are strongly linked to land-traffic emissions. The seasonal differences were observation of the studied air pollutants displays visible decreasing in warm period and increased concentrations in cold period. Significant higher (25%- Brasov, 28%- Iasi) PM_{10} were found in urban area concentration probably caused by enhanced vehicular emissions over these areas induced by urban planning and mobility policies. The average relative risk caused by PM_{10} for all-cause mortality in the urban region was 1.021 (±0.004) in Brasov, and significantly higher in Iasi 1.030 (±0.005). In suburban regions this risk was lower with 33 % 1.014 (±0.006) in Brasov and 30 % 1.021 (±0.003) in Iasi. The main objective of this research was to identify the difference of air pollutants and meteorological parameters in the urban and suburban region of the studied city.

1. Introduction

Atmospheric pollution is the first topic related to the environmental issues what need to be mitigate and resolve in our continuously developed century. Airborne particles are a well-done studied air pollutants and several negative effects are associated to them, as increased morbidity and mortality [1–5]. Similar to the PM, exposure to NO_x and SO_2 can induce several cardiovascular and lung diseases, premature deaths, and carcinogenic effects [6–9]. In addition, these atmospheric pollutants may also have a negative effect on the ecosystems and the agriculture productivity [1,10]. Furthermore, damages its built heritage and are related to the climate change to Refs. [11–13]. The incised level of pollutants concentration are related to the evaluated urbanization level in Romania increased from 34,21 %- to 54,33 % in the last 60 years (1960–2020) [14].

☆ Key air pollution, urban, suburban, meteorological parameters.

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Due to the swift growth in urbanization, it led to a speedy expansion of urban regions [15]. The atmospheric factors also have a notable impact on the fluctuation of air contaminants levels in both urban and suburban areas [16,17]. The rapid progress of urbanization has resulted in a speedy growth of urban infrastructure. In recent years due he massive consumption of fossil fuels has resulted a fast increase in anthropogenic aerosols concentration [15]. Especially in the cold period, where in many cities a frequently fog are present, the particulate matter concentration are very high [3,18]. The lifting condensation level also influence the particulate matter distribution in the lower level of the troposphere [3,15]. The main objective of the present study is to highlight the differences of air pollutants and meteorological parameters between the urban and suburban environment.

2. Material and methods

2.1. Sapling site

From the studied cities Brasov is located at an average altitude of 625 m and is situated in the Bârsei depression, in the curvature of the Carpathians. The climate of Brasov is a transitional temperate continental climate with some oceanic influences [19]. On the other hand, Iasi is a city in eastern Romania, close to the border with Moldova, with a pronounced continental climate with an average altitude of 60 m [20].

The geographical location of the studied two cities is presented in Fig. 1.

2.2. Monitoring network and data availability

Daily data of $PM_{2.5}$, PM_{10}, NO_x, SO_2, from 2010 to 2022 were analyzed, revalidated, and used in this study. Based on the criteria included in the European Directive [21], the monitoring sites used in this work are classified as urban and suburban and rural. The daily average concentration was calculated from the hourly concentrations.

The studied monitoring station data were centralized in Table 1. The availability of the monitoring stations data reached 75 % in all cases and therefore allowed averaging. In the case of each city only one suburban monitoring station was available. In the results presentation the urban and suburban background environments will be referred to as U and SU respectively.

2.3. Monitoring techniques and data quality

Air quality measurements performed in Romania are in concordant with the European directives [21]. The studied parameters were determined according to the following reference methods: gravimetric method for $PM_{2.5}$ and PM_{10} concentrations [22]; NO_x by chemiluminescence [23]; SO_2 by ultraviolet fluorescence [24]. The data were received from the National Air Quality Monitoring Network [25].

The first normality test was carried out using the Kolmogorov-Smirnov test in SPSS statistics, and for the normal distribution data was used two sample *t*-test, and for the not normal distribution the Mann–Whitney *U* test was applied in order to find the differences between the urban and suburban area.

From the meteorological parameters: daily air temperature, precipitation quantity, relative humidity and the lifting condensation

Fig. 1. Sampling site location on the Romanian map.

Table 1
The studied monitoring station detail.

Studied city	Monitoring station name	Types	Latitude	Longitude	Altitude, m	Emission types
Brasov	BV-1	urban	46.64	25.63	600	Traffic
	BV-2	urban	46.65	25.58	570	Fond
	BV-3	urban	46.66	25.62	565	Traffic
	BV-4	suburban	45.72	25.62	518	Fond
	BV-5	urban	46.65	25.63	580	Industrial
Iasi	IS-1	urban	47.16	27.57	40	Traffic
	IS-2	urban	47.15	27.58	42	Fond
	IS-3	urban	47.16	27.61	64	Industrial
	IS-4	rural	47.21	27.61	186	Fond
	IS-5	suburban	47.14	27.69	37	Fond

was followed up. The monthly average meteorological parameters were calculated from the daily data, except the precipitation quantity, where the summarized monthly values were used. The lifting condensation level (LCL) was determine based on the following equations (Equations (1) and (2)):

$$LCL = z^0 + 125 * (T - T_d) \tag{1}$$

$$T_d = T - (100 - RH)/5 \tag{2}$$

where the: LCL-lifting condensation level, T-air temperature (°C), RH- relative humidity (%), z^0 altitude, T_d- dew point temperature [26,27].

2.4. *Health risk assessment methodology for short-term effect of PM_{10}*

To evaluate the short-term exposure to PM_{10}, the relative risk (RR) for all-cause mortality was established by Ostro in Equation (3) [28]. The relative risk for all-cause death was calculated if the PM_{10} concentration was higher than the background level (10 g m^{-3}). As the risk function coefficient 0.008 was used (95 % CI: 0.0006–0.0010).

$$RR = exp[\beta(X - X_0)] \tag{3}$$

where: X represents the background PM_{10} concentration (10 g m^{-3}), X_0 the yearly mean PM_{10} concentration (g m^{-3}), and the risk function coefficient.

2.4.1. *Health risk assessment methodology for short-term effect of $PM_{2.5}$*

Equation (4) was used to determine the relative risk of lung cancer and cardiopulmonary disease deaths in people over 30 [28].

$$RR = [(X + 1)/(X_0 + 1)]\beta \tag{4}$$

where: X represents the annual mean concentration of $PM_{2.5}$ (μg m^{-3}), X_0 is the background concentration of $PM_{2,5}$ (3 μg m^{-3}), and β is the risk function coefficient. The applied β coefficients for the cardiopulmonary and lung cancer mortality were 0.15515 (95 % CI: 0.0562–0.2541) and 0.23218 (95 % CI: 0.08563–0.37873), respectively.

3. Result and discussion

3.1. *Descriptive statistics*

In order to represent the differences between urban and suburban air pollution and meteorological indicators, the averages values have been recorded in Table 2. The urban environment is the dominant source of $PM_{2.5}$, PM_{10}, NO_X and SO_2, mostly due to vehicular emissions. The differences between the urban and suburban region were obvious. In the case of the studied two cities in Brasov and Iasi the PM_{10} concentration measured in the urban environment was higher with 32 % and 41 %, respectively compared to the suburban level. One $PM_{2.5}$ measurement station was available for each city, so we were unable to detect differences between urban and suburban environments but the difference between the $PM_{2.5}$ and PM_{10} between the two studied city are significant: $PM_{2.5}$ concentration higher with 27 % in Iasi compared to the Brasov city. In the case of Brasov, a difference of 7.5 % in SO_2 concentrations was observed between the two different locations, the higher value was in the urban region, and the lower in the suburban. The most significant differences were found in the case of NO_x concentration, where difference was 4.4 (Brasov) and 2.8 (Iasi) times higher (Table 2.).

In the case of the studied meteorological parameters small differences were detected: higher air temperature in the urban area, on average 0.6–0.8 °C differences in the multiannual yearly concentration. These differences are related to the urban heat island effect caused by concrete blocks.

The average relative humidity was higher in the case of suburban areas in Brasov with 17.31 % as in urban area. In Iasi the opposite trend was observed.

Table 2
Multiannual and seasonal average (2010–2022) concentrations of $PM_{2.5}$, PM_{10}, NO_x, SO_2, (mg m^{-3}) at U (urban) and SB (suburban) environments.

	Multiannual				Spring				Summer				Autumn				Winter			
	BV-U	BV-SU	IS-U	IS-SU	BV-U	BV-SU	IS-U	IS-SU	BV-U	BV-SU	IS-U	IS-SU	BV-U	BV-SU	IS-U	IS-SU	BV-U	BV-SU	IS-U	IS-SU
$PM_{2,5}$, μg m^{-3}	17.39		22.09		13.43		22.26		12.44		16.76		16.4		22.12		26.7		27.2	
PM_{10}, μg m^{-3}	27.69	21.01	38.21	27.14	25.2	17.74	40.31	25.52	22.73	16.02	34.23	26.31	29.18	22.04	40.27	29.09	33.95	27.67	38.26	27.71
SO_2, μg m^{-3}	5.97	5.55	4.72	4.66	5.48	5.53	4.56	4.45	5.22	4.97	4.07	3.95	6.52	5.55	4.6	4.46	6.52	5.66	5.65	5.58
NO_x, μg m^{-3}	76.19	17.45	52.31	18.89	59.98	13.83	45.67	16.69	42.76	13.01	33.65	13.62	86.2	20.22	61.08	21.01	115.8	26.24	68.25	26.26
T, *°C*	10.85	10.06	12.63	11.17	10.79	10.15	13.02	10.98	21.1	20.5	24.12	21.87	11.15	10.46	12.73	11.4	0.68	−0.49	1.01	−0.26
RH, *%*	70.19	82.34	79.68	73.59	63.57	77.33	74.35	68.66	67.3	78.44	73.57	68.32	74.14	85.05	82.14	76.61	78.96	87.43	88.74	84.51
Prec, *mm/year*	514	506	373	375	159	156	108	84	189	207	132	138	96	69	84	72	72	42	51	84
LCL, *m*	726	446	506	639	911	564	641	783	815	540	659	789	653	373	446	584	529	311	281	388

3.2. Normality test

According to the Kolmogorov-Smirnov normality test where the significance level was lower than 0.05 the following studied parameters show not normal distribution: relative humidity in both cities, SO_2 in Brasov suburban and Iasi urban area, and NO_x and PM_{10} in Iasi urban and suburban area (Table 3.).

3.3. Mann-Whitney U test and two sample t-test

According to the Mann-Whitney *U* test and two sample t-tests, the differences between the urban and suburban area were quantitatively detected in both studied cities. After the results in case of the following parameters was found differences between the urban and suburban area in both studied city: NO_x, PM_{10}, SO_2, RH, and air temperature. In Iasi the precipitation quantity did not vary significantly between the urban and suburban region. In Brasov only the precipitation shows differences (Table 4.).

3.4. Temporal variation of the air pollutants

In Fig. 2 the multiannual air pollutant concentration was plotted. As the $PM_{2.5}$ trends show a slowly decreasing trend are found in Brasov and slowly increased trend in Iasi. In the case of PM_{10} concentration the maximum concentrations were measured in 2012 and in 2018. The concentration in Iasi suburban is in closer to the Brasov urban level. According to the WHO guideline the annually acceptable limits for PM_{10} is fixed in the 20-μg m^{-3}. Except for the Brasov sub-urban region, this limit value was broken every year in Iasi and the urban region of Brasov.

The SO_2 concentration in Iasi was not varied significantly in Iasi (1.18 %), both on the other side in Brasov significant variation was detected between the two monitoring station types (7.4 %). Based on the NO_x concentration huge concentration differences were found. The suburban station trends show very similar trends in the two cities, both in case of the urban site cumulative in the 5 years the differences between the two studied sites were 2.27. In 2015, the same concentrations were measured, and in the last 7 years the differences are 1.2 times. Between the meteorological parameters the air temperature, the relative humidity and the precipitation quantity was followed up. In the case of the temperature on average in the urban area with 0.8 °C (Brasov) and 1.5 °C (Iasi) were higher than in suburban region. In the case of the relative humidity in the suburban area was detected higher relative humidity values on average 17.31 % in Brasov (Fig. 3.).

3.5. Box plot analysis

The air pollutant concentration shows a very high seasonal difference. In the urban region the maximum monthly average concentration of NO_x was detected in the winter, and the minimum values in summer. The differences between the cold and the warm period concentration varied approximately 3 times in the case of Brasov and 2 times higher in case of Iasi. In suburban region the

Table 3
Normality test.

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
NO_X BV-U	0.142	58	0.005	0.91	58	0
NO_X BV-SU	0.143	58	0.005	0.915	58	0.001
PM_{10} BV-U	0.161	58	0.001	0.768	58	0
PM_{10} BV-SU	0.158	58	0.001	0.792	58	0
Prec BV-U	0.12	58	0.038	0.908	58	0
Prec BV-SU	0.243	58	0	0.627	58	0
Prec IS-U	0.137	58	0.009	0.872	58	0
Prec IS-SU	0.201	58	0	0.772	58	0
RH BV-U	0.075	58	**.200***	0.967	58	0.112
RH BV-SU	0.081	58	**.200***	0.977	58	0.324
SO_2 BV-U	0.067	58	**.200***	0.98	58	0.469
SO_2 BV-SU	0.164	58	0.001	0.894	58	0
T BV-U	0.107	58	0.095	0.948	58	0.015
T BV-SU	0.118	58	0.043	0.959	58	0.048
NO_x IS-U	0.097	58	**.200***	0.97	58	0.157
NO_x IS-SU	0.069	58	**.200***	0.985	58	0.706
PM_{10} IS-U	0.101	58	**.200***	0.96	58	0.054
PM_{10} IS-SU	0.095	58	**.200***	0.939	58	0.006
RH IS-U	0.084	58	**.200***	0.969	58	0.149
RH IS-SU	0.067	58	**.200***	0.982	58	0.564
SO_2 IS-U	0.055	58	**.200***	0.978	58	0.391
SO_2 IS-SU	0.121	58	0.035	0.857	58	0
T IS-U	0.114	58	0.06	0.935	58	0.004

Table 4
Statistical -test results.

Null Hypothesis	Methods	Sig./Critic/Calculated value	Decision
The distribution of **NO_X BV** is the same across categories (Urban, suburban)	Mann-Whitney *U* test	***0.00***	***Reject the null hypothesis***
The distribution of **NO_X IS** is the same across categories (Urban, suburban)	Two sample *t*-test	***1.97/16.75***	***Reject the null hypothesis***
The distribution of **PM_{10} BV** is the same across categories (Urban, suburban)	Mann-Whitney *U* test	***0.00***	***Reject the null hypothesis***
The distribution of **PM_{10} IS** is the same across categories (Urban, suburban)	Two sample *t*-test	***1.96/11.83***	***Reject the null hypothesis***
The distribution of **SO_2 BV** is the same across categories (Urban, suburban)	Mann-Whitney *U* test	***0.00***	***Reject the null hypothesis***
The distribution of **SO_2 BV** is the same across categories (Urban, suburban)	Two sample *t*-test	***1.96/2.42***	***Reject the null hypothesis***
The distribution of **SO_2 IS** is the same across categories (Urban, suburban)	Mann-Whitney *U* test	***0.01***	***Reject the null hypothesis***
The distribution of **SO_2 IS** is the same across categories (Urban, suburban)	Two sample *t*-test	***1.96/11.83***	***Reject the null hypothesis***
The distribution of **Prec BV** is the same across categories (Urban, suburban)	Mann-Whitney *U* test	***0.02***	***Reject the null hypothesis***
The distribution of **Prec IS** is the same across categories (Urban, suburban)	Mann-Whitney *U* test	0.534	Retain the null hypothesis
The distribution of **RH BV** is the same across categories (Urban, suburban)	Two sample *t*-test	1.96/9.20	***Reject the null hypothesis***
The distribution of **RH IS** is the same across categories (Urban, suburban)	Two sample *t*-test	1.96/3.78	***Reject the null hypothesis***
The distribution of **T BV** is the same across categories (Urban, suburban)	Mann-Whitney *U* test	***0.04***	***Reject the null hypothesis***
The distribution of **T IS** is the same across categories (Urban, suburban)	Mann-Whitney *U* test	***0.036***	***Reject the null hypothesis***

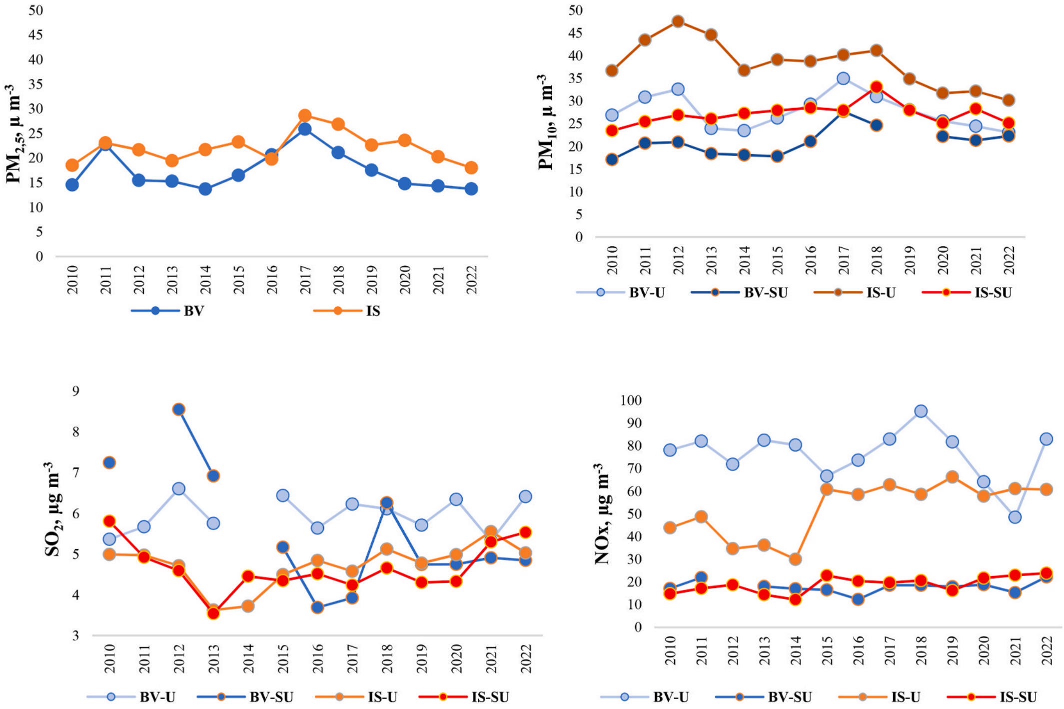

Fig. 2. Annually concentration of air pollutants in urban and suburban region.

concentration variation was smaller (Fig. 4.). In the urban environment, the dominant source of NOx is high, mainly due to vehicle emissions. The NO_x concentration shows a significantly higher level in Brasov compared to the Iasi urban sites and was quite similar in the two suburban regions. On average, 62 % (Iasi) and 74 % (Brasov) of the urban concentrations of NO_x are due to city emissions (Fig. 4.).

Based on the $PM_{2.5}$ concentration the maximum concentration was measured in the winter period, and the minimum in summer period (Fig. 5.).

The differences between the cold and the warm period $PM_{2.5}$ concentration were in Brasov 1.7 times and 1.6 times in Iasi. In the transition seasons the concentrations were almost identical.

Likewise, the urban region is an active source of PM_{10}, as 25.8 % (Brasov) and 28.6 % (Iasi) of the PM_{10} concentrations measured in the city are produced within the urban area. The concentration fluctuation (the ration between the minimum and maximum concentration evaluation during the year) over the seasons was 1.52 (Iasi) and 1.7 (Brasov) times in the urban area, and 1.4 (Iasi) and 2.4 (Brasov) in the suburban zone (Fig. 6.).

Less marked is the urban increase of SO_2, only 2 % (Iasi) and 8 % (Basov) higher than in the urban site (Fig. 7.). Among the meteorological parameters, air temperature, relative humidity and precipitation were measured.

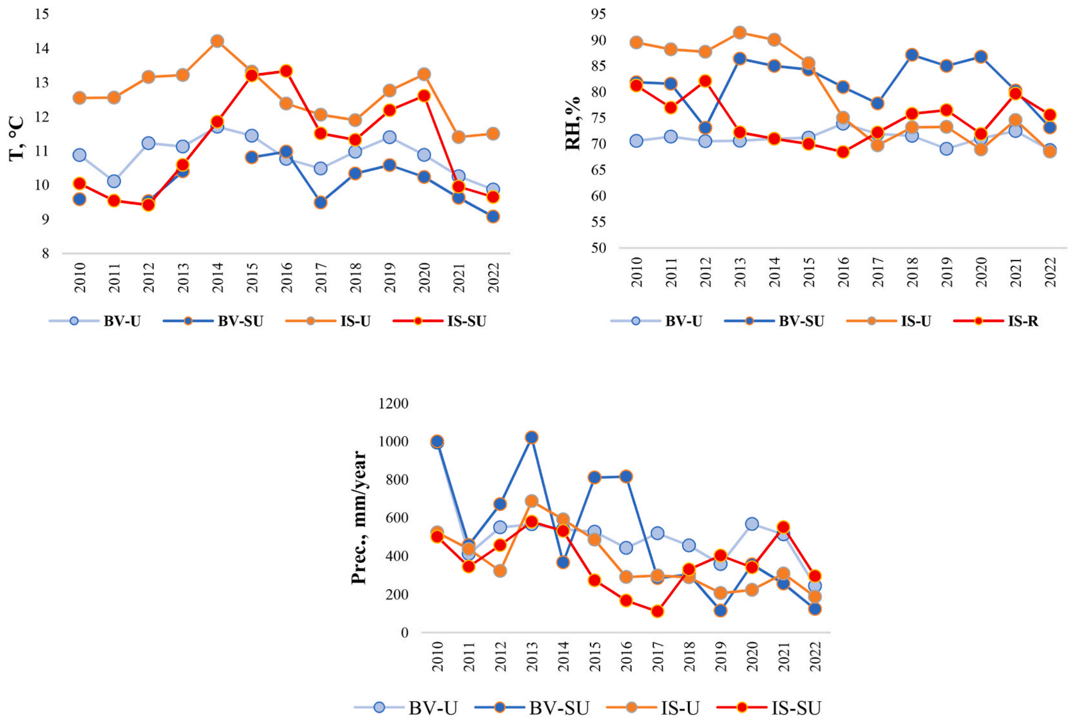

Fig. 3. Annually evaluation of meteorological parameters in urban and suburban region.

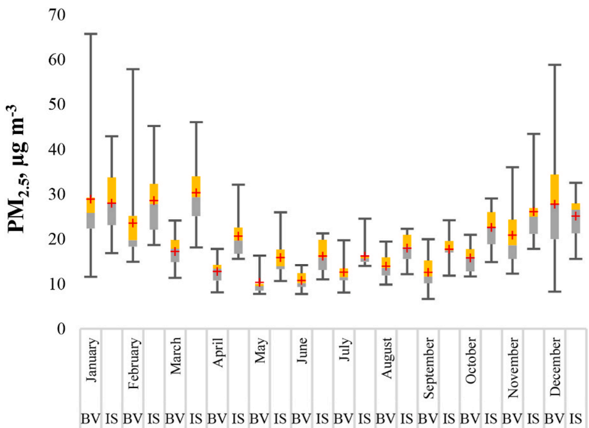

Fig. 4. Multiannual monthly box-plot analysis of the NO_x concentration.

As shown in Fig. 8 the annual distribution of precipitation shows an uneven distribution, with the highest precipitation occurring in the spring months and June, when a large proportion of the annual precipitation falls, especially in Iasi 38 % and in Brasov 44 % from the annually quantity was falls at this time. The driest months of the year can be placed in the winter period.

The monthly average air temperature is higher in urban regions with 0.7 °C in Brasov and 2 °C in Iasi in warm period, and similar 1 °C differences were detected in the cold period (Fig. 9.).

The relative humidity distribution shows the opposite trend compared to the air temperature, lower level in summer and higher level in wintertime. In the case of Iasi, the relative humidity was 74 % and 69 % in warm period, and 88 % and 83 % in cold period in urban and suburban region, respectively. In the case of Brasov, the relative humidity was 66 % and 77 % in warm period, and 80 % and 88 % in cold period in urban and suburban region, respectively (Fig. 10.).

The lifting condensation level shows a huge fluctuation over the season (Fig. 11).

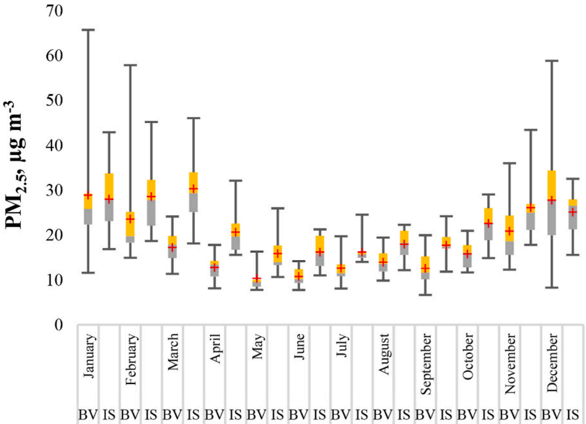

Fig. 5. Multiannual monthly box-plot analysis of the $PM_{2.5}$ concentration.

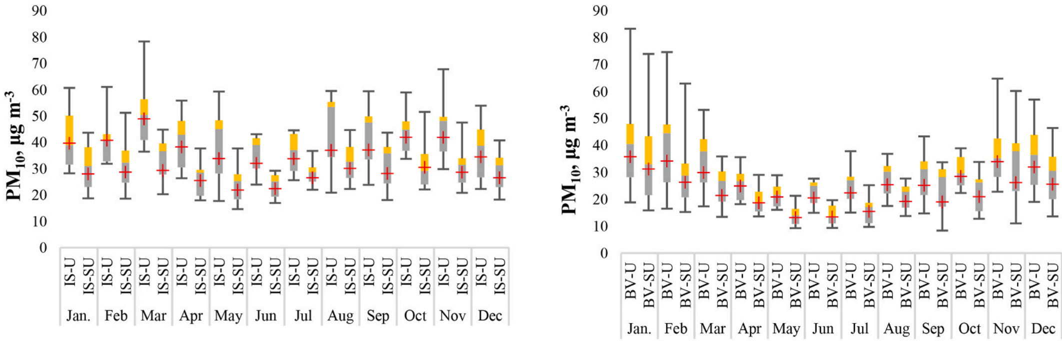

Fig. 6. Multiannual monthly box-plot analysis of the PM_{10} concentration.

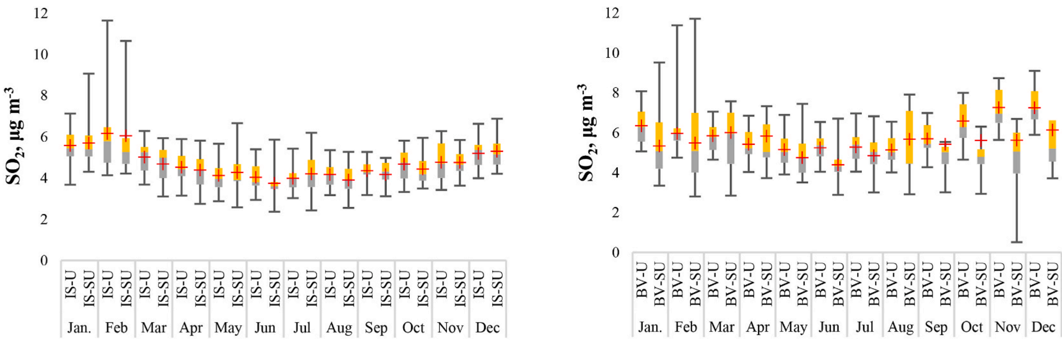

Fig. 7. Multiannual monthly box-plot analysis of the SO_2 concentration.

3.6. Relative risk calculation

The relative risk (RR), were calculated for all-cause mortality in case of the Iasi and Brasov urban and suburban region, separately using the average yearly PM_{10} concentration. The average relative risk caused by PM_{10} for all-cause mortality in the urban region were 1.021 (±0.004) in Brasov, and significantly higher in Iasi 1.030 (±0.005). In suburban region this risk was lower with 33 % 1.014 (±0.006) in Brasov and 30 % 1.021 (±0.003) in Iasi (Table 5.).

Also, high relative risk for cardiopulmonary disease observed which is mainly attributed to $PM_{2,5}$ exposure; according to the average values, the relative risk was 1.26 (±0.04) in Brasov and 1.31 in Iasi (±0.03), in respectively (Table 2). For the cancer risk the following relative risk values were detected: 1.42 in Brasov and 1.5 in Iasi.

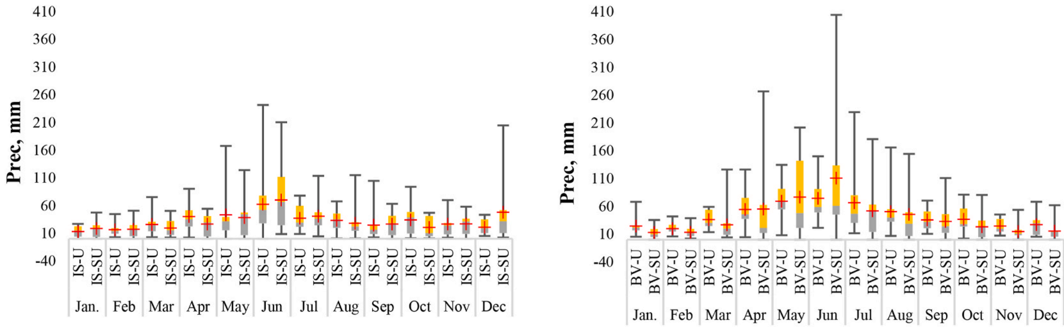

Fig. 8. Multiannual monthly box-plot analysis of the monthly summarized precipitation quantity.

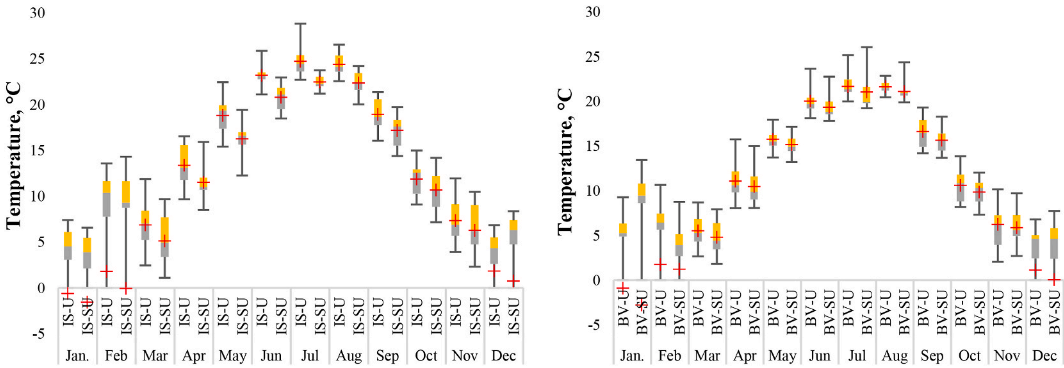

Fig. 9. Multiannual monthly box-plot analysis of the monthly air temperature.

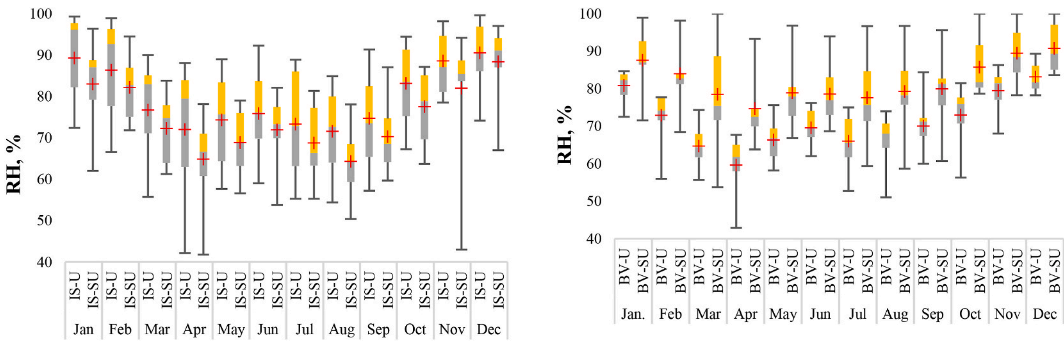

Fig. 10. Multiannual monthly box-plot analysis of the relative humidity distribution based on the monthly relative humidity distribution.

3.7. Spearman correlation analysis

Based on the samples size the significant correlation level was fixed: ±0.4. Spearman correlation analysis the following significant correlation coefficient were detected in Brasov: significantly higher correlation coefficient was found between the air pollutants: $PM_{2.5}$-PM_{10} ($r = 0.77$ urban, $r = 0.72$ suburban) The particulate matter concentration shows strong positive correlation with the NO_x and SO_2 in urban areas. Negative correlations were found between the air pollutants and precipitation quantity and air temperature (Fig. 12.). The correlation level was higher in urban sites, thanks to the intense emission from the traffic.

In Iasi the correlation level between the studied parameters shows significantly in case of $PM_{2.5}$-NO_x ($r = 0.62$-urban, $r = 0.48$-suburban). Between the $PM_{2.5}$ and PM_{10} the same correlation coefficient was found $r = 0.53$ (Fig. 13.).

4. Conclusion

In this research a 11-year database of different air quality parameters and meteorological data has been investigated to find the differences between the urban and suburban environment. The PM_{10} concentration was 25 % higher in urban areas compared to the

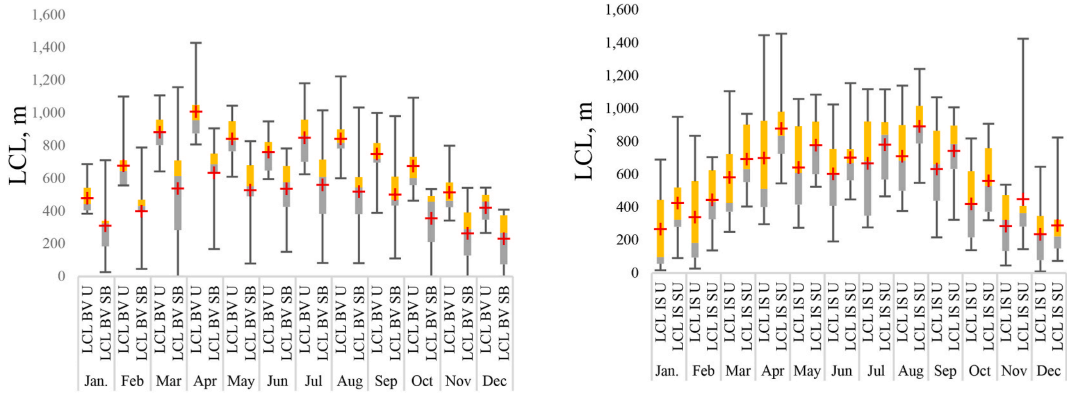

Fig. 11. Multiannual monthly box-plot analysis of the lifting condensation level distribution.

Table 5
Relative risk calculation for PM_{10} and $PM_{2.5}$.

	Relative risk for all ages due to PM_{10} for all-cause mortality				Relative risk for age >30 years due to $PM_{2.5}$ for cardiopulmonary disease		Relative risk for age >30 years due to $PM_{2.5}$ for lung cancer disease	
RR	**BV-U**	**BV-SU**	**IS-U**	**IS-SU**	**BV-SU**	**IS- SU**	**BV-U**	**IS-U**
2010	1014	1006	1022	1011	1.23	1.28	1.37	1.44
2011	1025	1017	1035	1021	1.32	1.32	1.51	1.52
2012	1026	1016	1038	1021	1.25	1.31	1.39	1.5
2013	1018	1014	1035	1.02	1.24	1.29	1.38	1.46
2014	1018	1014	1029	1021	1.22	1.31	1.35	1.5
2015	1.02	1014	1031	1022	1.26	1.32	1.41	1.52
2016	1023	1016	1031	1022	1.3	1.29	1.48	1.47
2017	1028	1022	1032	1022	1.34	1.36	1.56	1.59
2018	1024	1019	1033	1026	1.3	1.35	1.49	1.57
2019	1022	1	1027	1022	1.27	1.32	1.43	1.51
2020	1.02	1017	1025	1019	1.24	1.33	1.37	1.52
2021	1019	1016	1025	1022	1.23	1.3	1.37	1.47
2022	1018	1017	1024	1019	1.22	1.27	1.35	1.44
Avrg	**1021**	**1014**	**1.03**	**1021**	**1.26**	**1.31**	**1.42**	**1.5**
stdev	0.004	0.006	0.005	0.003	0.04	0.03	0.067	0.046

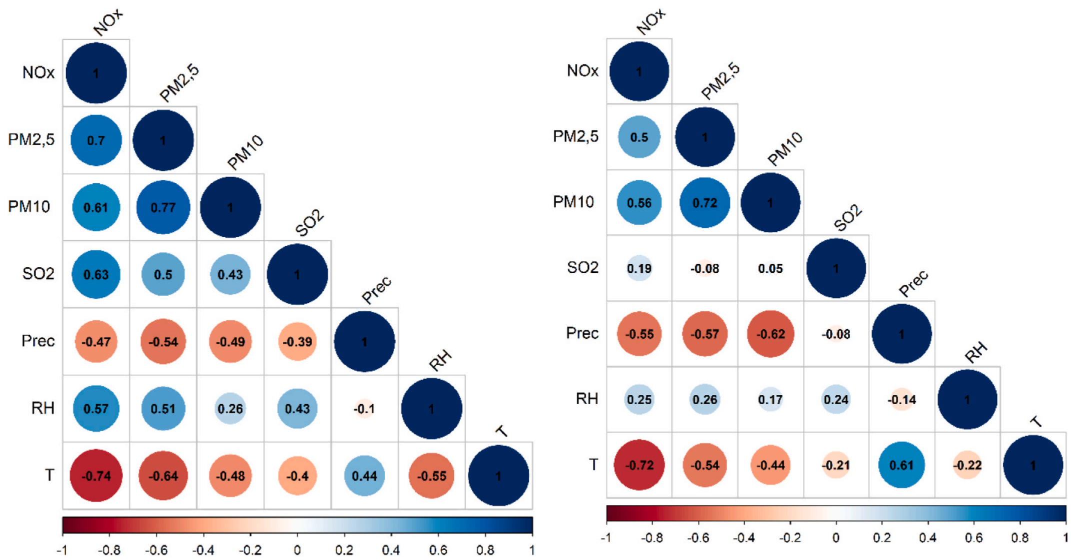

Fig. 12. Spearman correlation matrix of the studied parameters in Brasov urban and suburban region.

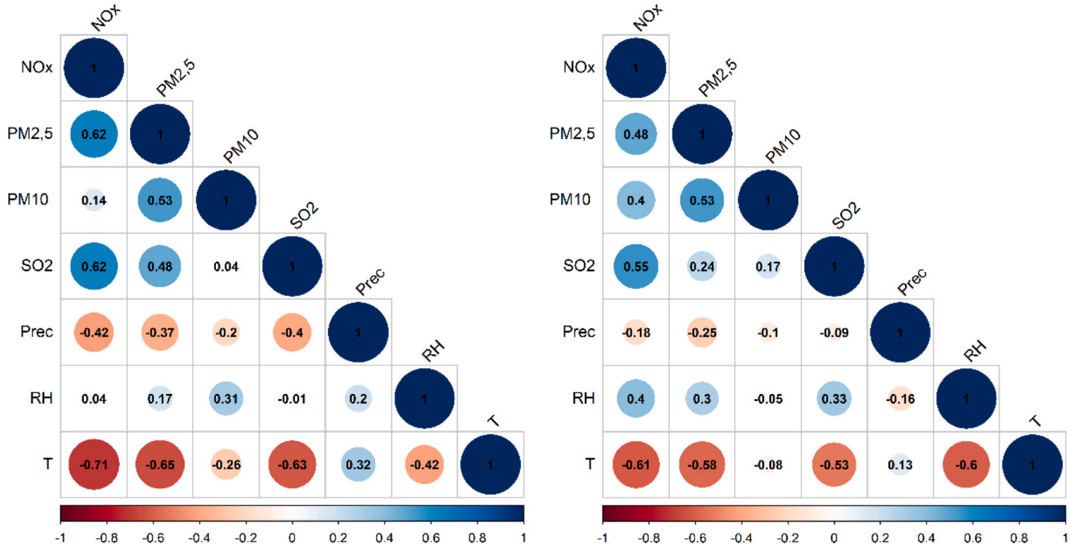

Fig. 13. Spearman correlation matrix of the studied parameters in Iasi urban and suburban region.

suburban region. The air pollutant concentration shows a very variable trend over the year: maximum concentration was measured in the winter period, and the minimum in summer period. The differences between the two cities are evident. The higher concentration of air pollutants in Iasi are related to the geopolitical location, are bordered with the non-EU member, where the Air pollution Directives are not applied yet.

The calculated relative risk in urban areas was 33 % part higher than in the suburban region. The annual distribution of precipitation shows an uneven distribution, with the highest precipitation occurring in the spring months and in June. Trend calculations reflect a clear improvement of the air quality in Iasi Urban environments, with a considerably drop of PM_{10} concentrations. Due to increased exposure to road traffic emissions as a result of urban development rules and mitigation methods, this decreased tendency is less noticeable in suburban areas. Due to the high levels of emissions from transportation, the correlation level was higher in urban areas.

The industry operates in accordance with the standards of the European Union, but due to Romania's specific climate and construction structure, it has not been able to solve the transport problem. The suburban zone near the big cities of Romania is combined with the industrial zone and agricultural areas. In Romania, many suburban areas are heated with biomass, and in the poorer parts they even cook with it. In the case of Brasov and Iasi, due to the exceeding of PM and NO_X concentrations, an obligation procedure was initiated against Romania.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Bodor Katalin: Conceptualization, Formal analysis, Investigation, Methodology, Resources, Validation, Writing – original draft. **Róbert Szép:** Methodology, Validation. **Zsolt Bodor:** Conceptualization, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – review & editing.

Declaration of competing interest

I, Zsolt Bodor the Corresponding Author, declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

I can confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. I further confirm that the order of authors listed in the manuscript has been approved by all of us.

I understand that the Corresponding Author is the sole contact for the Editorial process and is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

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Ethics declarations

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