Original Research

Analysis of Variability in PM_{10} Concentration in the Wrocław Agglomeration

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Abstract

Our research was designed to analyze the variability in PM_{10} concentrations in the Wrocław area from January 2008 to February 2010, and to relate the findings to the existing meteorological and terrain conditions. To this end, five measurement stations were located in places with distinctive environmental features. Stations used the TEOM 1400a gravimetric analyzer and the manual reference method. The distinction between warm and cold seasons also was made based on start and end dates of heating periods. Finally, the thorough analysis of observed fluctuations in PM_{10} was produced. This includes tabulating the data, establishing a correlation and, most importantly, presenting descriptive statistics. Moreover, the statistical analysis was extended to variability and correlation analysis. The figures revealed that there exists the spatial variation of PM_{10} concentrations throughout the year, and analysis showed similar dynamics of the PM_{10} concentrations. The highest annual average PM_{10} concentration was noted at one of the stations and was associated with numerous exceedings of the limit value. The analyzed stations show a high correlation during the cold period of the year (0.71-0.95). Coefficients were significant at the 0.99 confidence level. The value of coefficient of divergence ranged from 0.053 to 0.613 and indicated the sources of PM_{10} emission. A positive relationship was observed between PM_{10} concentration and, e.g., atmospheric pressure (0.40), and in the warm season, average daily air temperature (0.36); but a negative relationship was observed between PM_{10} concentration and, i.e., the average daily speed of the wind (-0.56), and during the cold period, the average daily air temperature (-0.56). In support of this claim, the following article discusses select examples of the interdependence between terrain characteristics and PM_{10} variations.

Keywords: PM_{10}, air pollution, meteorological and terrain conditions, Wrocław

Introduction

Particulate matter (including PM_{10}) is one of the most dangerous air pollutants, as it can cause risks to human health and life [1-3]. It has been reported that a high concentration of PM_{10} has an adverse effect on the respiratory system, which functions as the first protective barrier during exposure. Worse still, particulate matter (including toxic components) can be transported in the blood, and therefore seriously affect the functioning of the whole body, especially the vascular system. Such effects include cancer, heart complaints, and respiratory diseases [4]. High-risk groups include children, elderly people, and patients suffering from prolonged exposure to PM_{10} [5-7].

The highest emission rate of PM_{10} is observed in densely populated sites with many natural or anthropogenic contamination sources [8]. Thus, a national measuring network has been designed to control the level of PM_{10} in urbanized

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Table 1. Description of PM_{10} measuring stations in the Wrocław area.

Station	Location	Description	
S1	Wierzbowa Street 51º11' N 17º03' E	Voivodship Inspection for Environmental Protection in Wrocław	Station located in the city center, main sources of emission: road transport, individual heating system
S2	Orzechowa Street 51º08' N 17º04' E		Station situated in housing estate, limited influence of low-emission
S3	Wiśniowa Avenue 51º05' N 17º00' E		Station of urban transport, main sources of emission: road transport, individual heating system
S4	Wybrzeże Conrada-Korzeniowskiego 51º07'N 17º01' E		Station of city background, main sources of emission: road transport
S5	Kosiby Street 51º07'N 17º05'E	Department of Climatology and Atmosphere Protection (University of Wrocław)	Station situated in area of detached houses, allotments and park, main sources of emission: individual heating system, road transport

areas. According to numerous studies, there is a significant relationship between PM_{10} concentration, weather, and terrain conditions due to land use and urban structure [1, 9, 10].

The main aim of this article is analyzing the temporal and spatial variability of PM_{10} concentrations in the Wrocław area depending on weather and terrain conditions. Moreover, the issue of representativeness of the research stations in the city area is highlighted.

Description of Measuring Stations

Wrocław is the largest city in southwestern Poland where the emission of PM_{10} is estimated to constitute 11% of the entire emission in Lower Silesia Province. The highest pollutant load is produced at surface sources (so-called low-emission), whereas a lower pollutant load is produced at point and linear sources. It has been reported that the largest amounts of the pollutant are discharged by Zespół Elektrociepłowni Wrocławskich Kogeneracja S.A. However the emission from this combined heat and power station doesn't significantly affect local air quality, unless specific meteorological conditions exist (e.g. depth of an inversion layer larger than the chimney tower height, intense convection).

The specific climate in the city is attributed to both Wrocław`s geographic characteristics and the effects of an urban heat island [11]. On account of poor air quality, the Wrocław Agglomeration has joined the Air Quality Plan. The scheme was established according to the principles of the CAFE Directive (2008/50EC), which determines the acceptable levels of daily pollution.

During a set period (January 2008-February 2010) the data were collected at four stations of Voivodship Inspection for Environmental Protection in Wrocław placed in different city areas (Wierzbowa Street – S1, Orzechowa Street – S2, Wiśniowa Avenue – S3, Wybrzeże Conrada – Korzeniowskiego – S4). At the same time, automatic continuous PM_{10} measurements were conducted in the stations of Wrocław University (Kosiby Street – S5) (Table 1).

Material and Methods

In brief, PM_{10} was sampled according to the manual method (stations S1-S4) and the gravimetric method – using the TEOM 1400a Rupprecht & Pataschnick analyzer (station S5). The PM_{10} data were standardized, and the natural logarithm (ln) was used for correlation analysis. The impact of weather conditions was assessed on the basis of meteorological data: T [ºC] (air temperature), U [%] (relative humidity), V [$m \cdot s^{-1}$] (wind speed), DIR [0-32] (wind direction), R [mm] (precipitation), and P [hPa] (atmospheric pressure), which were collected at the Meteorological Observatory of Wrocław University. The synoptic data were downloaded from *www.wetterzentrale.de*. The vertical structure of the atmosphere was determined by means of the atmospheric soundings, which were conducted at the station in the Institute of the Meteorology and Water Management (IMGW) in Wrocław (*www.weather.uwyo.edu/upperair/sounding.html*).

The daily data concerning PM_{10} concentrations at stations belonging to the Voivodship Inspection for Environmental Protection in Wrocław and the Meteorological Observatory of Wrocław University were used to compare the variability of PM_{10} within the city network.

In the analysis, the following descriptive statistics for each measurement point were calculated: annual concentrations, maximum daily concentration and date of the maximum daily concentration, and the numbers of days where the PM_{10} concentration exceeded the daily limit value of 50 $\mu g \cdot m^{-3}$.

In order to conduct additional statistical analysis for each measurement point, the year was divided into warm (May-September) and cold seasons (October-April) on the basis of start and end dates of the heating seasons. For each period average, 98^{th} percentile, maximum, and minimum concentrations of PM_{10} were calculated. In order to explain the variability between the stations, the analysis of variance and its coefficiency have been presented. Moreover, the completeness of data was indicated. In 2009 and 2010 at stations S2 and S4 monitoring measurements were not taken because of maintenance work and temporary suspension of station operation.

Table 2. The descriptive statistics of PM_{10} concentrations at the stations owned by Voivodship Inspection for Environmental Protection in Wrocław and the Department of Climatology and Atmospheric Protection (the University of Wrocław).

Station / Criterion	Voivodship Inspection for Environmental Protection in Wrocław								The Department of Climatology and Atmospheric Protection (the University of Wrocław)	
	S1		S2		S3		S4		S5	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Annual average (μg·m^{-3})	34.9	41.2	17.1	×	35.4	×	15.2	×	25.9	28.7
Maximum daily concentration (μg·m^{-3})	111.1	147.0	61.0	×	160.0	×	76.0	×	179.2	113.1
Date of the maximum daily concentration	16.12.	06.01	30.12	×	12.02	×	12.02	×	12.02	21.11
The excess of the concentration limits	55	86	4	×	55	×	3	×	17	36

× – not determined

Pearson's correlation coefficients and coefficients of divergence (COD) for pair-wise comparison of mean daily PM_{10} concentration were calculated. The correlation coefficients were tested separately for cold and warm seasons for each year. Completeness of data is not sufficient for each station, therefore only cases were calculated. Moreover, Student's t-test was implemented to evaluate the statistical significance. Due to the lack of data in stations, the COD was calculated following Wongphatarakul et al. [12] in two steps: firstly for stations S1, S3 and S5 (321days) and next for stations S1, S3, S4, and S5 (140 days). The S2 station was excluded from analysis. In order to examine the homogeneity of intra-urban particulate concentrations the coefficient of divergence also was calculated for summer and winter in 2008 (Table 6). The COD is treated as a complimentary indicator of the relative intra-urban uniformity [13].

The relationship between PM_{10} concentration and other meteorological parameters in the study area was analyzed using correlation analysis.

Results and Discussion

The most complete data at levels close to 100% were observed at stations S5 (only during the 2009/10 cold season – 70.3%) and S1 (only during the 2009 warm season – under 70%). At the other stations data completeness was variable depending on the season of the analyzed period 2008-10. Therefore, each station and each period were analyzed separately.

In general, the worst air quality occurred in 2009, especially taking into account the number of days above the limit value (e.g. 86 days in 2009 vs. 55 days in 2008 at S1) (Table 2). The main reason for this was low temperature during the cold season (January) and the high frequency of the high-pressure system. The highest annual average of PM_{10}, which exceeded the permissible yearly concentration of 40 μg·m^{-3}, was noted at station S1 in 2009. According to the CAFE Directive, the acceptable daily PM_{10} value amounts 50 μg·m^{-3} and the number of days exceeding the reference value cannot be more than 35 in one year. The PM_{10} limit was significantly exceeded at stations S1 and S3 in 2008 (55 instances for each stations) and at station S1 in 2009 (86 instances). On the other hand, the slight exceedance was observed at station S5 in 2009. The corresponding results were drawn from the juxtaposition of analyzed warm and cold periods. At all stations concentrations of PM_{10} typically increased during the cold months, which may be attributed to the start of the heating season. During the cold season the concentrations of suspended particulates tended to be higher with a lower air temperature and a stable atmosphere.

Higher concentrations of PM_{10} were observed at stations S1 and S3, whereas lower concentrations were observed at stations S2 and S4. Given the average annual, 98th percentile, and maximum concentrations and the number of days where the PM_{10} value exceeded the limit value, it is evident that station S5 differs from other measurement points (Table 3).

Additional analysis that divided the year into warm and cold periods shows higher concentration of PM_{10} at stations situated in the city center. During the 2009/10 cold season, average daily concentrations of PM_{10} at stations S1 and S3 were higher than the limit value at 50 μg·m^{-3}. Also, these maximum concentrations in comparison to other winter periods were higher (even two or three times). Fig. 1 shows the course of the concentration of PM_{10} in 2008. Seasonal differences are clearly visible in the annual course. Based on the analysis of wind directions, it can be seen that the highest amount of pollution comes from the east and southeast at all the measurement stations (Fig. 2).

The spatial variation of PM_{10} concentration is statistically significant (ANOVA $p<0.01$) with a coefficient of variation equal to 0.15. This value is much lower than, e.g., in the area of Athens [14]. The ANOVA analysis (Table 4) indicate that stations S1-S5 are spatially different due to

Table 3. The descriptive statistics and analysis of variances of PM_{10} concentrations divided into warm and cold periods at the stations of Voivodship Inspection for Environmental Protection in Wrocław and the Department of Climatology and Atmospheric Protection (the University of Wrocław).

Station	Cold period			Warm period	
	01.01.2008 – 30.04.2008	01.10.2008 – 30.04.2009	01.10.2009 – 28.02.2010	01.05.2008 – 30.09.2008	01.05.2009 – 30.09.2009
Average ($\mu g \cdot m^{-3}$)					
S1	40.5	45.9	57.3	27.0	28.5
S2	18.7	23.2	×	12.9	×
S3	42.0	37.3	80.4	28.7	×
S4	17.5	38.5	×	9.6	×
S5	27.4	31.5	40.1	22.9	23.4
Percentile 98.0 ($\mu g \cdot m^{-3}$)					
S1	92.4	113.7	156.9	49.9	57.2
S2	34.6	53.9	×	24.0	×
S3	93.8	74.9	229.9	50.9	×
S4	52.5	39.9	×	14.0	×
S5	83.0	84.1	113.1	40.6	45.8
Maximum ($\mu g \cdot m^{-3}$)					
S1	103.6	147.0	239.2	55.3	61.3
S2	37.0	61.0	×	51.0	×
S3	160.0	87.8	267.3	57.6	×
S4	76.0	40.0	×	15.0	×
S5	179.2	98.9	182.9	52.4	51.3
Minimum ($\mu g \cdot m^{-3}$)					
S1	9.7	3.6	12.1	4.1	8.1
S2	8.0	5.0	×	2.0	×
S3	11.5	8.0	14.0	4.0	×
S4	4.0	37.0	×	6.0	×
S5	2.2	3.7	2.6	3.8	10.6
Completeness of data (%)					
S1	90.1	88.7	98.6	96.7	67.3
S2	10.7	40.1	0.0	84.3	0.0
S3	100.0	43.4	56.6	96.7	0.0
S4	86.0	0.9	0.0	34.0	0.0
S5	95.9	98.1	70.3	100.0	96.7
Analysis of variances s^2					
S1	426.1	627.4	1222.1	80.7	101.0
S2	×	153.6	×	35.3	×
S3	438.8	268.2	2268.0	81.1	×
S4	133.8	×	×	5.7	×
S5	485.7	386.4	839.2	62.6	80.1

× – not determined

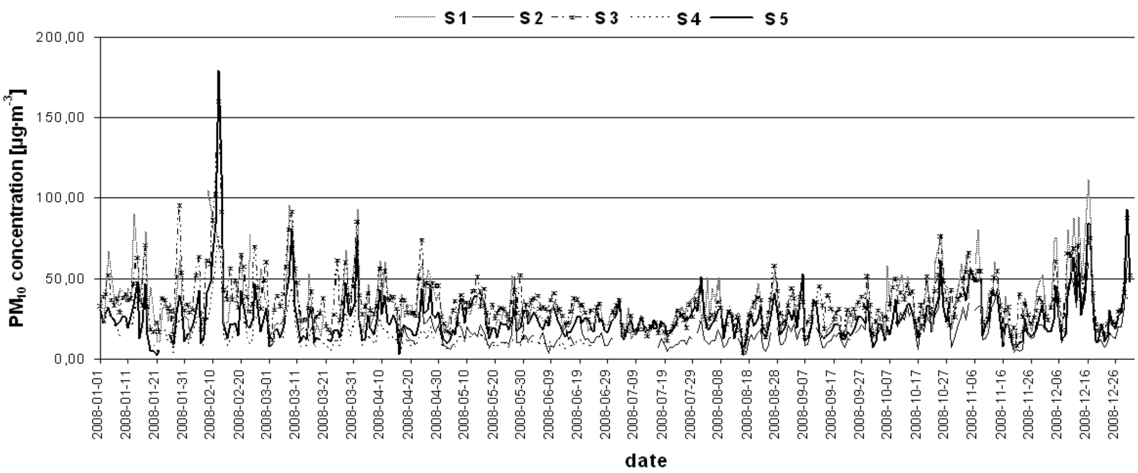

Fig. 1. Average daily concentrations of PM_{10} [$\mu g \cdot m^{-3}$] at measurement stations in Wrocław in 2008.

terrain conditions (i. e. use of the land, activity of the residents, types of buildings, and intensity of the road traffic). However, the course of PM_{10} concentrations at all stations reveal similarity, as indicated by the analysis of correlation. PM_{10} dynamics showed a relationship at all measurements. The correlation between the cold and warm season measurements in five station (Table 5) varied from 0.44 to 0.95. Correlation coefficient R shows that readings obtained at analyzed stations correlate more closely in the cold period (0.71-0.95). In order to demonstrate statistical significances between the measurement stations, the Student's t-test was calculated (statistical significance $\alpha \leq 0.05$ and $\alpha \leq 0.01$). The daily average PM_{10} concentrations at monitoring sites were well correlated with each other, but we observed large variations in absolute concentrations between monitoring sites.

For 26 of 30 pair of stations the correlation coefficients were significant at the 0.99 confidence level. This could indicate the influence of prevailing meteorological conditions on the concentration of air pollutants, and on the other hand the similar local emission sources.

The COD values were very low for stations S1, S3, and S5, below 0.1, but higher for station S4, in spite of the heterogeneity in temporal variation (Tables 5 and 6). It should be noted that the value of COD ranged from 0.05 to 0.19, lower than the criterion suggested by the US EPA to indicate heterogeneity (COD > 0.2). The division of the year into the summer and winter periods (e.g. 2008) can indicate the source of spatial variability. The relatively low COD value (0.05-0.17) in the winter may be due to similar emission sources across the whole city, reduced photochemistry reaction, the low boundary layer depth, and frequent calm conditions. The poorer summertime correlation and high COD value (0.05-0.61) may be driven by the strong impact of very local emission sources (road emission), wind transport and wind-driven PM_{10}, and impact of photochemistry on PM_x (especially fine mode) emissions.

At station S5 we used the gravimetric method, unlike the reference manual method at stations S1-S4 of the Voivodship Inspection for Environmental Protection. Possible undervalued value of PM_{10} concentrations in the method used a TEOM analyzer, which may be due to evaporation of VOCs (volatile organic compounds); however, general tendencies are maintained. On the basis of conducted statistical analysis and literature [15, 16] the gravimetric method may be considered acceptable in the city measuring network.

Due to the strong correlation between data at different stations, only data from S5 were used to analyze the impact of weather conditions on PM_{10} concentrations.

The data were statistically analyzed (statistical significance $\alpha \leq 0.05$) and the estimated trend model adequately explains the correlation between meteorological factors and concentration of PM_{10} (Table 7). A positive relationship has been observed between PM_{10} concentrations and the atmospheric pressure, daily temperature amplitude, and average daily air temperature (but only during the warm period). A negative relationship, in turn, was observed between PM_{10} concentrations and the average daily wind speed, the maximum daily wind speed and the average daily air temperature

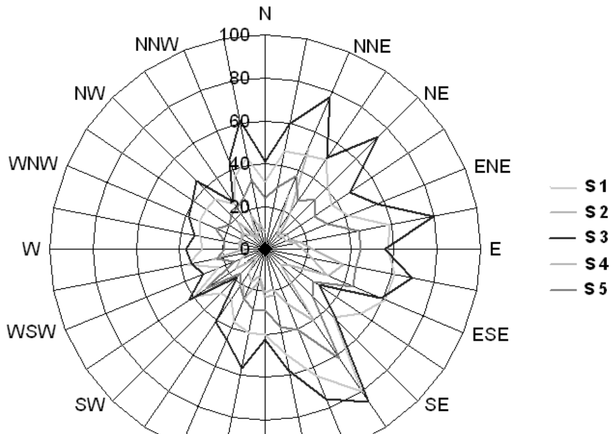

Fig. 2. The wind and pollution rose at the stations owned by Voivodship Inspection for Environmental Protection in Wrocław and the Department of Climatology and Atmospheric Protection (the University of Wrocław).

(but only during the cold period) (Fig. 3). Additional analysis of the synoptic situation and the vertical structure of the atmosphere shows that occurrences of higher concentrations of PM_{10} during the cold period are related to anticyclone systems and the existence of an inversion. The results of statistical analysis correspond to literature data [17, 18] and show the main meteorological and terrain conditions that affect the modification process of an urban aerosanitary situation. In cities during the cold periods, when an inversion is maintained, low-emission constitutes the major part of emissions. In such cases, a rise in temperature and wind speed may contribute to a dispersion of particulate matter.

Undoubtedly, there is an interdependency between meteorological conditions and concentrations of particulate matter. Still, it is possible to establish the relationship between PM_{10} levels and the terrain conditions in the Wrocław Agglomeration. In particular instances, concentration limits of PM_{10} were exceeded only at select stations. Such situations are especially observed during the warm period of the year and when the weather favours the dispersion and transportation of PM_{10}. For that purpose, chosen episodes with PM_{10} levels exceeding the limit value were taken into consideration.

The first episode was observed at station S1 on 23 February 2008 (daily PM_{10} concentration – 76.8 μg·m^{-3}). At the same time, PM_{10} levels at other stations were visibly lower (S3 – 29.6 μg·m^{-3}, S4 – 9.0 μg·m^{-3}, S5 – 19.0 μg·m^{-3}). This can be attributed to the weather conditions (the average wind speed reached 5.3 m·s^{-1} while daily precipitation reached 0.1 mm), which favoured the dispersion of pollutants into the city atmosphere. However, in this case it should be noted that dominant westerly wind could lead to

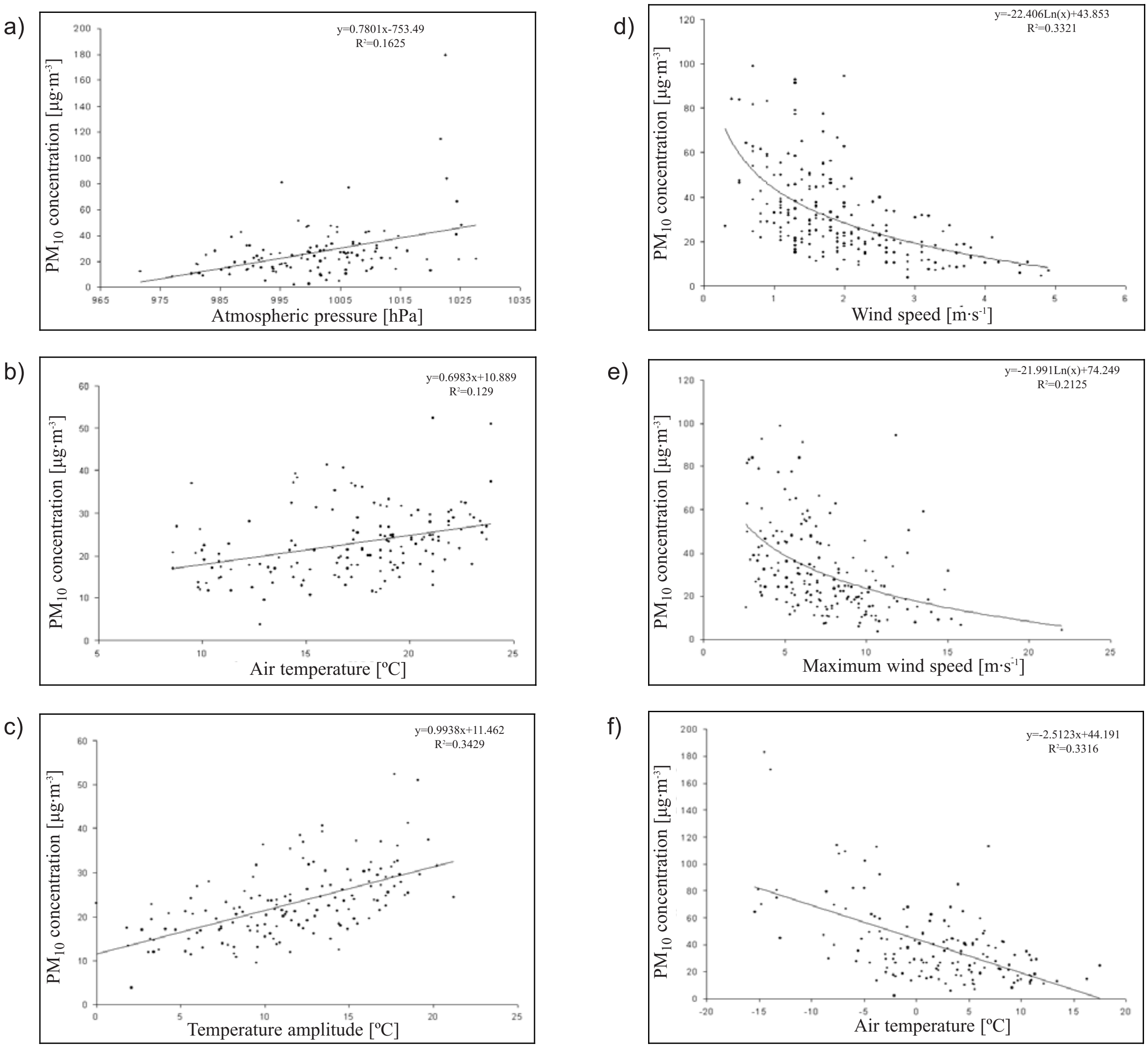

Fig. 3. Correlation between PM_{10} concentrations and meteorological conditions: atmospheric pressure in winter period at the beginning of 2008 (a), air temperature in warm period in 2008 (b), temperature amplitude in warm period in 2008 (c), wind speed in heating winter period 2008/09 (d), maximum wind speed in winter period 2008/2009 (e), air temperature in winter period 2009/10 (f).

Table 4. Analysis of variance of PM_{10} concentrations at the stations owned by Voivodship Inspection for Environmental Protection in Wrocław and the Department of Climatology and Atmosphere Protection (the University of Wrocław).

Analysis of variance	Cold period			Warm period	
	01.01.2008 – 30.04.2008	01.10.2008 – 30.04.2009	01.10.2009 – 28.02.2010	01.05.2008 – 30.09.2008	01.05.2009 – 30.09.2009
SS	66.7	34.2	40.1	546.6	2.5
MS	16.7	11.4	20.0	136.6	2.5
F	54.6	34.1	54.8	1092.2	18.9
p-value	1.21E-37	2.9E-20	3.97E-22	1.2E-299	1.98E-05
F-test	2.4	2.6	3.0	2.4	3.9

SS – sum of the squares, MS – mean of the squares, F – empirical value of F, p-value – probability, F-test – critical value of F

Table 5. Compatibility PM_{10} measurements at different stations expressed as correlation coefficients and coefficient of divergence (COD) in Wrocław.

Correlated stations		Correlation coefficient R					COD
		Cold period			Warm period		
		01.01.2008 – 30.04.2008	01.10.2008 – 30.04.2009	01.10.2009 – 28.02.2010	01.05.2008 – 30.09. 2008	01.05.2009 – 30.09.2009	
S1	S3	0.75¯	0.75**	0.82**	0.68**	×	0.05
S2	S1	0.71**	0.83**	×	0.57**	×	×
S2	S3	0.90**	0.83*	×	0.69**	×	×
S4	S1	0.75**	×	×	0.64**	×	0.18
S4	S2	0.84¯	×	×	0.58**	×	×
S4	S3	0.87**	×	×	0.52**	×	0.19
S5	S1	0.79**	0.82**	0.85**	0.72**	0.44**	0.08
S5	S2	0.95¯	0.93**	×	0.69**	×	×
S5	S3	0.89**	0.87**	0.87**	0.70**	×	0.09
S5	S4	0.88**	×	×	0.89**	×	0.13

× – not determined, *results of Student's t-test significant at $\alpha \leq 0.05$, **results of Student's t-test significant at $\alpha \leq 0.01$, ¯ – no statistical significances, COD – coefficient of divergence

an inflow of particulate from the low-emission sites located in the centre of Wrocław.

Furthermore, on 25 March 2008 the exceedance of the PM_{10} limit value was noted at station S3 (60.7 $\mu g \cdot m^{-3}$). For comparison, the readings at other measurement points were significantly lower (S1 – 22.1 $\mu g \cdot m^{-3}$, S4 – 11.0 $\mu g \cdot m^{-3}$, S5 – 18.0 $\mu g \cdot m^{-3}$). Although the weather conditions (atmospheric pressure v – 981.0 hPa, precipitation – 1.3 mm) contributed to the dispersion of PM_{10}, the high levels of the pollutant could be caused by "a tunnel effect." More specifically, a westerly wind could transport the particulate matter from a nearby road to station S3 located on the axis W-E.

Another episode was observed on 6 September 2008 at station S5 (daily concentration 52.4 $\mu g \cdot m^{-3}$, maximum temporary concentration 290.9 $\mu g \cdot m^{-3}$). On the other hand, at other stations the daily level of PM_{10} reached: S1 – 36.3 $\mu g \cdot m^{-3}$, S2 – 19.0 $\mu g \cdot m^{-3}$, S3 – 35.1 $\mu g \cdot m^{-3}$. First, the dominant wind direction (SE) indicates an inflow of pollutants coming from roads and allotments situated near station S5. In addition, a sudden gust of wind on that day (in the last week there had been moderate winds and no precipitation) could have blown particulate matter to the measurement point.

Conclusions

From the foregoing analysis of the dependency between PM_{10} concentrations and weather and terrain conditions in the period January 2008-February 2010, it is apparent that the examined research stations are completely different. In fact, both the average daily and yearly concentration limits

Table 6. Coefficient of divergence (COD) at the stations owned by Voivodship Inspection for Environmental Protection in Wrocław and the Department of Climatology and Atmosphere Protection (the University of Wrocław) in 2008.

COD		Cold period	Warm period
S1	S3	0.05	0.05
S4	S1	0.17	0.17
S4	S3	0.17	0.15
S5	S1	0.11	0.61
S5	S3	0.12	0.59
S5	S4	0.10	0.59

are exceeded at stations near the city centre. Other contributing terrain factors include the proximity of buildings, congested roads, or adjacent housing and industrial complexes. Our paper also highlights the changes in PM_{10} levels during summer and winter seasons. The limits were severely exceeded during the cold period, which was attributed to elevated PM_{10} concentrations in high pressure and cold weather. Moreover, a high PM_{10} concentration and frequent exceedances of the limit value were observed in the stations exposed to low emissions from vehicles and heating systems in winter, for example at S1 and S3. However, due to certain legal restrictions, there are low-emission zones in which a decrease in PM_{10} levels was noted (stations S2 and S4). The characteristic features of station S5 used gravimetric method are something between the measurement points S2, S4 and S1, S3.

It has been proven that the location of the research stations in the city is an important factor affecting the measurements. Additionally, the terrain features, e.g. the location of main roads, determines the meteorological conditions (the dominant wind direction, the urban heat island). It is hard to escape the obvious conclusion that measurement stations must be carefully located. Otherwise, the obtained data may be irrelevant. Variance and correlation analysis reveals significance and representativeness of measuring stations in the city network. Higher PM_{10} concentration and exceedances of the acceptable value were observed at the correlated stations. Analysis of variance showed that spatial variability was important. However, the authorities must not only measure PM_{10} levels, but also control them. It is of utmost importance to impose certain laws that would restrict emissions in the Wrocław area. Knowledge of the spatial variability of air pollution is crucial to avoid errors in exposure assessment.

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Table 7. The relationship between PM_{10} concentration and meteorological conditions at the station of the Department of Climatology and Atmosphere Protection (the University of Wrocław) expressed as a correlation coefficient and its statistical significance.

Variables		Coefficient correlation R				
		Cold period			Warm period	
		01.01.2008 – 30.04.2008	01.10.2008 – 30.04.2009	01.10.2009 – 28.02.2010	01.05.2008 – 30.09.2008	01.05.2009 – 30.09.2009
PM_{10}	T [ºC]	-0.14*	-0.22*	-0.56*	0.36*	0.31*
PM_{10}	V [m·s^{-1}]	-0.54*	-0.56*	-0.40*	-0.39*	-0.37*
PM_{10}	V_{max} [m·s^{-1}]	-0.49*	-0.43*	-0.45*	-0.14*	-0.29*
PM_{10}	P [hPa]	0.40*	0.22*	0.27*	0.02^{-}	0.20*
PM_{10}	A [ºC]	0.26*	0.36*	0.16*	0.59*	0.56*

T – average daily air temperature, V – average daily wind speed, V_{max} – maximum daily wind speed, P – atmospheric pressure, A – daily temperature amplitude, *significant at α≤0.05, $^{-}$ – no statistical significances

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