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Influence of meteorological conditions on the concentration of NO_2 and NO_x in northwest Poland in relation to wind direction

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Abstract: *Influence of meteorological conditions on the concentration of NO_2 and NO_x in northwest Poland in relation to wind direction.* The aim of the work was to assess the temporal distribution of NO_2 and NO_x concentration in relation to wind direction and to determine the effect of major meteorological elements on the size of NO_2 and NO_x concentration in northwest Poland. In the area of the research, in the period from 1st May 2005 to 30th April 2007 the highest average concentration of NO_2 and NO_x, both during cold and warm half-years, occurred with south-easterly wind, and the lowest with south-westerly wind for NO_2 and with north-easterly wind for NO_x. The highest determination coefficients and, at the same time, the smallest estimation errors for multiple regression equations, describing the dependence of the concentration of NO_2 and NO_x from meteorological elements, were obtained with westerly wind in the cold half-year and with south-westerly wind in the warm half-year.

Key words: concentration of NO_2 and NO_x, regression equations, wind direction, meteorological conditions.

INTRODUCTION

Levels of nitrogen concentrations in the area of northwest Poland are diverse. The lowest concentrations occur in rural areas, in small towns and villages, in places distant from car transport. In bigger towns the concentrations are higher, around 75% to 50% of the yearly average level (Landsberg-Uczciwek et al., 2007). According to measurements by the Provincial Environmental Protection Inspectorate (WIOŚ), in 2005 in the city centre of Szczecin the yearly average permissible concentration of nitrogen dioxide in the air was exceeded (Landsberg-Uczciwek, 2006). Concentrations of NO_x in 2004 and 2005 were low and did not exceed acceptable limits determined both for the sake of plant protection and for national parks. Main sources of nitrogen dioxides emission into the air, apart from natural sources, are predominantly power engineering industry and heating and also motor vehicles (Shi and Harrison, 1997; Rozbicka, 2007). An important source of NO_2 is chemical processes of NO oxidation occurring in the atmosphere (Uno et al., 1996; Rozbicka, 2004; Mazzeo et al., 2005). As a result of reactions of nitrogen oxides with hydrocarbons, happening in the air due to solar radiation, there arise strong photochemical oxidants, e.g. ozone, which cause photochemical smog in the lower atmospheric layer. In northwest Poland, excluding 4 districts situated in the western industrialised part of the Zachodniopomorskie Province, the emission of NO_2 from linear sources dominate. In contrast to other main pollutants, since 2000 a downward trend of NO_2 concentration in the air has not been noticed. Major meteorological elements affecting the concentration of nitrogen oxides in the air are: wind direction, wind velocity and air temperature and relative air humidity (Shi and Harrison, 1997; Rozbicka, 2007). The effect of meteorological elements on pollutants concentration is not straightforward because of the complexity of relations. It is, however, the most important factor, in addition to the level of emission, shaping the pollutant content of the air (Shi and Harrison, 1997; Elminir, 2005; Badyda and Majewski, 2006).

The goal of the work was to assess the temporal distribution of NO_2 and NO_x concentration in relation to wind direction and to determine the influence of main meteorological elements on the volume of NO_2 and NO_x concentration in northwest Poland.

MATERIAL AND METHODS

The foundation of the work was hourly values of the concentrations of nitrogen dioxide and nitrogen oxides (NO, NO_2 and N_2O_4) and meteorological elements data: total radiation, average air temperature, relative air humidity, precipitation total, atmospheric pressure, wind direction and wind velocity in the period from 1st May 2005 to 30th April 2007 from 7 stations of the State Environmental Monitoring (3 from Szczecin, 1 from Gorzów Wielkopolski, Koszalin, Piła and Widuchowa) located in northwest Poland (Fig. 1).

The influence of meteorological elements on the concentration of gas air pollutants in relation to winds direction was investigated with the use of the multiple regression analysis. The values of nitrogen dioxide and nitrogen oxides concentration in examined half-years, a cold one (October to March)

Stadion of the PMŚ	Longitude	Latitude	Elevation [height above sea level]
Gorzów Wlkopolski	15°13'E	52°44'N	22
Koszalin	16°11'E	54°11'N	43
Piła	16°45'E	53°09'N	71
Szczecin	14°33'E	53°26'N	20
	14°33'E	53°28'N	100
	14°39'E	53°22'N	10
Widuchowa	14°23'E	53°17'N	2

FIGURE 1. Location of the PMŚ (National Environmental Monitoring) stations conducting measurements of the NO_2 and NO_x concentration in north-western Poland and main point emission sources of NO_2: 1 – Port Handlowy Świnoujście (Commercial Port), 2 – Zakłady Chemiczne “Police” S.A. (Chemical Plant), 3 – Elektrownia Szczecin (Power Plant), 4 – Elektrownia Pomorzany (Power Plant), 5 – Elektrownia Dolna Odra (Power Plant), 6 – Elektrociepłownia Gorzów (Heat and Power Plant)

and a warm one (April to September), being a dependent variable, had a distribution which was different from normal. Therefore, the normalisation of dependent variables by means of the following function was conducted:

$$f(NO_2) = \sqrt{NO_2},\ f(NO_x) = \sqrt{NO_x}$$

where:
NO_2 – value of nitrogen dioxide concentration, $\mu g \cdot m^{-3}$,
NO_x – value of nitrogen oxides concentration, $\mu g \cdot m^{-3}$.

The compatibility of NO_2 and NO_x concentration variables with a normal distribution was examined with the Chi-square test where assumed level $\alpha = 0.05$.

A determination coefficient (%) served as a measure of fitting the regression function to empirical data, whereas the partial correlation analysis (%) was used to determine the share that each of the selected meteorological elements possesses in predicting NO_2 and NO_x concentrations.

RESULTS

Analysis of temporal variation of NO_2 and NO_x concentration

In northwest Poland in the period from 1st May 2005 to 30th April 2007 the average concentration of NO_x was higher than that of NO_2 in all examined seasons (Fig. 2), whereas the biggest difference between the concentrations of analysed gases was observed in autumn (14.2 $\mu g \cdot m^{-3}$), then in winter (12.0 $\mu g \cdot m^{-3}$), and the smallest in summer (4.8 $\mu g \cdot m^{-3}$). The temporal distribution of NO_2 and NO_x concentration in northwest Poland characterised itself with a distinct seasonal structure. The highest concentration of NO_2 and NO_x occurred in autumn and equalled respectively 20.8 and 35.1 $\mu g \cdot m^{-3}$, and the lowest in summer: 13.5 and 18.3 $\mu g \cdot m^{-3}$. Clearly higher concentration of NO_2 and NO in the winter half-year than in the summer one was shown by Uno et al. (1996). Similar results were obtained by Rozbicka (2007). According to her, the highest values of NO_2 concentration occur in autumn and the lowest in summer. In a weekly cycle, on the other hand, the highest concentrations occur on Friday and the lowest on Sunday. Rozbicka (2007) claims that the temporal distribution of NO_2 concentration closely depends on traffic congestion. Significant seasonal variation of the value of nitrogen oxides concentration in north-western Poland reveals the predominant influence of point emission sources connected with the thermal power industry in comparison with traffic emission which is slightly changeable during the year. In the cold half-year (October–March) the average concentration of NO_2 amounted to 20.2 $\mu g \cdot m^{-3}$ and was by 13.3 $\mu g \cdot m^{-3}$ lower than the concentration of NO_x. In the warm half-year (April–September), on the other hand, the difference was by half lower (6.1 $\mu g \cdot m^{-3}$). The average yearly concentration of nitrogen dioxide in the period from 1st May 2005 to 30th April 2007 equalled 17.7 $\mu g \cdot m^{-3}$ and constituted only 44.3% of the yearly norm according to the Minister of the Environment regulation from 5th December 2002, whereas the average concentration of non-standardised nitrogen oxides equalled

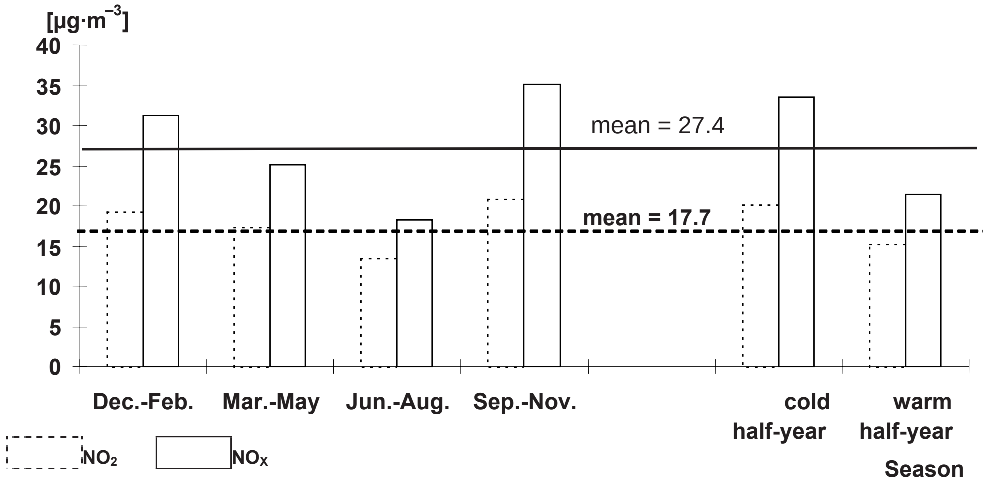


FIGURE 2. Average seasonal concentration of NO_2 and NO_x in northwest Poland in the period from 1st May 2005 to 30th April 2007

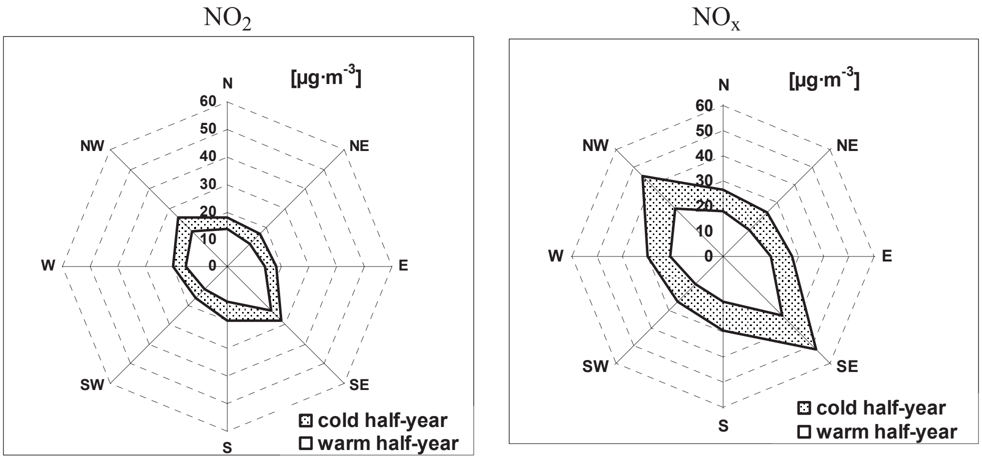
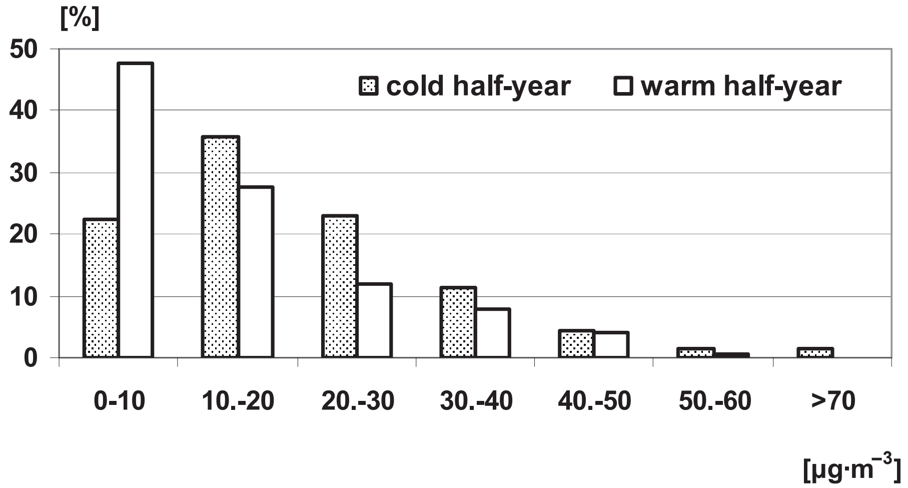


FIGURE 3. Distribution of hourly NO_2 i NO_x concentration according to wind directions in northwest Poland in the period from 1st May 2005 to 30th April 2007

27.4 $\mu g \cdot m^{-3}$. Analysing the wind-rose for the concentration of NO_2 and NO_x measured in northwest Poland (Fig. 3), it was stated that the highest ambient concentration of the two gas pollutants, both in the cold half-year and in the warm one, occurred with south-easterly wind, and the lowest with south-westerly wind for NO_2 and with north-easterly wind for NO_x. The correlation may originate from the location of the biggest in West Pomerania power engineering enterprise – Zespół Elektrowni Dolna Odra (Fig. 1), and also from the location of main traffic routes, including a section of motorway A6 running round Szczecin in the south and the southeast. A similar distribution analysis of the size of NO_2 concentration in relation to wind direction in the area of Cairo was carried out by Elminir

(2005). According to him, the highest concentration of the gas occurs with southerly wind and the lowest with WNW winds. The difference between the highest and the lowest concentration of NO_2 in both examined half-years was almost identical and amounted to 11.2 $\mu g \cdot m^{-3}$ for the cold half-year and 11.3 $\mu g \cdot m^{-3}$ for the warm half-year. However, the difference calculated for the concentration of NO_x in the winter half-year (26.8 $\mu g \cdot m^{-3}$) was considerably higher than in the warm half-year (18.6 $\mu g \cdot m^{-3}$).

Daily frequency diagrams of the concentrations of both gas pollutants in adopted size ranges showed that in the cold half-year nearly 36% for NO_2 and 29% for NO_x of all obtained results were within the range between 10 and 20 $\mu g \cdot m^{-3}$ (Fig. 4). On the other hand, in the warm half-year, the size range



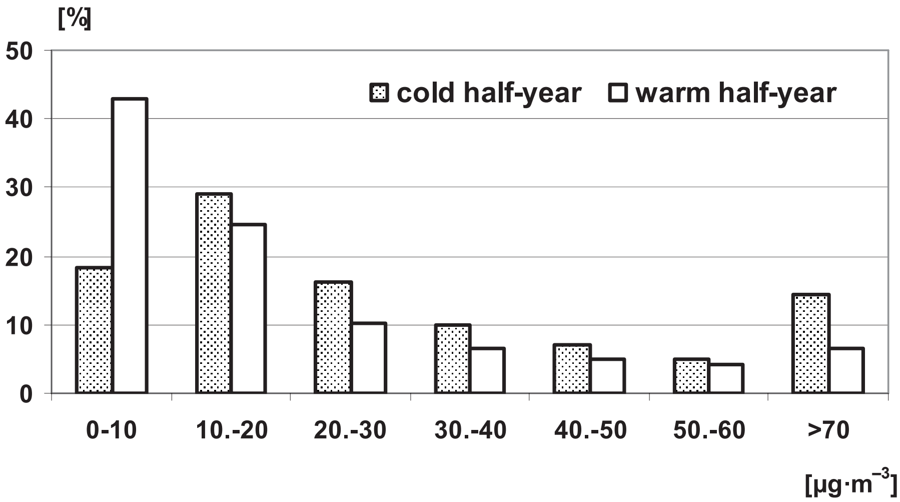


FIGURE 4. Frequency of the occurrence of NO_2 and NO_x daily concentrations in adopted rangesin northwest Poland in the period from 1st May 2005 to 30th April 2007

from 0 do 10 μg·m^{-3} was represented most numerously; it encompassed 47.7% of all obtained measurements of NO_2 and 42.8% of NO_x. The frequency distribution of daily concentration values of the analysed gas pollutants measured in some sites of northwest Poland is characteristic also for other Polish towns (Skotak et al., 2002, Czarnecka and Kalbarczyk, 2005; Rozbicka, 2007).

Low daily concentrations of NO_2 and NO_x, below 10 μg·m^{-3}, were noted most often with south-westerly wind in both half-years; the least frequently with north-westerly winds in the cold half-year and in the warm half-year with south-easterly wind (Fig. 5).

High concentrations of nitrogen oxides, above 20 μg·m^{-3}, were most frequently noted in the cold half-year with south-easterly wind, for NO_x also with westerly wind, the least frequently with northerly wind for NO_2 and with north-easterly wind for NO_x (Fig. 6). On the other hand, concentrations of the examined pollutants (> 20 μg·m^{-3}) in the warm half-year most often occurred with north-westerly wind, the least frequently with north-easterly wind for NO_2 and with northerly wind for NO_x.

Statistical analysis of NO_2 and NO_x dependence on meteorological conditions

The multiple regression analysis made possible selecting out of all the set the most important meteorological elements which considerably affected the size of the ambient concentration of both gas pollutants in northwest Poland in relation to wind direction (Tabs 1, 2). The results of the analysis were presented in such a form which enables the reconstruction of the equation in a full form. To achieve this, apart from multiple regression coefficients, also the numerical value of a intercept, being an integral part of the regression equation, was given for meteorological elements. The data placed in Table 1 show that in the cold half-year the best results concerning the description of the changeability of

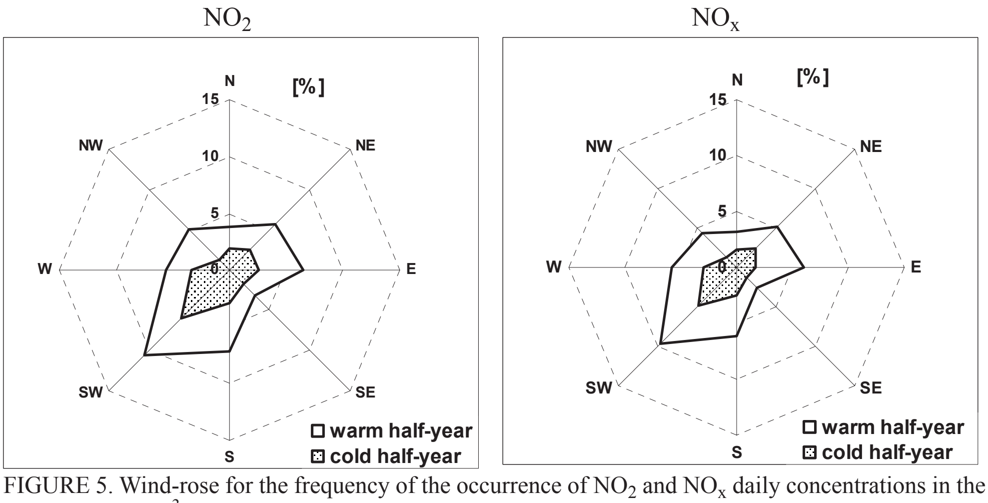


FIGURE 5. Wind-rose for the frequency of the occurrence of NO_2 and NO_x daily concentrations in the range < 10 μg·m^{-3} in northwest Poland in the period from 1st May 2005 to 30th April 2007

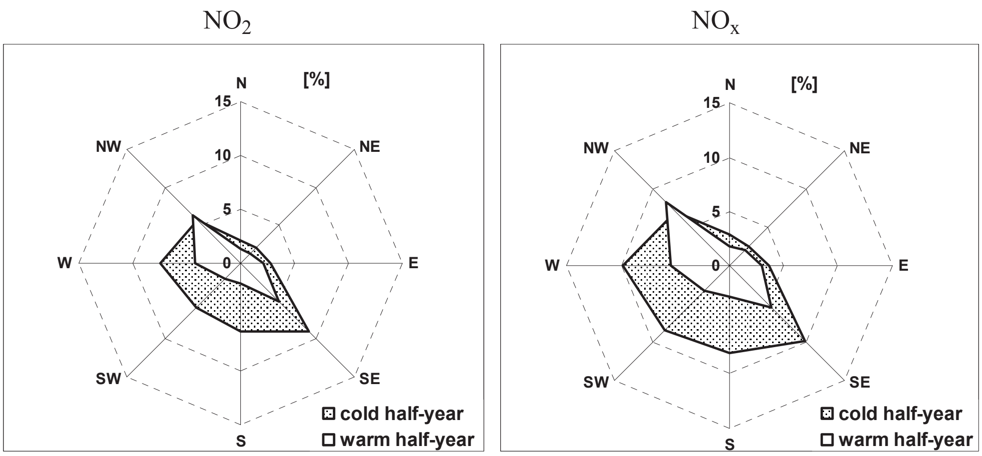


FIGURE 6. Wind-rose for the frequency of the occurrence of NO_2 and NO_x daily concentrations in the range > 20 $\mu g \cdot m^{-3}$ in northwest Poland in the period from 1st May 2005 to 30th April 2007

NO_2 concentration with meteorological elements were obtained with westerly and southerly winds; R^2 equalled respectively 42.5 and 42.3%. In these equations the average wind velocity and solar radiation were taken into consideration, but only in the case of westerly wind. In the warm half-year, on the other hand, the best description of the size of NO_2 concentration with wind velocity and atmospheric pressure was obtained with south-westerly wind; R^2 equalled 42.8%. In all regression equations (Tab. 1) determining the dependence of NO_2 concentration from weather conditions, for both cold and warm half-years, there occurred wind velocity, of which increase contributed to the improvement of air quality. Wind velocity is the most important factor, in addition to the level of emission, shaping the concentration of NO_x and NO_2 in the work of Shi and Harrison (1997). As partial correlation coefficients show, the highest impact of wind velocity on the concentration of NO_2 was shown with southerly wind (r = –0.65) in the cold half-year and westerly wind (r = –0.58) in the warm half-year, whereas the lowest with northerly wind (r = –0.33) in the cold half-year and south-easterly wind (r = –0.27) in the warm half-year.

In the cold half-year, apart from wind velocity, also relative air humidity had a significant negative influence on the concentration of NO_2 (with northerly and north-easterly winds). Atmospheric pressure (with northerly, north-easterly, south-westerly and north-westerly winds) and solar radiation (with westerly wind) had a positive influence. On the other hand, in the warm half-year, also average air temperature (with northerly and westerly winds) had a considerable negative impact on the concentration of NO_2. Atmospheric pressure had a positive effect with almost all analysed wind directions, except for westerly one. The presence of atmospheric pressure in regression equations results from the properties of this meteorological element to which diverse weather conditions indirectly refer. These diverse weather conditions are connected with the

TABLE 1. Multiple regression equations for the relation between the concentration of NO2 and selected meteorological elements with relation to wind direction in northwest Poland in the period from 1st May 2005 to 30th April 2007

cold half-year (Oct.-March)

Wind Direction	Coeffi-cient	Intercept	Meteorological element						R^2
			Rad	Tp	Rf	Rh	Ws_1	Ph	
N	rw	–17.14***				–0.038	–0.55	0.024	26.7
	r					–0.28***	–0.33***	0.24***	
NE	rw	–15.23***				–0.026	–0.65	0.021	18.8
	r					–0.21***	–0.35***	0.205***	
E	rw	4.018***					-0.46		26.4
	r						–0.51***		
SE	rw	5.0014***					–0.59		28.4
	r						–0.53***		
S	rw	4.503***					–0.68		42.3
	r						–0.65***		
SW	rw	–16.31***					–0.66	0.0203	29.1
	r						–0.45***	0.22***	
W	rw	3.26***	0.016				–1.051		42.5
	r		7.1***				–0.53***		
NW	rw	–30.99***					–0.62	0.034	22.5
	r						–0.36***	0.26***	

warm half-year (Apr.-Sep.)

Wind Direction	Coeffi-cient	Intercept	Meteorological element						R^2
			Rad	Tp	Rf	Rh	Ws_1	Ph	
N	rw	–3.43***		–0.053			–0.74	0.037	29.0
	r			–0.21**			–0.45***	0.28***	
NE	rw	–33.505***					–0.43	0.036	24.4
	r						–0.38***	0.33***	
E	rw	–61.18***					–0.53	0.064	33.2
	r						–0.33***	0.42***	
SE	rw	–77.32***					–0.52	0.081	30.2
	r						–0.27***	0.49***	
S	rw	–18.99***					–0.74	0.022	27.5
	r						–0.49***	0.16***	
SW	rw	–20.97***					–0.69	0.024	42.8
	r						–0.57***	0.24***	
W	rw	3.91***		–0.043			–1.017		33.3
	r			–0.19***			–0.58***		
NW	rw	–42.51***					–0.47	0.046	17.2
	r						–0.29***	0.25***	

Explanations:
[1] x = ln (Ws), R^2 – determination coefficient [%], rw – multiple regression coefficient, r – partial correlation coefficient [%], *** – regression coefficient significant at $\alpha \leq 0.01$, ** – regression coefficient significant at $\alpha \leq 0.05$, Rad – total solar radiation [$W \cdot m^{-2}$], Tp – mean air temperature [ºC], Rf – precipitation total [mm], Rh – relative air humidity [%], Ws – mean wind speed [$m \cdot s^{-1}$], Ph – air-pressure [hPa].

TABLE 2. Multiple regression equations for the relation between the concentration of NO_x and selected meteorological elements with relation to wind direction in northwest Poland in the period from 1st May 2005 to 30th April 2007

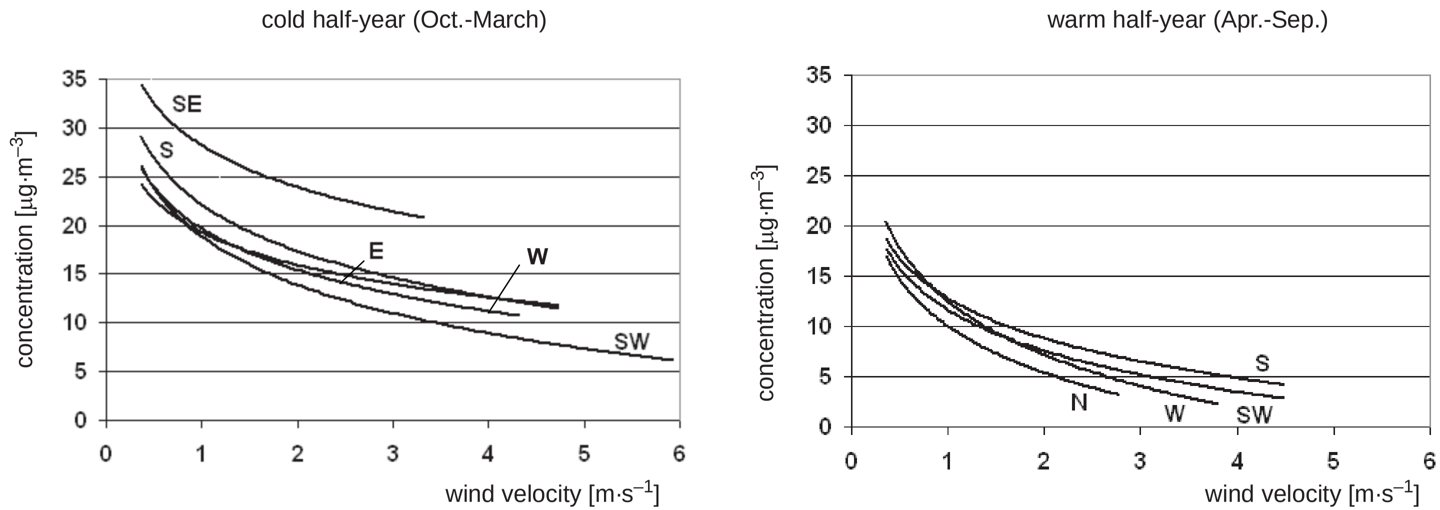
Wind direction	Coef-ficient	cold half-year (Oct.-March) Intercept	Meteorological element						R^2	warm half-year (Apr.-Sep.) Intercept	Meteorological element						R^2
			Rad	Tp	Rf	Rh	Ws[1]	Ph			Rad	Tp	Rf	Rh	Ws[1]	Ph	
N	rw	10.2006***				–0.068	–1.085ln		29.0	–47.407***		–0.093			–0.95	0.051	28.8
	r					–0.31***	–0.42***					–0.25***			–0.41***	0.29***	
NE	rw	–24.502***				–0.038	–1.14	0.031	21.9	–41.62***					–0.54	0.044	21.0
	r					–0.209***	–0.403***	0.202***							–0.35***	0.29***	
E	rw	4.98***					–1.096		19.5	–89.65***					–0.808	0.093	36.3
	r						–0.44***								–0.36***	0.43***	
SE	rw	6.48***					–1.67		19.8	–121.77***					–0.809	0.12	33.9
	r						–0.44***								–0.29***	0.52***	
S	rw	5.55***					–1.61		39.2	–34.98***					–0.97	0.038	29.3
	r						–0.63***								–0.49***	0.21***	
SW	rw	–14.606***					–1.35	0.019	41.8	–31.93***					–0.81	0.035	37.1
	r						–0.59***	0.16***							–0.51***	0.25***	
W	rw	3.64***	0.021				–1.72		46.7	4.76***		–0.077			–1.32		26.9
	r		0.24***				–0.58***					–0.22***			–0.52***		
NW	rw	–44.89***					–1.18	0.0501	21.3	-77.14***					–0.59	0.0808	18.6
	r						–0.38***	0.22***							–0.26***	0.31***	

Explanations: see Table 1.

following patterns: the anticyclonic pattern, which leads to the formation of a stratum of stable equilibrium and with the lack of cloud cover and with low wind velocity to low inversion and considerable accumulation of pollutants at the surface of the ground, and the cyclonic pattern in which weather conditions undergo frequent changes, which is conducive to the improvement of air quality. Not a single relation between the concentration of the described gas pollutant and precipitation total in both half-years was statistically proven, which may be the evidence that precipitation total is not a good indicator to evaluate this dependence. Low, negative correlation coefficients for the dependence of NO_2 from precipitation total were obtained in some towns of Pomerania by Czarnecka and Kalbarczyk (2005), and in Suwałki by Kalbarczyk and Kalbarczyk (2008).

Similar results, like for the concentration of NO_2, were obtained for the dependence of the size of NO_x concentration from meteorological elements (Tab. 2), for which determination coefficient oscillated in the cold half-year between 19.5% with easterly wind and 46.7% with westerly wind, and in the warm half-year between 18.6% with north-westerly wind and 37.1% with south-westerly wind. Like in multiple regression equations for the concentration of NO_2 and meteorological elements, also for the concentration of NO_x the biggest impact of wind velocity in the cold half-year was noted with southerly wind and in the warm half-year with westerly wind. Not only the description of the quality factor of multiple regression equations for the concentration of NO_x was similar to the concentration of NO_2, but also the occurrence of particular meteorological elements with given wind direction. The regression equation built for northerly direction in the cold half-year is the exception. In this equation, beside wind velocity and relative air humidity, atmospheric pressure was not taken into account. Also Shi and Harrison (1997), in regression models formed to assess the size of the concentration of NO_2 and NO_x in relation to meteorological conditions prevailing in London, employed the following elements: solar radiation, wind velocity, wind direction, air temperature and relative air humidity.

Figures 7, 8 and 9 show graphs displaying the relation between the concentration of both gas pollutants and meteorological elements, but only for those which had a strong effect ($r^2 >$ 20%) in the analysed set of elements on the volume of the ambient concentration of NO_2 and NO_x. In the cold half-year wind velocity most strongly affected the volume of the ambient concentration of NO_2 with easterly, south-easterly, southerly, south-westerly and westerly winds; in the warm half-year, on the other hand, with northerly, southerly, south-westerly and westerly winds (Fig. 7), which is the evidence of a big number of emission sources affecting recorded concentrations of pollutants. In the cold half-year the highest concentration of NO_2, amounting to 35.0 $\mu g \cdot m^{-3}$, occurred with the average wind velocity of 0.4 $m \cdot s^{-1}$ and south-easterly direction, and the lowest, equal to 5.3 $\mu g \cdot m^{-3}$, with wind velocity of 5.9 $m \cdot s^{-1}$ and south-westerly direction. In the warm half-year there were not such big differences in the size of the concentration, unlike in the cold half-year, as the highest average



E = –4.83ln(Ws)*** + 17.045***, R^2 = 29.4%

SE = –6.18ln(Ws)*** + 25.37***, R^2 = 29.2%

S = –6.85ln(Ws)*** + 21.0089***, R^2 = 43.3%

SW = –7.15ln(Ws)*** + 18.84***, R^2 = 22.3%

W = –6.12ln(Ws)*** + 19.65***, R^2 = 37.6%

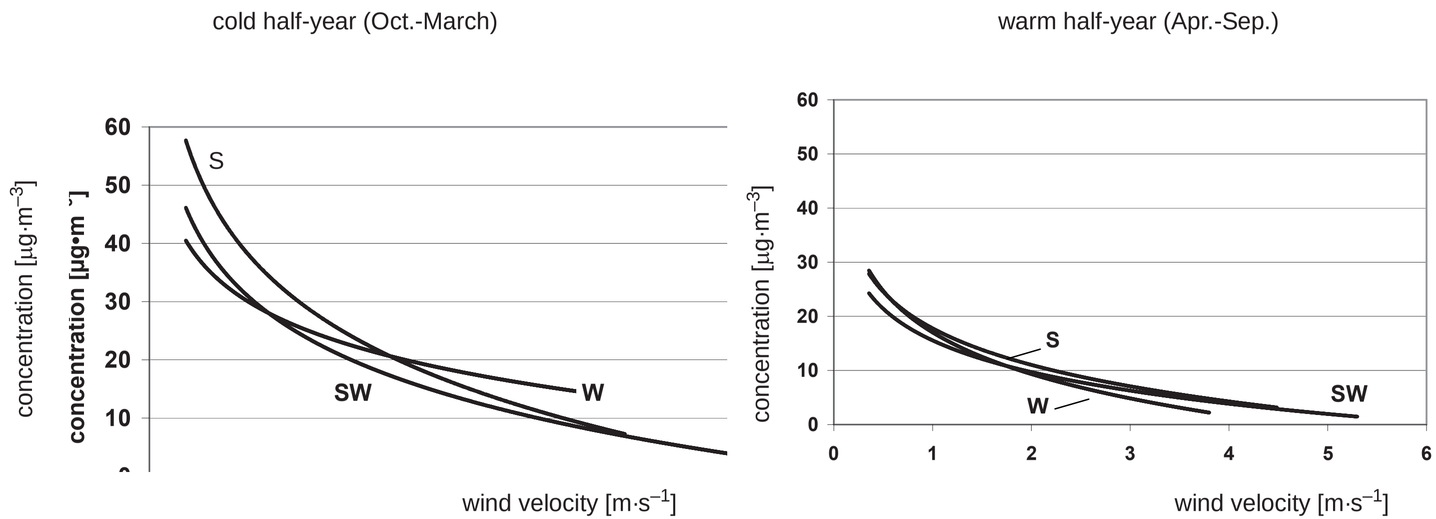
N = –6.73ln(Ws)*** + 10.025***, R^2 = 22.4%

S = –5.73ln(Ws)*** + 12.79***, R^2 = 23.4%

SW = –5.89ln(Ws)*** + 11.64***, R^2 = 34.3%

W = –7.68ln(Ws)*** + 12.48***, R^2 = 25.1%

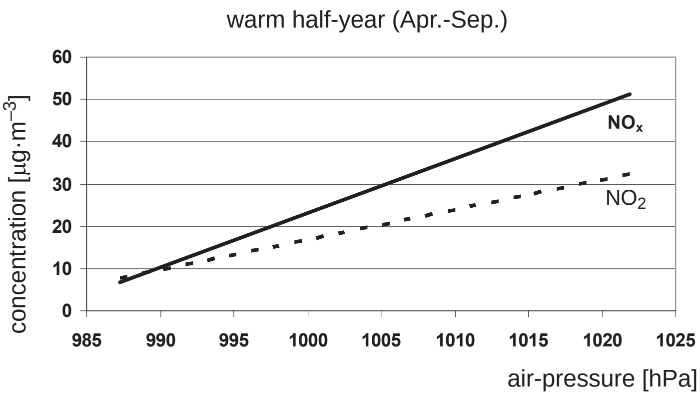
FIGURE 7. Relation between the concentration of NO_2 and wind velocity depending on the direction in northwest Poland in the period from 1st May 2005 to 30th April 2007



S = –19.63ln(Ws)*** + 33.29***, R^2 = 41.1%
SW = –15.26ln(Ws)*** + 30.64***, R^2 = 31.5%
W = –10.15ln(Ws)*** + 29.83***, R^2 = 34.3%

S = –19.63ln(Ws)*** + 37.78***, R^2 = 23.0%
SW = –15.26ln(Ws) + 30.64, R^2 = 31.1%
W = –10.15ln(Ws)*** + 29.83***, R^2 = 25.7%

FIGURE 8. Relation between the concentration of NO_x and wind velocity depending on the direction in northwest Poland in the period from 1st May 2005 to 30th April 2007



$NO_2 = 1.28Ph^{***} – 1261.39^{***}, R^2 = 24.2\%$

$NO_x = 0.71Ph^{***} – 698.37^{***}, R^2 = 27.3\%$

FIGURE 9. Relation between the concentration of NO_2 and NO_x and atmospheric pressure in northwest Poland, with south-easterly wind direction in the period from 1st May 2005 to 30th April 2007

concentration of NO_2 equalled 20.9 $\mu g \cdot m^{-3}$, and the lowest 2.3 $\mu g \cdot m^{-3}$.

On the other hand, Figure 8 show that wind velocity in both examined half-years most strongly affected the ambient concentration of NO_x with southerly, south-westerly and westerly winds. In the cold half-year the highest concentration of NO_x, equal to 59.0 $\mu g \cdot m^{-3}$, occurred with southerly wind, and the lowest, equal to 4.6 $\mu g \cdot m^{-3}$, with south-westerly wind, that is, in a similar way like for NO_2. In the warm half-year there was a similar effect of wind velocity on the size of the ambient concentration of NO_x from three analysed directions: S, SW and W.

In the warm half-year as well, a big influence on the size of the concentration of NO_2 and NO_x was exerted by atmospheric pressure with south-easterly wind, whereas the highest concentration of both analysed gases occurred when the pressure equalled 1021.8 hPa, and the lowest at 987.2 hPa (Fig. 9).

CONCLUSIONS

1. The distinctly seasonal changeability of nitrogen oxides concentration in north-western Poland shows the prevailing influence of point emission sources connected to the thermal power industry in this part of Poland.
2. In the set of meteorological elements most strongly correlated with the concentration of both gas pollutants, average wind velocity and atmospheric pressure were the most important.
3. The highest determination coefficients and, at the same time, the smallest estimation errors for multiple regression equations, describing the dependence of the concentration of NO_2 and NO_x from meteorological elements, were obtained with westerly wind in the cold half-year and with south-westerly wind in the warm half-year.

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Streszczenie: *Wpływ warunków meteorologicznych na stężenie NO_2 i NO_x w północno-zachodniej Polsce w zależności od kierunków wiatru.* Celem pracy była ocena czasowego rozkładu stężenia NO_2 i NO_x w zależności od kierunku wiatrów oraz określenie wpływu głównych elementów meteorologicznych na wielkość stężenia NO_2 i NO_x w północno-zachodniej Polsce. Na obszarze badań w okresie od 01.05.2005 r. do 30.04.2007 r. największe średnie stężenie NO_2 i NO_x zarówno w półroczu chłodnym, jak ciepłym, występowało przy wietrze wiejącym z kierunku SE, a najmniejsze – z kierunku SW dla NO_2 i z kierunku NE dla NO_x. Największe współczynniki determinacji i zarazem najmniejsze błędy estymacji dla równań regresji wielokrotnej, opisującej zależność stężenia NO_2 i NO_x od elementów meteorologicznych, uzyskano przy wietrze wiejącym z kierunku W – w półroczu chłodnym i z kierunku SW – w półroczu ciepłym.

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