 https://doi.org/10.1051/e3sconf/20182801013

Long-term trends of pollutant concentrations in selected sites in Silesian Voivodeship

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Abstract. The assessment of the air pollution quality in selected sites of Silesian Voivodeship was presented in this paper. The evaluation based on the sets of long-term data, recorded by the state air monitoring network. Concentrations of main air pollutants such as PM10, O_3, CO, SO_2, NO_2, NO were considered. The basis for the calculations were 12-year time series of hourly concentrations. Using this data, the monthly averages of pollutant concentrations were calculated. Long-time trends of concentration changes were determined for each pollutant separately. Based on the analysis of trends, risks that may arise in the future were identified.

1 Introduction

Silesian Voivodeship has the opinion of the most polluted region of Poland. Cities like Zabrze and Rybnik are often mentioned as extremely contaminated places [1]. Long-term measurements of the air monitoring stations allow to answer the question how the air quality has changed in these towns. The aim of the study is to identify the trends of changes in the concentration level of main air pollutants.

Currently in Poland, the state network of air monitoring operates according to the new regulations, which are in line with the European Union legal acts. The present monitoring program started functioning shortly before Poland's accession to the EU [2, 3]. In previous years, air monitoring measurements were actually carried out, but on other principles. Therefore, in this examination, 2005 was adopted as the starting point in the analysed time series. 12-year observations should allow to determine the real trends. Designing trends allow to identify the air quality hazards that may emerge in the future.

2 Methods

Concentrations of basic air pollutants such as: O_3, NO, NO_2, CO, SO_2, PM10, registered in the years 2005-2016 at air monitoring stations in Zabrze and Rybnik, were used in the analysis. Both stations are located in big industrial centers and belong to the

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type of urban background monitoring sites. The analysed data were received from the Voivodeship Inspectorate of Environmental Protection in Katowice. Using time series of 1-hour (instantaneous) concentrations, the monthly mean concentrations were calculated. For each pollutant, 12-year courses of monthly concentrations were determined. Linear trends were adjusted to the courses. Trend lines were determined by the least squares method. Based on the analysis of trends, risks that may arise in the future were identified.

3 Results

Results of the analysis were shown in figures 1-12. The figures picture long-term courses of monthly concentrations as well as trend lines, for each pollutant and each site separately.

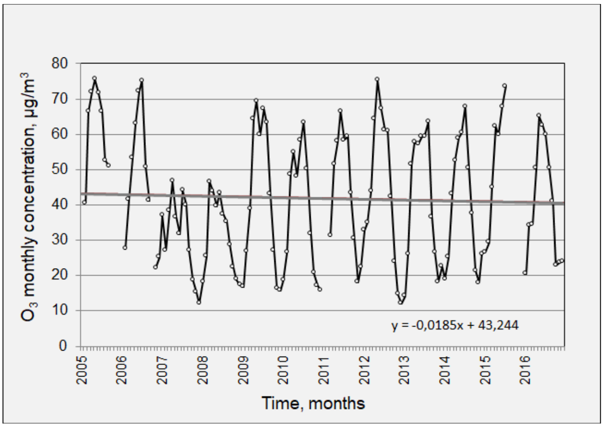

Fig. 1. The course of monthly average concentrations of O_3 at the Zabrze station in the period 2005-2016 with adjusted linear trend.

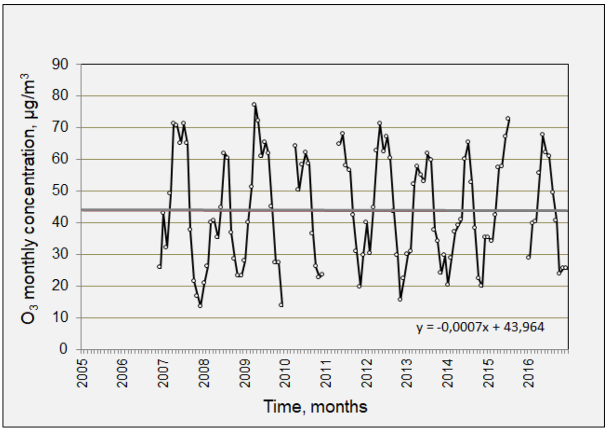

Fig. 2. The course of monthly average concentrations of O_3 at the Rybnik station in the period 2005-2016 with adjusted linear trend.

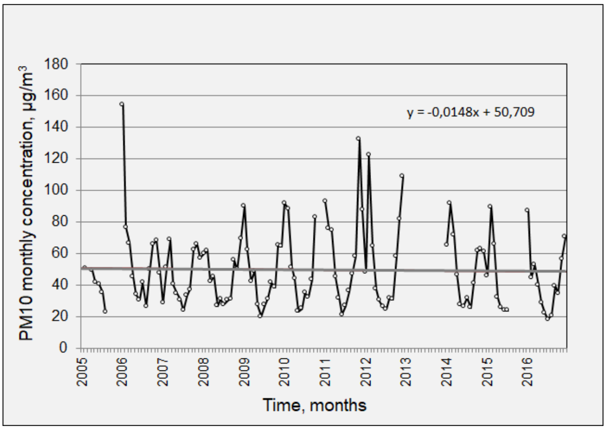

Fig. 3. The course of monthly average concentrations of PM10 at the Zabrze station in the period 2005-2016 with adjusted linear trend.

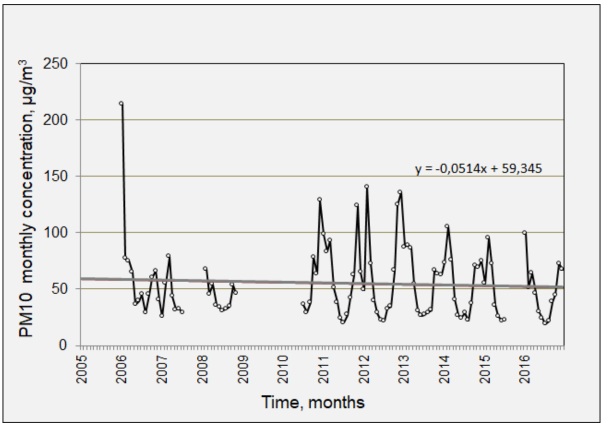

Fig. 4. The course of monthly average concentrations of PM10 at the Rybnik station in the period 2005-2016 with adjusted linear trend.

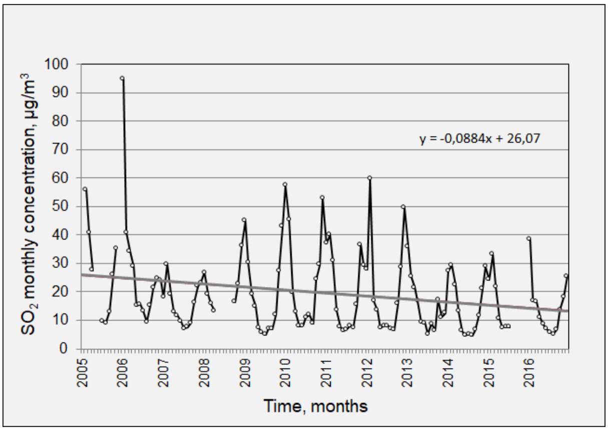

Fig. 5. The course of monthly average concentrations of SO_2 at the Zabrze station in the period 2005-2016 with adjusted linear trend.

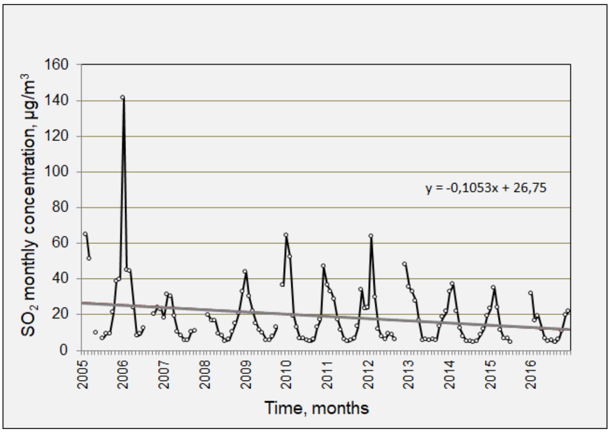

Fig. 6. The course of monthly average concentrations of SO_2 at the Rybnik station in the period 2005-2016 with adjusted linear trend.

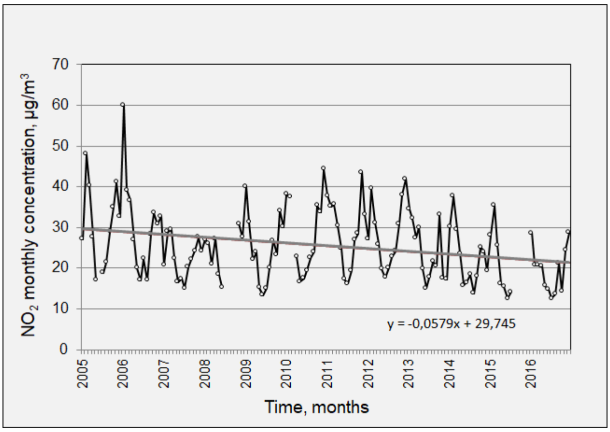

Fig. 7. The course of monthly average concentrations of NO_2 at the Zabrze station in the period 2005-2016 with adjusted linear trend.

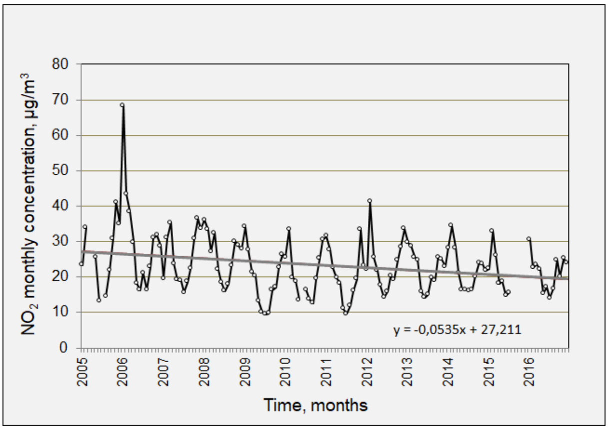

Fig. 8. The course of monthly average concentrations of NO_2 at the Rybnik station in the period 2005-2016 with adjusted linear trend.

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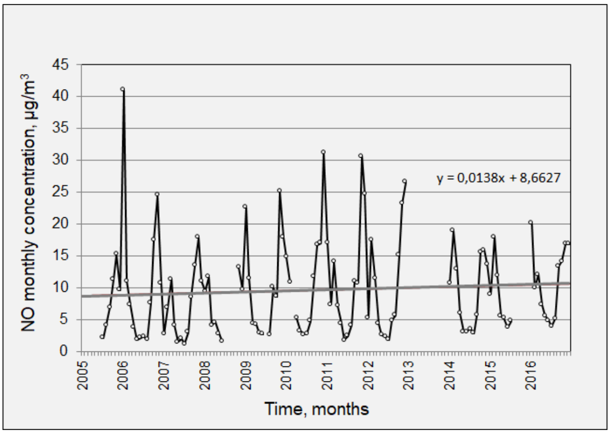

Fig. 9. The course of monthly average concentrations of NO at the Zabrze station in the period 2005-2016 with adjusted linear trend.

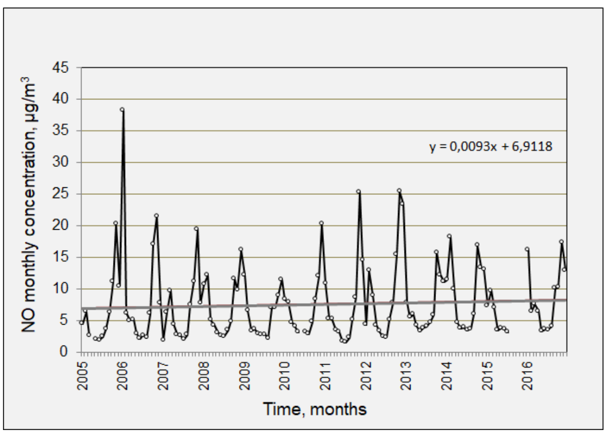

Fig. 10. The course of monthly average concentrations of NO at the Rybnik station in the period 2005-2016 with adjusted linear trend.

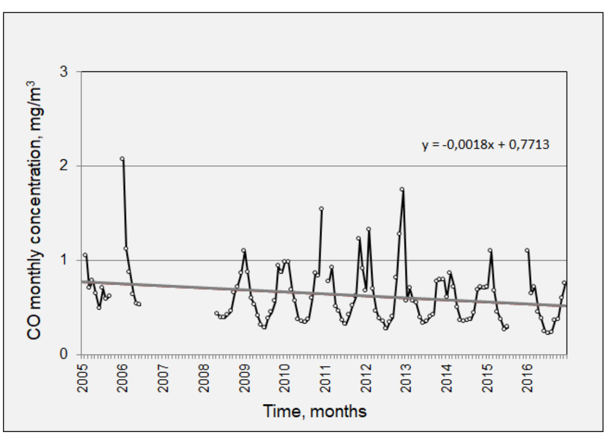

Fig. 11. The course of monthly average concentrations of CO at the Zabrze station in the period 2005-2016 with adjusted linear trend.

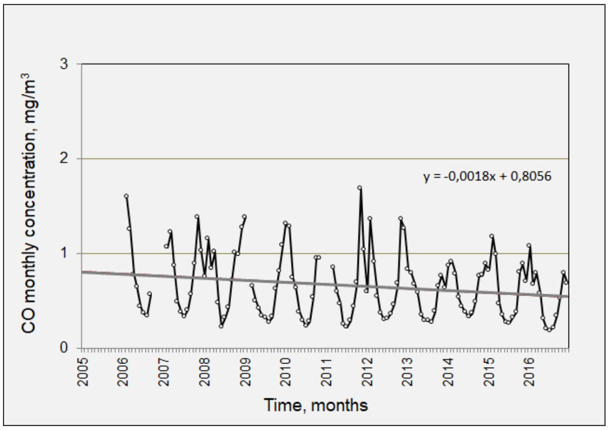

Fig. 12. The course of monthly average concentrations of CO at the Rybnik station in the period 2005-2016 with adjusted linear trend.

4 Summary and discussion

Summary of the results was shown in tab. 1. The direction coefficient values of the obtained trend equations were analysed to estimate the direction and strength of the concentrations changes. The strongest changes were observed in the case of SO_2, NO_2 and CO concentrations. In the both towns those concentrations have been decreasing. Concentrations of PM10 have been decreasing slower. O_3 concentrations have been decreasing in Zabrze but in Rybnik they were more stable. Only in the case of NO concentrations, the increasing was observed, however, at low concentration level.

Table 1. Long-term concentration changes – summary

Pollutant	Monitoring site	Trend equation (x – number of months)	Estimation of trend
O_3	Zabrze	y = -0.0185x + 43.2	Slight decrease
	Rybnik	y = -0.0007x + 44.0	Stabilization
PM10	Zabrze	y = -0.0148x + 50.7	Slight decrease
	Rybnik	y = -0.0514x + 59.3	Decrease
SO_2	Zabrze	y = -0.0884x + 26.1	Strong decrease
	Rybnik	y = -0.1053x + 26.8	Strong decrease
NO_2	Zabrze	y = -0.0579x + 29.7	Strong decrease
	Rybnik	y = -0.0535x + 27.2	Strong decrease
NO	Zabrze	y = 0.0138x + 8.66	Increase
	Rybnik	y = 0.0093x + 6.91	Increase
CO	Zabrze	y = -0.0018x + 0.771	Strong decrease
	Rybnik	y = -0.0018x + 0.806	Strong decrease

According to the European Environment Agency report, in the years 2000-2015 total emissions of air pollutants decreased in EU [4]. Similar trends have been observed in Poland. Since 2000 the following drops of emission has been estimated: 51% for SO_2, 25% for CO, 22% for particulates, 14% for NO_x [5].

Generally, the changes in pollution levels at stations Zabrze and Rybnik should be considered advantageous for the environment. The rapid fall in SO_2, CO and NO_2 levels indicates an effective policy of reducing air pollution. Several years ago Poland was classified as a country with exceptionally high SO_2 emission. An evident drop of SO_2 concentrations indicates that long-term programs for limitation emission of this gas are effective. Moreover, the favourable trends are noticeable in Silesia, the region where coal is mined and burned in large quantities. The increase of NO concentrations with the simultaneous decline of NO_2 concentration is not something dangerous. The biggest problem are PM10 concentrations. Although the gradual decrease in concentration can be noted, but still the levels of concentration during heating periods are too high. The reason is low emission from very common domestic installations burning coal waste. It can be assumed that smog episodes resulting from high concentrations of PM10 will continue to occur in many sites in Poland, because government policy is very hesitant in this regard.

Trends observed in Silesian cities coincide with European trends. Europe's air quality is slowly improving, but particulate matter and ground-level ozone continue to cause serious impacts on health [6]. Despite numerous actions to improve the air quality, the following issues still constitute an serious problem in Poland: exceedances of target value for tropospheric ozone during the summer season and exceedances of limit values for particulate matter PM10 and benzo[a]pyrene during the winter season [7].

5 Conclusions

The 12-year observations of the concentration levels of the basic pollutants registered at two air monitoring stations allow the following conclusions:

1. Concentrations of the most of main air pollutants tend to decrease. The strongest drops are observed in the case of SO_2, NO_2 and CO concentrations.
2. Concentrations of PM-10 decrease slower.
3. Exceptionally, NO concentrations increase.

This study was carried out within a research project of Czestochowa University of Technology BS-PB-402-301/15.

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