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Improving local air quality in cities by reducing nitrogen dioxide pollution from road traffic

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Abstract. Trucks and buses play a major role in our lives, transporting goods and thousands of people to cities every day. But these vehicles, although in a much smaller number than the car generates a significant amount of air pollutants. The daily NO_2 concentrations measured by a traffic monitoring station over a period of two years are used to identify the temporal variation of NO_2 pollution as a result of measures to ban the circulation of trucks that do not meet the EURO 6 standard on Stresemannstraße Street in Hamburg. The data shows a decrease in NO_2 concentration due to the measure taken so that in January 2017 the maximum daily NO_2 concentration was 86 μg/m^3 compared to 63 μg/m^3 in 2019. There was also a difference between the daily minimum concentrations during the same period, being approximately 28 μg/m^3 in 2017 and 10 μg/m^3 in 2019. The daily NO_2 observations show a significant decrease in concentration since May 2018 when the non-EURO 6 trucks were banned. The largest decrease in daily concentrations was recorded in March 2019 compared with levels in March 2018, with a lower concentration for 28 days. A different situation was observed in October 2018, when compared to October 2017, showed an increase in concentration for 23 days.

1 Introduction

The urban air in many European cities has become inadequate for breathing due to the high levels of pollution caused mainly by vehicles, especially by diesel cars. Urban citizens are forced to breathe this highly polluted air despite EU legislation that limit ambient air-pollution levels, thus leading to hundreds of thousands of premature deaths every year at European level [1].

Vehicles are the main source of pollution because of their ubiquity and the proximity of gas emitted to people. Some progress has been made to reduce particulate emissions by introducing Euro 6 limits for diesel cars, but NOx remains a key issue, especially from diesel engines. NOx convert in the air to toxic nitrogen dioxide and finally into nitrate aerosol particles and ozone. A stringent problem is the particulate and pollutant emission from older diesel engines and from diesel vehicles with particle filters that have been damaged or removed illegally.

Breathing air with a high concentration of NO_2 it may irritate the airways of the human respiratory system and even for short exposures may worsen respiratory diseases, especially asthma. Longer exposure to high concentrations of NO_2 can contribute to the development of asthma and the most exposed to the effects of this pollutant are children and the elderly.

Local concentrations of NO_2 are largely determined by road traffic emissions from passenger cars, light trucks and heavy duty vehicles [2, 7, 9].

The Euro standards for exhaust emission gases are important tools in Europe to reduce NOx emissions from road traffic in order to reduce NO_2 concentration levels below the limit value and to improve air quality in cities and along highways.

The German government has adopted an ambitious air quality program aimed to ensure that the air quality limit is accomplished throughout Germany over time.

Low emission zones can be an effective way to reduce NOx emissions in cities. An increasing number of large cities implement low emission zones, which ban circulation either for all vehicles or just for heavy goods vehicles only. Low emission zones must be large in size, meet severe emission standards (Euro 6 or better) and be strictly enforced [3, 4].

The ban on circulating certain types of more polluting vehicles in low emission zones could lead to the relocation of pollution sources instead of reducing them, so they do not necessarily lead to a good result.

Low emission zones are areas - usually in cities with different restrictions on the operation of more polluting vehicles, usually older (vehicles with higher emissions cannot enter into the area or have to pay a higher tax if they enter into the area with low emissions) [5, 6, 8].

Cities and governments have adopted low emission zones as a measure to reduce air pollution to comply with EU air quality standards. Low emission zones are often considered the most effective measure that cities can take to improve air quality and the number of these zones has increased steadily and they have been implemented in many EU countries [10, 11].

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Low emission zones requirements are not harmonized in the EU, they are rather governed by different regulations at local and / or national level.

Typical requirements of low emission zones includes: prohibition of higher emission vehicles and of vehicles below a certain EURO emission standard. Some low emission zones have different standards for petrol and diesel cars to take into account different levels of NO_2 emissions.

On 27 February 2018, a decision of the highest court of the federal administration in Germany confirmed that the German cities could introduce restrictions for diesel cars with immediate effect and clarifies that the right of citizens to breathe clean air takes precedence over the rights of private car owners to drive polluting vehicles. As more cities introduce restrictions for polluting diesel cars, the air pollution problem could become more severe for Central and Eastern European countries due to second-hand cars imported from Western Europe.

2 Data

Starting from 31st May 2018, the circulation of diesel lorries that did not comply with the Euro 6 standard on Stresemannstrasse street in Hamburg was banned (Figure 1).

For our study, we obtained data on NO_2 concentrations collected at the traffic monitoring station located on Stresemannstrasse street in Hamburg (the sampling height of the monitoring station: 4 m above ground). The monitoring station is operated by the Hamburg Monitoring System for Air Quality, Germany. Our objective of this study was to evaluate the air quality improvement by applying the measure to ban the circulation of diesel trucks [12, 13].

In our analysis, we compared the NO_2 concentrations measured prior to the implementation of the diesel car ban, with the NO_2 levels measured after the measures came into force. For the analysis, the measurements in the period prior to the application of the prohibition measure from 1 January 2017 to 31 May 2018 were used. The data from the second analysis period from 1 June 2018 to 30 March 2019 covered the period when the trucks transit ban was effective.

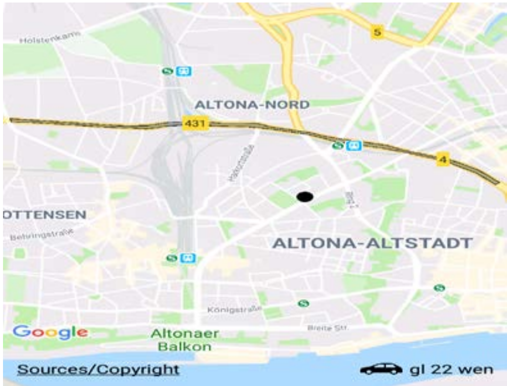

Fig. 1. The environmental zone on Stresemannstrasse street in Hamburg

3 Results and discussions

As shown in Figure 2, during the study period in the evolution of NO_2 concentrations in Hamburg, the average NO_2 concentrations have exceeded the limit value of the EU air quality standard of 40 µg / m³. In January, February and March, it is noted that most exceedances of the limit value are recorded in 2017 and 2018 when no traffic restriction measures were applied.

Following of road traffic restrictions for diesel cars (starting on 31 May 2018), in 2019 there is a downward trend in NO_2 concentrations below the limit value, the highest decrease has been registered in March, when the number of the exceeding days was only 10, compared to 28 days recorded in 2017 and 25 days in 2018. The number of days in January in which exceedances of NO_2 concentrations were recorded were 25 days in 2017, 17 days in 2018 and 15 days in 2019. In February, the number of days with exceedances of the limit value it was 22 days in 2017, 23 days in 2018 and 16 days in 2019.

Figure 2 shows the trend and the value of the increase or decrease of the NO_2 concentration in the case of the restrictive measures application (2019) and in the base case without measures (2018), the red bars representing the absolute value of the increase in concentration in the days when it exceeds occurred in 2019 compared to 2018, and with green bars the value with which the concentration was reduced in the days when the decreases occurred.

The negative numbers represent the absolute value of the decrease in NO_2 concentration and the positive numbers the absolute value of the increase of the concentration compared to the previous year.

Figure 2 shows that the NO_2 concentration has a decreasing trend due to the measures applied, the most obvious decrease being registered in March when the concentrations measured in 2019 exceeded the values from 2018 for only two days. Daily average NO_2 concentrations over the three months and for the three years ranged from 10 µg / m³ to 98 µg / m³. The maximum NO_2 concentration was observed on March 27, 2017, and the lowest NO_2 concentration was detected on January 2, 2019.

Figure 3 shows the daily average NO_2 concentration variation in the pre-restrictive period of 2017 and 2018.

The data monitored in April and May 2017 and 2018 show a general trend of exceeding the limit value of NO_2 concentrations, with exceeding being recorded for 20 days in April in 2017 and 24 days in 2018 respectively.

In May, the days in which the limit value of NO_2 concentrations was exceeded was 28 in 2017 and 22 in 2018 respectively. In April, there was an increase in NO_2 concentrations in 2018 compared to 2017 for 16 days, while in May the exceedance was registered for 13 days.

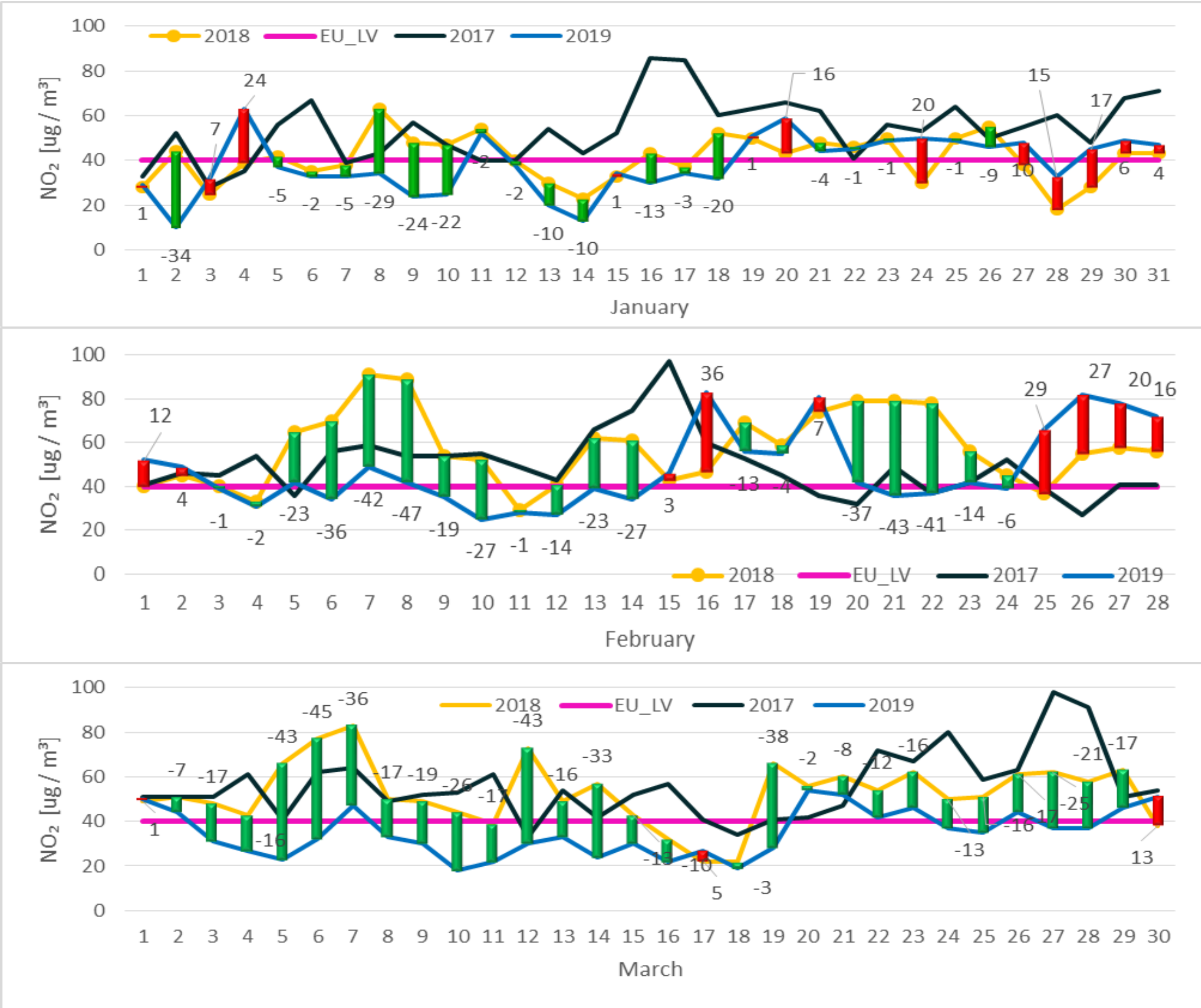

Fig. 2. Daily average of NO_2 concentrations during the pre-restriction and restriction period in the years 2017-2019

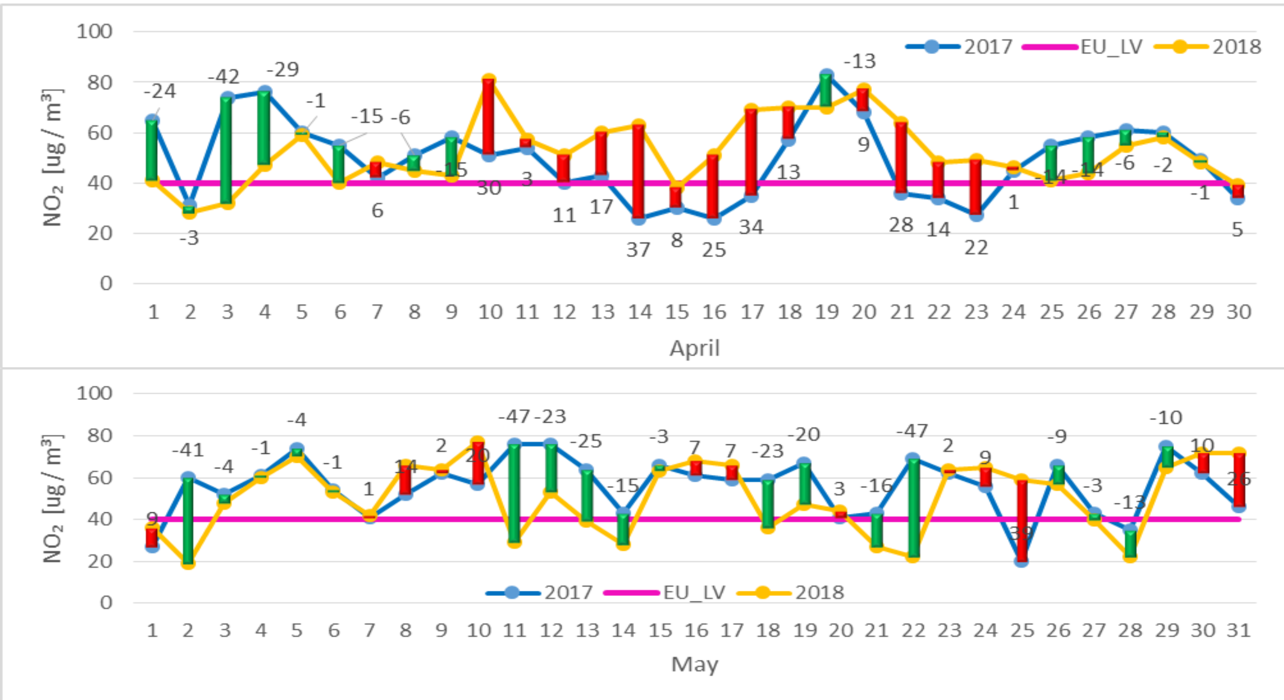

Fig. 3. Daily average of NO_2 concentrations during the pre-restriction period in the years 2017-2018

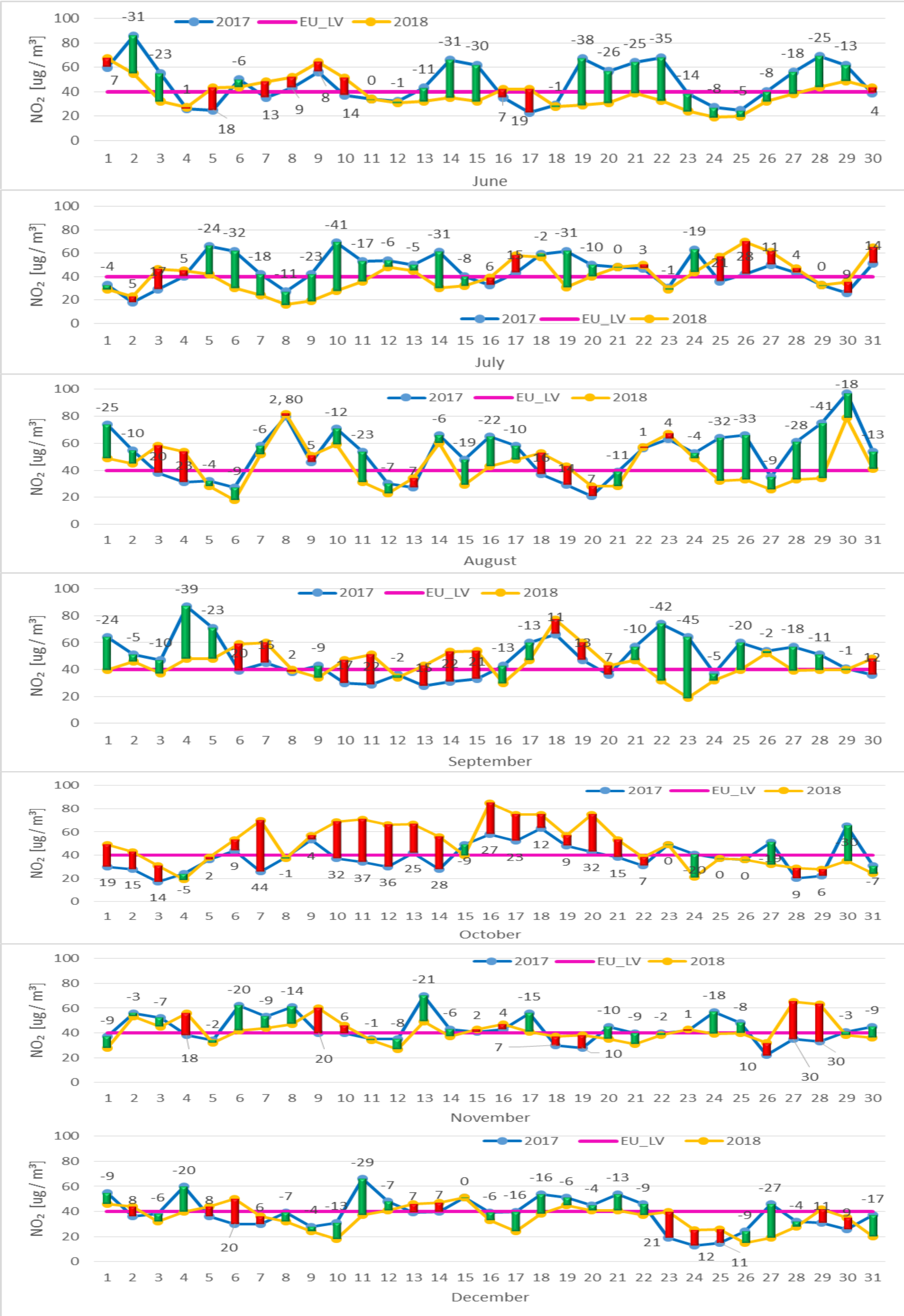

Fig. 4. Daily average of NO_2 concentrations during the pre-restriction and restriction period in the years 2017-2018

The results of the analysis performed for different time periods (June to December) are shown in Figure 4. The average daily variation of the NO_2 concentration shows a decreasing trend during the period of restriction application compared to the time before restriction introduction. The greatest value of the NO_2 concentration was 97 µg / m3 recorded on August 30, 2017.

From Figure 4 it can be seen that in the months before the restriction, the days in which the limit value were exceeded are higher, except October when the trend was reversed and the exceedances were higher during the period of restriction application (2018) and have recorded higher concentrations than in the same period of 2017.

The results show that the daily average concentration of NO_2 has a downward trend after application of traffic restriction on diesel cars, registering higher concentrations than the limit value for 10 days in January 2019 to 18 days in September 2018.

In the period before restriction introduction, the limit value of NO_2 concentrations was exceeded for 11 days in December 2017 and for 28 days in March and May 2017.

Lower values of NO_2 concentrations in December may be due to lower traffic, especially during the holidays (the Christmas) when it is observed a greater reduction in the NO_2 concentrations than the usual values.

4 Conclusion

NO_2 concentrations fluctuate visibly day by day, with daily average concentrations ranging from 10 to 98 µg / m3.

During the nine months before restrictions apply to diesel lorries (June 2017 - March 2018), 66% of days exceeded the NO2 concentration limit. After the restriction application has been a decrease of 12% of days in which there were breaches of the limit on concentrations of NO_2. Due to the measures implemented, the daily average concentration of NO_2 decreased, the strongest effect was in March when except two days all the daily average values were lower than in the pre-ban period and at the same time there were exceedances of the limit value of the NO_2 concentration for only 10 days as shown in Figure 2.

The results presented in this paper clearly confirm the beneficial effect of the measure taken on Stresemannstrasse Street in Hamburg. However, the limit value for NO_2 concentration is still exceeded. In order to comply with the minimum level, important measures need to be taken further and interpretation of past air quality trends can generate relevant results for planning beneficial actions.

Since the ban applies only for lorries and not to all diesel vehicles, in a future analysis, we must study the influence of the background concentrations due to ban on all diesel cars that do not comply with Euro 6 standard applied on nearby Max-Brauer-Allee and the possible relocation of these cars on the Stresemannstrasse street. When the ban does not apply to a large area, the expected effects could be minimal due to influence of the background concentrations that could increase due to increasing traffic on adjacent streets.

The analysis showed that in some days, even after the introduction of the traffic restrictions, there were exceedances of concentration compared with the previous period this may have been due to the influence of atmospheric factors (solar radiation, relative humidity, wind speed) on the lifetime of NO_2.

References

1. K. Gładyszewska-Fiedoruk, E3S Web of Conferences **101**, 03002 (2019)
2. P. Spiru, P.L. Simona, Energy Procedia **157**, 1553-1560 (2017)
3. C. Johansson, B. Lövenheim, P. Schantz, L. Wahlgren, P. Almström, A. Markstedt, M. Strömgren, B. Forsberg, J.N. Sommar, Science of the Total Environment **584–585**, 55–63 (2017)
4. V. Fensterer, H. Küchenhoff, V. Maier, H.E. Wichmann, S. Breitner, A. Peters, J. Gu, J. Cyrys, Int. J. Environ. Res. Public Health, **11**, 5094-5112 (2014)
5. *I*.S. Mudway, I. Dundas, H.E. Wood, N. Marlin, J.B. Jamaludin, S.A. Bremner, L. Cross, A. Grieve, A. Nanzer, B.M. Barratt, S. Beevers, D. Dajnak, G.W. Fuller, A. Font, G. Colligan, A. Sheikh, R. Walton, J. Grigg, F.J. Kelly, T.H. Lee, C.J. Griffiths, Public-health, **4**, e28-e40 (2019)
6. S. Alahmadi, K. Al-Ahmadi, M. Almeshari, Science of the Total Environment, **676**, 131-143 (2019)
7. S. Paraschiv, D.E. Constantin, S.L. Paraschiv, M. Voiculescu, Int. J. Environ. Res. Public Health **14** (11), 1415 (2017)
8. T.V. Russkova, P.N. Zenkova, Modern problems of remote sensing of the earth from space, **15** 7 221–235 (2018)
9. P Spiru, PL Simona, Energy Procedia **128**, 179-186 (2017)
10. D.M. Agudelo–Castaneda, E.C. Teixeira, F.N. Pereira, Atmospheric Pollution Research, **5**, 411–420 (2014)
11. S. Alahmadi, K. Al-Ahmadi, M. Almeshari, Science of the Total Environment, **676**, 131-143 (2019)
12. The Hamburg Climate Action Plan https://luft.hamburg.de/
13. The ambient air pollution network of Hamburg https://luft.hamburg.de/