The impact of COVID-19 confinement measures in the air quality in an urban-industrial zone in Portugal

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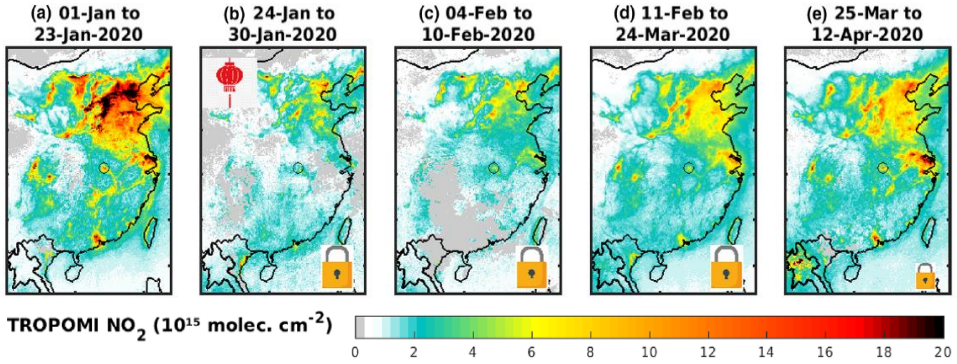
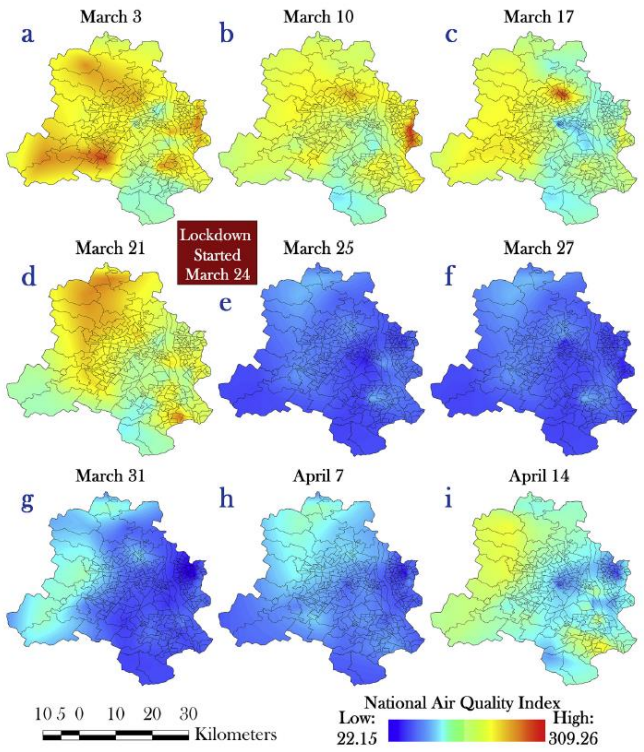
BETTER OR WORSE THAN BEFORE?

The pandemic offered a unique opportunity to examine the effects of human-related activities, especially mobility, on air quality.

Several studies have demonstrated that COVID-19 lockdowns caused a **positive impact on air quality**:



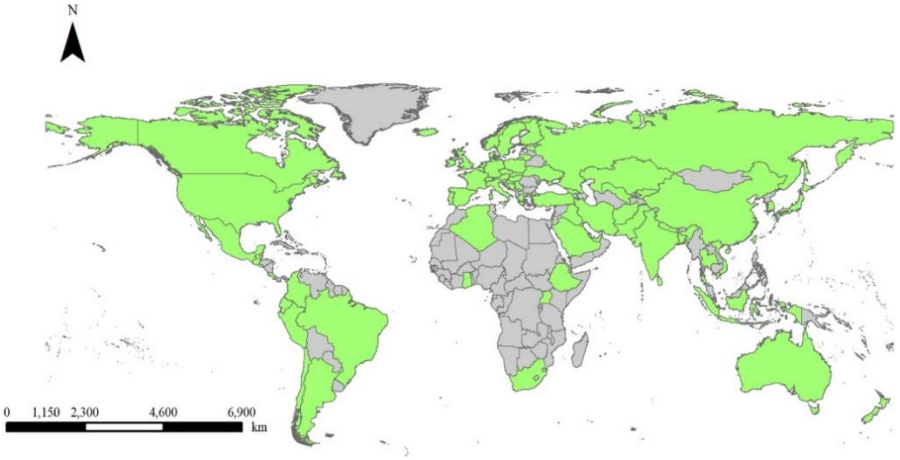
[1] Bauwens, M. *et al.* (2020) 'Impact of Coronavirus Outbreak on NO_2 Pollution Assessed Using TROPOMI and OMI Observations', *Geoph. Res. Letters*, 47(11), 1–9, doi: 10.1029/2020GL087978



[2] Mahato, S., Pal, S. and Ghosh, K. G. (2020) 'Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi, India', *Sci. Total Environ.*, 730, 139086. doi: 10.1016/j.scitotenv.2020.139086.

BETTER OR WORSE THAN BEFORE?

- Liu et al. (2021) studied the effect of COVID-19 lockdown on global air quality and health [3]
- 597 cities worldwide (air pollution data + weather data)



- Air pollutants responded differently to the lockdown measures:

- NO_2 (23–37%)
- PM_{10} (14–20%)
- SO_2 (2–20%)
- $PM_{2.5}$ (7–16%)
- CO (7–11%)

- O_3 (10-27%)

[3] Liu F., Wang M., Zheng M. (2021) Effects of COVID-19 lockdown on global air quality and health, Sci. Total Environ., 755, 142533, doi: 10.1016/j.scitotenv.2020.142533

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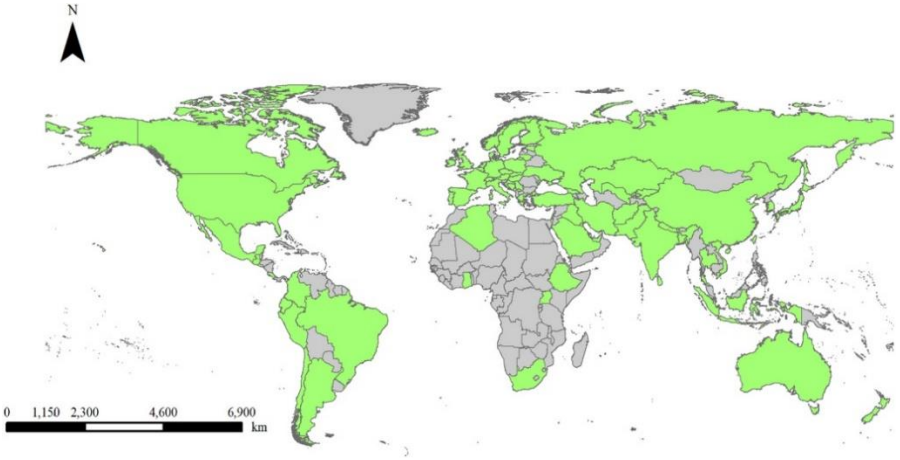

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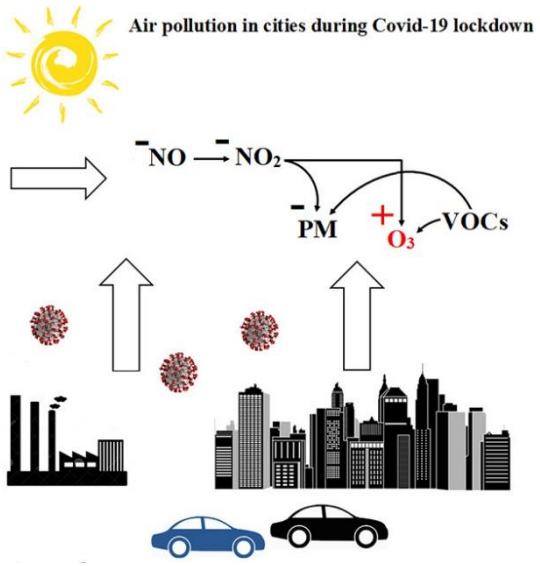
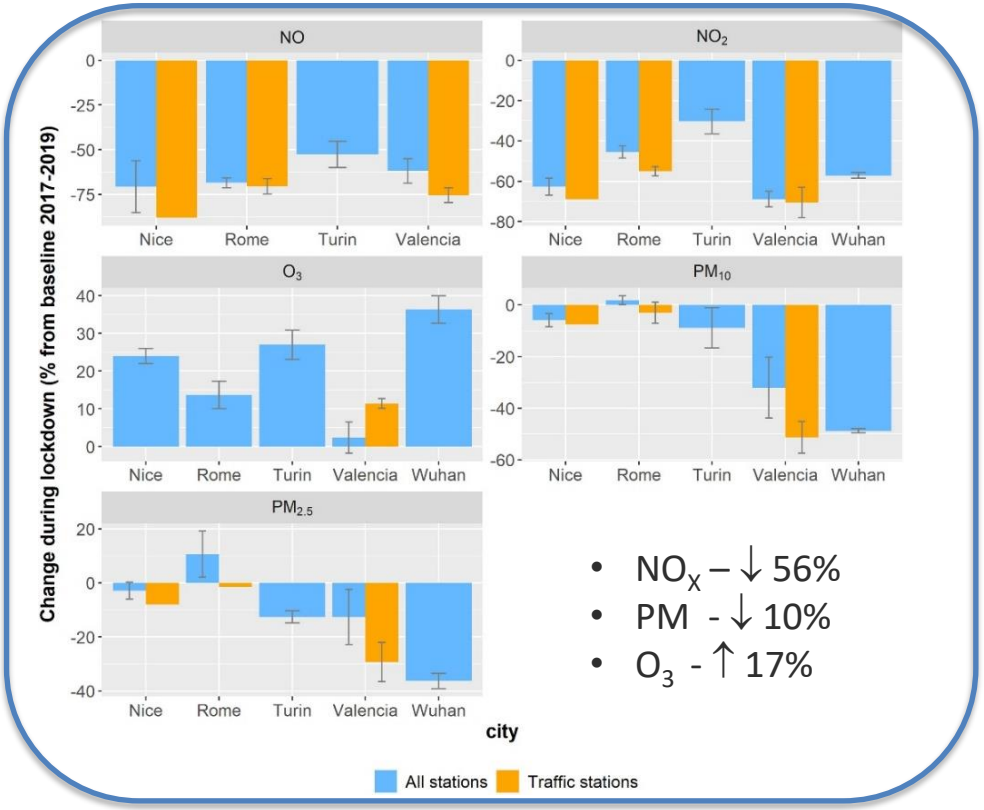
Ozone?

- Sicard *et al.* (2021) studied the amplification of ozone pollution in cities during COVID-19 lockdown [4]
- 4 European and 1 Chinese cities





- NO_X – ↓ 56%
- PM - ↓ 10%
- O_3 - ↑ 17%

[4] Sicard P. *et al.* (2021) Amplified ozone pollution in cities during the COVID-19 lockdown, Sci. Total Environ., 735, 139542, doi: 10.1016/j.scitotenv.2020.139542

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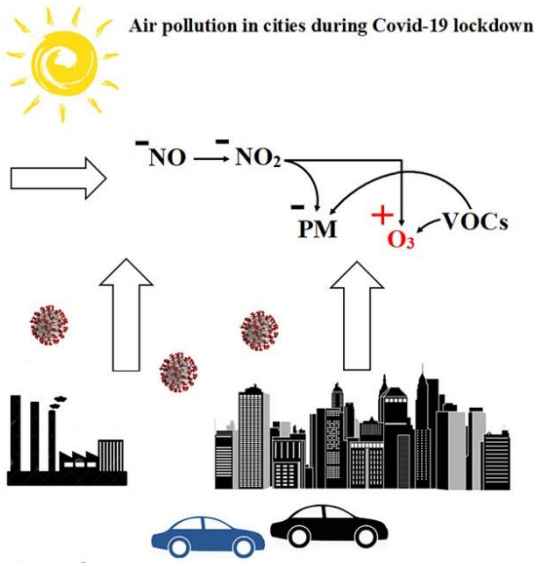


Why?

NOx species:

- **NO_2** is a **precursor** of O_3 in the presence of sunlight
- **NO** is a **scavenger** of O_3 during the night ($NO+O_3 \rightarrow NO_2+O_2$)

Main causes of higher O_3 levels during the lockdown (similar to "weekend effect"):

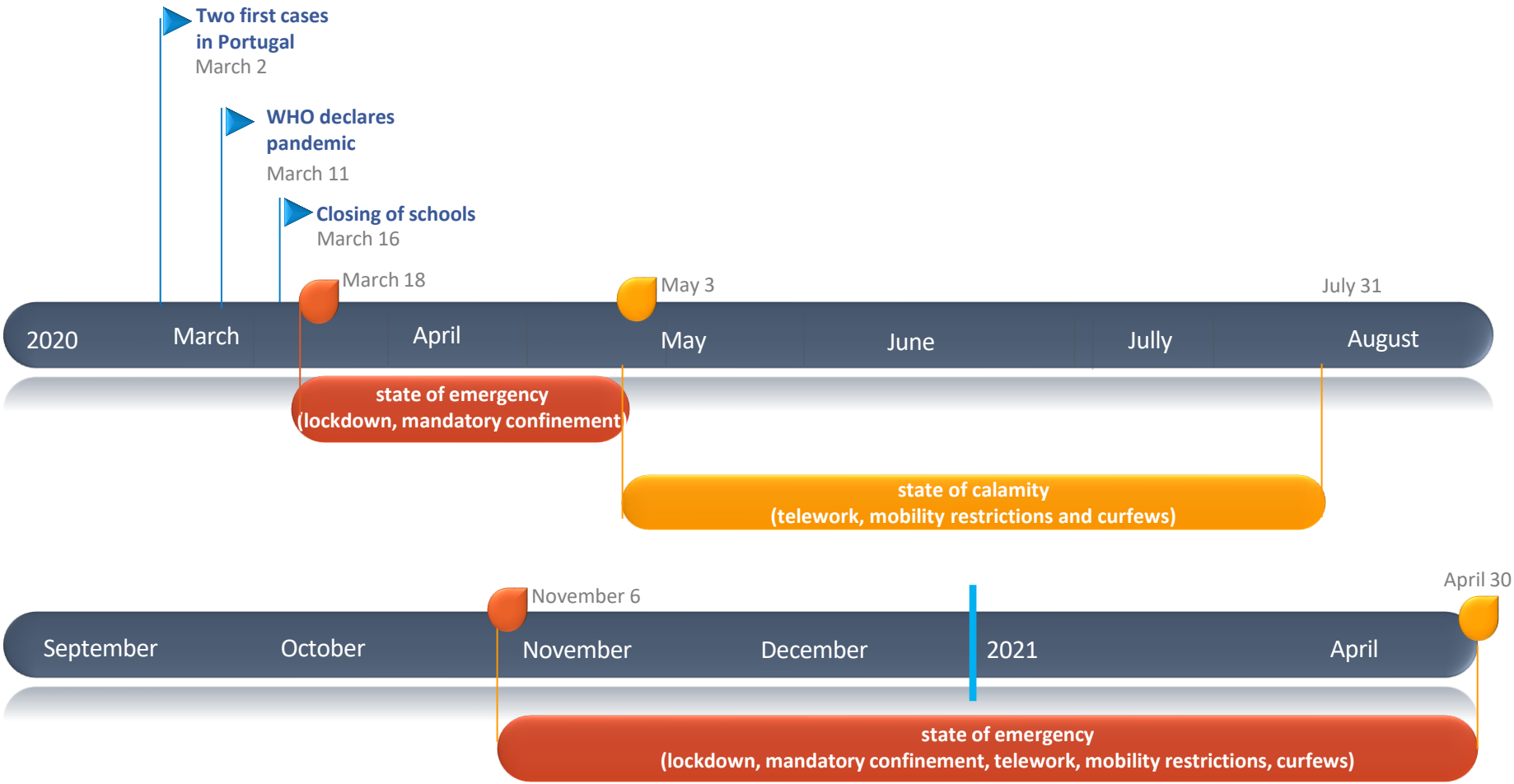
i) a reduction in NOx emissions from traffic leading to a **lower O_3 titration by NO**

ii) with lower PM emissions, the **higher solar radiation** favored O_3 formation

iii) increase of O_3 precursors emissions from residential activities

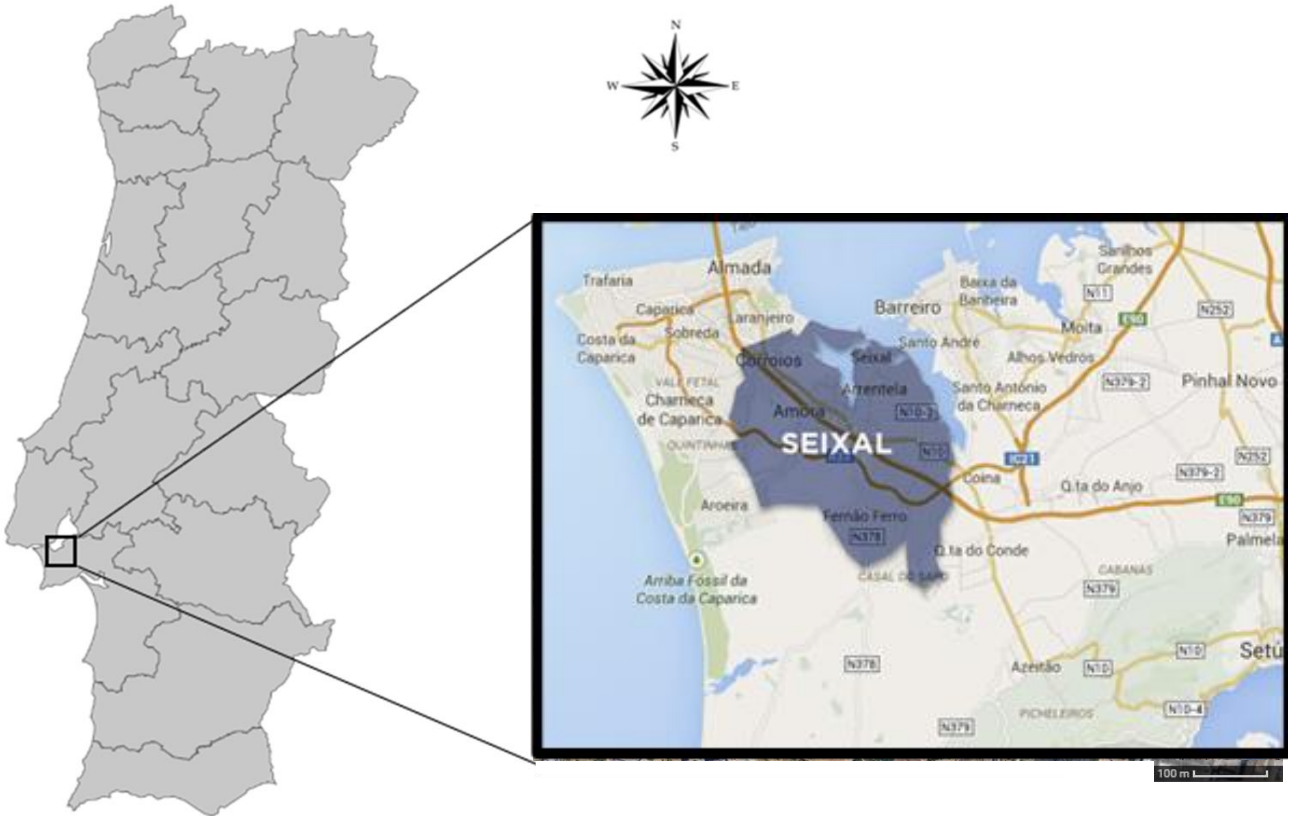
[4] Sicard P. *et al.* (2021) Amplified ozone pollution in cities during the COVID-19 lockdown, Sci. Total Environ., 735, 139542, doi: 10.1016/j.scitotenv.2020.139542

COVID-19 IN PORTUGAL



Aim

- to evaluate the temporal evolution of PM10, NO_2 and O_3, in an urban-industrial zone in Portugal (Paio Pires-Seixal), from 2001 to 2020
- to assess the impact of the COVID-19 pandemic on the concentrations of these air pollutants.



Seixal [5]:

- densely populated (165547 inhab in 95.5 km^2)
- **industrial** influence (steelworks, shipyard)
- **traffic** influence (highways)

monitoring station

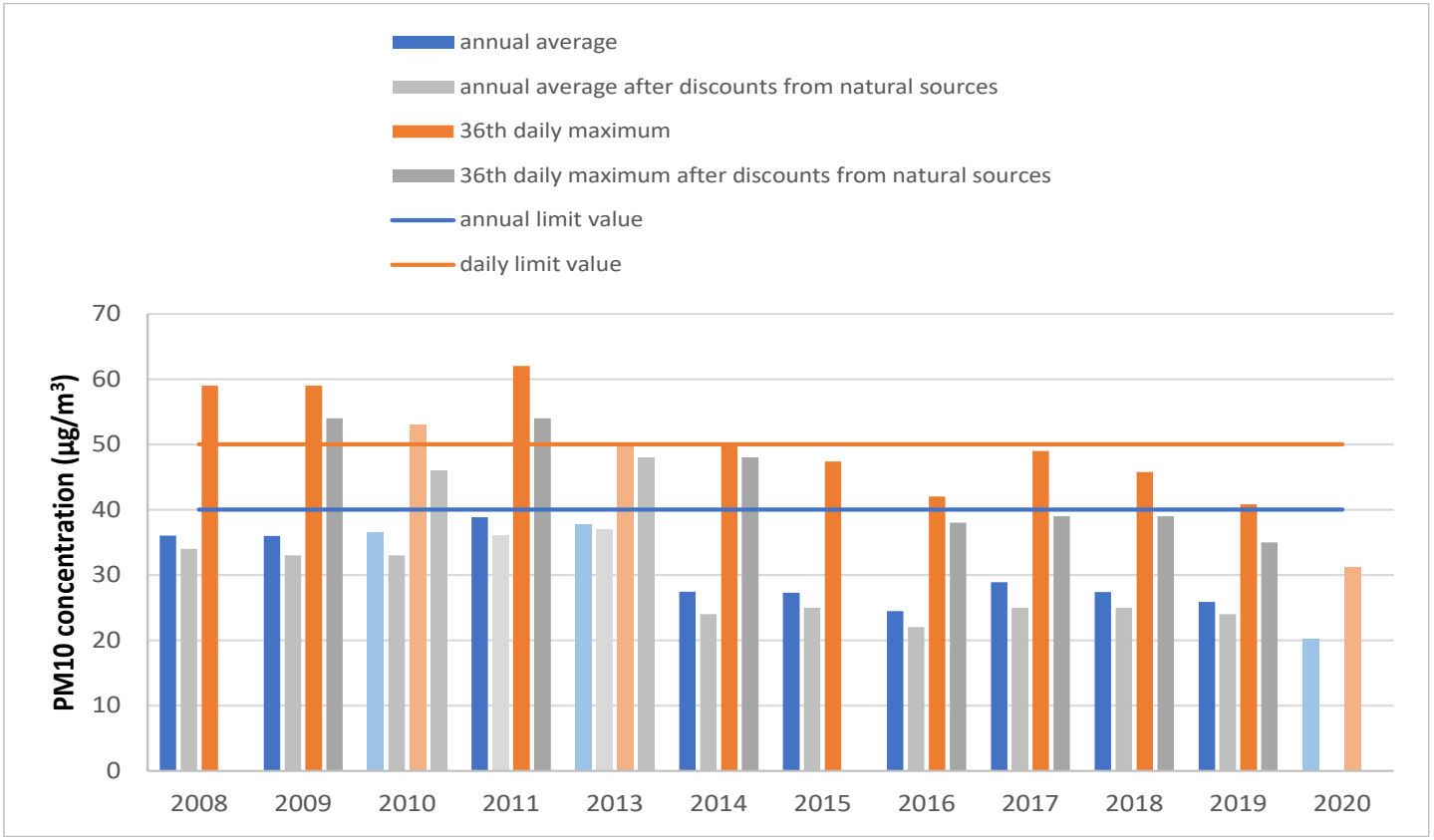
steelworks

Data: hourly average concentrations of PM10, NO_2 and O_3 from the QUALAR database (APA), relative to the Paio Pires-Seixal station (38°37'15.7"N 9°04'55.4"W) of the National Air Quality Monitoring Network.

[5] Justino, A. R. *et al.* (2019) 'Contribution of micro-PIXE to the characterization of settled dust events in an urban area affected by industrial activities', *Journal of Radioanalytical and Nuclear Chemistry,* 322(3), 1953–1964. doi: 10.1007/s10967-019-06860-8.

Results

Air quality legal compliance *(Decree-Law No. 47/2017 of May 10, transposition of the EU Directive 2015/1480)*



- For PM10, the DLV was exceeded in 2009 and 2011;
- No concentrations higher than the ALV were recorded in the period.

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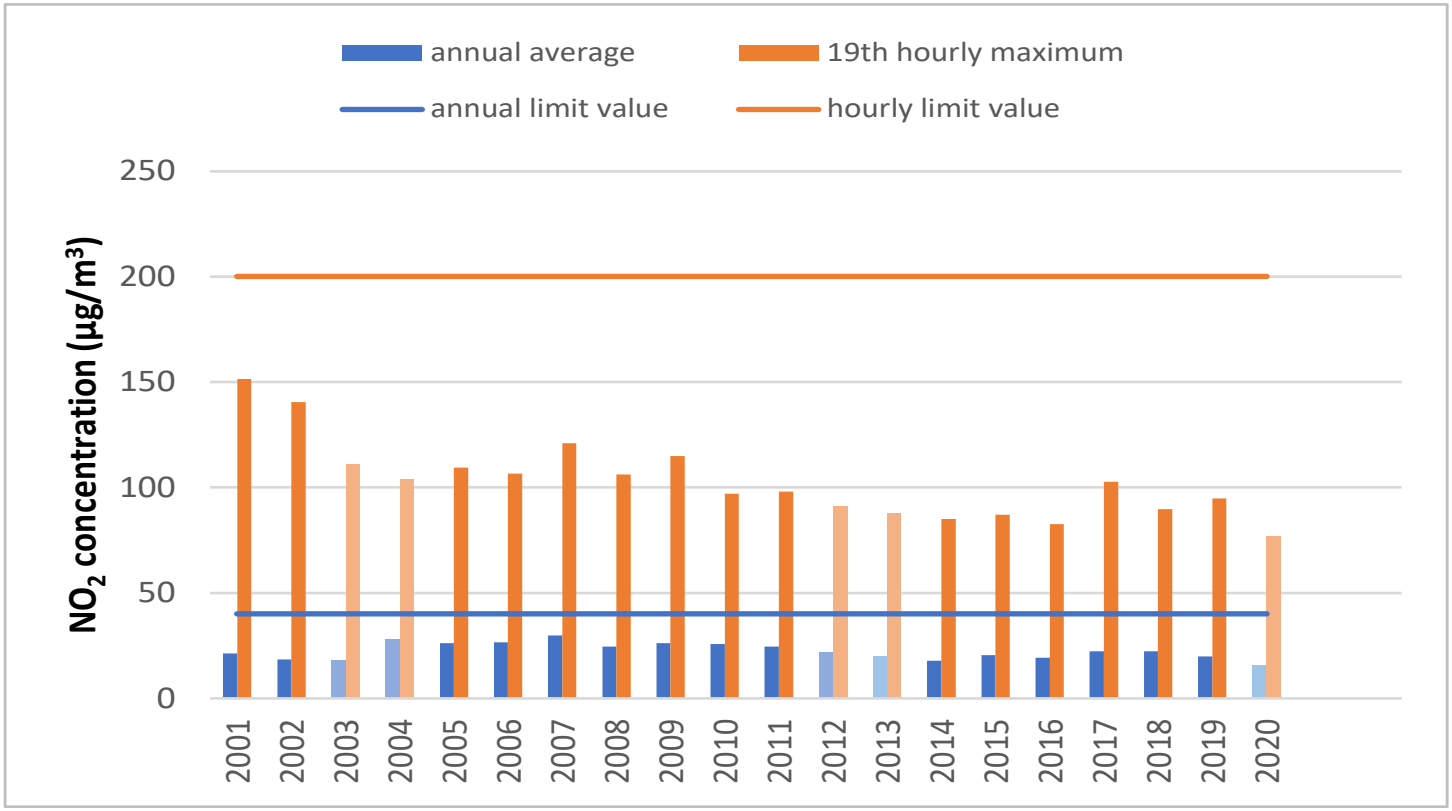

- For NO_2, there were no no-compliances;

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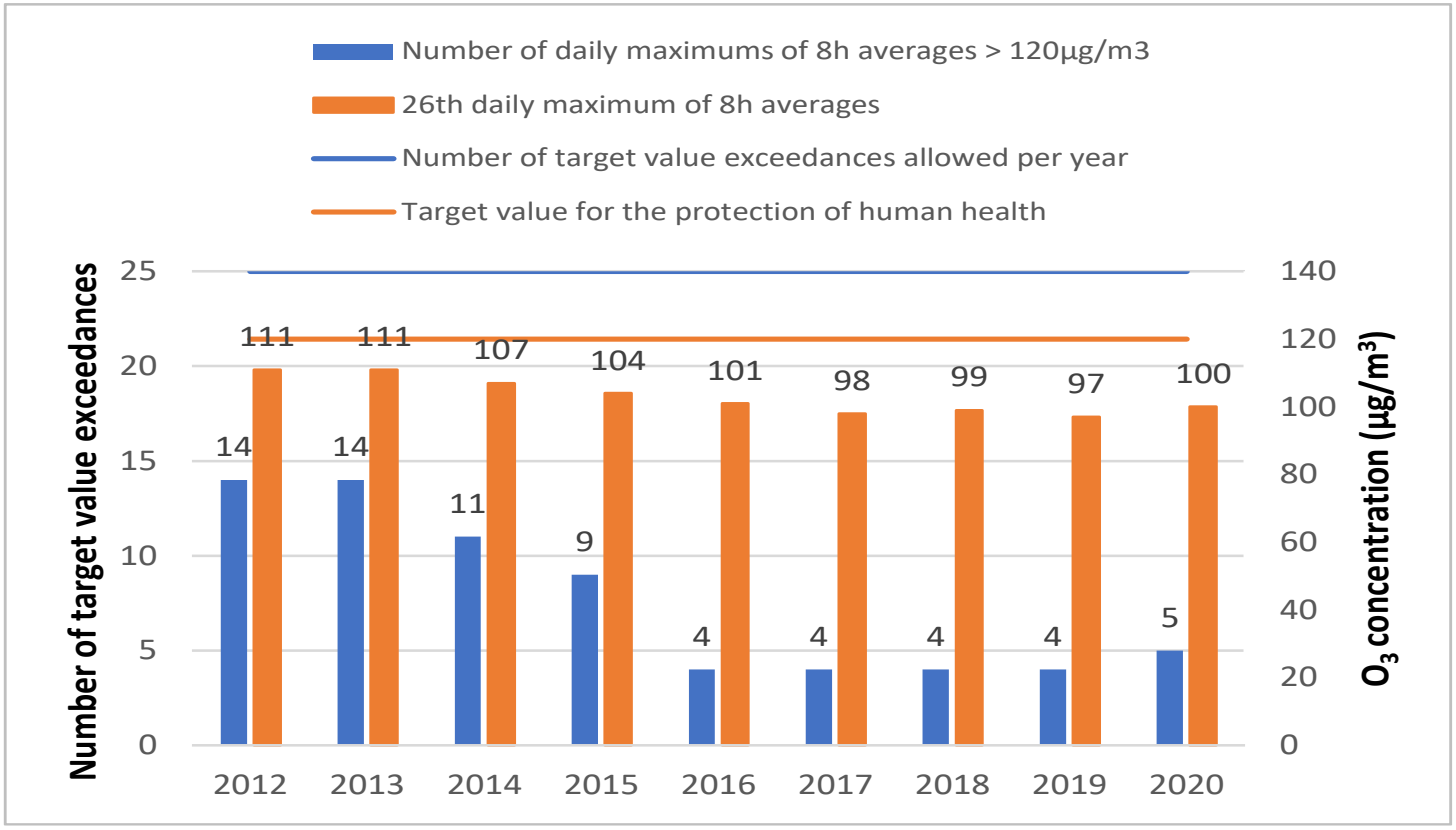
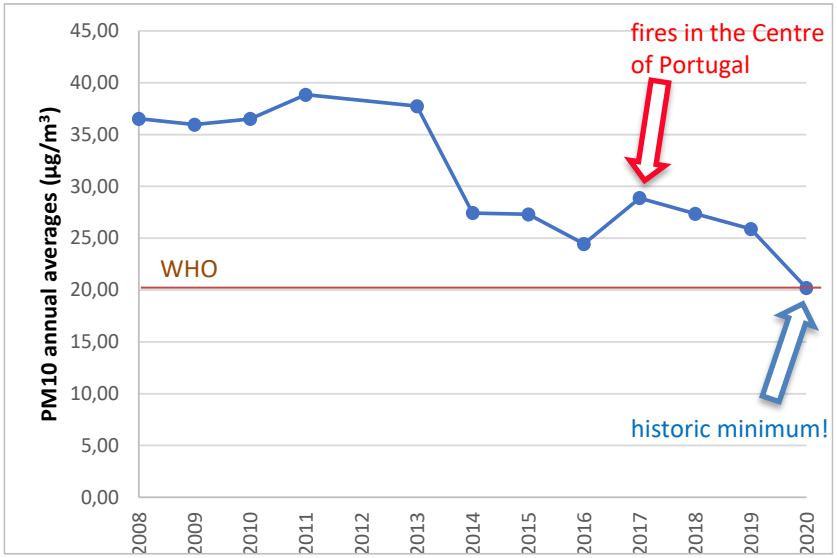
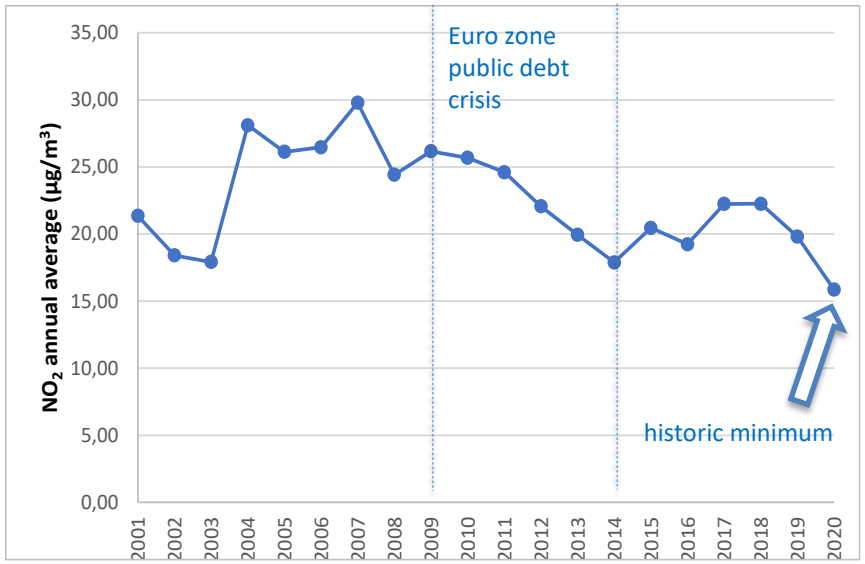


- For O_3, there was no non-compliance with the TV;
- A downward trend of the number of exceedances of the TV was registered.

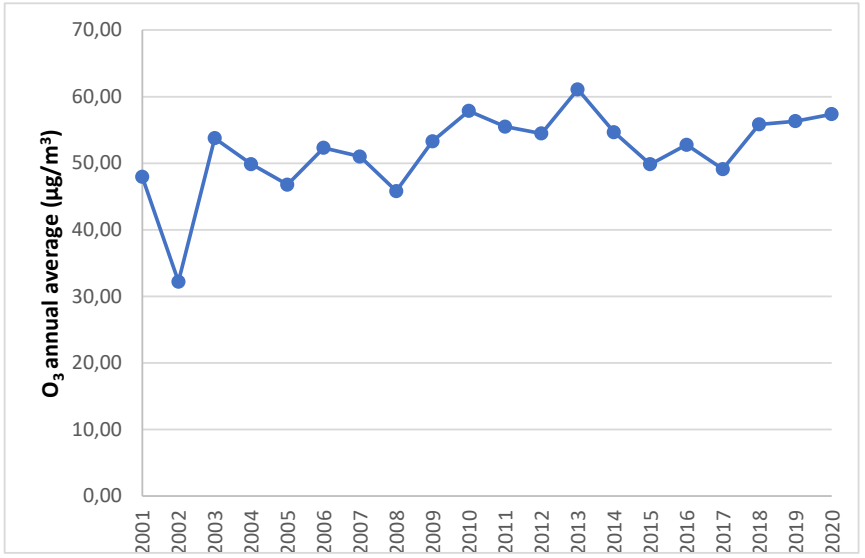
Results

Air quality temporal analysis



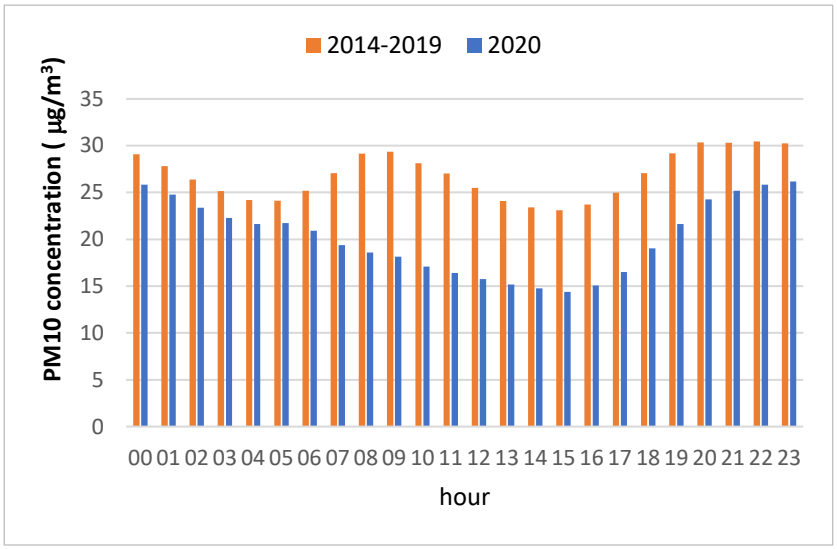


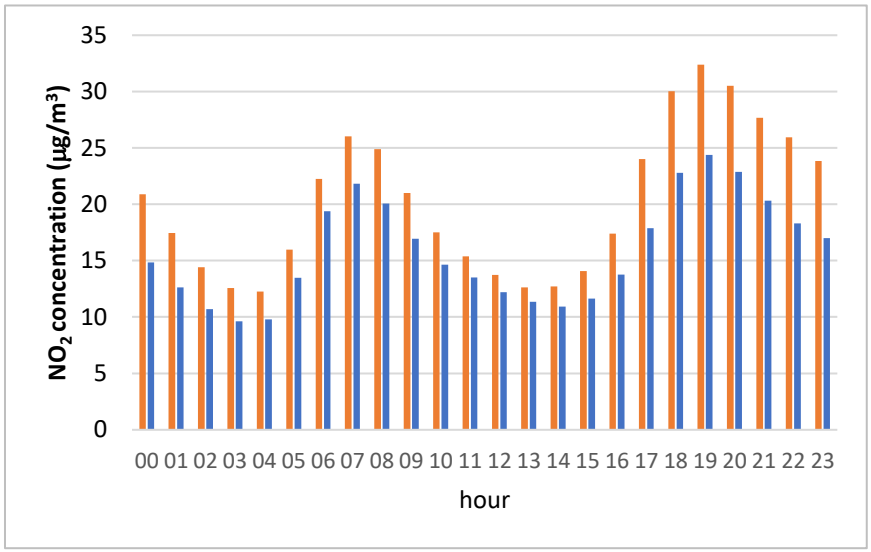
- The evolution of PM10 and NO_2 in Paio Pires-Seixal followed the European decreasing trends in 2009-2018 (-19%), due to the emission reductions of the energy and transport sectors (EEA, 2020).
- **In 2020**, PM10 annual average in Paio Pires-Seixal was 20 µg/m³, and this was **the first time the WHO guideline was attained**, since 2008.



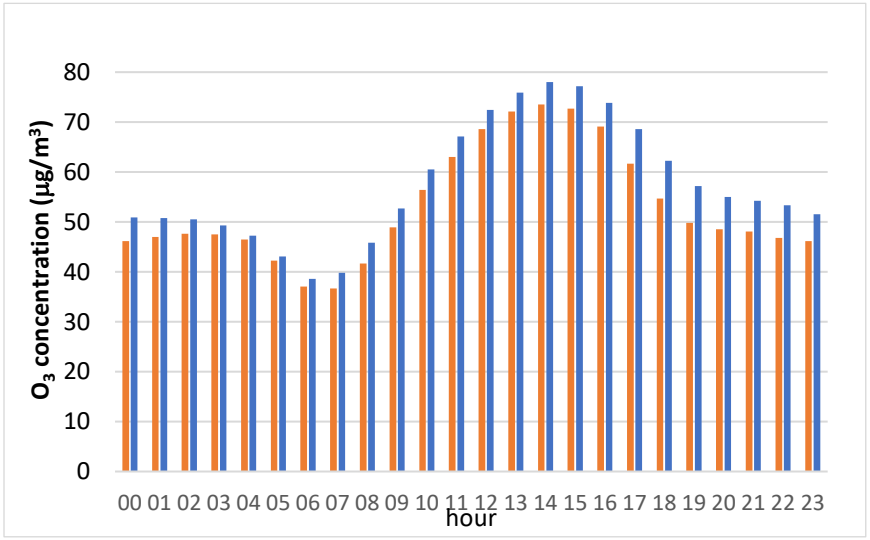
Results

Impact of COVID-19 containment measures on air quality





- Typically, PM10 and NO_2 display a daily cycle with two maximums at peak hours. In 2020, there was a reduction in the average hourly concentrations and a remarkable **flattening of the PM10 daily profile:**
  - teleworking
  - restrictions of movements



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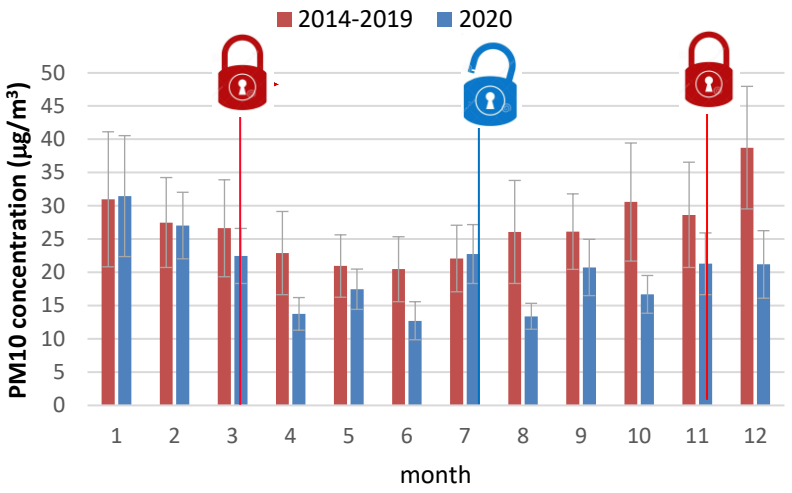

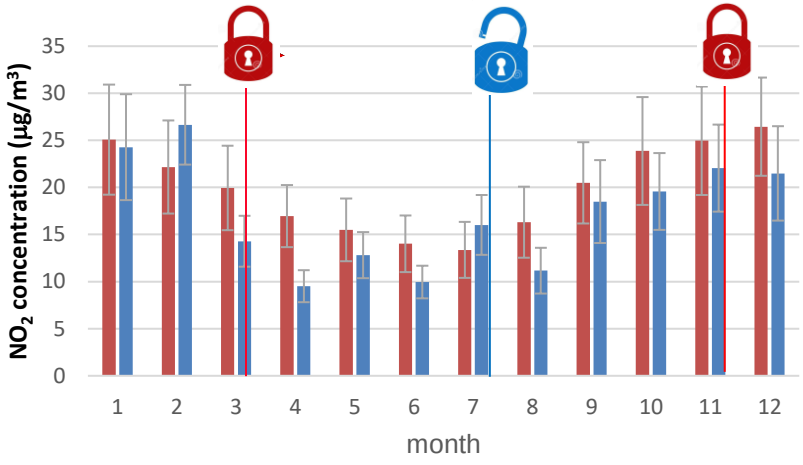

- PM10 and NO_2, higher concentrations in winter (thermal inversion);
- The monthly averages of PM10 and NO_2 for 2020 were **significantly lower** than the last six-year average;
- The reductions of PM10 and NO_2 in Paio Pires-Seixal, spanned **the whole year:**
  - teleworking
  - restrictions of movements
  - curfews
  - the slowing economic activity.

	PM10	NO_2
March	-15.7% (n.s.)	-28.4% (p=0.000)
April	-40.0% (p=0.000)	-43.9% (p=0.000)
May	-16.7% (n.s.)	-17.5% (p=0.046)
June	-38.0% (p=0.000)	-28.9% (p=0.000)
July	+3.0% (n.s.)	+19.9% (p=0.045)
August	-48.7% (p=0.000)	-31.6% (p=0.000)
September	-20.7% (p=0.013)	-9.7% (n.s.)
October	-45.4% (p=0.000)	-18.0% (p=0.044)
November	-25.6% (p=0.018)	-11.7% (n.s.)
December	-45.3% (p=0.000)	-18.8% (p=0.005)

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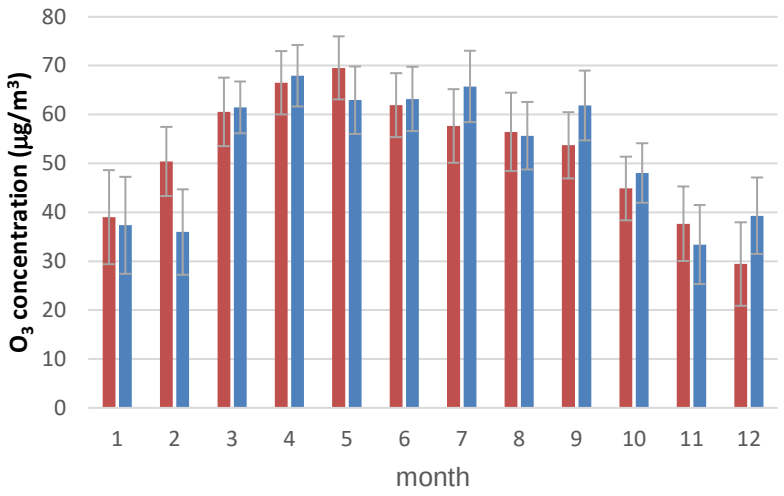

	NO_2	O_3
February	+20.2% (p=0.015)	-40.1% (p=0.000)
March	-28.4% (p=0.000)	+1.5% (n.s.)
April	-43.9% (p=0.000)	+2.1% (n.s.)
May	-17.5% (p=0.046)	-10.5% (p=0.017)
June	-28.9% (p=0.000)	+2.0% (n.s.)
July	+19.9% (p=0.045)	+12.3% (p=0.006)
August	-31.6% (p=0.000)	-1.4% (n.s.)
September	-9.7% (n.s.)	+13.2% (p=0.007)
October	-18.0% (p=0.044)	+6.6% (n.s.)
November	-11.7% (n.s.)	-12.7% (n.s.)
December	-18.8% (p=0.005)	+25.1% (p=0.003)

- O_3, higher concentrations in spring and summer (solar radiation);
- There were months when both NO_2 and O_3 significantly increased (July) or both decreased (May), but there were also months when a decrease in NO_2 was accompanied by an increase in O_3 (December) and vice versa (February).

This "nonlinearity" of O_3 production with NO_x is long known, since the balance between the NO_x and VOC precursors is decisive [6]. Furthermore, O_3 concentrations are determined not only by precursor emissions, but also by meteorological conditions and long-distance transport.

[6] Sillman, S. (2002) 'Chapter 12 The relation between ozone, NOx and hydrocarbons in urban and polluted rural environments', *Develop. Environm. Sci.*, 1(C), 339–385.

Conclusions

- The impact of COVID-19 lockdown in the air quality in an urban-industrial site in Portugal (Paio Pires-Seixal) was assessed, by comparing air quality data collected during the pandemic (2020) with baseline conditions (six-year averaged data, 2014-2019).

- The confinement measures had a singular impact on PM10 and NO_2 concentrations, confirming that traffic is one of the main sources of these pollutants, since industry has not stopped or reduced activity in the region.

- Efforts are needed in order to maintain the pollutants concentrations when the pandemic is over and the economy fully restarts.

- This study gives regulators confidence that a significant improvement in air quality could be expected if mobility strategies are implemented.

QUESTIONS?

Thank you for your attention

Acknowledgements: are due to FCT/MCTES for the financial support to C2TN-IST-UL (UIDB/04349/2020). The authors also acknowledge the Portuguese Environment Agency (APA) and the LVT Regional Coordination and Development Commission (CCDR-LVT) for their effort in establishing and maintaining the air quality monitoring network used in this investigation. C. A. Gamelas acknowledges Instituto Politécnico de Setúbal – IPS for funding.

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