IMPACT OF COVID-19 LOCKDOWN TO AIR QUALITY IN TWO LARGEST CITIES IN ESTONIA

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INTRODUCTION

Impact of COVID-19 lockdown measures in 2020 studied in:

- Tallinn, capital and largest city of Estonia (400 thousand inhabitants);
- Tartu, second largest city (100 thousand inhabitants).

Lockdown measures:

- closing the bars, restaurants and most of shops;
- distant learning in schools and universities;
- encouraging the office workers to work from home;
- number of public busses and trains decreased;

Industries continued to operate in general.

Unusual weather patterns:

- extremely mild winter;
- cold late spring (May).

DATA AND METHODS

Phases of lockdown in 2020:

- pre-lockdown, February 14 – March 14;
- full lockdown, March 15 – May 1;
- partial relaxation, May 2 – May 31;
- full relaxation, June 1 – June 30.

Hourly-based concentrations of PM_{10}, $PM_{2.5}$ and NOx from monitoring stations:

Station name	Latitude (deg. N)	Longitude (deg. E)	Type
Tallinn - Liivalaia	59.43112	24.76047	Urban-street
Tallinn - Rahu	59.44728	24.71544	Urban-industrial
Tallinn - Õismäe	59.41413	24.64923	Urban background
Lahemaa	59.51533	25.92929	Rural background
Tallinn - Harku	59.39810	24.60280	Meteorological
Tartu-Karlova	58.37060	26.73485	Urban background
Saarejärve	58.70146	26.75471	Rural background
Tartu -Tõravere	58.26420	27.46140	Meteorological

MODELLING

- Gaussian plume model AEROPOL.
- Urban domain of Tallinn, 15 by 12 km, grid resolution 0.2 km.
- Four-hourly-based single-site (Tallinn-Harku) meteorological data.
- Rural background from Lahemaa station added to modelled values.
- For full and partial lockdown (1) realistic and (2) business as usual (BAU, with seasonal typical emission) scenarios.
- Equivalent time intervals in 2019 for comparison.
- Street transport emissions based on traffic counting and EURO vehicle categories.
- Domestic heating (mainly firewood) emissions bsed on 2013 inventory, assuming 30% increase during lockdown.

RESULTS: OVERIEW OF MEASURED CONCENTRATIONS

Averages through lockdown-related periods in 2020 and equivalent time intervals in 2019 are presented in Figure 1.

- In winter and spring of 2019 the concentrations were remarkably higher than in 2020. During pre-lockdown this might be a result of lower temperatures, less precipitation and slightly weaker winds in 2019.
- Peaking concentrations of PM10 in March and April 2019 in urban stations: a dust episode after snowmelt.
- Almost no snow in winter of 2020, thus no dust episode.

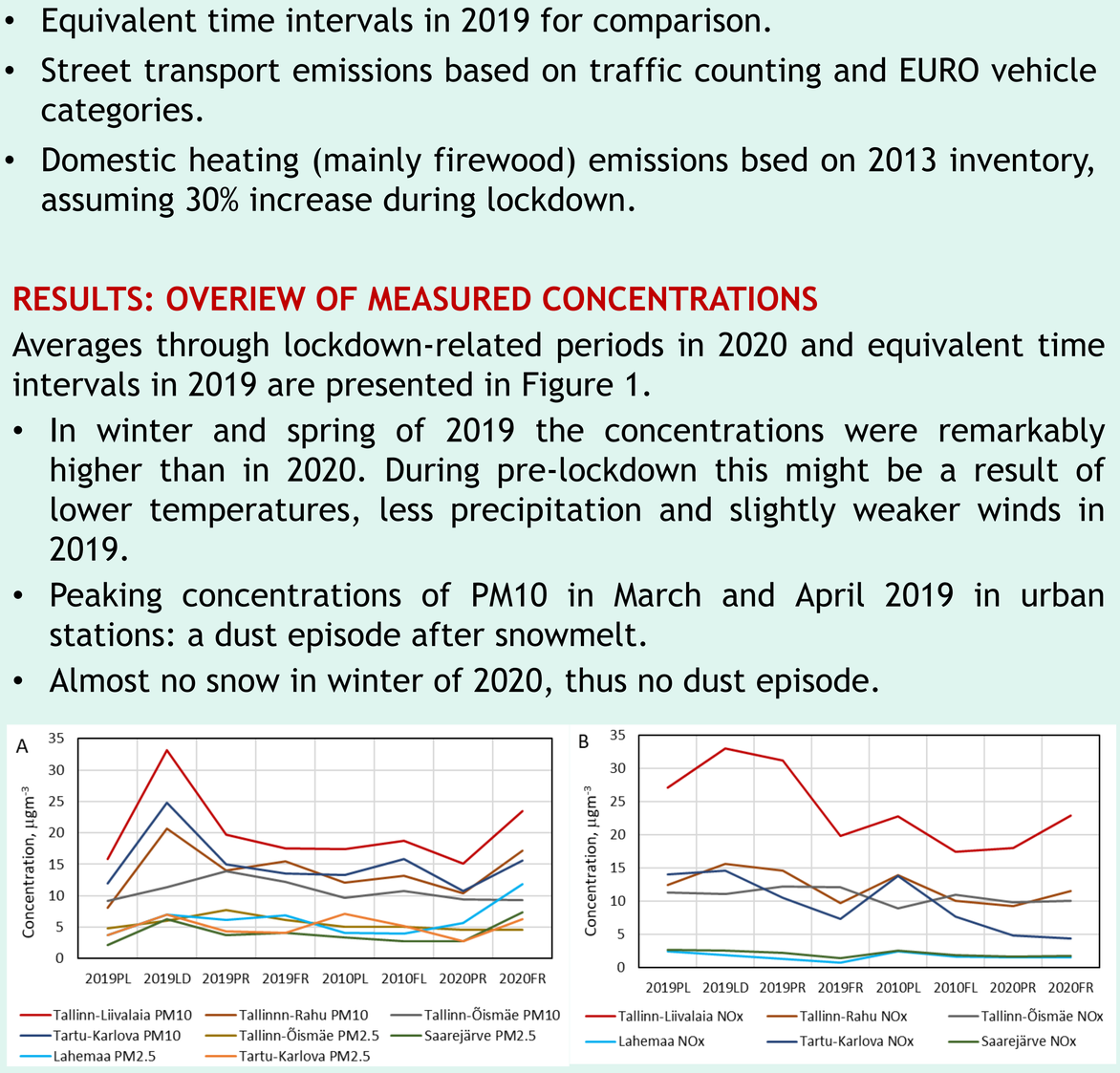

Figure 1. Average measured PM (A) and NOx (B) concentrations during pre-lockdown (PL), full lockdown (FL), partial relaxation (PL) and full relaxation (FR) in 2020 and equivalent time intervals in 2019.

MODELLING RESULTS AND COMPARISON WITH MEASUREMENTS

- AEROPOL model overestimates the concentrations in the street station and underestimates in remote urban areas (see Figures 2 and 3).
- Overestimation increases dramatically in 2020 partial and full relaxation periods.
- AEROPOL model reproduces the basic features of day-to-day variations, as the Pearson correlations between daily-based modelled and measured concentrations are remarkable:
  - PM_{10} correlations in Liivalaia mostly in range of 0.3 – 0.5, lowest 0.21 and highest 0.83 (in Rahu and Liivalaia slightly higher);
  - for NOx in Liivalaia in range of 0.62 – 0.84 through all periods;
  - for NOx in Rahu and Õismäe somewhat lower, mostly 0.4 – 0.7.

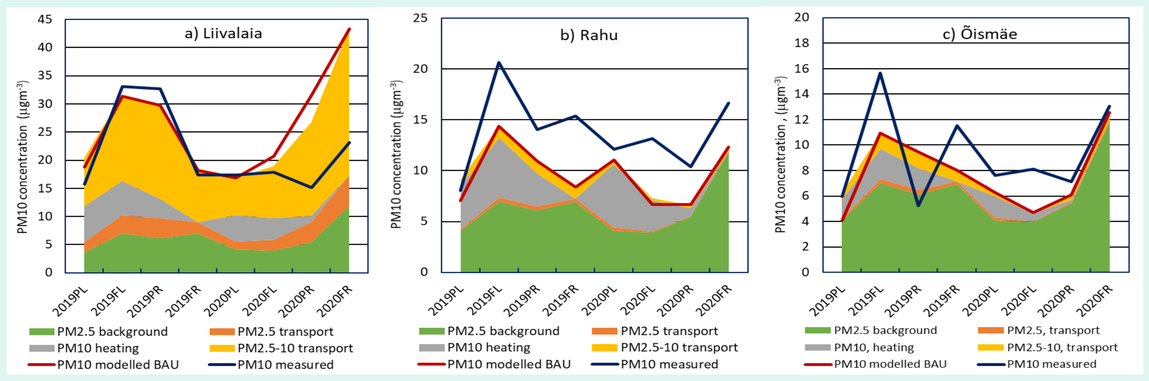

Figure 2. Modelled lockdown scenario concentrations of PM_{10} (cumulative contributions of sources) compared to BAU scenario and measured values in monitoring stations in Tallinn. Labels for periods, see Figure 1.

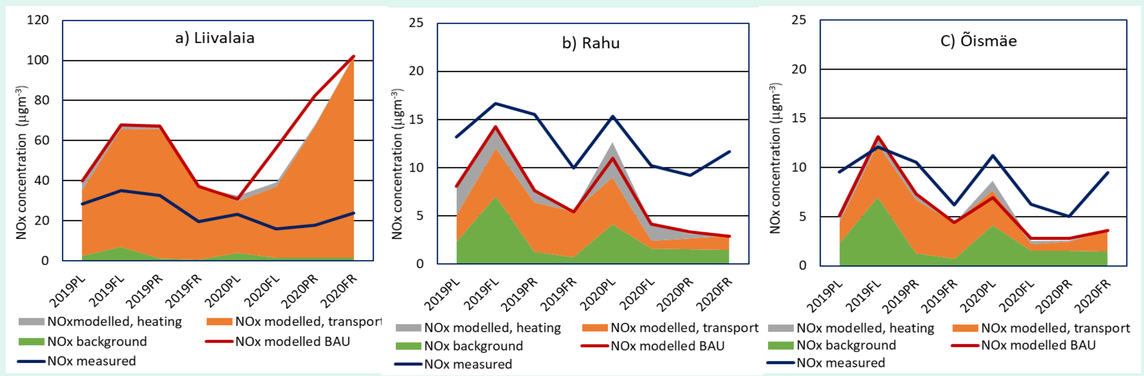

Figure 3. Modelled lockdown scenario concentrations of NOx (cumulative contributions of sources) compared to BAU scenario and measured values in monitoring stations in Tallinn. Labels for periods, see Figure 1.

MODELLING RESULTS: DAILY COURSE

It appears that AEROPOL model highly overestimates the daily maxima of traffic-induced concentrations, more pronouncedly of NOx (Figure 3). Misrpresenting the daily course was found the main reason of overetsimation of averages.

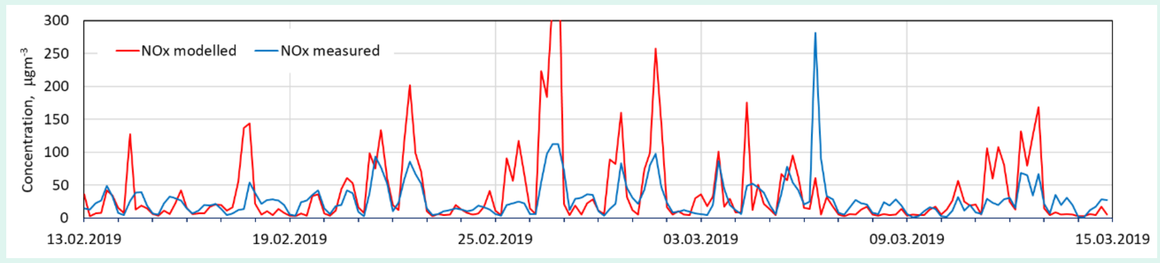

Figure 4. Modelled and measured 4-hourly concentrations of NOx in Liivalaia station during lockdown-equivalent period in 2019.

Based on all 4-hourly measured and modelled NOx concentrations in Liivalaia, Rahu and Õismäe stations during all considered periods in 2019, a power-law regression formula was fitted (R^2=0.41):

$$C_{fit} = 4.7433 C_{modelled}^{0.409}$$

Applying this correction to lockdown scenario in 2020, the overestimating bias was eliminated.

CONCLUSIONS

- The modelling results affirm the reduction of concentrations of PM_{10} and NOx in an urban hotspot of medium-sized town Tallinn due to COVID-19 lockdown in spring of 2020.
- Keeping in mind further development of the AEROPOL model, the dispersion parameters for low-level sources, as well as the algorithm for washout should be revised, to reproduce the dispersioon from street source adequately.

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