
NO_x and other air pollutants in ambient air and in the indoor environment: sources and health effects

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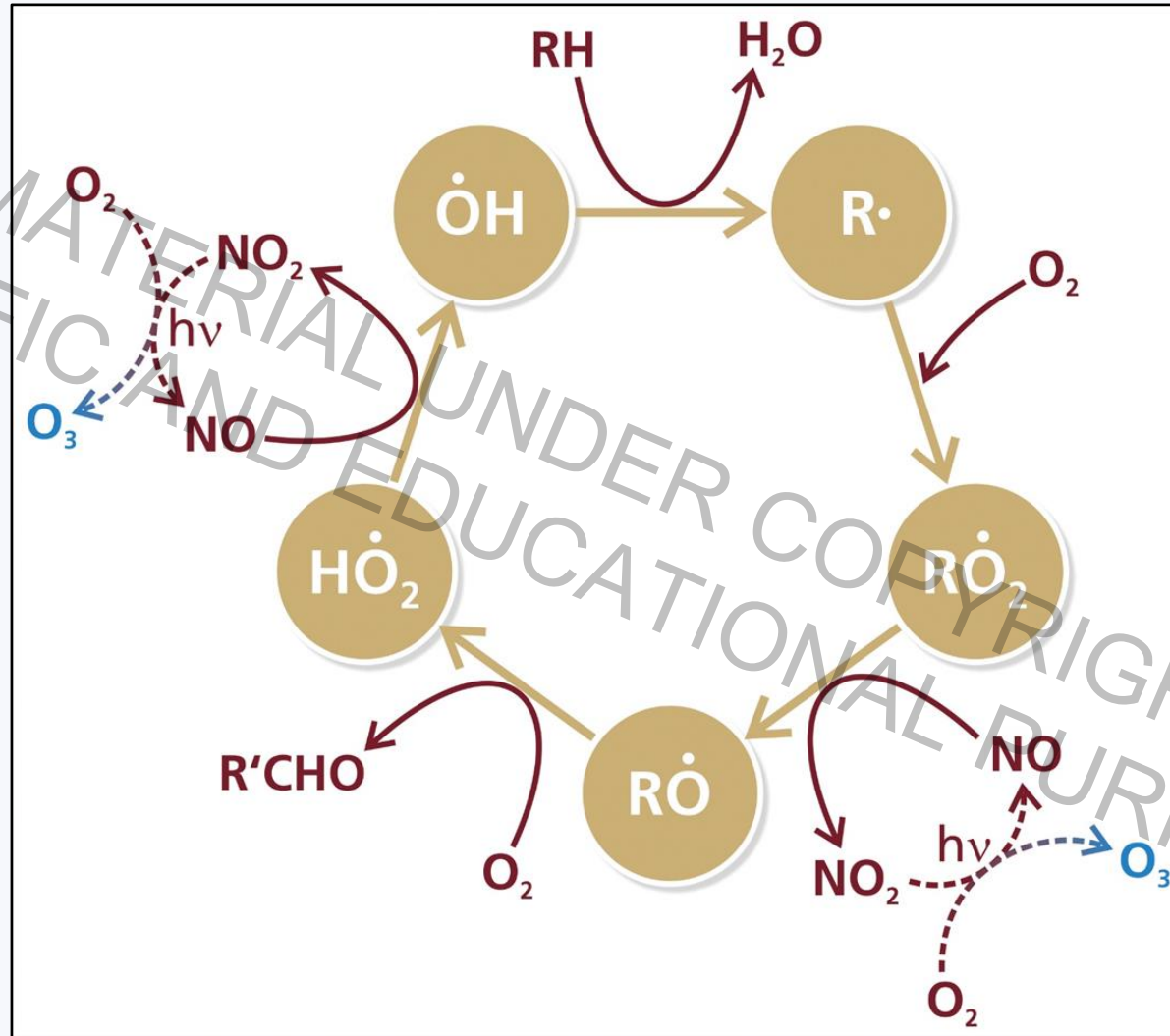
In 2021 the WHO released new guidelines for NO₂ in ambient air



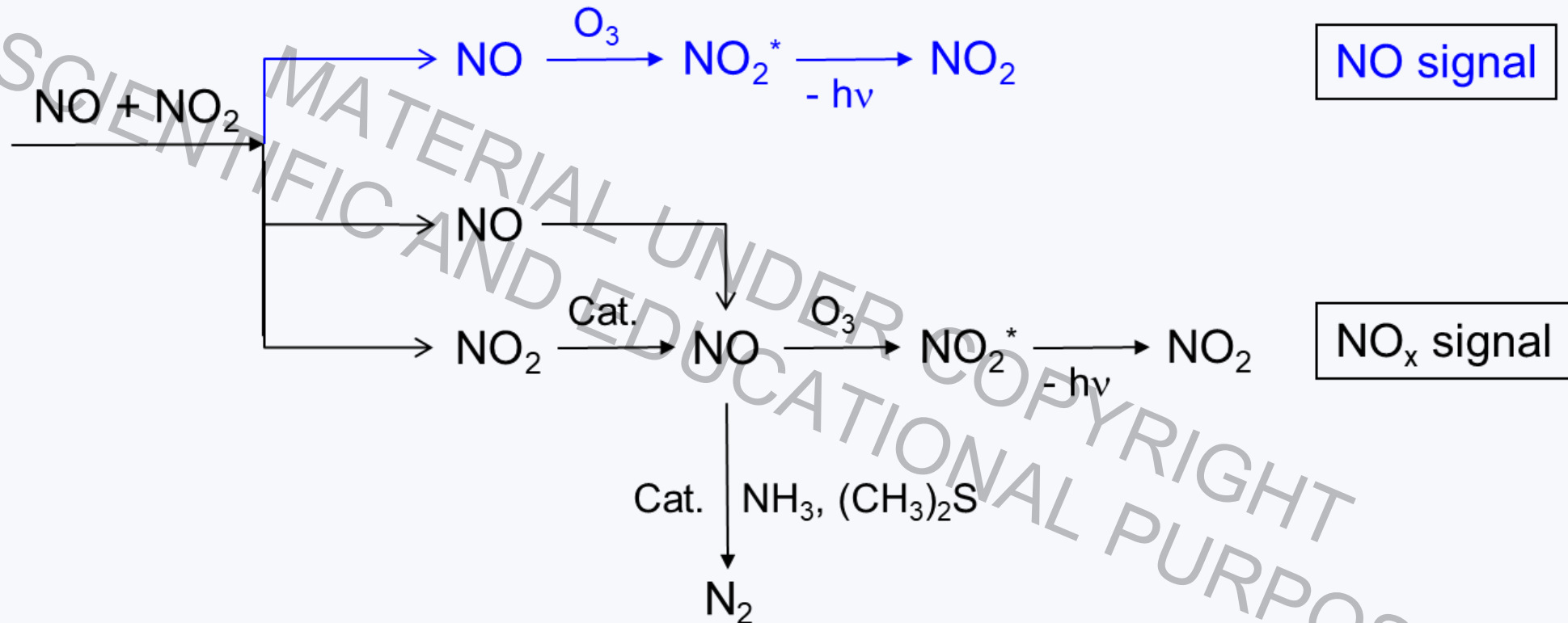
Table 3.16. Recommended AQG level and interim targets for nitrogen dioxide

Recommendation	NO ₂ (µg/m ³)
Interim target 1	40
Interim target 2	30
Interim target 3	20
AQG level	10

Catalytic cycle of atmospheric ozone formation in polluted air

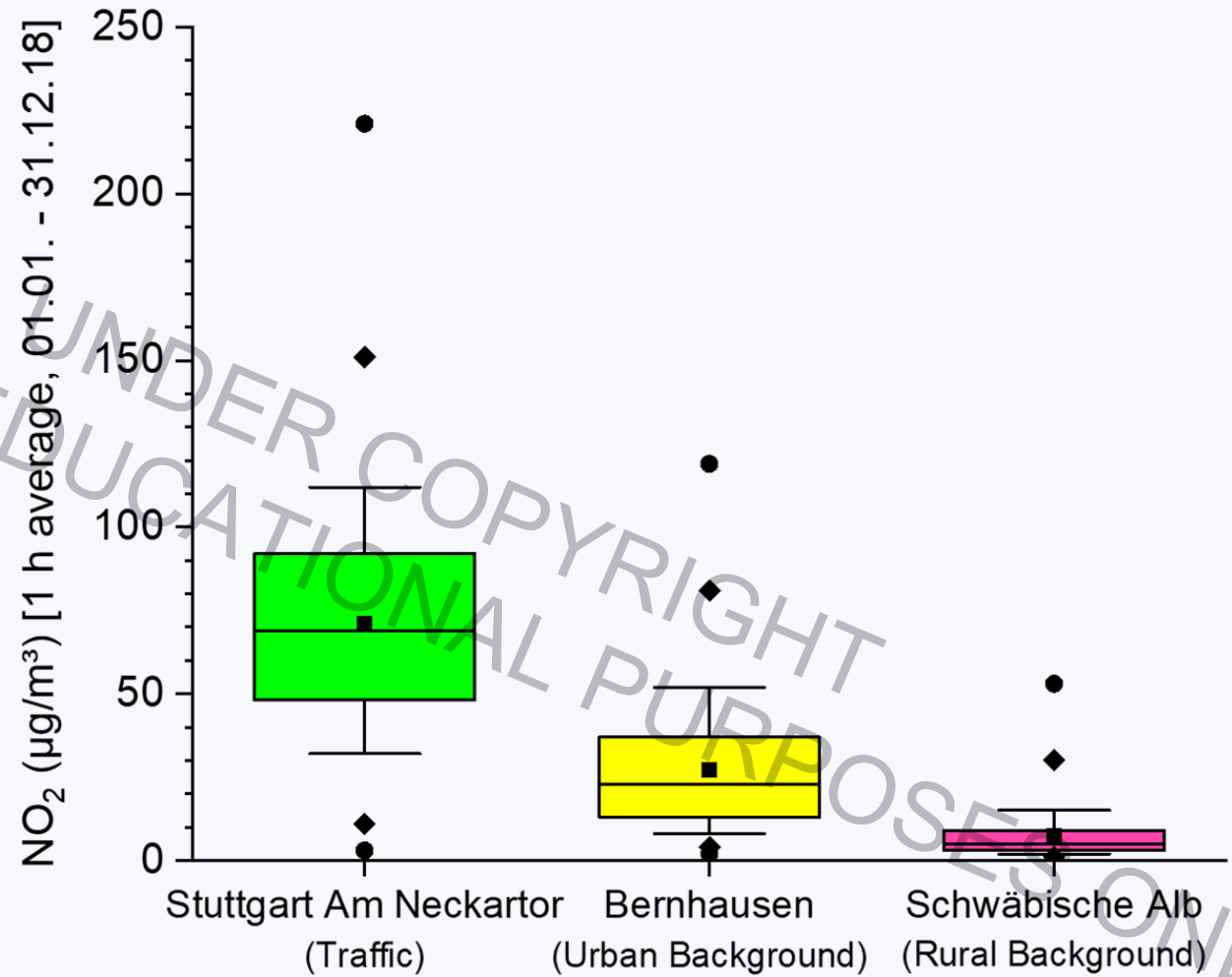
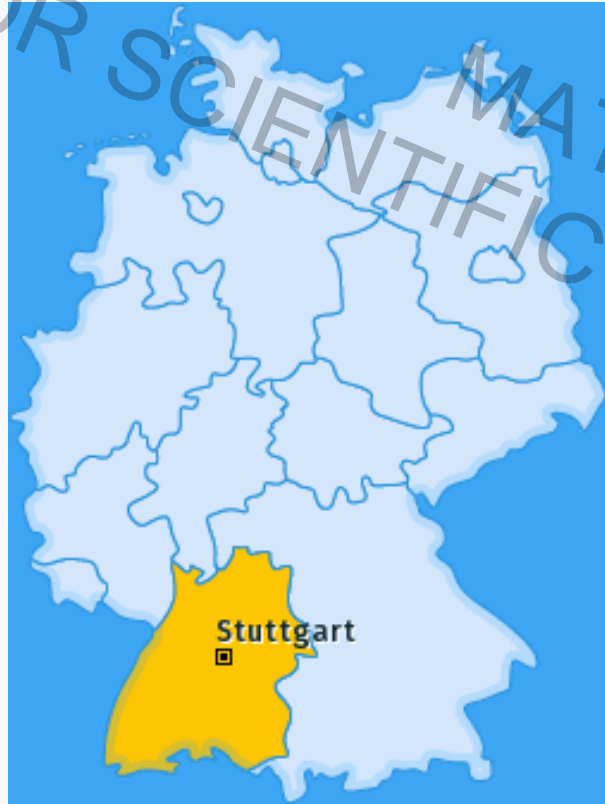


Measurement principle for NO, NO₂ and NO_x by chemiluminescence



The NO₂ concentration is calculated from the difference of [NO_x] and [NO]

NO₂ concentrations (1 h mean) in ambient air, measured in the greater area of Stuttgart, Germany

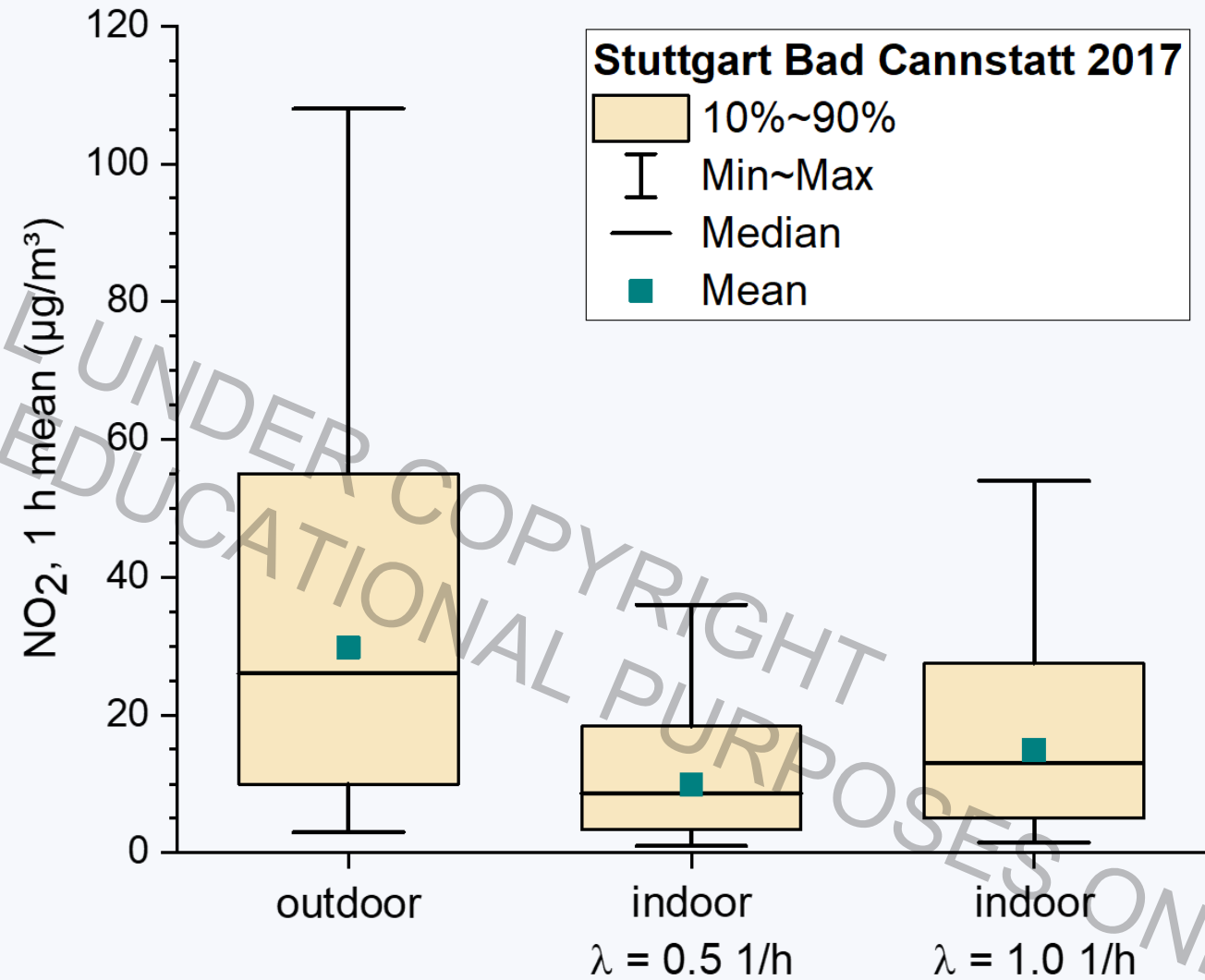


Measured NO₂ outdoor concentrations and calculated indoor concentrations for different scenarios

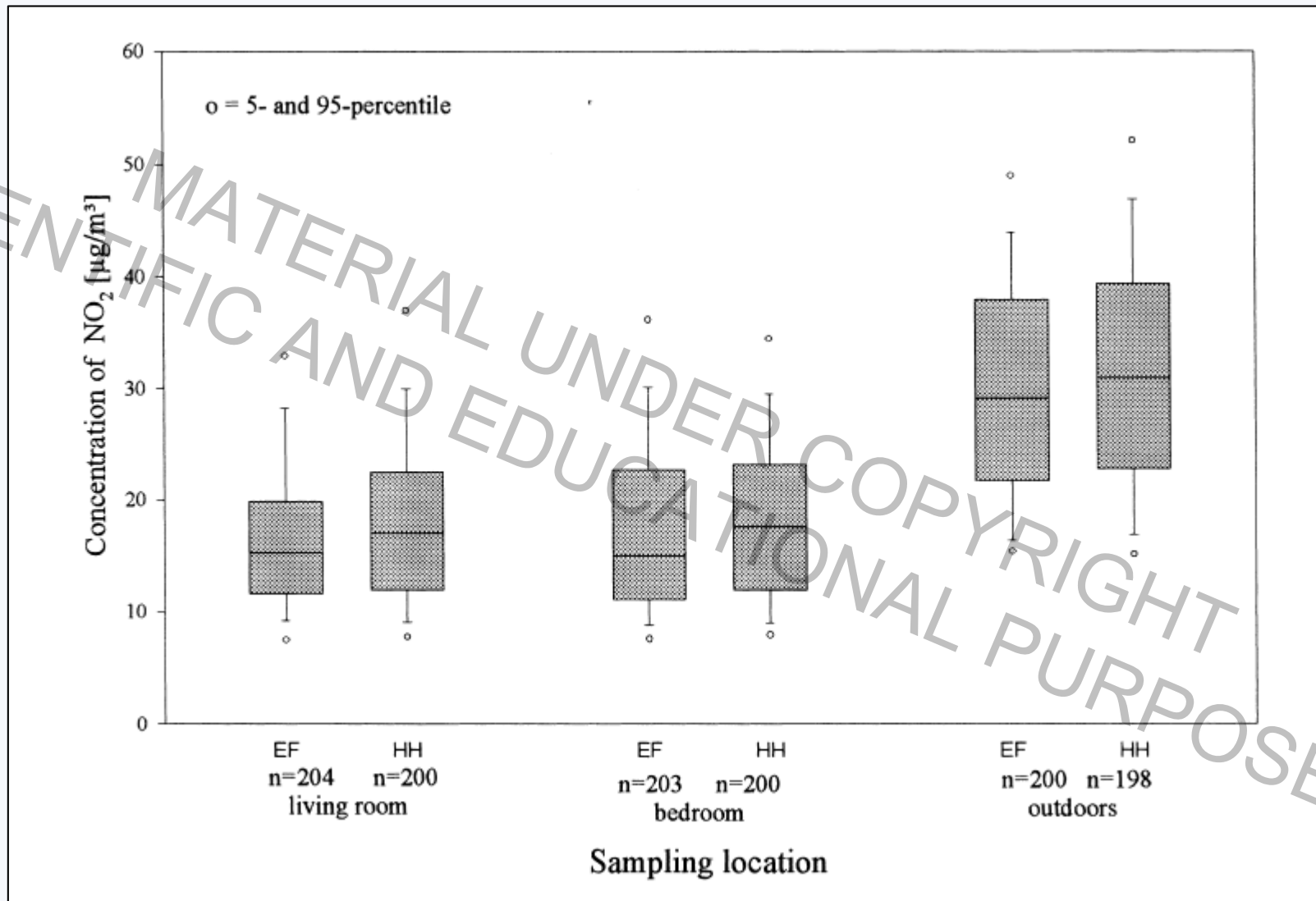
$$\frac{\text{Indoor}}{\text{Outdoor}} = \frac{\lambda}{\lambda + k_{\text{NO}_2}}$$

Removal rate $k_{\text{NO}_2} = 1.0 \text{ h}^{-1}$

λ is the air exchange rate



Sources and concentrations of indoor NO₂ in Hamburg and Erfurt (passive sampling!)

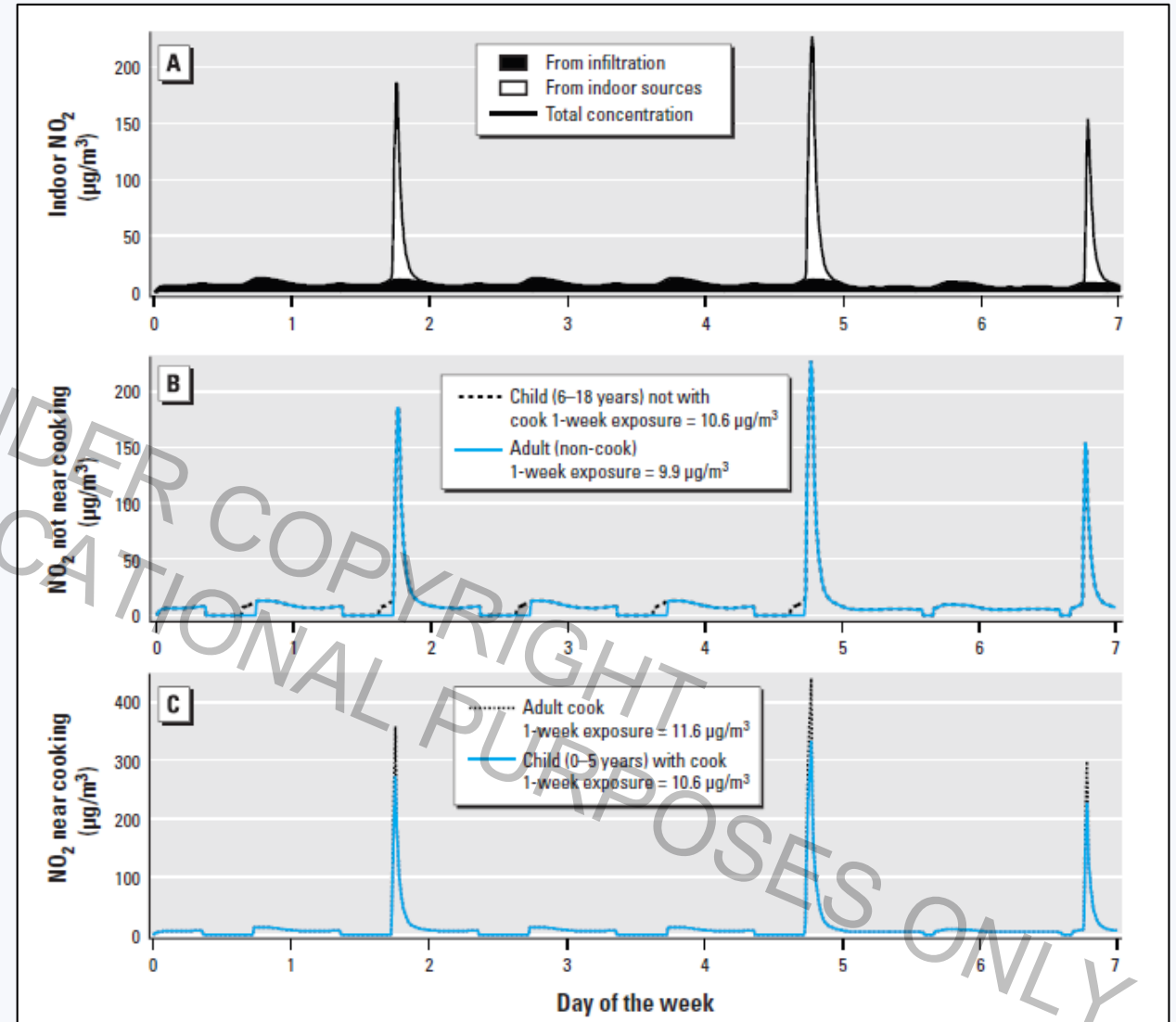


Exposure to NO₂ from natural gas cooking burners

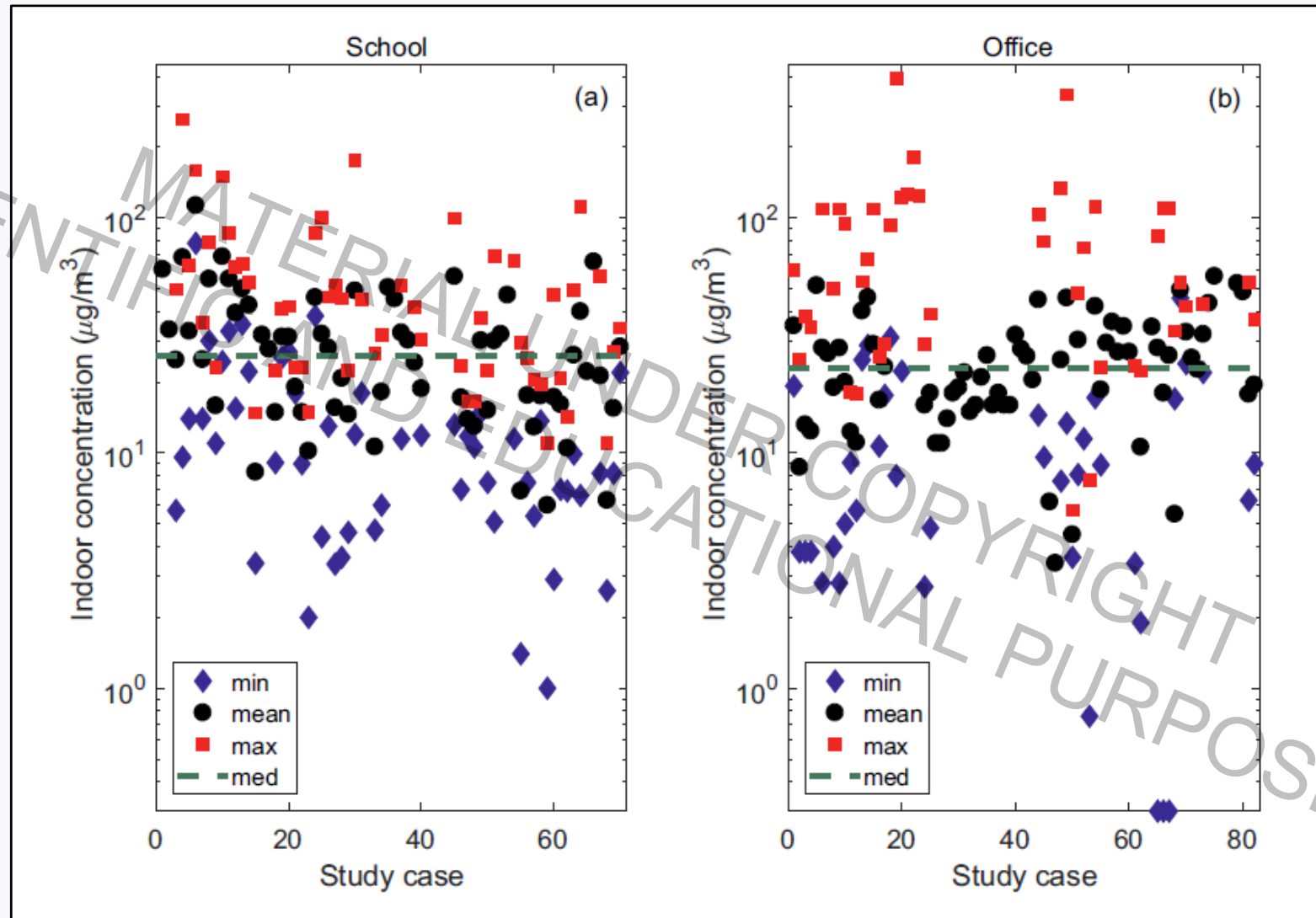
(A) Indoor concentration of NO₂ originating from indoor and outdoor sources.

(B) Simulated exposure concentration experienced by the two occupants assumed to not be near the cooking activity.

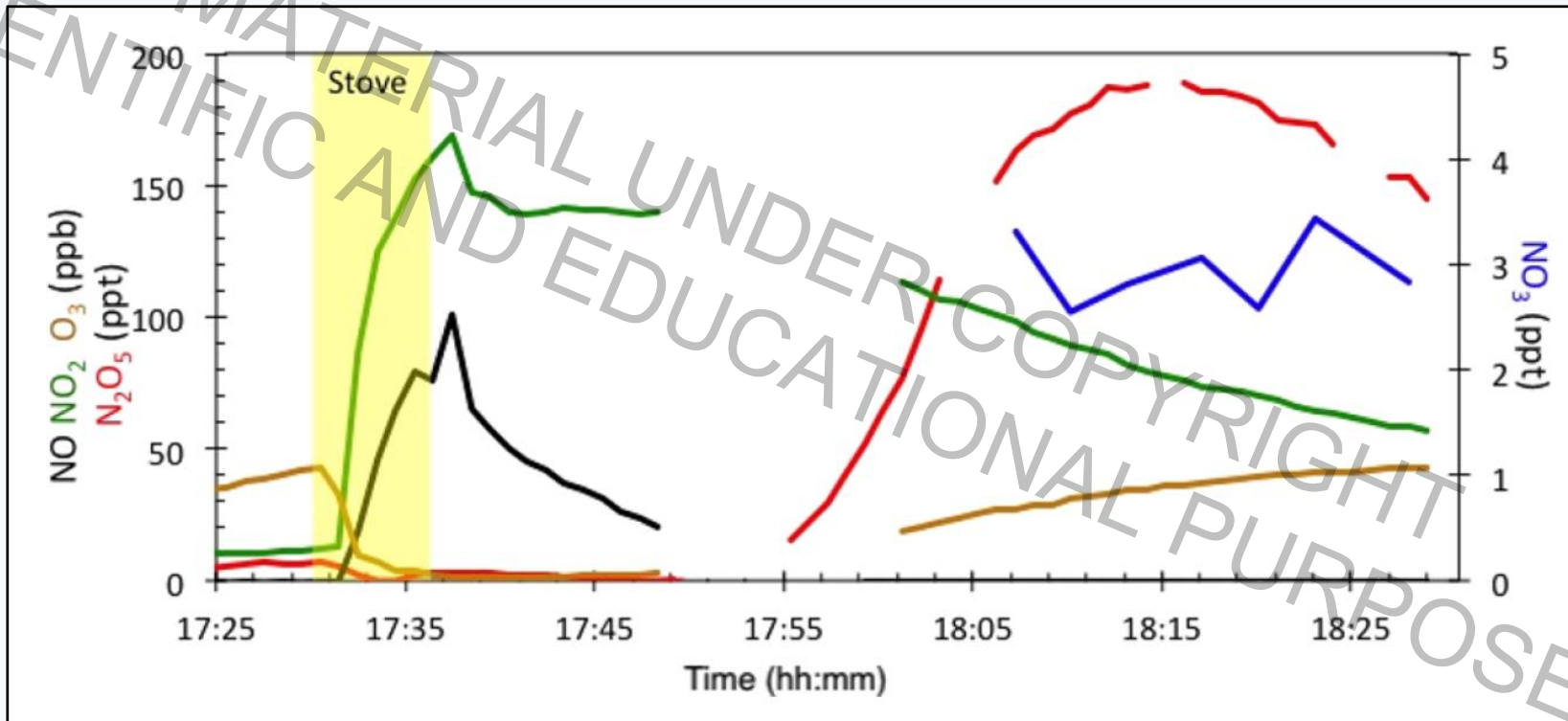
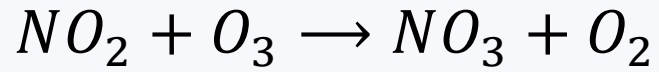
(C) Simulated exposure concentration for the cook and a small child assumed to be near the cooking.



Statistical values (min, mean, max, median) of NO₂ in school and office environments

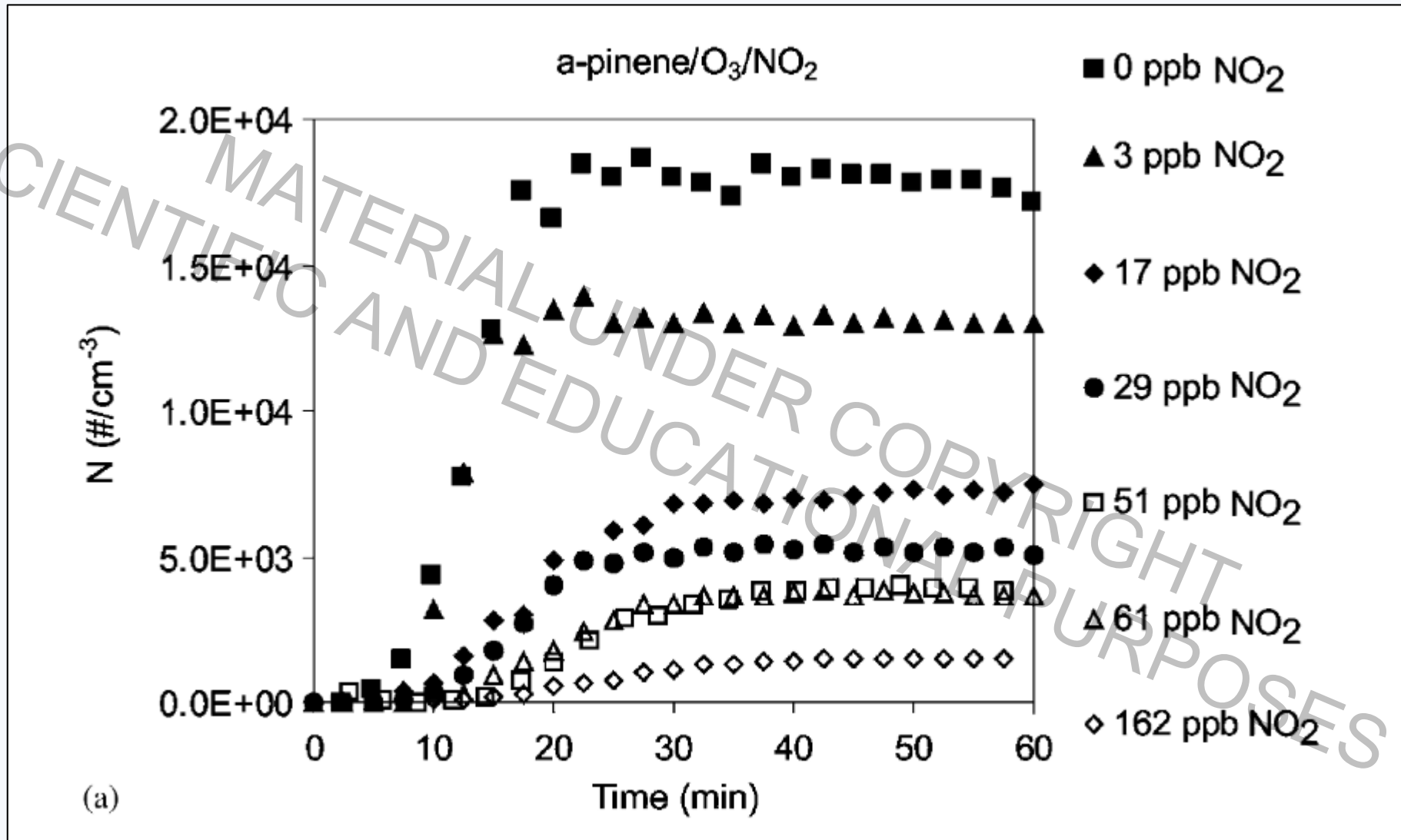


Concentrations of NO, NO₂, NO₃, N₂O₅, and O₃ in a kitchen during a stove experiment with ozone



NO₃ and N₂O₅ were measured by cavity ring-down spectroscopy

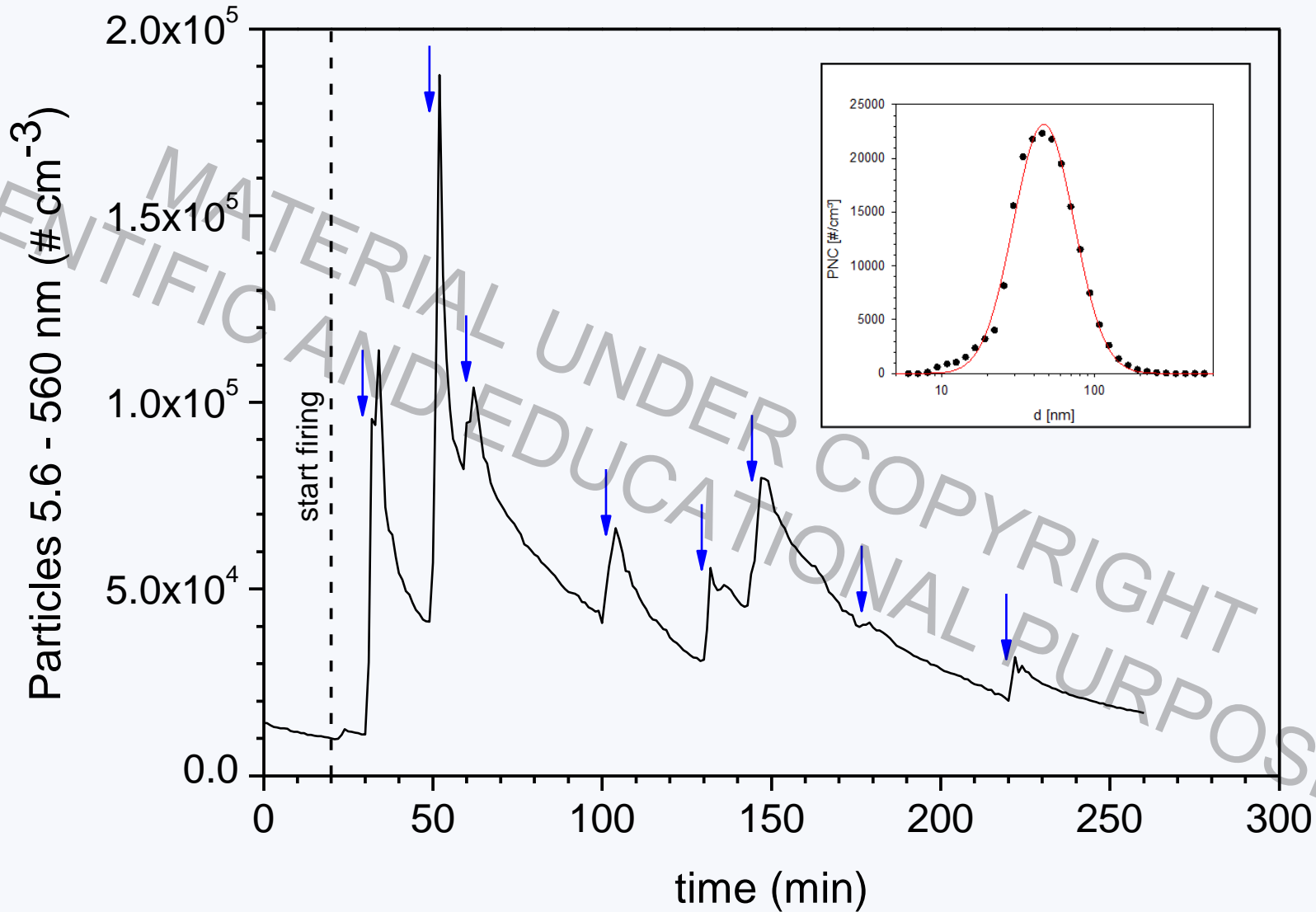
NO₂ decreases the formation of particles from terpene/ozone reactions



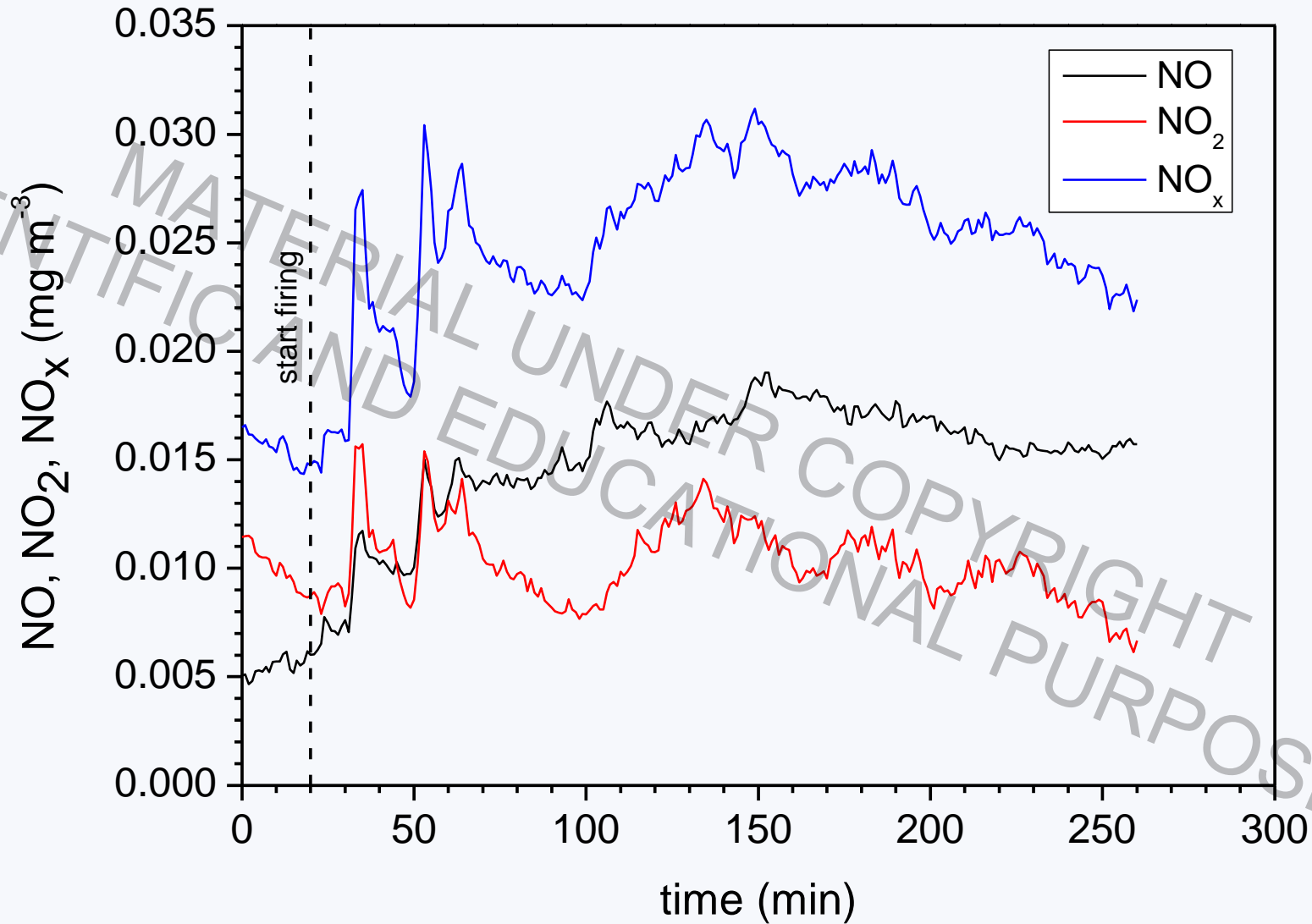
Indoor combustion sources – wood burning fireplaces



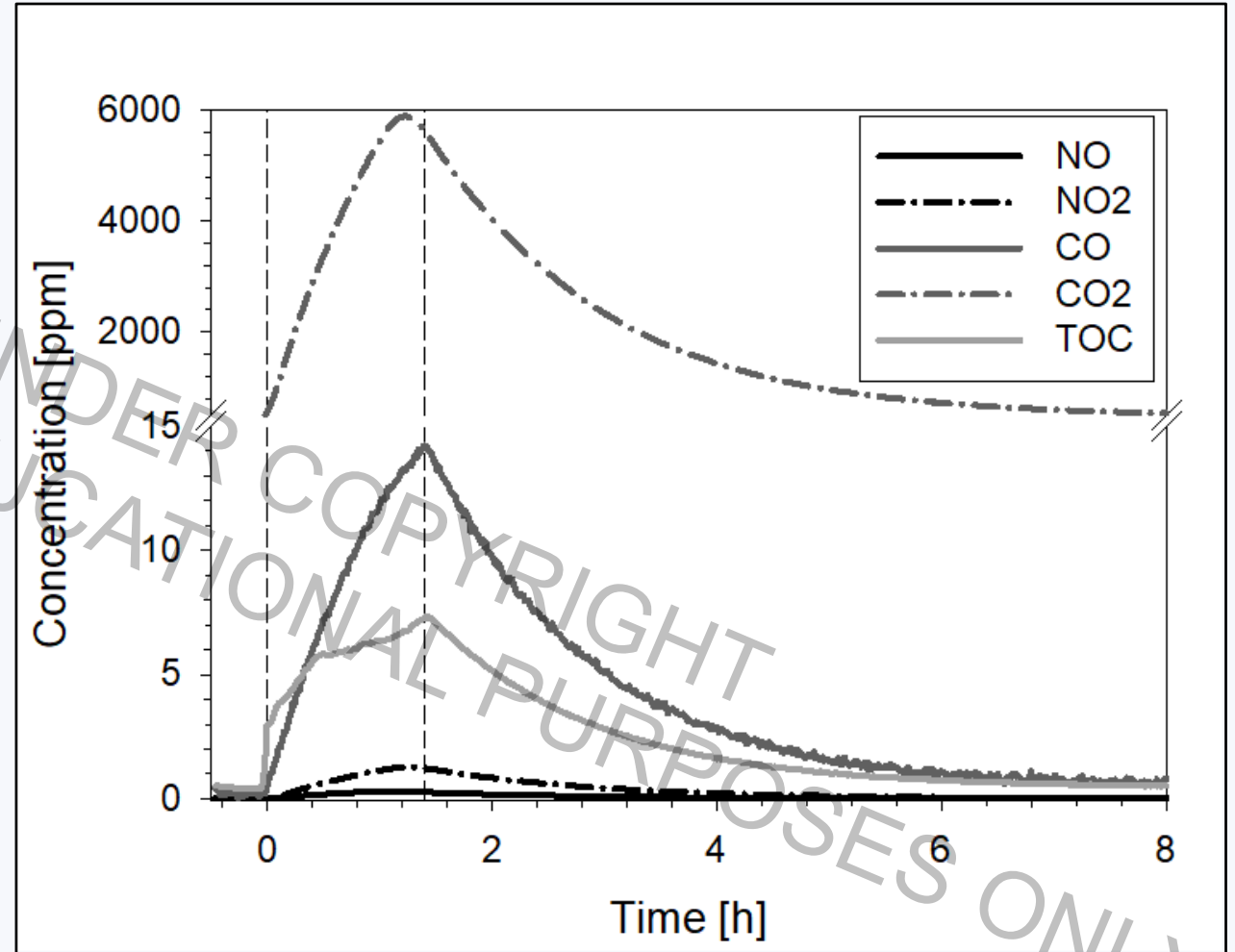
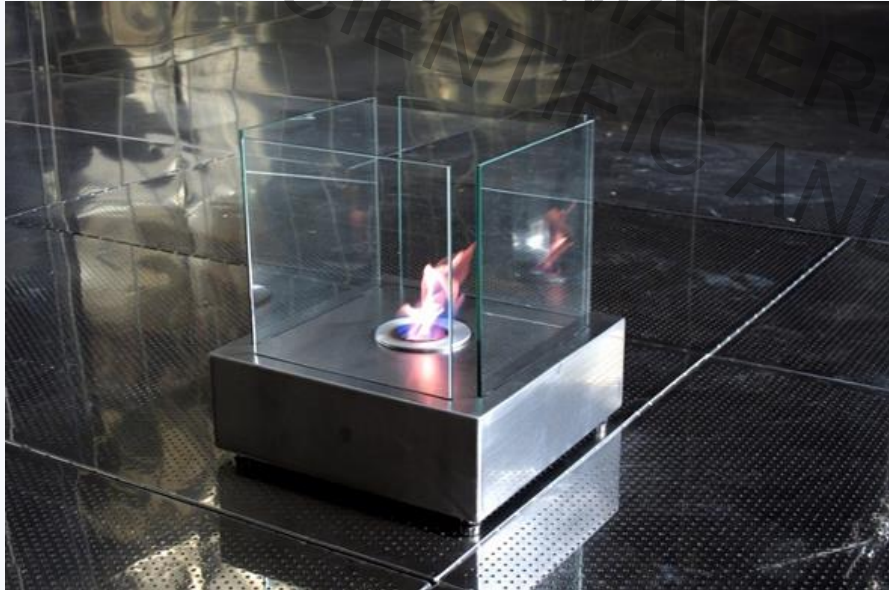
Wood burning fireplace - ultra-fine particle concentration (5.6 – 560 nm) over time



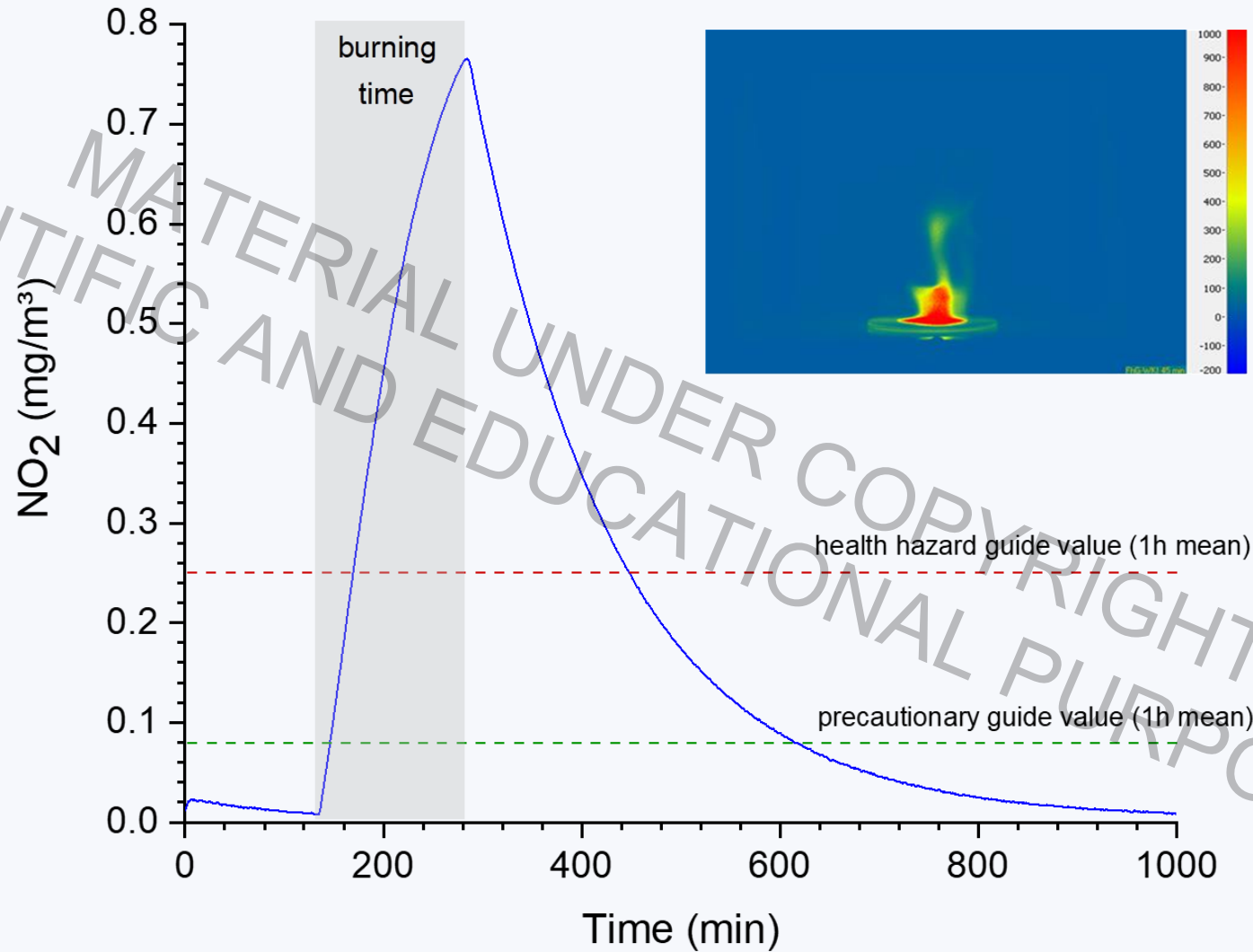
Wood burning fireplace - NO, NO₂ and NO_x concentration over time



Indoor combustion sources – ethanol burning fireplaces



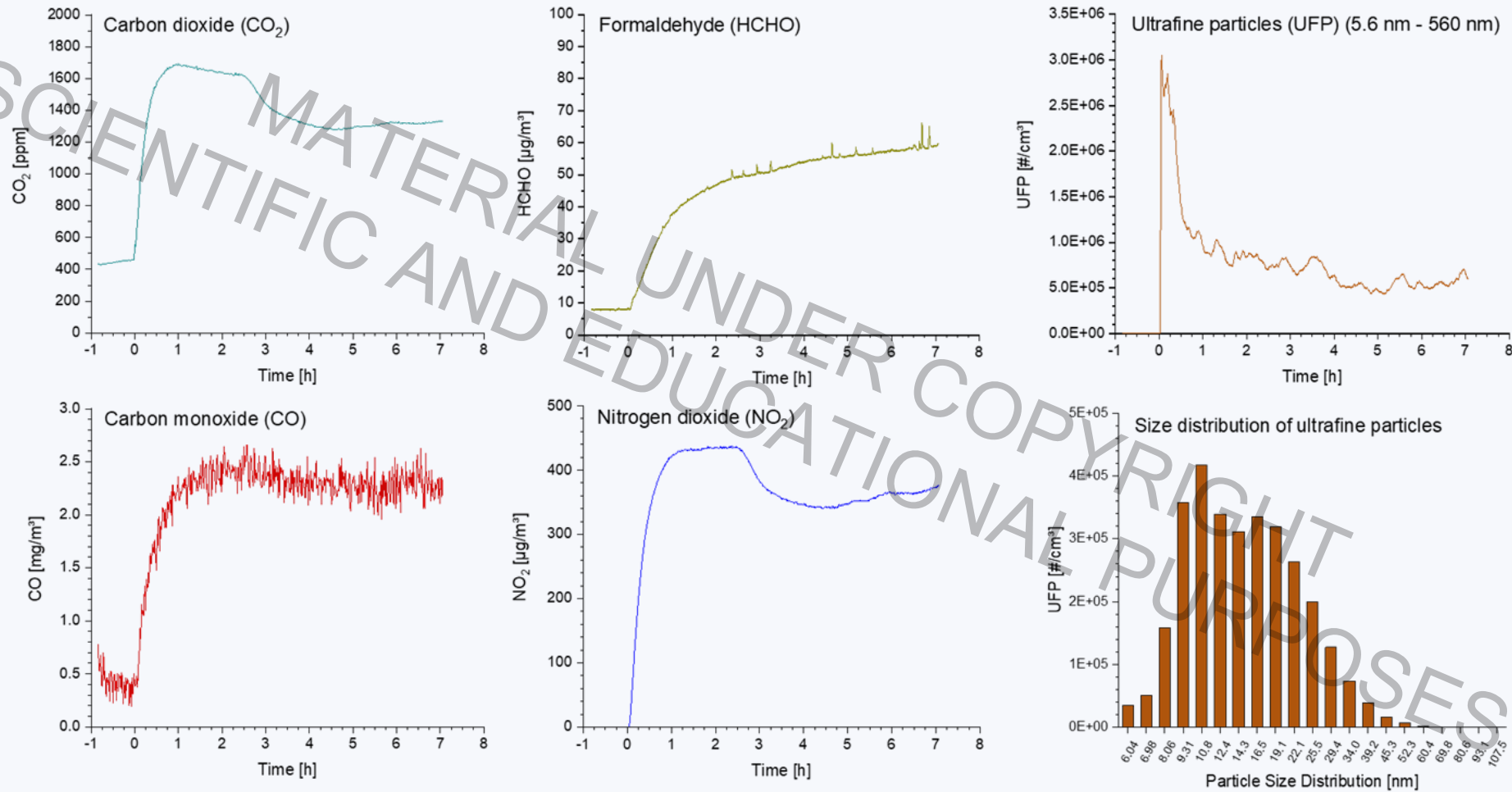
Ethanol burning fireplaces – release of NO₂



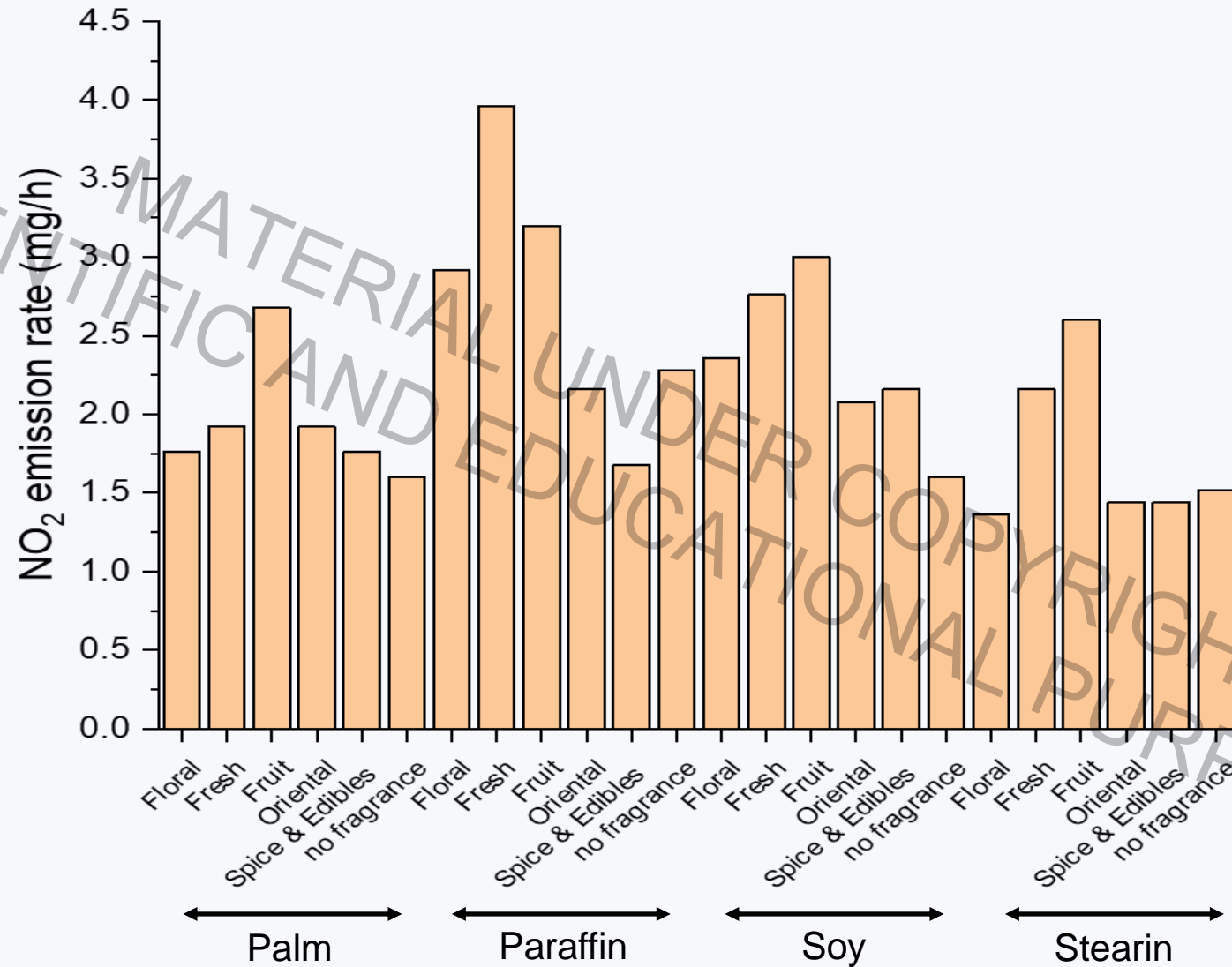
Indoor combustion sources – candles



Concentration vs. time curves of online measured parameters for the combination stearin/floral



NO₂ emission rates for different combinations of fuel and fragrance



- Reaction with antioxidant substances in the mucous membrane
 - Extrapulmonary effects
 - Indications of a hypersensitivity of the bronchi from 2.9 mg/m³ (healthy adults).
 - Deteriorated lung function with increased airway resistance was found predominantly from a NO₂ concentration of 3.8 mg/m³ (healthy adults).
 - In the concentration range between 0.38 mg/m³ and 0.51 mg/m³, five out of eleven studies found a statistically significant relationship between short-term inhalation exposure to NO₂ and the increase in respiratory sensitivity in the subjects with asthma.
 - In an epidemiological study with children aged 5–12 years with asthma, the preparation of food on a gas stove in the apartment led to a significantly more frequent use of asthma medication during a four-day measurement.

National and international guidelines and air quality standards for NO₂ in ambient and indoor air

Concentration	Period	Comment	Reference
0.25 mg/m ³	1 h mean	Health hazard guide value	AIR (2019) ^a
0.08 mg/m ³	1 h mean	Precautionary guide value	AIR (2019) ^a
170 µg/m ³	Short term		Health Canada (2015) ^a
20 µg/m ³	Long term		Health Canada (2015) ^a
200 µg/m ³	1 h mean		WHO (2010) ^a
40 µg/m ³	Annual mean		WHO (2010) ^a
200 µg/m ³	1 h mean		EEA (2018) ^b
40 µg/m ³	Annual mean		EEA (2018) ^b
100 ppb ^c	1 h mean		US EPA (2018) ^b
53 ppb ^c	Annual mean		US EPA (2018) ^b
0.18 ppm ^c	1 h mean		CARB (2007) ^b
0.030 ppm ^c	Annual mean		CARB (2007) ^b
0.12 ppm ^c	1 h mean		Australia (2005) ^b
0.03 ppm ^c	Annual mean		Australia (2005) ^b
200 µg/m ³	1 h mean	Class 1 and Class 2	China (2012) ^b
40 µg/m ³	Annual mean	Class 1 and Class 2	China (2012) ^b

^a Indoor air.

^b Ambient air.

^c 1 ppb (ppm) = 1.91 µg/m³ (mg/m³) (P = 1013 mbar, T = 293 K).