AIR QUALITY

Coordinating Lead authors

Fermoso, J.; San José, E.; Sánchez, R.

Lead authors

Ascenso, A.; Baldacchini, C.; Gómez, S.; González, M.; Nolan, P.; Pilla, F.; Sanesi, G.; Sanz, J. M.; Wendling, L.

Contributing authors

Calfapietra, C.; Dubovik, M.; Fatima, Z.; Guidolotti, G.; Jermakka, J.; Kraus, F.; Laikari, A.; Miranda, A. I.; Olver, C.; Ozturk, E. D.; Rinta-Hiiro, V.; Roebeling, P.; Scharf, B.; zu-Castell Rüdenhausen, M.

11 RECOMMENDED INDICATORS OF AIR QUALITY

11.1 Number of days during which air quality parameters exceed threshold values

Project Name: UNaLab (Grant Agreement no. 730052) and URBAN GreenUP (Grant Agreement no. 730426)

Author/s and affiliations: Laura Wendling[1], Ville Rinta-Hiiro[1], Maria Dubovik[1], Arto Laikari[1], Johannes Jermakka[1], Zarrin Fatima[1], Malin zu-Castell Rüdenhausen[1], Ana Ascenso[2], Ana Isabel Miranda[2], Peter Roebeling[2], Ricardo Martins[2], Rita Mendonça[2], Raúl Sánchez[3], Jose Fermoso[3], Silvia Gómez[3], María González[3], Jose María Sanz[3], Esther San José[3]

[1] *VTT Technical Research Centre Ltd, P.O. Box 1000 FI-02044 VTT, Finland*

[2] *CESAM – Department of Environment and Planning, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal*

[3] *CARTIF Foundation. Parque Tecnológico de Boecillo, 205, 47151, Boecillo, Valladolid, Spain*

Number of days during which air quality parameters (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3 and PAHs) in ambient air exceed threshold values	**Air Quality**
Description and justification	Air pollution is considered the single largest environmental health risk in the world, causing an estimated 2-6 million or more yearly deaths globally (Health Effects Institute [HEI], 2018; World Health Organisation [WHO], 2016). An important focus of research has been on the role of urban vegetation in the formation and removal of air pollutants in cities (e.g., Miranda et al., 2017) and the associated impacts of air pollution on morbidity, mortality and life-expectancy (e.g., Costa et al., 2014). The most relevant air pollutants are particulate matter of different sizes (PM2.5, PM10),

	ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), polycyclic aromatic hydrocarbons (PAHs), carbon monoxide (CO), benzene (C_6H_6) and toxic metals (As, Cd, Ni, Pb and Hg) (EEA, 2018b).
Definition	Number of documented exceedances to the limit value established in the Air Quality Framework Directive (Directive 2008/50/EC) for $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, ground-level O_3 and PAHs (as indicated by benzo[a]pyrene).
Strengths and weaknesses	+ Accurate results with automated measurements - Some of the measurement systems can be expensive and require continual management and upkeep
Measurement procedure and tool	Air pollution concentrations for regulatory compliance are based on measured pollutant concentrations (PM_{10} and $PM_{2.5}$, O_3, NO_2, SO_2, CO and PAHs) in ambient air. To assess differences in air quality as a result of NBS implementation, air quality monitoring should be conducted in close proximity to the NBS of interest and at an analogous reference site. ***Particulate matter (PM_{10} and $PM_{2.5}$) concentration:*** The reference method for the sampling and measurement of $PM_{2.5}$ and PM_{10} is described in EN12341:2014 "*Ambient Air — standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2,5}$ mass concentration of suspended particulate matter*". Briefly, particulate matter is measured using an air sampler that draws ambient air at a constant flow rate through a specially shaped inlet onto a filter that is weighed periodically to measure the accumulated particle load. The inlet defines the particle size cut-off (2.5 or 10 µm). A stationary measuring station is placed in a representative traffic, urban, industrial or rural location and continuous measurement of particulate matter using standardized air sampler equipment is undertaken. The limit concentration for $PM_{2.5}$ is 25 µg/m^3 averaged over one calendar year. Similarly, the limit concentration for PM_{10} is 40 µg/m^3 averaged over one year. To obtain these values, daily $PM_{2.5}$ and PM_{10} averages are averaged over a year to reach a yearly average, which acts as the indicator (ISO, 2018). There is an additional daily average limit value for PM_{10} of 50 µg/m^3, which cannot be exceeded more than 35 times in a calendar year. ***Nitrogen dioxide (NO_2) concentration:*** The reference method for the measurement of nitrogen dioxide and oxides of nitrogen is that described in EN 14211:2012 "*Ambient air — Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence*". To quantify nitrogen dioxide, a stationary measuring station is placed in a representative traffic, urban, industrial or rural location and continuous measurement of nitrogen dioxide is undertaken using standardized chemiluminescence detection equipment. An average of hourly averages is used to calculate a daily average. Daily

averages are then used to calculate a yearly average (ISO, 2018). The limit concentration for NO_2 is 200 µg/m^3 in any one-hour time period, and 40 µg/m^3 averaged over one year.

Sulfur dioxide (SO_2) concentration:

The reference method for the measurement of sulphur dioxide is described in EN 14212:2012 "*Ambient air — Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence*". To quantify sulfur dioxide, a stationary measuring station is placed in a representative traffic, urban, industrial or rural location and continuous measurement of nitrogen dioxide is undertaken using ultraviolet fluorescence detection equipment. An average of hourly averages is used to calculate a daily average. Daily averages are used to calculate a yearly average (ISO, 2018). The limit concentration for SO_2 is 350 µg/m^3 in any one-hour time period and 125 µg/m^3 averaged over one day.

Ground-level ozone (O_3) concentration:

The reference method for the measurement of ozone is described in EN 14625:2012 "*Ambient air — Standard method for the measurement of the concentration of ozone by ultraviolet photometry*". A stationary measuring station is placed in a representative traffic, urban, industrial or rural location and continuous measurement of ozone by ultraviolet photometry using standardized equipment is undertaken. The convention for ozone measurement is to calculate a daily maximum 8-hour mean (ISO, 2018). The limit concentration for maximum daily 8-hour mean ground-level O_3 is 120 µg/m^3.

Carbon monoxide (CO) concentration:

The reference method for the measurement of carbon monoxide is described in EN 14626:2012 "*Ambient air — Standard method for the measurement of the concentration of carbon monoxide by non-dispersive infrared spectroscopy*". A stationary measuring station is placed in a representative traffic, urban, industrial or rural location and continuous measurement of CO using non-dispersive infrared spectroscopy equipment is undertaken. Like O_3, the convention for CO measurement is to calculate a daily maximum 8-hour mean (ISO, 2018). The limit concentration for maximum daily 8-hour mean CO is 10 µg/m^3.

Polycyclic aromatic hydrocarbon (PAH) concentration:

The reference method for the sampling of polycyclic aromatic hydrocarbons in ambient air is described in EN 12341:2014. The PAH benzo(a)pyrene (BaP) serves as an analogue for all PAHs in the European air quality regulations. To assess the contribution of BaP in ambient air, the Ambient Air Quality Directive (2004/107/EC) outlines an obligation for Member States to monitor other relevant PAHs at a limited number of measurement sites including at least: benzo(a)anthracene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene. The reference method for the measurement of benzo(a)pyrene in ambient air is described in EN 15549:2008 "*Air quality — Standard method for the measurement of concentration of benzo[a]pyrene in ambient air*". Briefly, benzo(a)pyrene (BaP) is analysed as part of the captured PM_{10} matter. BaP samples are extracted from captured PM_{10} then analysed by high performance liquid chromatography (HPLC) with fluorescence detection (FLD) or by gas chromatography with mass spectrometric detection (GC/MS). The target value for BaP is 1 ng/m^3 averaged over one calendar year

Summary list of ambient air quality pollutants and limit concentrations.

Pollutant	Units	Limit concentration	Averaging period
$PM_{2.5}$	µg/m^3	25 µg/m^3	1 year
PM_{10}	µg/m^3	50 µg/m^3	24 hours
PM_{10}	µg/m^3	40 µg/m^3	1 year
NO_2	µg/m^3	200 µg/m^3	1 hour
NO_2	µg/m^3	40 µg/m^3	1 year
SO_2	µg/m^3	350 µg/m^3	1 hour
SO_2	µg/m^3	125 µg/m^3	24 hours
CO	mg/m^3	10 mg/m^3	Maximum daily 8-hour mean
O_3	µg/m^3	120 µg/m^3	Maximum daily 8-hour mean
PAHs	ng BaP/m^3	1 ng/m^3	1 year

Scale of measurement	District to region scale
Data source	
Required data	Pollutant measurement data from municipalities and regional, national and European authorities
Data input type	Quantitative
Data collection frequency	Continuous measurements with hourly, daily, monthly, and yearly averages
Level of expertise required	Moderate
Synergies with other indicators	Directly related to the *European Air Quality Index* indicator and the other indicators of the *Air Quality* group.
Connection with SDGs	SDG 3 Good health and well-being; SDG 11 Sustainable cities and communities; SDG 15 Life on land

Opportunities for participatory data collection	No opportunities identified
Additional information	
References	Directive 2015/1480 of 28 August 2015 amending several annexes to Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council laying down the rules concerning reference methods, data validation and location of sampling points for the assessment of ambient air quality Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air Costa, S., Ferreira, J., Silveira, C., Costa, C., Lopes, D., Relvas, H., … Teixeira, J.P. (2014). Integrating Health on Air Quality Assessment - Review Report on Health Risks of Two Major European Outdoor Air Pollutants: PM and NO_2. Journal of Toxicology and Environmental Health - Part B Critical Reviews, 17(6), 307-340. European Environment Agency. (2018b). Air quality in Europe – 2018 report. EEA Report No. 12/2018. Luxembourg: Publications Office of the European Union. https://www.eea.europa.eu/publications/ air-quality-in-europe-2018 Health Effects Institute (HEI). (2018). State of Global Air 2018. Special Report. Boston, MA: Health Effects Institute. International Organization for Standardization (ISO). (2018). Sustainable cities and communities — Indicators for city services and quality of life (ISO 37120:2018). https://www.iso.org/standard/68498.html Miranda, A.I., Martins, H., Valente, J., Amorim, J.H., Borrego, C., Tavares, R., … Alonso, R. (2017). Case Studies: modeling the atmospheric benefits of urban greening, In D. Pearlmutter, C. Calfapietra, R. Samson, L. O'Brien,S. Ostoic, G. Sanesi, R. Alonso (Eds.), The Urban Forest. Cultivating Green Infrastructures for People and the Environment (pp. 89-99). New York: Springer International Publishing. National Oceanic and Atmospheric Administration (NOAA). (n.d.). Weather Research and Forecasting model coupled to Chemistry (WRF-Chem). Retrieved from https://ruc.noaa.gov/wrf/wrf-chem/ World Health Organization (WHO). (2016). Ambient air pollution: A global assessment of exposure and burden of disease. Geneva: World Health Organization. https://www.who.int/phe/publications/air-pollution-global-assessment/en/