

THE IMPORTANCE OF ASSESSING AIR QUALITY IN NATURE-BASED SOLUTIONS WITH A FOCUS ON HEALTH AND WELL-BEING

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ABSTRACT

Understanding the full potential of Nature-Based Solutions (NBS) is crucial in facing many societal and environmental challenges. The NATURELAB project promotes NBS for health and well-being and acknowledges the relevance of air quality within this context, which aligns with existing evidence and EC directions. Air quality is key for enhancing urban population health and protecting vulnerable participants in Nature-Based Interventions (NBI), such as those with respiratory or cardiovascular conditions. NATURELAB selected, from the proposal stage, NO₂, PM₁₀ and PM_{2.5} as the air quality parameters to be assessed at some of the experimental sites where NBI will take place. Compared to the Directive 2008/50/EC, the WHO's air quality standards for the three selected air quality parameters are more aligned with the motivation and purposes of the project.

Keywords: Air Quality; Nature-Based Solutions; Nature-Based Interventions; Urban Population; Health; Well-Being; Particulate Matter; Dioxide Nitrogen.

1. Introduction

The NATURELAB project deals with Nature-Based Solutions (NBS) located in 15 experimental sites, from 5 countries. These NBS represent very distinct nature and climate contexts and are the foundation for research activities aiming at promoting health, well-being and environmental sustainability. Understanding the full potential of NBS is crucial in a world facing so many societal and environmental challenges. NBS are interventions that harness the functions of healthy, natural or restored ecosystems to address societal challenges in an integrated way. Notably, the EC (2024) list of NBS projects includes NATURELAB in the list of cross-cutting projects, with a focus on "health and well-being".

According to the European Union (EU), NBS are defined as: "*solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more*

diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions” (EU, 2021). The International Union for Conservation of Nature (IUCN, 2020) defines NBS similarly but with greater emphasis on ecosystem integrity as: *“actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature.”*

Together, the two definitions agree that NBS should be cost-effective, multi-benefit, and adaptive, with the EU stressing policy, design, and systemic interventions, and the IUCN emphasising ecological health and the linkage to human well-being and biodiversity.

NBS air quality is a key topic, both from the perspective of co-benefits for the health and well-being of the urban population living nearby, and for specific cases, such as Nature-Based Interventions, where participants with health issues (e.g., respiratory or cardiovascular issues), likely to be directly affected by air quality, must be protected. The vegetation cover in urban areas directly influences air pollution levels in an indirect manner (Zhan *et al.*, 2022), reinforcing the imperative of enhancing natural environments to significantly improve air quality.

The Commission’s handbook for practitioners complements NBS definition with an operational impact-assessment framework that lists air quality among twelve societal and environmental dimensions (c.f. Figure 1) and provides indicators and methodologies to measure NBS effects on air quality and microclimate (EU, 2021). The IUCN’s core definition (IUCN, 2024) embeds air quality within the wider suite of ecosystem services and human-health co-benefits; IUCN guidance and urban tools (for example, the Urban Nature Indexes) operationalise this by including air-quality-related indicators when assessing urban NBS.

2. Objectives

This work aims at enhancing the relevance of air quality assessment in NBS with a focus on the promotion of the health and well-being of urban populations.

3. Air Quality in Urban Areas

The increase in air pollution levels in urban areas affects the quality of city residents’ everyday life, endangers human health, and harms the environment. Air quality is a major concern worldwide, particularly in urban areas, due to its direct consequences not only for life (humans, fauna and flora) but also on infrastructure and buildings, including historic ones (Barbosa *et al.*, 2025). In the political agenda, air quality issues are related with climate change mitigation, since many actions towards air quality improvement contribute to the reduction of greenhouse gas emissions.

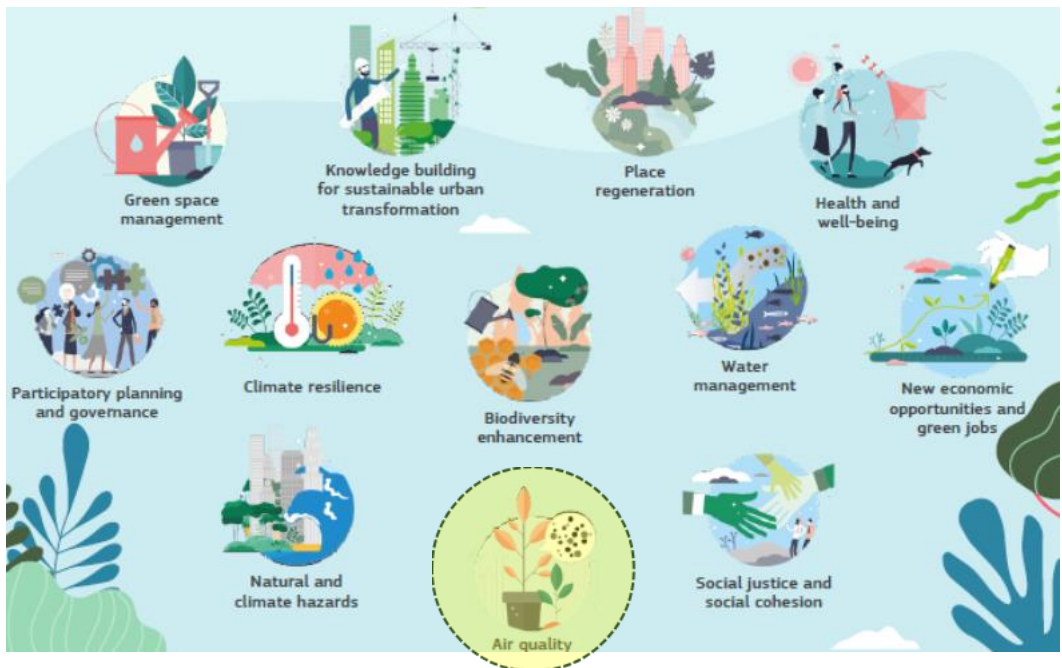


Figure 1. The air quality among the dimensions of Nature-Based Solutions, according to the European Commission. Image extracted from the front cover of EC (2021).

Traffic emissions, a bigger number of vehicles, road-traffic density, industrial areas, as well as anthropogenic activities, are some of the dominant factors that contribute to the increase in the concentration of pollutants in ambient air, leading to the deterioration of air quality (Antonopoulou *et al.*, 2023). Around 90% of city dwellers in Europe are exposed to pollutants at higher concentrations than the air quality levels deemed harmful to health. For example, fine particulate matter (PM_{2.5}) in air has been estimated to reduce life expectancy in the EU by more than eight months (EC, 2021). The scientific community has developed an array of air quality indices that describe the potential impact of pollution levels on human health, to research the air quality and its related effects. In general, these indices are a metric for a population health risk assessment (Antonopoulou *et al.*, 2023; Cairncross *et al.*, 2007; WHO, 2021).

The distribution of air pollutants in urban settings results from complex interactions between factors such as street morphology (e.g., building volume, roof shape), green spaces (e.g., street trees, vegetation barriers, type of leaves), microclimatic factors (e.g., humidity, wind direction and intensity, temperature), traffic emissions, background pollutant concentrations, pollution sources, physical processes, and photochemical reactions (Khan *et al.*, 2022; Miao *et al.*, 2023).

It is known that air pollution impacts particularly sensitive population – children, the elderly, and people with respiratory and cardiovascular conditions. Exposure to fine particulate matter (PM_{2.5}), a dominant air pollutant, is associated with adverse health effects such as respiratory and cardiovascular diseases and premature mortality (e.g., Anderson *et al.*, 2012; Zhan *et al.*, 2023).

4. Air Quality Guidelines and the NATURELAB Approach

The Directive 2008/50/EC sets air quality assessment and air quality management, with the purpose of ensuring ambient air pollution assessment. The framework is based on the need to manage sources of pollution and ensure that exposure, even in the long term (yearly basis), is below acceptable guidelines and thresholds. The NATURELAB project selected three representative air quality parameters to be assessed at ES where the therapeutic programmes will take place, namely: NO₂; PM₁₀ and PM_{2.5}. It was understood that, compared to the Directive 2008/50/EC, the WHO's air quality standards are more aligned with the motivation and purposes of NATURELAB. Table 1 reports the WHO most recent standards for these parameters, and the previous one, dated from 2005. It is observed from the comparison of the 2005 and the 2021 guidelines that the updates in research and practice have pushed the concentration levels to reduced values.

Table 1. Ambient air quality standards based on WHO (2021)

Pollutant	Averaging time	WHO 2005 air quality standards	WHO 2021 air quality guidelines
Nitrogen Dioxide (NO₂)	24h ^{a)} Annual	^{b)} 40 µg/m ³	25 µg/m ³ 10 µg/m ³
Particulate Matter: PM₁₀	24h ^{a)} Annual	50 µg/m ³ 20 µg/m ³	45 µg/m ³ 15 µg/m ³
Particulate Matter: PM_{2.5}	24h ^{a)} Annual	25 µg/m ³ 10 µg/m ³	15 µg/m ³ 15 µg/m ³

a) 99th percentile, i.e., 3–4 exceedance days per year.

b) NO₂ standard for 24h was not established. A 1h-average of 200 µg/m³ was proposed.

The portable AEROQUAL™ portable air quality series 500 equipment was selected for use at project ES due to its suitability for use on-site. A straightforward methodological approach was established for measuring local air quality data by non-experts at the NATURELAB ES (c.f., Fernandes *et al.*, 2024). Note that this information is to be used as a site-specific characteristic that may inform on ambient NO₂; PM₁₀ and PM_{2.5} levels vis-à-vis participants' needs and is not intended to describe the local air quality. Delgado-Saborit (2012) informs that assessing instantaneous peak personal exposure enables researchers to examine the relationship between short-term exposure events and corresponding health effects. NATURELAB aims to keep air quality data as an additional indicator that may support an improved understanding of the success of NBI.

5. Final Remarks

Air quality in urban areas requires significant attention and care. The NATURELAB project focuses on raising awareness and assessing this important aspect, which is crucial for the health and well-being of the population. It also ensures a safe environment for nature-based interventions involving individuals who are sensitive to air pollution. All project activities are grounded in the understanding that nature plays a vital role in improving air quality.

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