"Visibility" at the Italian natural parks: preliminary data from the first-ever pilot project by ENEA and CUFAA

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THE PROJECT – "VISIBILITY"

"Visibility" is meant as the greatest distance at which an observer can see a distant object in contrast with the horizon and, when referred to a landscape, it depends on the optical characteristics of the atmosphere, which are also linked to the presence of gaseous or particulate pollutants that contribute to generating haze that obstructs clear vision. The visibility is therefore a useful indicator of air quality in natural areas with a significant naturalistic, ecological or attractiveness vocation such as the National Parks. In these areas the possibility of enjoying a clear panorama immersed in a natural landscape represents a precious recreational value, a de facto ecosystem service. The Italian Constitution itself (Article 9) and several Italian laws point at preserving the nature and the landscape.

OBJECTIVE. The goal is to employ the American protocol IMPROV.E (Interagency Monitoring of PROtected Visual Environment) based on the algorithm developed by Malm et al (1994) for the quantification of the coefficient \( B_{vis} \) (light extinction, equation (a)) as a function of different chemical-physical parameters associated with compounds in the particulate and gaseous phase of both anthropic and natural origin.

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B_{vis} = 2.2 \cdot I_0(RH) \cdot [\text{Small Ammonium Sulfate}] + 4.8 \cdot f_1(RH) \cdot [\text{Large Ammonium Sulfate}] + 2.4 \cdot f_2(RH) \cdot [\text{Small Ammonium Nitrate}] + 5.1 \cdot f_1(RH) \cdot [\text{Large Ammonium Nitrate}] + 2.8 \cdot f_2(RH) \cdot [\text{Small Organic Mass}] + 6.1 \cdot [\text{Large Organic Mass}] + 10 \cdot [\text{Elemental Carbon}] + 1 \cdot [\text{Fire Soil}] + 1.7 \cdot [\text{Sea Salt}] + 0.6 \cdot [\text{Coarse Mass}] + \text{Rayleigh Scattering (Site Specific)} + 0.33 \cdot [\text{NO}_2, \text{ppb}]
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(a)


EXPERIMENTAL MEASURES. During spring-summer 2021 and winter 2021/2022, 24-hours samples were collected with a frequency of one every three days. The following chemical species and components were characterized and quantified (µg/m³) according to equation (a): PM₁₀, PM₂.₅, water soluble anions and cations[2], Elemental and Organic Carbon[3], metals and trace elements[4] and NO₂ (concentration quantified in ppb with a dedicated monitor).

THE PILOT SITE. The first site study to apply the Visibility approach in Europe, is the Circeo National Park (LT). The measuring instruments are located near the Lago dei Monaci site. The identified site is far from local sources of pollutant emissions, is characterized by good local ventilation and faces a site of high naturalistic interest, namely the Circeo promontory.

THE VISIBILITY SAMPLING CABINET. The cabinet developed for Visibility is equipped with two FAI Hydra dual channel samplers for atmospheric particulate matter sampling, an analyzer for NOx, a camera for image acquisition (pointed towards Monte Circeo, necessary for the definition of long-distance optical visibility) and a weather station for the collection of local meteorological data (in particular, relative humidity is one of the factors required for calculating the visibility coefficient).

THE "VISIBILITY INDEX". A first visibility index \( B_{vis} \) was calculated (according to equation (a)) and preliminary results show that an increasing \( B_{vis} \) effectively corresponds to a decreasing optical visibility at long distance. The parameters that seem to contribute the most to reduce the visibility and hence to the increase of \( B_{vis} \) are the secondary inorganic species (Ammonium Sulfate and Ammonium Nitrate) closely linked to atmospheric humidity.

Fig. 1. Sampling site near the Lago dei Monaci and view of the Circeo promontory from the sampling area (distance = 230km). Brown arrow: the Circeo Mount, focus point of the photocamera.

Fig. 2. The Visibility cabinet near the Lago dei Monaci, drone view and focus on the sampling lines for particulate matter and the meteorological measurements.

Fig. 3. Daily measures of the different sources affecting air quality characterized according to the equation (a). The chemical species underlying this sources (see notes [2], [3] and [4]) were used to determine the \( B_{vis} \) parameter. The daily values were used to calculate the \( B_{vis} \) parameter during each day and to correlate the obtained value to actual pictures giving evidence of the real possibility to distinguish the Circeo promontory (examples in Fig. 4).

[1] Sulphates, Nitrates and Ammonium for Secondary inorganic pollutants, or Chloride to calculate the marine – Sea salt aerosol concentration.
[2] Trace of organic emissions from both natural sources or anthropogenic sources such as combustion.

Fig. 4. Pre-sharpened results from the visibility approach. Low value of the \( B_{vis} \) coefficient are related to good visibility while high values correlate to scarce or reduced visibility of the Circeo promontory.

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