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Change – The transformative power of citizen science

Lichens and air quality: a new citizen science approach

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Abstract

Citizen science has been widely adopted in monitoring air quality by indexes of lichen diversity. Since the identification of lichens is challenging, volunteers are often involved in adopting simplified sampling protocols, which require identification at a higher level than the species, or the use of morpho-types, or colors. In Italy, a simple citizen science protocol for monitoring air quality with lichens by involving schools has been successfully tested, and will be replicated at the national level.

Keywords: anthropic pressure, biomonitoring, identification, schools, urban ecosystems.

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Lichens, air quality and citizen science

Epiphytic lichens have been used as bioindicators since the second half of the 20th century (De Wit 1983). They are also used in several citizen science efforts for assessing air quality (e.g. Counoy et al. 2023). A first relevant experience with schools was carried out in the UK during the ’70s (Gilbert 1974), followed by several experiences at different scales.

This study aimed at developing a replicable, cost-efficient protocol for monitoring air quality in an early warning, permanent network in Italy, involving (mostly, but not exclusively) high and junior high school students. Schools were selected as targets for the study since, being present everywhere in the country, they could provide ideal nodes for the network. Plus, hands-on participatory activities are particularly appreciated by students and teachers. The activity was supported by the Municipality of Verona, its Natural History Museum, the CariVerona Foundation, the Italian Association for Citizen Science, National Biodiversity Future Center, Botanical and Lichen Societies, and WWF.

Identification of lichen species

Lichens identification is quite a challenging task, especially for volunteers, since it often requires spot tests, and microscopic features. McMullin and Allen (2022) reported (from iNaturalist research grade records) a rate of correct observations of 59% for lichens which can be identified by macroscopic morphological features. The rate dropped to 7% and 5% when microscopic or chemical features were required. Munzi et al. (2023) reported an error rate of ca. 70% for iNaturalist observations for three towns, Palermo, Turin and Lisbon. The error rate of volunteers during the CSMON-LIFE project (LIFE13 ENV/IT/842) ranged from 14% for the very easy-to-identify *Xanthoria parietina*, up to 55% and 52% respectively for the easy *Flavoparmelia caperata* and *Evernia prunastri*, and 86% of the relatively difficult *Diploicia canescens* (Martellos et al. 2021).

Given these experiences, a protocol for monitoring air quality by means of epiphytic lichens with a citizen science approach should not require identification, at least at the species level.

The protocol

The monitoring protocol does not require the identification of lichens, but rather of “morphological functional traits” (Fig. 1a–d), defined as:

a) crustose lichens (two-dimensional thallus completely attached to the substratum with its lower surface, resembling a crust);
b) narrow-lobed foliose lichens (two-dimensional thallus attached to the substratum by means of small root-like structures, free at least at the margins; marginal lobes not wider than 3 mm);
c) narrow-lobed foliose lichens (same as b, but marginal lobes wider than 3 mm)
d) fruticose lichens (three-dimensional thallus)

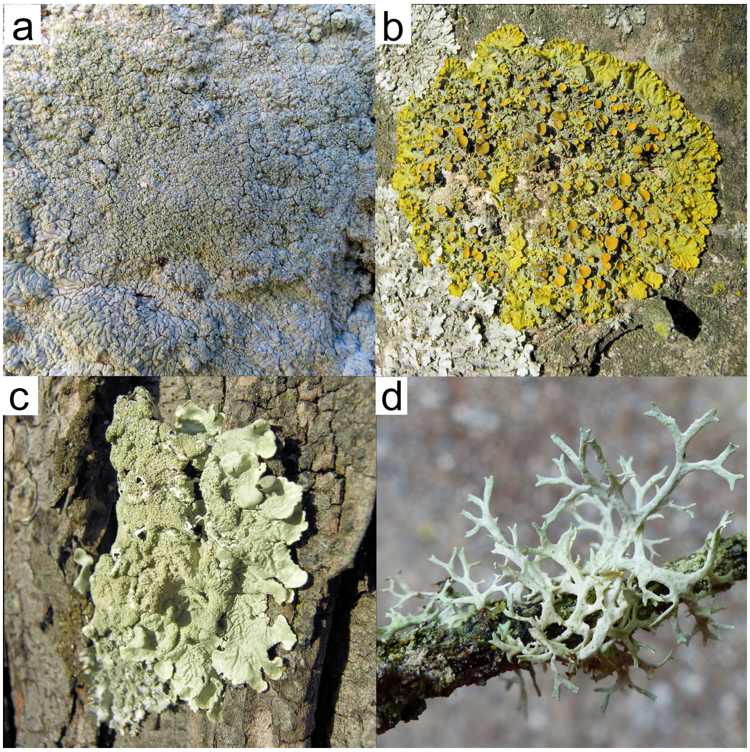

Figure 1. The four morphological functional traits: a) crustose lichens (as an example, a thallus of *Diploicia canescens*); b) narrow lobed foliose lichens (*Xanthoria parietina*); c) broad lobed folios lichens (*Flavoparmelia caperata*); d) fruticose lichens (*Evernia prunastri*).

The protocol requires the monitoring of survey sites with a radius of 50 meters. Starting from the center, 3 trees must be surveyed for lichens. The trees must belong to genera with a similar pH and texture of the bark (Hawksworth and Rose 1970). The protocol allows the surveying of *Populus nigra*, *Quercus* ssp., *Tilia* ssp., and *Ulmus glabra*. The trees should be isolated (at least 5 meters one from the other), without signs of mechanical or chemical disturbance, straight (inclination < 10°), not included in hedges.

Each tree's score ranges from 0 to 3, as follows: 0 – no lichens, or crustose lichens only; 1 – presence of foliose, narrow lobed lichens; 2 – presence of foliose, broad lobed lichens; 3 – presence of fruticose lichens.

Scores should be stored in a spreadsheet with the following columns: survey site number; address; coordinates; tree 1 score; tree 2 score; tree 3 score.

Volunteers must follow the following workflow:

1) identify a survey site, and report its data in the spreadsheet;
2) select the trees, according to the guidelines;
3) survey each tree for morphological functional traits between 100 and 200 cm from the base, and report the score in the spreadsheet;
4) take an image of each tree on the side with the higher-scoring morphological functional traits.

The surveying process (1 to 4) must be repeated for each survey site volunteers plan to investigate. At the end of the experience, the spreadsheet and the images are sent to a repository for validation and verification.

Results

The activity was carried out in Verona (Northern Italy), during a week (19–24 September 2023). Ten schools (junior and junior high), 14 classes and ca. 300 students monitored 176 sites and 528 trees.

All data were verified by expert lichenologists. Plus, 10% of the survey sites were resampled for verification, and no bias emerged.

The average score per site (sum of the score of each tree divided by the number of trees) ranged from 0 to 2.5. Considering the center of Verona only, it ranged from 0 to 1.67, demonstrating a higher anthropogenic impact. The distribution of the survey sites (Fig. 2) is uneven, concentrated around each school, hampering general considerations. However, lower scores were obtained in areas where vehicular traffic is more intensive, as expected, given the sensitivity of lichens to phytotoxic gases deriving from fuel combustion.

After the elaboration, all the data, along with a simple manual describing how they were processed and mapped, were returned to the schools, to allow replication of the activity.

This first experience provided relevant feedback, which led to the protocol's improvement, in order to make the data more informative.

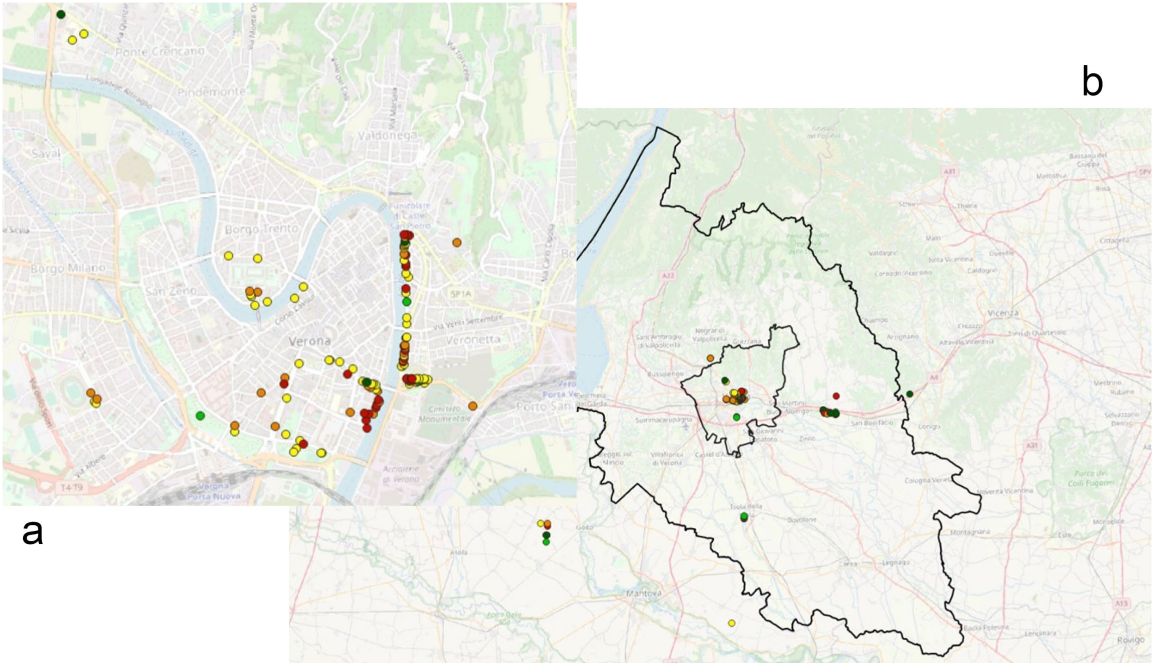

Figure 2. Survey sites. Depending on the score, the survey sites are colored in red (lower score) to green (higher score): a) magnification of the urban center of Verona; b) the whole study area.

As a consequence, the score is now: 0 – no lichens; 1 – crustose lichens; 2 – narrow lobed foliose lichens; 3 – broad lobed foliose lichens; 4 – fruticose lichens. Furthermore, volunteers are asked to report, in cases 1–3, also the coverage, i.e. the total area of the tree which is covered by lichens, providing a second score as follows: 1 = <5%; 2 = 5–25%; 3 = 25–50%; 4 = 50–75%; 5 = >75%.

Conclusion and future perspectives

The results demonstrated the feasibility of a sustainable, replicable protocol for monitoring air quality using epiphytic lichens as bioindicators involving volunteers in a citizen science approach. The protocol is a trade-off between how much informative the data are and the difficulty of the task which have to be performed by volunteers.

This experience was a first test. The protocol and the approach will be replicated at a national level between 2024 and 2025, thanks to the support of the Italian National Biodiversity Future Center (https://www.nbfc.it)

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