

**LICHENS AS SENTINELS OF AIR QUALITY IN URBAN AREAS**  
**A CITIZEN SCIENCE PROJECT**  
**promoted by the IABEP**  
**International Association for Biomonitoring of Environmental Pollution**

**OPERATIVE PROTOCOL**

**1. Site Selection**

**1.1** Select a representative number of sampling sites throughout the city, possibly based on a randomized or systematic design.

Note: the availability of trees limits the choice of sites to be sampled (see §2); Google maps or Google street view may be useful tools for planning site selection;

**1.2** Sampling sites have roughly a circular shape, with a radius of about 50 m;

**1.3** The center of two adjoining sampling sites must be at least 200 m apart (i.e. the outer boundaries must be at least 100 m apart);

**2. Tree selection**

**2.1** Sites must have a minimum of 3 trees suitable for lichen sampling (see §2.2 and §2.3)

**2.2** The trees to be sampled must be chosen in such a way as to ensure that the survey is carried out under comparable ecological conditions. The trees must thus comply with the following features:

- isolated position (trees within bushes must not be included, as in these environments the lower amount of light can limit lichen presence)

- straight trunk, with inclination  $<10^\circ$  and without large branches or forks in the part to be sampled (1-2 m from ground, see 2.1) , where water stagnation or areas of preferential stemflow may influence lichen presence;

- trunk circumference at breast height  $>60$  cm;

- absence of obvious disturbances (e.g. painting, wounds, diseases, fungicide treatments, etc.).

**2.3** Since bark features (especially pH) may greatly influence the lichen vegetation, only trees belonging to the genera *Tilia* and *Quercus* (linden/lime tree and oak) should be sampled; poplar (*Populus* spp.) and elm (*Ulmus* spp.) may be included if necessary. Unsuitable trees: horse chestnut (*Aesculus hippocastanum*), plane tree (*Platanus orientalis*), since their bark is flaking off, black locust (*Robinia pseudacacia*) since its bark is eutrophic and has a very high water-holding capacity. All conifers must be excluded as well, since their bark has a very low pH.

**3. Lichen sampling**

**3.1** For each of the at least 3 trees selected in each sampling site, the lichens all around the trunk from 1 to 2 m from ground must be observed, and the groups present recorded as follows:

*lichen desert* – absence of lichens

*crustose* – presence of crustose lichens

*foliose* – presence of large-lobed foliose lichens (e.g. *Parmelia sulcata*, *P. tiliacea*, *F. caperata*, *Parmotrema perlatum*, "melanoparmelia", *P. acetabulum*, *Physconia distorta*)

*fruticose* – presence of fruticose lichens (e.g. *Evernia prunastri*, *Pseudevernia furfuracea*, *Usnea* sp.)

*nitrophytic* - presence of narrow-lobed foliose lichens, with orange or grey color (e.g. *Physcia adscendens*, *Hyperphyscia adglutinata*, *Phaeophyscia orbicularis*, *Physconia grisea*, *Xanthoria parietina*)

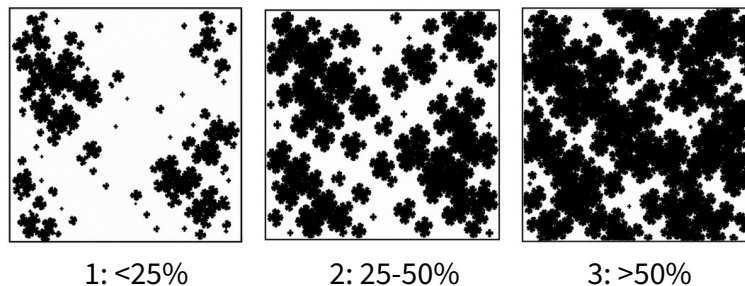
**3.2** For each lichen group, roughly indicate the degree of trunk cover (abundance) for each category, according to the scale:

1: <25%

2: 25-50%

3: >50%

See the pictogram below for a quick visual comparison of % cover



**3.3** Additional data: record the coordinates (e.g. from Google maps) of the center of the sampling site and of the individual trees; take photos of the sampled trees; shortly describe the site (e.g. avenue with heavy traffic, urban park, residential area, etc.)

## 4. Interpretation

**4.1** The following scale has to be used for the interpretation of the results. Categories are ranked in order of decreasing sensitivity to air pollutants as follows: fruticose - foliose – crustose. At each site, the most sensitive found has to be selected as the entrance row. Afterwards, the cell at the intersection between the highest abundance score at the site for that category and the abundance score of nitrophytic lichens has to be used.

| Category abundance  | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 |
|---------------------|---|---|---|---|---|---|---|---|---|---|---|---|
| Fruticose           | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 |
| Foliose             | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 |
| Crustose            | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 |
| Lichen desert       | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 |
| Nitrophytic lichens | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 |

**4.2** The final classification of the site is based on the following scales of air quality and eutrophication.

| Air quality   |  |
|---------------|--|
| very good     |  |
| good          |  |
| moderate      |  |
| low           |  |
| lichen desert |  |

| Eutrophication |            |
|----------------|------------|
| 0              | negligible |
| 1              | low        |
| 2              | moderate   |
| 3              | high       |