

Lichens and Air Pollution



Without air pollution



with air pollution

Lichens on *Borassus flabellifer* (Palmyrah palm) from unpolluted and polluted parts of Chennai city



Lichens and air pollution

Lichens have long been recognized as sensitive indicators of environmental conditions.

In 1859, Grindson attributed the decline of lichens around city centres to air pollution.

Lichens lack a protective cuticle and stomata, direct dependence on atmosphere for nutrients (poikilohydrous nature), longevity, stability, perennial condition of thallus, high degree of sensitivity to changes in substrate pH and pollutants makes them ideal organisms to study the impact of air pollution.

Lichens are good accumulators of many elements, particularly heavy metals and radio nuclides.

Lichens and air pollution

Lichens show their sensitivity to air pollution in various ways such as decline in diversity, absence of sensitive species, and morphological, anatomical and physiological changes.

High sensitivity of lichens is related to their physiology and morphology

Alteration of the symbiotic balance between the partners leads to a breakdown of the association

This can come about by accumulation of toxins, metabolic interference, or altered nutrition favoring one partner of the other.

Several studies are available on lichens in relation to air pollution and metal deposition from different regions of the world.

In India, air pollution-monitoring using lichens are still remain at infancy stages and needs standardization specific to locations and problems

Types of Pollutants that affect lichens.....

SO₂

By- product of fossil fuel combustion (coal or fuel oil), ore reduction, paper manufacture, and automobile exhaust

Photochemical toxins such as Ozone, NO₂, PAN (peroxyacetyl nitrate):

Combustion products, automobile exhaust (common pollutants in “smog” and “smaze”)

Acid Rain

SO₂ and NO₂ dissolved in both rain and snow

Ability of the substrate to “buffer” acidic conditions helps lichens survive on limestones and some basic barks

Heavy Metals

Lead (Pb) Nickel (Ni), Mercury (Hg), Zinc (Zn), Arsenic (As),Cadmium (Cd), Chromium (Cr) etc.

Oil Spill Pollution

Ionizing Radiation

¹³⁷Cs and ⁹⁰Sr from nuclear testing or accidents

Lichens and air pollution

The sensitivity of lichen species to pollutants may be estimated from several sources:

- **Measurements of air pollution may be compared with the lichens occurring at a site**
- **Corroborative information may be used, usually derived from abiotic observations**
- **Sensitivity may be estimated from the species composition at the investigated sites**
- **From the general state (vitality) and the degree of damage observed in the thalli**
- **Known sensitivity values may be used, derived from earlier studies**

To study the impact of air pollution on lichens requires.....

Data on species distribution

Auto-ecological information, Eg. Indicator values for individual species

An index expressing the species' sensitivity to air pollution

The drawing of isopleths on a map

The results also depend on the selection and size of the sampling units and on the sampling procedures.

Furthermore, every study has its own regional validity, dependent on the local lichen diversity, climate, etc.

Based on sensitivity to air pollution lichens can be classified into...

Sensitive species that deleted by air pollution

Tolerant species that are resistant to pollution

Species which appear after the major part of the native lichen community has been destroyed by the effect of pollution

Air Pollution Studies....

Mapping of lichens (communities) in relation to air pollution

collect quantitative data on lichen communities, air pollution, condition of resources of site and linking them using multivariate statistical procedures to identify sensitive/tolerant species and the zonation patterns.

Use of indices like **Index of Atmospheric Purity (IAP)** using selected lichen species.

Transplantation studies - placing lichen thalli from unpolluted area to a polluted area for a specific time period and assessing the extent of damage at the morphological, cellular and physiological and elemental contents.

Morphological and anatomical changes due to pollution using scanning electron microscopy to assess the extent of damage

Physiological effects of pollutants on lichens – assessing extent of physiological damage using methods like membrane integrity and chlorophyll degradation assessments

Industrial melanism. . .

The darkening of several species of moths during the recent period of industrialization in many countries by the spread of a gene controlling elevated melanin synthesis.



Peppered moths on trees and camouflage for protection.

- In unpolluted areas trees are covered in lichens and the light form of the moth is hard to see.
- In mid 1800's air pollution in British cities covered trees with soot.
- In cities dark form became common and light form rare.
- In mid 1950's pollution controls were introduced in Britain and frequency of melanic form has declined since then.

Kettlewell, H. B. D. 1955. Selection experiments on industrial melanism in the Lepidoptera. *Heredity* 9:323-342.

Kettlewell, H. B. D. 1956. Further selection experiments on industrial melanism in the Lepidoptera. *Heredity* 10:287-301.

Kettlewell, H. B. D. 1973. *The evolution of melanism: the study of a recurring necessity; with special reference to industrial melanism in the Lepidoptera*. Clarendon Press, Oxford 423p.



Lichens and air pollution

Hawksworth and Rose 1973 developed qualitative scales using selected lichen species

Their scales to measure SO₂ levels within England is based upon presence or absence of selected lichen species, the species are categorized into ten groups.

Lecanora conizaeoides is found all along the trunks with bark colonized by algae when the SO₂ concentration is about 125 μg m⁻³ (0.04ppm).

Usnea ceratina will be found on the same trees only when the concentration of SO₂ is about 35 μg m⁻³

U. florida will be found if the concentration is less than 30 μg m⁻³

These scales were used by the British Lichen Society to develop a illustrated chart against SO₂ pollution levels – widely used by the non specialist to assess the pollution levels.

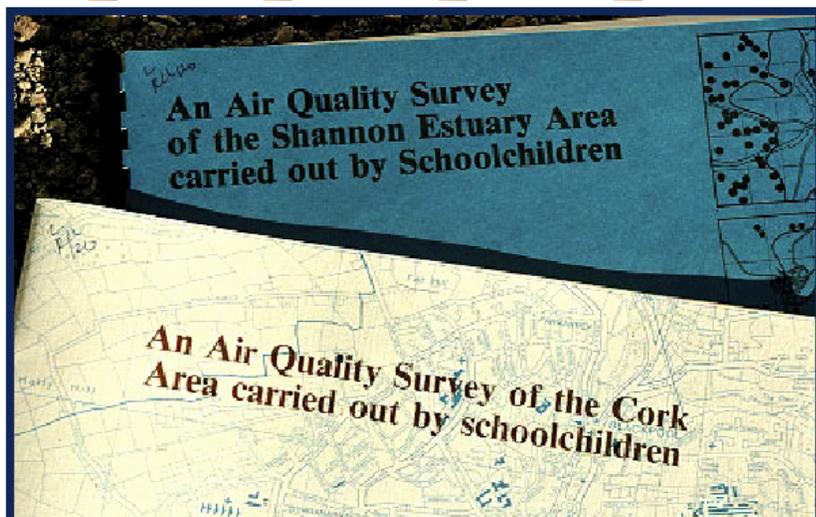
Deruelle developed a lichen SO₂ pollution monitoring scales for Mantes area (France).



Lichen distribution & Human health

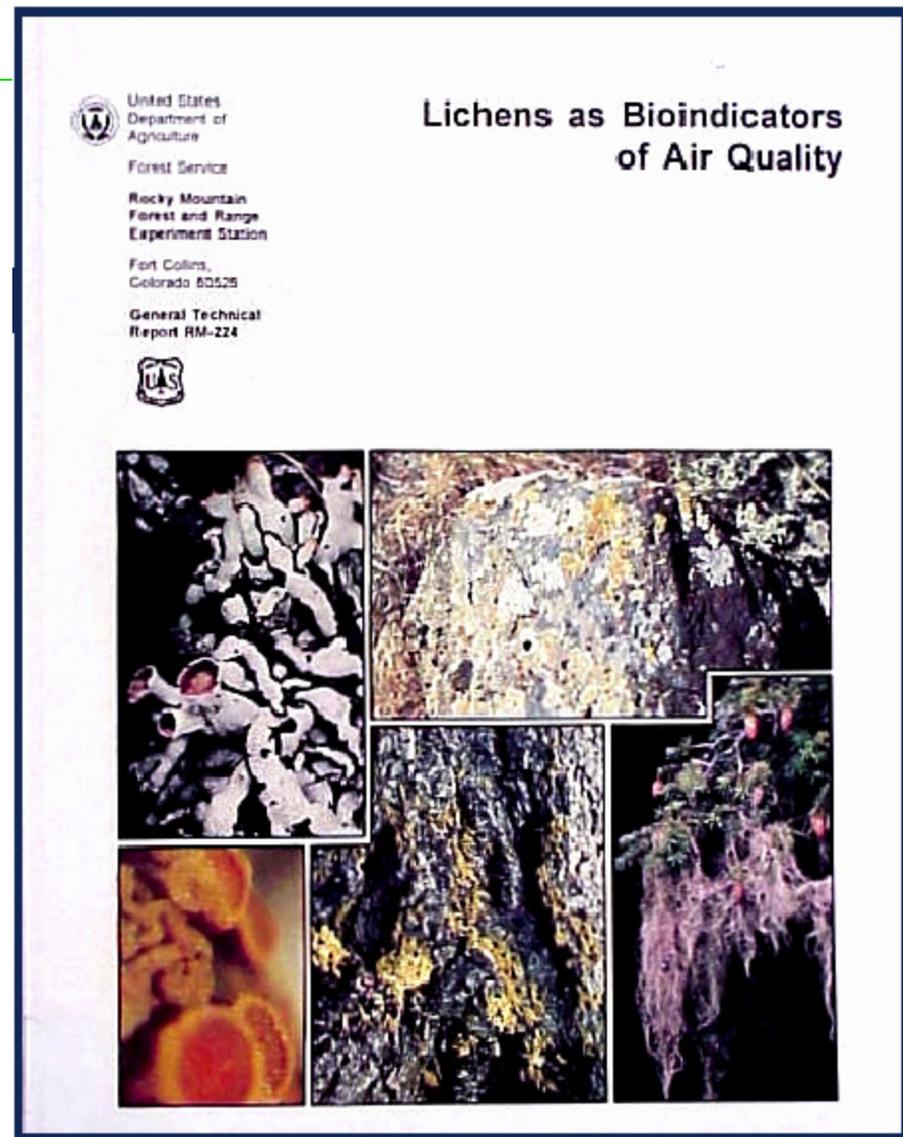
Lichens, air pollution and lung cancer in Northern Italy

- **P.L.Nimis and colleagues surveyed the Lichens of N.Italy in relation to the frequency of lung cancer**
- **Datasets include historic, demographic, occupational and medical data to overcome bias**
- **A strict and inverse relationship between diversity of Lichens and frequency of Lung Cancer**
- **The incidence of SO₂ killed lichens and increased lung cancer**



Air pollution surveys using lichens in Ireland

In India we can also assess air quality using lichens



***“How To Survey”* recently published by the US Forest Service**