Plants Biomonitoring of Air Pollution

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Introduction

The main focus of ARCHIMEDES is to capitalize on and integrate ChArMEx, AC-HIA and Med-Particles expertise to push further ahead the limits of what we know on the sanitary and economic impacts of air quality and climate change over the Mediterranean in the near and mid future, with a focus on the eastern and southern sides of the basin.

It is in this context that this review presentation discusses the principes, mecanisms, advantages and desadvantage of Biomonitoring of air quality.

Background

Air pollution has been recognized as the world's top problem in many strategic environmental policies.

However, it is still inadequately corroborated by regulatory monitoring due to the balance between ***costs*** and ***practicable constraints***.

The need for an interdisciplinary methodology.

We can divide the Study of air pollution (AP) into Three obviously overlapping but some-what distinct areas:

The generation And control of AP at their source

Backgroung PM pollution

The transport, dispersion, Chemical transfomation in, and removal of species from the atmosphere.

The effects of AP on human, animals, materials, vegetation, crops, and Forest and aquatic ecosystems

Impacts on human health

Tools used in monitoring of AP

Tools and concepts applied in air quality monitoring

It is essential to monitor air pollution in order to properly understand its effects on our health and the natural environment

Different approaches to air quality monitoring are presented including:

-ground stations of monitoring networks,

-satellite telemonitoring,

-the application of biomonitoring.

Outline of the presentation

I- Biological Monitoring (Concepts)

II- Human Biomonitoring (HBM)

- Biomarkers of exposure
- Biomarkers of Effects

III-Plants Biomonitoring

- Passive and active approch
- Lichens, Mousses and higher plants

IV- advantages en disadvantages of biomonitoring

1. Concept

Biomonitoring or biological monitoring is "the systematic use of the organisms or their responses to determine the conditions or changes in the environment".
Organisms used as biomonitors have to be

- characterized by a settled living mode of the organism to be representative for a given ecosystem or region
- and they should be characterized by the wide geographical occurrence.
- The biomonitoring organism should be easy to identify even by a non-expert and it should be easily collected.

1. Concept

1- Objectives of biomonitoring

It is possible to distinguish different global objectives from biomonitoring studies:

- monitoring spatial and temporal distributions of the effects of pollutants;
- point source tracking;
- participation in health risk assessment studies;
- public information and decision support in public policies.

1. Concepts

2- Passive and active approaches (1)

Depending on the situation we are facing, we often use either a passive approach or an active approach.

Passive approaches
rely on indigenous organisms

Active approaches
rely on transplanted individuals from a reference site

- Transplantation
- Test chamber
- Test plant

In order to increase the performance of the diagnosis, the two approaches will be used simultaneously.

1. Concepts

2- Passive or active approaches (2)

Passive approach

+ accumulation levels generally above detection thresholds because of longer exposure time.
+ low risk of vandalism and unnecessary monitoring stations.
+ reduced cost of transportation and analysis.
-- possible lack of samples
-- False positives due to multiple stresses
-- Responses under the influence of other factors

or

Active approach

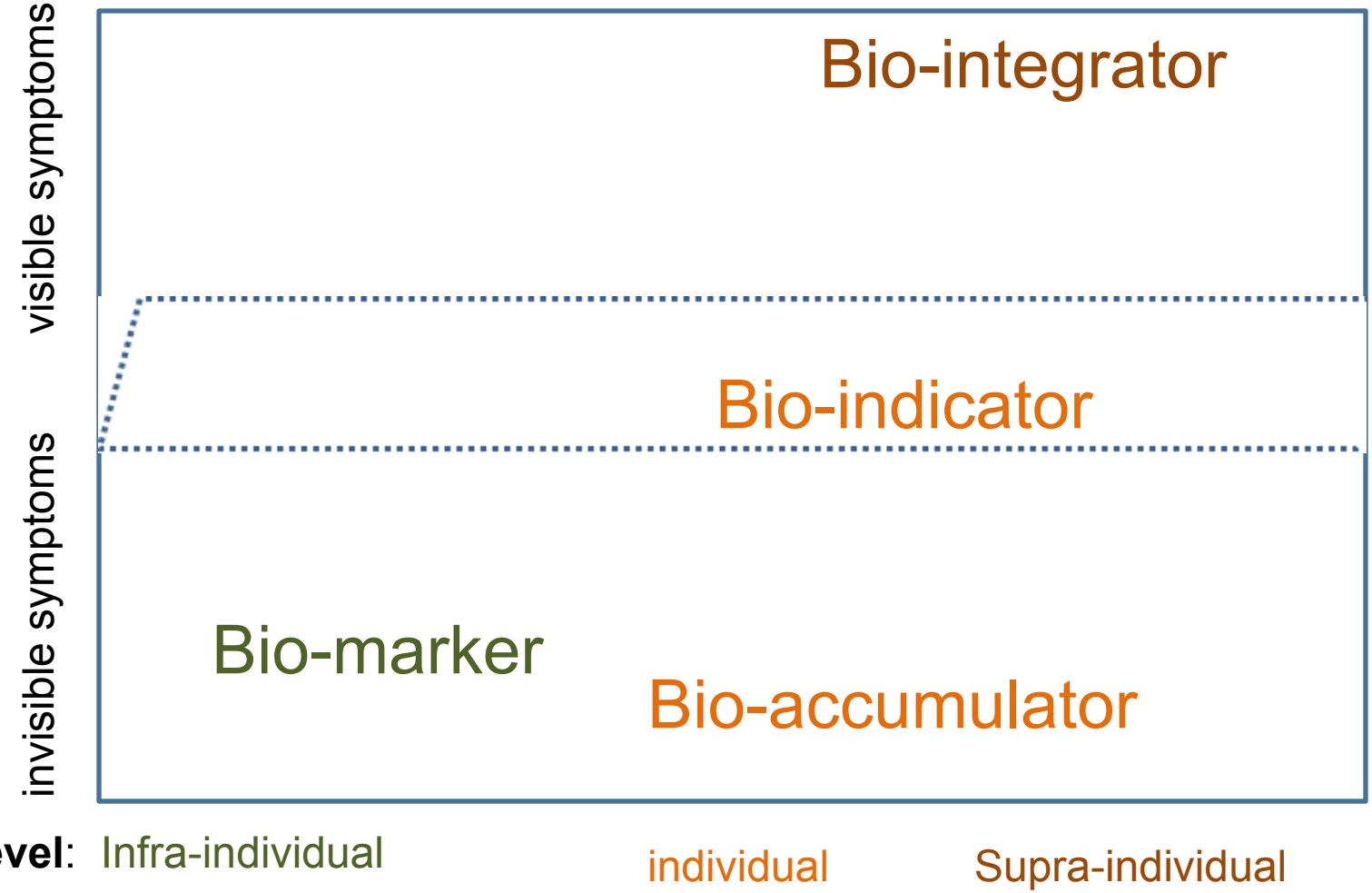
+ density of sites, locations and species, as desired
+ deposition rate calculated from the exposure time
+ use of organisms from an uncontaminated environment
+ concentration of pollutants directly related to pollution
-- undetectable concentrations and accumulation levels over a short period
-- possible risk of vandalism
-- additional costs for equipment, transportion and preparation and maintenance of transplants

1.Concepts

3- Effects of Air Pollution at various levels of organization

Spatial scale	Type of interaction
Molecular and cellular	Chemical and biochemical processes
Individual *(Bioindicator)*	Direct physiological response
Population *(Biointegrator)*	Change of population characteristics like productivity or mortality rates.
Community	Changes of community structure and competitive patterns.

1. Concepts



4-Levels of biological organization/ Legibility effects

II- Human Biomonitoring (HBM)

1- Concept of HBM

External dose

↓

Internal dose (*Chemical, Metabolites,Thioethers)*

↓

Early biological effect (*Mutagenicity, Protein adducts, DNA adducts, DNA excision products)*

↓

Altered structure fonction (*Chromosomal aberrations, Sister Chromatid exchange micronuclei, Gene mutations)*

↓

Clinical diseases

↓

Prognostic significance

II- Human Biomonitoring (HBM)

2- Uses and benefits of human biomonitoring

To improve exposure assessment & provide risk management strategies for environmental substances

- Identify priority chemicals and concentrations
- Determine who has levels associated with health effects
- Identify vulnerable groups
- Track trends in exposures to current and emerging chemicals
- Assess effectiveness of public health efforts
- Set priorities for research & policy action to reduce exposure

II- Human Biomonitoring (HBM)

3- Issues and limitations

- Lack of toxicological and epidemiological information to interpret the results
- Lack of meaningful reference levels
- Exposure biomarkers can be difficult to relate to possible health outcomes
- Effect biomarkers can be difficult to relate to exposure • Does not define sources or route of exposure
- No information about the source or history of exposure
- Snapshot of substances present in the body at a single point in time
- Or accumulation of exposure from many sources and routes over a period of time

III- Plants biomonitoring

1- Advantage of Using Plants in biomonitoring of Air Quality

Actually, the methods using plants for biomonitoring of air quality may turn out to be sucessful, as they are:

- simple,
- cheap,
- fast,
- and can supplement the classical physico-chemical methods.

III- Plants biomonitoring

2- The Mechanism of Monitoring Air Pollutants by Plants

The basic principle of monitoring air pollutants by plants is using the biological effect of them for air pollutants.

The damage symptoms of plants is related with:

- the types,
- concentration
- and contacting time of pollutants.

III- Plants biomonitoring

2- The Mechanism of Monitoring Air Pollutants by Plants

Symptoms of endangered plants by several kinds of harmful air pollutants.

Air Pollutants	Dammage mecanism
SO_2	Induce plasmolysis of spongy cells and palisade cells, then shrink or collapse, chlorophyll decomposition
Floride	Induce plasmolysis of mesophyll and cell
O_3	Destruct cell wall of palisade tissue and epidermal cells, oxidize glucose
Peroxyacyl - nitrates(PAN)	Induce leaves to shrink, loss water, and then be filled into the air
NO_2	Break cell
Chlorine and chloride	Destruct chlorophyll

III- Plants biomonitoring

3- Higher plants used in biomonitoring (1)

Class I: Very phytotoxic gaseous polluants (**HF, O3, SO2**)

Bio-indication (O3)

Active approach (Tobacco)

Passive approach (*Pinus sp)*

Bioaccumulation (O3) (Lolium perenne) Rye Grass

Class II: Dry or wet deposits of less phytotoxic pollutants: acidic and nitrogenous deposits **(NOx, NH3)**

Bioaccumulation

(Active or passive approach): Rye Grass

Class III: **Trace metals**

Bioaccumulation

Passive approach (needles, leaves, barks)

Active approach (Herbacious, Rye Grass)

Class IV: **Organic pollutants**

Bioaccumulation

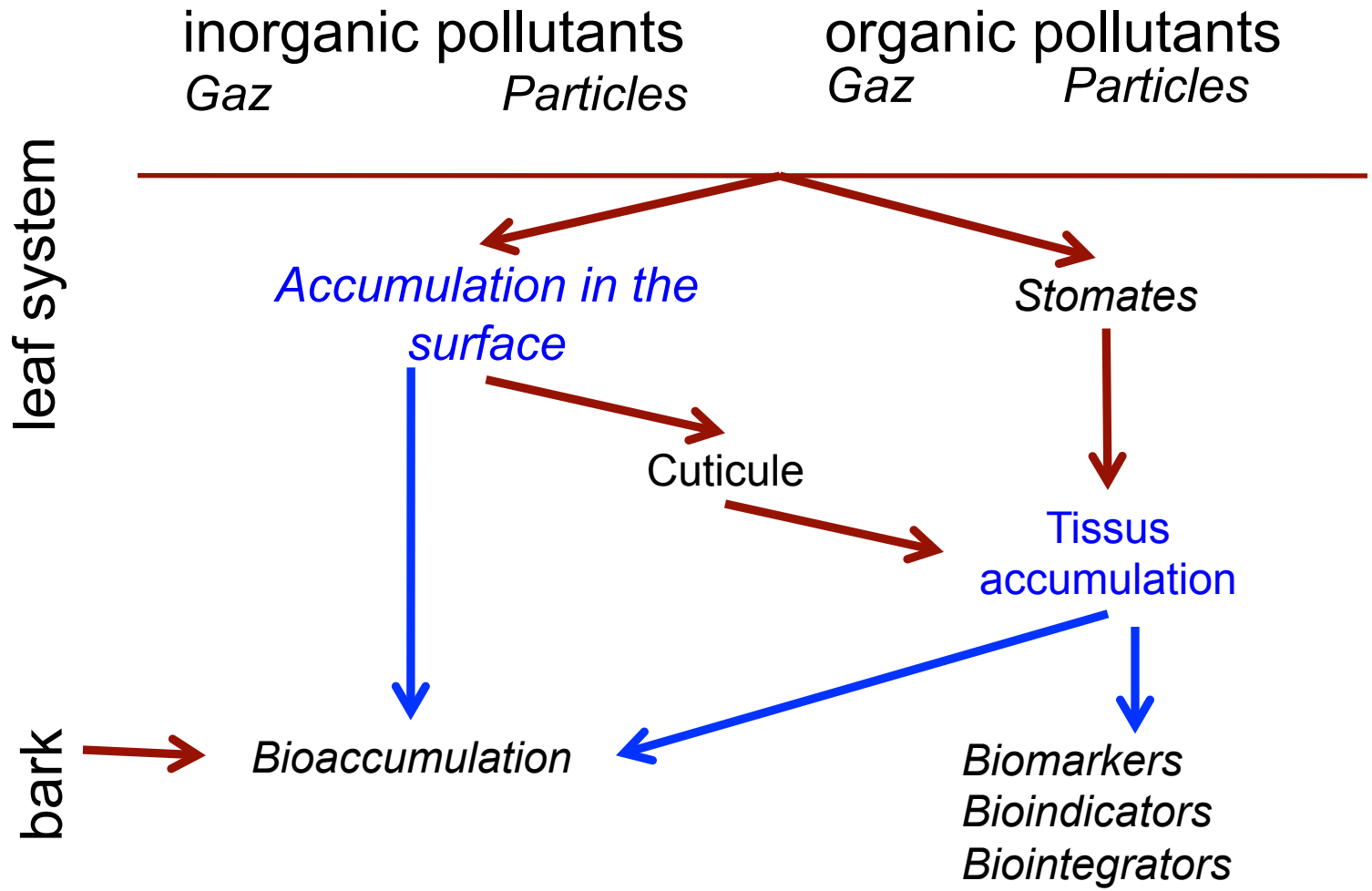
Active approach (cabbage, coniferous)

Passive approach (coniferous)

Bio-indication *Petunia hybrida*

III- Plants biomonitoring

3- Practical use of higher plants in Biomonitoring (2)



III- Plants biomonitoring

4- Mosses as biomonitors (1)

The uptake of pollutants by mosses takes place during precipitation and via atmospheric deposition, while uptake from soil (in the case of ground mosses) is negligible.

These biomonitors do not have an epidermis and, thus, pollutants easily penetrate their tissues.

Mosses are used as Bioaccumulator for (gaseous polluants (HF, O3, SO2), acidic and nitrogenous deposits (NOx, NH3), organic pollutants.

III- Plants biomonitoring

4- Mosses as Biomonitors (2)

Mosses as indicators have the following advantages:

- As they are ubiquitous, they are used for the assessment of AP in remote areas, such as the Antarctic, but also in heavily industrialized or urbanized ones.

- Mosses are easily transplanted from uncontaminated sites to polluted ones. In such cases, they are held in mesh bags and exposed to the contaminant.

✓The procedures, however, have not been standardized yet.

III- Plants biomonitoring

5- Lichens as biomonitors of AP (1)

Lichens are symbiotic organisms and similarly to mosses, do not have roots. So, they do not take up pollutants from the ground, but from the atmosphere only.

Lichen epiphytes are a well-established bioindicator of air pollution and the consequent effects on human health.

Several major initiatives have been designed to map lichens as proxies for air pollution.

III- Plants biomonitoring

5- Lichens as biomonitors of AP (2)

Lichens have been utilized to monitor air pollution in three different ways:

(i) to determine the concentration of specific pollutants accumulated in the thallus,

(ii) to use the effect of pollution sources on the life span and *presence or absence* of lichen species to map out the distribution and effect of pollution in a specific area,

(iii) and to take healthy lichens with little background pollutant accumulation and to transplant them into polluted areas to measure the accumulation of pollutants or the consequential degradation of the thallus.

III- Plants biomonitoring

5- Lichens as biomonitors of AP (3)

The index of atmospheric purity

IAP=∑ Fi

Quality levels of index of atmospheric purity (IAP)		
Level A	0≤ IAP ≤ 12.5	Very high level of pollution
Level B	12.5 < IAP ≤ 25	High level of pollution
Level C	25 < IAP ≤ 37.5	Moderate level of pollution
Level D	37.5 ≤ IAP ≤ 50	Low level of pollution
Level E	IAP > 50	Very low level of pollution

IV- Advantages and limits of biomonitoring

1- Advantages of biomonitoring

Contribution of biomonitoring in environmental education and as a decision aid in public policies.

Biomonitoring is an excellent teaching aid.

The visible foliar damage but also the observation of the lichenic communities have already been the object of many educational uses because they allow:

- visualize the presence and impact of pollutants;
- provide readily understandable information on levels of air pollution;
- to identify the risks posed by air pollution;
- to initiate broader educational actions on air pollution.

IV- limits of biomonitoring

2- Disadvantage of biomonitoring

- The main disadvantage of biomonitoring is the lack of similarity in the exposure of biomonitors and humans to a given pollutant.

- Another problem is that, in some cases, knowledge of the correlation between the concentration of pollutants in biomonitor samples and environmental concentrations or depositional fluxes are incomplete.

Conclusion

Physico-chemical techniques and Biomonitorin are complementary because the first technique monitors measure pollutant concentrations or deposition fluxes, whereas biomonitors reflect effects.

For our health, it's always good to know and to find more about air pollution monitoring and so, to take measures to prevent the disease.

But the most fundamental way for our health is that do everything to reduce emissions of pollutants.

Only in this way, environment will become cleaner, and our children will thrive under the blue sky and white clouds.