Bioindication And Biomonitoring Of Air Pollution

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Abstract: Nowadays, the knowledge about organisms reaction on environmental pollution or changes of climate conditions, which is closely connected, is very wide. Many articles and research have been made for last several dozen years. The analytical-chemical methods of pollution detection are usually expensive, labor intensive and their implementation is possible only "*ex situ*". Fortunately, sometimes simple observation of organisms, as plants, lichens or even animals is enough to indicate hazardous environmental changes. Plants are very good bioindicators. Scientists found that leaves of *Gladiolus sp*. are very sensitive to fluoride air pollution. Moreover, tobacco strongly reacts to tropospheric ozone, which is very dangerous to humans health. Not only plants can be used as biomonitors of air pollution, but also lichens (organisms which are a combination of fungi and algae). The specialized lichens species scale can provide information about SO_2 pollution level in the wide area. The aim of the article was to indicate natural methods of bioindication and biomonitoring of air pollution.

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Monitoring, Bioindication, Biomonitoring ….. Definitions

Environmental monitoring is a system of measurements, assessments and forecasts of the environment condition, the aim of which is to protect the environment and improve it. Bioindication methods of environmental monitoring utilize biological indicators - living organisms determining many features of their natural habitats (Hłuszyk and Stankiewicz, 1997).

According to Hłuszyk and Stankiewicz (1997) bioindication is an assessment of environmental conditions based on the presence or absence of certain organisms- bio-indicators (plants and animals), which are sensitive to toxic substances emitted to the environment.

However, this definition does not describe all the possibilities related to the environment and functions of bioindicators. Another definition (Zimny, 2006) shows the degree of relationships between biotic and abiotic elements of environment. Zimny claims that it is a method based on quantitative and qualitative characteristics of one object which determines the state of another object or the entire ecological system including biotic and abiotic parameters of its components, also the xenobiotics and anthropogenic influence. Each of these definitions determine the possibility of using organisms in environmental monitoring, thanks to their properties and distinctive qualities.

The best classification of bio-indicators reactions to environmental conditions was presented by Richling and Solon (2002). Five groups of bioindicators were distinguished:

– biomarkers - respond to biochemical factors without visible external changes;

– responsive indicators - their reaction is based on the appearance of damage dependent on the concentration of pollutants;

– accumulative indicators - are able to accumulate large amount of chemical compounds in their biomass;

– species scale - the modification in species composition determines the changes in the environment;

– landscape scale - shows changes in spatial systems and structures of ecosystems, for instant: the colour of leaves reflects the quality and intensity of environmental pollution.

Another important bio-indicators division, presented by Roo-Zielińska et al (2007) takes into account their usefulness for different spheres of monitoring:

– autoindicators - are used to assess changes in the indicator organism;

– pedoindicators - are used to assess soil conditions;

– hydroindicators - related to water habitats, they are divided into open water and groundwater indicators.

– thermoindicators - are used to assess climatic conditions;

– lithoindicators - are used to assess the establishment of physico-chemical properties of the lithosphere;

– chemoindicators – are used for determining the content of chemical compounds in the environment;

– sanoindicators – are used for assessment of natural and acquired health properties of ecosystems;

– indicators of the landscape – are used to assess the condition of the entire landscape.

Fluoride Air Pollution Bioindicators

Plants are particularly important bio-indicators of changes in the environment. They are very useful in the assessment of environmental pollution because of their distinctive, macroscopically visible symptoms appearing as a result of the occurrence of a particular pollutant in the air or its overabundance.. Another advantage is the specialization of the sensitivity of particular species of plants in relation to the substantial type of pollution.

Gladiola sp. are bio-indicators of fluoride air pollution. The leaves of *Gladiola sp.* are very sensitive to fluoride pollution, which is visible in distinguishing damage in leaves tissue. Specific changes can be observed on the on the leaves, namely: characteristic apical chlorosis - initially light green, then discolouring to pale yellow in color with rust stripes across the leaf (Hartmann et all, 1992). On the dicotyledonous plants leaves, fluoride pollution results in irregular chlorosis, which then turns into necrosis. Changes in leaf damage occurring from the edge of the leaves toward the main leaf nerve. In contrast, the needles of coniferous in the initial stage take a bright green color, and then from the top to the base of spreading reddish necrosis (Dmuchowski and Molski, 1975). Weinstein and Davison published a list of native plants species that may act as bio-indicators of fluoride air pollution in the United States, South America and Australia and New Zealand. Among them are: *Berberis repens*, *Pinus ponderosa*, *Acer negundo*, *Pinus strobus*, *Pinus sylvestris*, *Agave sisalana*, *Eucalyptus citriodora*, *Acacia fimbriata*, *Eucalyptus grandis*, *Rubus sqarrosus*, *Corymbia facifolia* and many others.

Tobacco vs. O_3

Tropospheric ozone is one of the secondary air pollutants and has strong oxidizing properties, affecting not only on the human body, but also on the plants. It can cause a general weakening of the plant and its homeostasis disorder, enhance the susceptibility to adverse climatic conditions, disease and pests, but also reduce the efficiency of photosynthesis and disturb the plant cell metabolism (Bell and Treshow, 2002; Godzik and Grodzińska, 2002). The first plant - the bioindicator of tropospheric O_3 pollution was *Nicotiana tabacum*. American farmers cultivating tobacco in Connecticut and Florida suffered in 1950 'very large losses because of the white spots that suddenly covered with leaves of plants. Some farmers began to cultivate tobacco under cover on the surface even 2 000 ha. Scientists have clearly diagnosed the cause of plant diseases, which was the increased of ozone concentration in the air. In such situation the scientist had started work at breeding ozone-immune tobacco. The results was obtainment of 3 tobacco variety: Bel-W3 - very sensitive, Bel-C - sensitive, Bel-B - the least sensitive to ozone [Kołodziejak-Nieckuła, 1998; Gebala, 1994).

Sulphur Dioxide Bioindication Methods

Commonly used method for assessing the SO_2 pollution "*in situ*" is to make lichen scale, based on the monitoring of epiphytic species of lichens. The concentration of SO_2 is strictly correlated with occurrence or absence of some species of lichens. Fałtynowicz (1995) and Kiszka (1990) has developed a special lichen scale associated with SO_2 concentration.

Table 1. The lichen scale of SO_2 pollution according to Fałtynowicz (1995) and Kiszka (1990)

Zone		Description	SO_2 concentration [$\mu g SO_2 \cdot m^{-3}$]
I	absolute lichen dessert	with particularly strongly polluted air (no arboreal lichens)	>170
II	conditional lichen dessert	very heavily polluted air (only most resistant to contamination crusty lichens)	170 - 100
III	internal weakened vegetation zone	The heavily polluted air (except for crusty species of lichens are also found squamulose lichens	100-70
IV	central weakened vegetation zone	an average air pollution (foliose lichens appear)	70-50
V	outer weakened vegetation zone	with relatively low air pollution (less sensitive fruticose lichens with usually small and deformed halli)	50-40
VI	internal zone of normal vegetation	foslightly polluted air, species from the zone V are typically cultured, additionaly more sensitive foliose and fruticose lichens occure	40-30
VII	normal vegetation zone	clean air or with little impurity, the only limiting factor is habitat conditions, very sensitive to pollution species of lichens	<30

Another method of lichens using in the evaluation of air pollution is the transplantation *Hypogymnia physodes* thallus from pure air areas, without source of emissions, to potentially polluted research area. The thallus is 3-6 months exposure, after which scientists observe microscopically and count degraded methyl blue stained algal cells (Marska, 1982).

Summary

In summary, there are plenty of methods and organisms which can be used in biomonitoring of environmental pollution, especially air pollution. The knowledge of plants reactions to some substances can be really useful in fast diagnosis of environment conditions. Furthermore, it can save yields of many crops and indicate a direct threat to humans health.

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