Bioindicator

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Caddisfly (order *Trichoptera*), a macroinvertebrate used as an indicator of water quality.

Biological indicators are species used to monitor the health of an environment or ecosystem. They are any biological species or group of species whose function, population, or status can be used to determine ecosystem or environmental integrity. An example of such a group are the copepods and other small water crustaceans present in many water bodies. Such organisms are monitored for changes (biochemical, physiological, or behavioural) that may indicate a problem within their ecosystem. Bioindicators can tell us about the cumulative effects of different pollutants in the ecosystem and about how long a problem may have been present, which physical and chemical testing cannot.[1]

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Description

A **biological monitor**, or **biomonitor**, is defined as an organism that provides quantitative information on the quality of the environment around it. Therefore, a good biomonitor will indicate the presence of the pollutant and also attempt to provide additional information about the amount and intensity of the exposure.

A **bioindicator** is an organism or biological response that reveals the presence of the pollutants by the occurrence of typical symptoms or measurable responses, and is therefore more qualitative. These organisms (or communities of organisms) deliver information on alterations in the environment or the quantity of environmental pollutants by changing in one of the following ways: physiologically, chemically or behaviourally. The information can be deduced through the study of:

1. their content of certain elements or compounds
2. their morphological or cellular structure
3. metabolic-biochemical processes
4. behaviour, or
5. population structure(s).

The importance and relevance of biomonitors, rather than man-made equipment, is justified by the statement: "There is no better indicator of the status of a species or a system than a species or system itself."[2]:74

The use of a biomonitor is described as biological monitoring (*abbr*. biomonitoring) and is the use of the properties of an organism to obtain information on certain aspects of the biosphere. Biomonitoring of air pollutants can be passive or active. Passive methods observe plants growing naturally within the area of interest. Active methods detect the presence of air pollutants by placing test plants of known response and genotype into the study area.

Bioaccumulative indicators are frequently regarded as biomonitors.

Depending on the organism selected and their use, there are several types of bioindicators.[3][4]

Plant indicators

Main article: Indicator plant

The presence or absence of certain plant or other vegetative life in an ecosystem can provide important clues about the health of the environment: environmental preservation.

There are several types of plant biomonitors, including mosses, lichens, tree bark, bark pockets, tree rings, leaves, and fungi.

- Lichens are organisms comprising both fungi and algae. (They are not *plants*.) Lichens are found on rocks and tree trunks, and they respond to environmental changes in forests, including changes in forest structure--conservation biology, air quality, and climate. The disappearance of

lichens in a forest may indicate environmental stresses, such as high levels of sulfur dioxide, sulfur-based pollutants, and nitrogen-oxides.
- The composition and total biomass of algal species in aquatic systems serves as an important metric for organic pollution and nutrient loading such as nitrogen and phosphorus.

There are genetically engineered organisms, that help us indicate toxicity levels in the environment; *e.g.*, a type of genetically engineered grass that grows a different colour if there are toxins in the soil.

Animal indicators, and toxins

An increase or decrease in an animal population may indicate damage to the ecosystem caused by pollution. For example, if pollution causes the depletion of important food sources, animal species dependent upon these food sources will also be reduced in number: population decline. Overpopulation, can be the result of opportunistic species growth. In addition to monitoring the size and number of certain species, other mechanisms of animal indication include monitoring the concentration of toxins in animal tissues, or monitoring the rate at which deformities arise in animal populations.

Microbial indicators and chemical pollutants

Microorganisms can be used as indicators of aquatic or terrestrial ecosystem health. Found in large quantities, microorganisms are easier to sample than other organisms. Some microorganisms will produce new proteins, called stress proteins, when exposed to contaminants like cadmium and benzene. These stress proteins can be used as an early warning system to detect high levels of pollution.

Microbial indicators in oil and gas exploration

Microbial Prospecting for Oil and Gas (MPOG) is often used in frontier basins to identify prospective areas for oil and gas occurrences. In many cases oil and gas is known to seep toward the surface as a hydrocarbon reservoir will usually leak or have leaked towards the surface through buoyancy forces overcoming sealing pressures. These hydrocarbons can alter the chemical and microbial occurrences found in the near surface soils or can be picked up directly. Techniques used for MPOG include DNA analysis, simple bug counts after culturing a soil sample in a hydrocarbon based medium or by looking at the consumption of hydrocarbon gases in a culture cell.[5]

Macroinvertebrate bioindicators

Macroinvertebrates are useful and convenient indicators of the ecological health of a waterbody or river.[6] They are almost always present, and are easy to sample and identify. The sensitivity of the range of macroinvertebrates found will enable an objective judgement of the ecological condition to be made.

In Australia, the SIGNAL method has been developed and is used by researchers and community Waterwatch groups to monitor water health.[4]

In the United States, the Environmental Protection Agency (EPA) has published *Rapid Bioassessment Protocols,* based on macroinvertebrates, as well as periphyton and fish. These protocols are used by many federal, state and local government agencies to design biosurveys for assessment of water quality.[7] Volunteer stream monitoring organizations around the U.S., working in cooperation with government agencies, typically use macroinvertebrate methods.[8] The species identification procedures are conducted in the field without the use of specialized equipment, and the techniques can be easily taught in volunteer training sessions.[9]

In South Africa, the Southern African Scoring System (SASS) method was developed as a rapid bioassessment technique, based on benthic macroinvertebrates, and is used for the assessment of water quality in Southern African rivers. The SASS aquatic biomonitoring tool has been refined over the past 30 years and is now on the fifth version (SASS5) which has been specifically modified in accordance with international standards, namely the ISO/IEC 17025 protocol.[10] The SASS5 method is used by the South African Department of Water Affairs as a standard method for River Health Assessment, which feeds the national River Health Programme and the national Rivers Database.