# Bioindicators – mechanism, uses, advantages and examples

**Introduction**

A bioindicator is a living organism that gives us an idea of the health of an ecosystem. Some organisms are very sensitive to pollution in their environment, so if pollutants are present, the organism may change its morphology, physiology or behaviour, or it could even die. One example of a group of bio-indicators are the copepods and other small water crustaceans that are present in many water bodies. Such organisms can be monitored for changes (biochemical, physiological, orbehavioural) that may indicate a problem within their ecosystem. Bio indicators 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. A **biological monitor**, or **biomonitor**, can be 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.

**What can be a bioindicator?**

Bioindicators can be plants, animals or microorganisms.

**How various bioindicators tell about the environmental health?**

1. If toxins are present, certain plants may not be able to grow in the area affected.

2. Monitoring population numbers of animals may indicate damage to the ecosystem in which they live.

3. Algae blooms are often used to indicate large increases of nitrates and phosphates in lakes and rivers.

4. If pollution causes the reduction of an important food source, the animals dependent on it for food may also decrease. Animals may also change their behaviour or physiology if a toxin is present.

5. The levels of certain liver enzymes in fish increase if they are exposed to pollutants in the water.

6. Changes in the functioning of the nervous systems of worms are used to measure levels of soil pollution.

7. The increase in the number of mutated frogs found in the USA is used as an indicator of toxins in their environment.

8. Microorganisms can also be used as indicators of toxins in an ecosystem. Some microorganisms will produce **stress proteins** if exposed to certain pollutants. By measuring the levels of stress proteins, we can get an idea of the level of pollution present in the environment.

**Types of bio-indicators**

**Plant indicators**

- 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 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 water pollution and nutrient loading such as nitrogen and phosphorus.

There are genetically engineered organisms that that can respond to 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

**Example - Lichens – The most well know bioindicator**

A lichen is a composite organism that arises from algae or cyanobacteria (or both) living among filaments of a fungus in a mutually beneficial relationship (symbiotoc relationship).The hardy lichens are useful bioindicators for air pollution, especially **sulfur dioxide pollution.**

**How are lichens able to act as bioindicators?**

1. Lichens live on surfaces such as trees or rocks or soil and are very sensitive to toxins in the air.

2. They have no roots, no cuticle, and **acquire all their nutrients from direct exposure to the atmosphere** rather than from the soil.

3. Their **high surface area to volume ratio** further encourages the interception and accumulation of contaminants from the air.

4. they are able to react to air pollutants all year round.

5. Compared with most physical/chemical monitors, they are **inexpensive** to use in evaluating air pollution.

**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, or their behaviour either directly in the field or in a lab.

**Frogs as bioindicators**

1. Most frogs require suitable habitat in both the terrestrial and aquatic environments, and have permeable skin that can easily absorb toxic chemicals.

2. These traits make frogs especially susceptible to environmental disturbances, and thus frogs are considered accurate indicators of environmental stress: the health of frogs is thought to be indicative of the health of the biosphere as a whole.

**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, calledstress proteins, when exposed to contaminants such as cadmium and benzene. These stress proteins can be used as an early warning system to detect changes in levels of pollution.

**Aquatic insects and other macroinvertebrates as indicator of water quality**

They are preferred bioindicator for measuring water quality because –

1. Aquatic macroinvertebrates are found in nearly every body of inland (non-marine) water, so they are **ubiquitous.**

2. They are easy to collect compared to a lot of other things like fishes.

3. They live in the water all the time and are reasonably long-lived. Pollution can and sometimes does occur steadily over time (imagine a wastewater treatment plant outfall or a paper mill dumping waste into a river). Sometimes, every trace of the pollutant has disappeared from the water by the time a researcher can collect a water sample from the stream. However, many of the insects were in the stream during the pollution event! This means that, even if you can no longer find the pollutant in the water, or never even knew a pollution event occurred, the organisms in the stream can show you that something is wrong.

**Bioindicators and biomonitors**

Bioindicators **qualitatively** assesses biotic responses to environmental stress (e.g., presence of the lichen indicates poor air quality) while biomonitors **quantitatively**determine a response (e.g., reductions in lichen chlorophyll content or diversity indicates the presence and severity of air pollution).

**Why Are Bioindicators Better Than Traditional Methods?**

1. Bioindicators add a temporal component corresponding to the life span or residence time of an organism in a particular system, allowing the **integration of current, past, or future environmental conditions**. In contrast, many chemical and physical measurements only characterize conditions at the time of sampling, increasing the probability of missing sporadic pulses of pollutants.

2. Bioindicators can indicate indirect biotic effects of pollutants when many physical or chemical measurements cannot.

3. Given the thousands of substances and factors to monitor, scientists now understand that the biota itself is the best predictor of how ecosystems respond to disturbance or the presence of a stressor.

4. In most cases they are **inexpensive** compared to chemical methods.