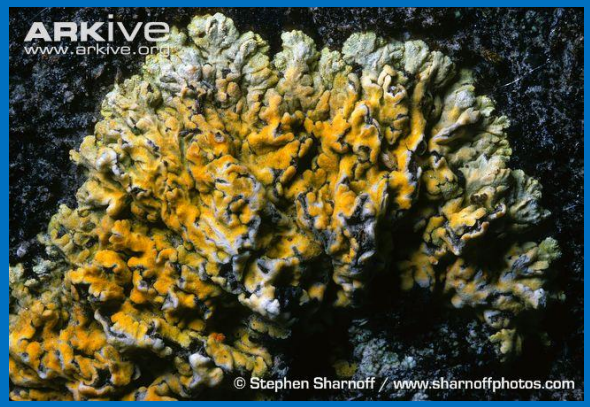
Indicator Species



- A species whose **presence**, **absence** or **abundance** reflects a specific environmental condition, habitat or community.

- Indicator species may:

  - Provide information on the overall health of an ecosystem.

  - Reflect a particular environmental condition, such as pollution.

  - Be indicative of a particular habitat type or biological community.

Why use indicator species?

- Indicator species can provide an early warning of environmental changes.

- They can be used to assess the health of an environment or ecosystem – they are often termed '**bioindicators**'.

- They can be a useful management tool.

How might indicator species show changes in the environment?

- Increase or decrease in abundance
- Presence or absence
- Change in behaviour
- Change physiologically or chemically

Note: Indicator species may be used **passively** or **actively**

CLASSIFICATION OF BIOINDICATORS

1) BASED ON THE AIM OF INDICATORS

- ***COMPLIANCE INDICATORS –*** For e.g. fish population attributes are measured at the population, community or ecosystem levels and are focussed on issues such as the sustainability of population.
- ***DIAGNOSTIC INDICATORS –*** They are used to measure on the individual or sub organism (biomarker)
- ***EARLY WARNING INDICATORS –*** They focuses on rapid and sensitive response to environmental changes.
- ***ACCUMULATION INDICATORS –*** They are distinguished for toxic effects bioindicator, with the effects being studied on different biological organisation level e.g. lichens , mussels etc.

2) BASED ON THE APPLICATIONS OF INDICATORS

- ***ENVIRONMENTAL INDICATORS –*** This is a species or group of species responding predictably to environmental disturbances or change (e.g. sentinels, detector, exploiters, accumulators, bioassa yorganisms). An environmental indicators system is an act set of indicators aiming at diagnosing the state of the environment for environmental policy making.
- ***ECOLOGICAL INDICATORS –*** This is a species that is known to be sensitive to pollution, habitat fragmentation or other stresses. The response of the indicator is representative for the community.
- ***BIODIVERSITY INDICATORS –***indicator for species richness of a community. However, the definition has been broadened to measurable parameter of biodiversity including e.g species richness, endemism, genetic parameter, population-specific parameter and landscape parameter

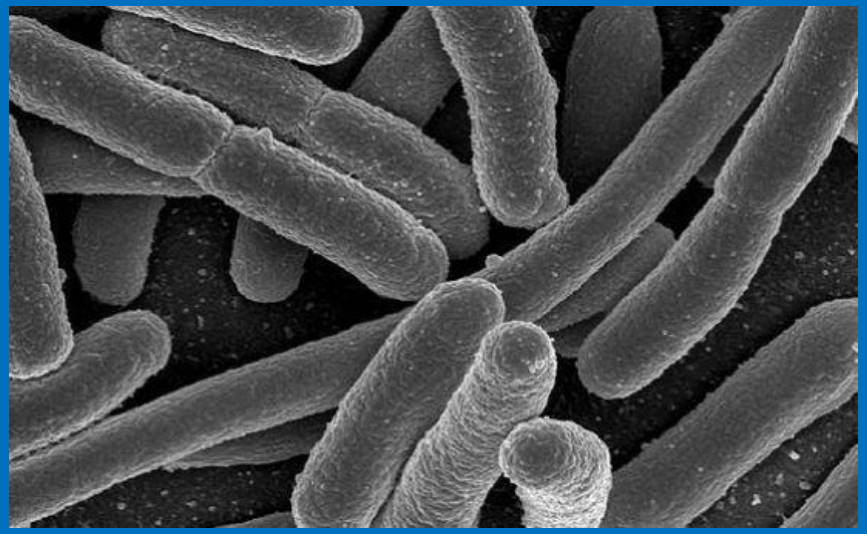
BASED ON IUBS BIOINDICATORS ARE GROUPED INTO :

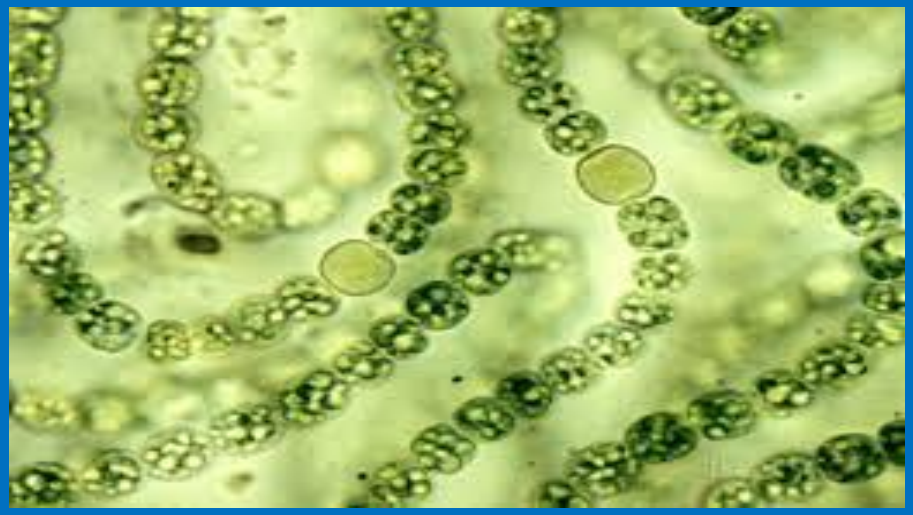
- Microbial system
- Plants system
- Animal system
- Cell biology and genetics system

MICROBIAL SYSTEM

- Microorganisms are diverse group of organisms found in large quantities and are easier to detect and sample.

- The presence of some microorganisms is well correlated with particular type of pollution and it serves as standard indicator of pollution.



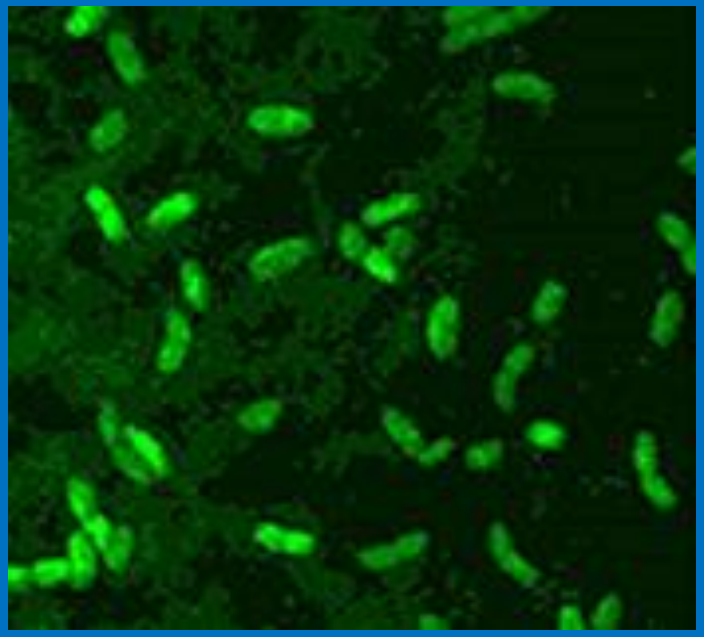


Some bio indicators indicating status of aquatic systems
Micro organism/bacteria Status

Micro organism/bacteria	Status of aquatic system
Escherichia coli	Faecal origin
Streptococcus faecalis	-do-
kliebsella	-do-
Clostridium perfringens	-do-
C.perfringens	-do-
Spirillium volutants pores	Industrial chemicals and toxic chemical wastes

Bioluminescent bacteria as bioindicators

- Bioluminescent bacteria: These are used to test water for environmental toxins
- If there are toxins present in the water, the cellular metabolism of bacteria is inhibited or disrupted
- This affects quality or amount of light emitted by bacteria
- It is very quick method and takes just 30 minutes to complete but could not identify the toxin



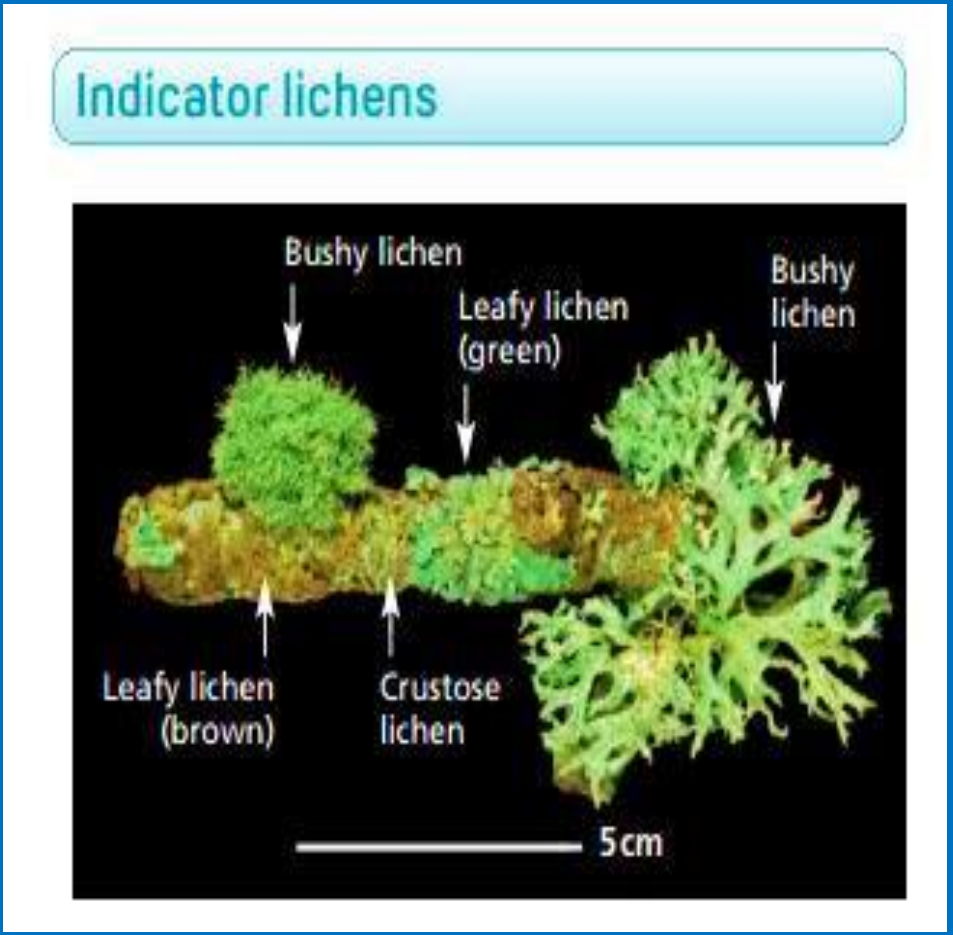
Vibrio fischeri

PLANTS SYSTEM

- The presence or absence of certain plant or other vegetative life in an ecosystem can provide important clues about the health of the environment. They can be from both higher and lower classes of Plantae
- Lower plants :Different plants indicate the nature of environment. The susceptibility of resistance towards a substance in the environment varies with species. For e.g lichens
- Higher plants :Various groups of higher plants serve as bioindicators. Sensitive species are employed to detect and monitor specific air pollutants. Studies on higher plants are more specified on its ability to indicate the heavy metal pollution in water.

LOWER PLANTS

- Lichens are alga and fungi living symbiotically (they have to live together to survive) Lichens can live in extreme conditions, but they hate pollution The cleaner the air the bigger and more elaborate the lichen. So by looking at the lichens growing in a certain area you can tell how bad the air pollution is



Air pollution - Lichens

- Lichens are formed from a symbiotic relationship between a fungus and an alga.
- They often grow on exposed rocks and trees, and need to be efficient at absorbing water.
- Air pollutants dissolved in rainwater, especially sulphur dioxide, can damage lichens and prevent them from growing.

low

high

Shrubby lichen

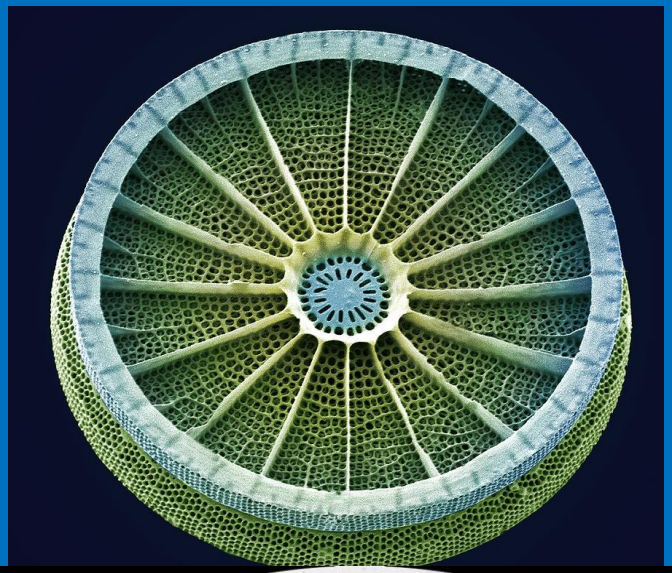
Leafy lichen

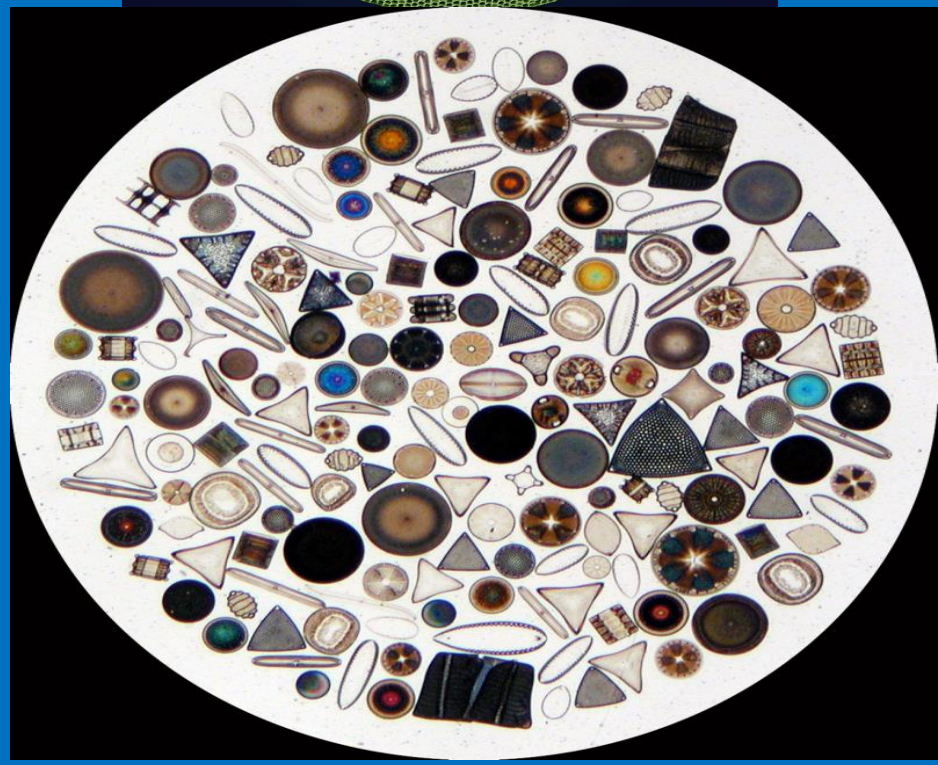
Crusty lichen

Air pollution - Lichens

- Different lichens show different levels of tolerance to pollution.
- Shrubby and bushy lichens are usually the most sensitive to pollution and are often absent from polluted areas.
- Crusty lichens are usually more tolerant of pollution and can grow in more polluted areas.
- By looking at the species present in a particular area, scientists can assess the level of air pollution.

- Changes in Diatom community , decrease in plankton algae and aquatic hydrophyte indicated increased water acidity . Specific changes in aquatic flora can indicate the pH of the fresh water correctly





HIGHER PLANTS

- The chlortic flakes of pine needle are good examples of ozone damages. The collapse, glazing and bronzing of leaf cells are products of damage by peroxyacetyl nitrate (PAN).
- *Caesalpinia pulcherrima* and grass (*Cyndon dactylon*) was evaluated as the bioindicators of heavy metals such as the Lead (Pb), Copper (Cu), Cadmium (Cd), Manganese (Mn), Zinc (Zn), Chromium (Cr) and Nickel (Ni)

- Abundance of *Eichhornia* indicates sewage and heavy metal pollution of water .
- *Equisetum* spp. Indicate the presence of gold in the soil.
- Annual weeds and short lived perennials like *Amaranthus, Chenopodium* and *Polygonum* etc. grow better in overgrazed areas. They are the indicators of overgrazing .

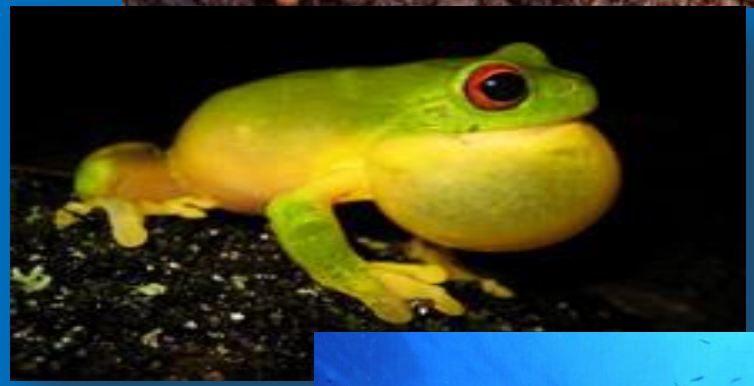
ANIMAL SYSTEM

- An increase or decrease in an animal population may indicate damage to ecosystem caused by pollution.

- 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 population.

- Earthworm density and biomass are strongly influence by contamination. Therefore the earth worm is used as bioindicator to determine acute toxicity.

- Frogs are considered accurate indicators of environmental stress and the health of biosphere as a whole.
- Fish is a good indicator of water pollution .



- Macro invertebrates are often used as bioindiacators because they are very sensitive to pollution, excess nutrients, increased turbidity, chlorine, etc.

Water pollution

Many aquatic animals can't survive in polluted water, so their presence / absence can indicate the level of pollution in a water body.

Types of water pollution can include:

- Nitrates (e.g. from fertilisers)
- Acid rain
- Heavy metals
- Pesticides
- Oil
- Other chemicals

Fish as a good pollution indication

Fish need oxygen to live in the water. Water pollution effects the oxygen level in the water. If the water is so polluted the oxygen levels will fall and fish will die. This is how fish are a good indicator or pollution.

Water pollution - Invertebrates

- Mayfly and stonefly larvae prefer clean water

- Freshwater shrimp can tolerate low levels of pollution

- The water louse can tolerate high levels of pollution

- Species such as the rat-tailed maggot and sludgeworm can tolerate very high levels of pollution

Clean water

Stone fly nymph

Mayfly nymph

Freshwater shrimp

Pond skater

Sludge worm

Rat-tailed maggot

Very polluted water

Water pollution - Invertebrates

- Mussels are suspension feeders and accumulate heavy metals and toxins in their tissues.
- Mussels are often used as indicator species for monitoring the health of coastal environments.
- There is a ‘Mussel Watch’ programme that runs in U.S. coastal and Great Lakes waters to assess chemical and biological contamination.

Water pollution - Amphibians

- Amphibians breathe through their skin so are easily affected by changes in water quality.
- For example, some chemicals may potentially cause physical abnormalities and malformations.
- Amphibians live both on land and in water.

Climate change – Montane species

Montane species (species which live in the mountains) can be good indicators of climate change, as they often have specific habitat requirements and cannot easily disperse elsewhere.

For example, the American pika is a good indicator of the effects of climate change, as it:

- Lives in a very specific habitat type
- Has a very low reproductive rate
- Shows very limited dispersal ability
- Is extremely sensitive to warm temperatures

Climate change – Montane species

- As temperatures rise, the American pika would be forced to seek higher elevations to find suitable cool, moist habitat.
- However, as this species already occupies high elevations, it has nowhere to go.
- Climate change may already be a factor in the extinction of local pika populations, and the range of the species is already moving uphill.

CELL BIOLOGY, GENETICS SYSTEM

- Cellular and sub-cellular components, including chromosomes, adapted to specific environmental conditions, form an excellent parameter for bioindicator.
- Many animals show behavioural responses following the detection of environmental changes in the functioning of endocrine, nervous, muscular, cardiovascular and excretory systems.
- Such changes may be investigated at morphological, biochemical or physiological levels and can indicate the presence of toxic substances

Criteria for selecting bioindicator

- **Sensitivity –** dose responsiveness to specific stressors .
- **Specificity –** responds to specific stressors
- **Broad Applicability –** over temporal and spatial scale .
- **Representativeness –** role as surrogate for other responses .
- **Cost –** reasonable for available resources and scope of study .

Bioindicator and biomonitoring

- 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)

- Chemical measurement of pollutant area is like snapshot of that that area while biological measurement is like taking video tape.

- Bioindicators actually indicate the general toxicity of the environment , without telling the exact quantity of the toxicity .

Why Are Bioindicators Better Than Traditional Methods?

- Scientists have traditionally conducted chemical assays and directly measured physical parameters of the environment (e.g., ambient temperature, salinity, nutrients, pollutants, available light and gas levels), whereas the use of bioindicators uses the biota to assess the cumulative impacts of both chemical pollutants and habitat alterations over time.
- Bioindicators have the ability to indicate indirect biotic effects of pollutants when many physical or chemical measurements cannot.
- Through bioindicators scientists need to observe only the single indicating species to check on the environment , they don't have to monitor whole community.

Summary

- Some organisms are very sensitive to changes in the environment and can be used to measure the impact of human activities.
- Indicator species can be useful in helping to assess different environmental conditions, such as pollution and climate change.
- Scientists, industrial companies and landowners may wish to use indicator species to monitor the health of a particular ecosystem.
- Care must be taken when choosing an indicator species to ensure that the results of a study accurately reflect the environmental conditions.