

# Standard IX

# Action Research Project

# Topic for 2023–2024

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## Bioindicators

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### Introduction

This year's topic is Bioindicators. Although bioindicators include all the plants, animals, microorganisms, and ecological processes that indicate the adversities of the environment, students may have to focus more on the ecological processes, where the biodiversity is deteriorated to such an extent that it is not sufficient to be assessed and hence the topic is challenging.

As indicated by the bioindicators, the rapid loss of biodiversity is alarming and the need of the hour is to conserve biodiversity. Why do we have to conserve biodiversity and bioindicators? Human beings have evolved after the evolution of all other organisms, which form the foundation of our evolution. Human activities are destroying this very foundation. Life, other than humans, is slowly diminishing and perishing. The next in line to perish is of us – the human beings. Because we can't trap the solar energy, carbon, and nitrogen. We can't produce the raw material to produce our packed food. We can't decompose and recycle nutrients. We can't be a link between the food chain. We only take from nature but don't give it back. We over-exploit and don't conserve. Take a moment to think... as far as nature is concerned, human beings are counterproductive to its sustainability.

Think, when biodiversity in some locality is restricted to rats, mosquitos, flies, and germs of dengue and malaria, what kind of environment these bioindicators indicate?

### Objectives

- To introduce the concept of bioindicators.
- To encourage students to monitor the environment, ecological processes, and biodiversity changes.
- To encourage students to find remedial measures to minimise the impact of human activities on environment, improve biodiversity and micro-ecosystems, and strengthen the food chain.
- To bring awareness in the society to live in harmony with the nature.
- Contribute in conserving bioindicators
- To develop vision to realize the importance of saving natural environment.

**Definition of Bioindicators:** Bioindicators are organisms or ecological phenomena that are used as indicators to assess the quality or condition of an ecosystem and how it changes over time.

Bioindicators include biological processes, species and communities.

**Passive and Active Bioindication:** Bioindication is active when the organism is deliberately introduced to some environmental condition, and it is passive when organisms are already present in the natural ecosystem.

### How is Bioindication Measured?

- The biotic conditions of a specific indicator species are measured within both the reference site and the study region over time. Data collected from the study region

are compared against similar data collected from the reference site in order to infer the relative environmental health.

- The environmental stressors induce cellular, physiological, behavioural changes in organisms leading to reduction in growth, development, reproduction, population, migration, and ultimately, extinction and loss of biodiversity.
- The use of bioindicators is not restricted to a single species with a limited environmental tolerance. Entire communities, encompassing a broad range of environmental tolerances, can serve as bioindicators and represent multiple sources of data to assess environmental condition in a “biotic index” or “multimetric” approach.
- Examples of environmental, ecological, and biodiversity indicators can be found in many different organisms inhabiting many different environments.

### Functions of Bioindicators

- To monitor the environment. (i.e., physical and/or chemical changes)
- To monitor ecological processes. (Energy flow, water cycle, nutrient cycle, community dynamics, etc.)
- To monitor biodiversity. (Changes of biodiversity in its various forms including structures, functions, genes, species, community, and ecosystem.)

### Importance of Bioindicators

**Environmental monitoring:** Help in monitoring the impact of human activities, pollution levels, and overall environmental health.

**Early warning signs:** Changes in bioindicators can serve as early warnings of environmental degradation or ecological imbalances.

**Conservation efforts:** Provide insights into the status of biodiversity, the effects of habitat

loss, and the success of conservation measures.

**Policy and decision-making:** Contribute to the development of effective environmental policies and management strategies.

### Applications of Bioindicators

**Pollution assessment:** Bioindicators can reveal biotic effects of pollutants when many physical or chemical measurements cannot. They help assess the presence and extent of pollution in air, water, and soil.

**Habitat evaluation:** Bioindicators can be used to evaluate the quality and suitability of habitats for different organisms.

**Ecological study:** They provide valuable data for studying ecological processes, biodiversity, and ecosystem dynamics – the changes in the characteristics of ecosystems and their population over time.

**Environmental impact assessments:** Through bioindicators, only a single indicating species is observed to evaluate the environment rather than monitor the whole community. Bioindicators aid in assessing the impact of human activities, such as industrial development on ecosystems.

### Traits of Good Bioindicators

- Provides a measurable response to exposure without perishing during exposure.
- Its response reflects the whole population / community / ecosystem response
- Its response is proportional to the severity of contamination.
- The species is abundant, widely distributed, and stable despite moderate climate and environmental variability.
- Its lifespan is long enough to compare different life stages.
- It is easy and inexpensive to sample and survey.
- It has a relevant role in the ecosystem such as role in the food chain, public interest, etc.

## Types of Bioindicators

Bioindicators are grouped into plant, animal, microbial, cellular, and genetic system indicators.

### Types of bioindicators based on the aim of bioindication:

1. **Compliance indicators:** They measure suitability of the environment for the population. The population characteristics of the compliance bioindicators are measured and are correlated to the characteristics of the environment.
2. **Diagnostic indicators:** They are used at organism level or sub-organism level (biomarker).
3. **Early warning indicators:** They focus on rapid and sensitive responses to environmental changes.
4. **Accumulation indicators:** They are distinguished for measuring toxicity in the environment like lichens and mussels.

### Types of bioindicators based on the applications of bioindicators:

1. **Environmental indicators:** These are species or a group of species responding predictably to environmental change. Ex. Detectors, accumulators, etc.
2. **Ecological indicators:** This is a species that is sensitive to pollution, habitat fragmentation, or other external stressors like loud noises, weather, crowds, temperature, pollution, crime, etc., which can lead to increased levels of discomfort, anxiety, and aggression.
3. **Biodiversity indicators:** Indicators of a species' richness in a community. The parameters are species' richness, genetic diversity, endemic species, population specific parameter, ecosystem diversity, and unique ecosystems.

### Types of bioindicators based on the function of bioindicator:

1. **Indicator species:** Species that are particularly sensitive to specific environmental conditions, and their presence, absence, or abundance can indicate the specific environmental condition. Ex. Environmental factors influence traits like weight, height, size, and color in species like birds, Mollusca, etc.
2. **Biomarkers:** Biomarkers are biological responses at cellular, molecular or physiological levels of biological organization (at the species, population, community, ecosystem, and biosphere levels.) that can provide direct evidence of exposure to environmental stressors and serve as early warning indicators of impaired organism health. Ex.1. Biomarkers in humans include pulse rate, blood pressure, basic chemistries, laboratory tests of tissues, etc. Ex.2. Chemical pesticides affect soil invertebrates in many ways, from directly killing them to reducing reproduction, growth, cellular function, and overall species diversity. Ex.3. Chemical exposure causes the local extinction, behavioural changes, loss of safe habitat, and population decline in several birds like Robins and Eagles. Ex.4. Ecological factors affect population of an organism. These factors include food or nutrient limitation, pollutants in the environment, extreme climates or catastrophic factors such as fires and hurricanes.
3. **Ecosystem processes:** Indicators that assess the functioning of ecological processes, such as primary production, respiration, energy, carbon and nutrient flow through food webs, reproduction, and decomposition rates, which can be influenced by environmental changes. Ex.1. Concretization causes damage to

the fertile layer of the earth, the topsoil, decrease in water absorption, decrease in primary producers, consumers, habitat destruction, etc and ultimately leading to reduction in biodiversity.

4. **Physical and chemical indicators:** Abiotic factors like water quality, air quality, soil characteristics, or temperature cause direct impact on the health of an ecosystem. Ex. A terrestrial ecosystem is considered physically polluted when it exhibits low rates of water infiltration, enhanced surface runoff, poor cohesion, low aeration, and root density.

### Role of Students in Saving Bioindicators

#### Documenting traditional knowledge:

Today, there is an urgent need to document all traditional knowledge before the traditional cultures are completely lost. Ex.1 The tribal people of Mizoram formerly forecasted the weather through applications of long-standing Traditional Ecological Knowledge. Ex.2 As observed by people, Animals like Elephants and Weaver ants (*Oecophylla smaragdina*) indicate rains. Animals like dog, cat, monkeys warn of dangers like presence of a predator, earthquake, storm, etc.

- **Raising awareness:** Ex. In school, community etc.
- **Participating in citizen science projects:** Ex. Data collection, monitoring, and research initiatives focused on bioindicators.
- **Supporting conservation efforts:** Ex. Contribute to conservation projects, participate in habitat restoration activities, and advocate for sustainable practices.
- **Promoting responsible behaviour:** Ex. Responsible waste management, sustainable resource use, conservation practices, habitat restoration, minimising concretization, developing microecosystems etc.

### What Students have to Do?

- Whatever subtopic you choose, stick to the main topic and see how the status of the bioindicator and that of the environment is correlated. Find remedial measures to minimise negative impact of human activities on the environmental factors.
- Implementation of remedial measures is important.
- Form a group of students, teachers, friends, parents, experts to assist you in completing your project.
- Select a locality around your residence, school, native place, etc. to study the impact of human activities on the environmental factors, organisms, ecological processes, or biodiversity.
- Make a survey of the area and collect data from the available resources.
- Identify the problem/work area.
- Correlate the status of the environment and bioindicator.
- Find and implement remedial measures for improving environmental factors.
- Analyse the proceedings to improve plan.
- Bring awareness in the locality to improve the environmental health.
- Write report.

### Some Examples of Bioindicators to Assess the Quality of the Following

#### Food/nutrition assessment:

- 1) Find correlation between healthy diet and health parameters like body composition, cholesterol levels, and blood pressure, healthy skin and hair, sleep and energy levels, regular bowel movements etc.
- 2) Indicators for malnutrition diagnosis: Weight loss, low body mass index (BMI), reduced muscle mass, reduced food intake or assimilation, disease burden/inflammation, occurrence of diet deficiency disorders etc.

**Air pollution assessment:**

- 1) Use of lichens from different areas for air pollution assessment.
- 2) Experiments to show that pH of leaf extract of roadside trees decreases with increase in road traffic density.

**Soil health assessment:**

- 1) Identification of key indicator species based on their relationship with specific nutrients, water levels, pH, and other soil properties that impact crop growth and productivity. Ex. Earthworm density is used to determine the soil toxicity which is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste.
- 2) Evaluation of existing methodologies used to monitor these indicator species and determining the most effective means of data collection and analysis.
- 3) Investigating how changes in soil quality affects the diversity and abundance of bioindicator species over time, and developing models to predict shifts in soil health conditions.
- 4) Developing guidelines for cultivators selecting appropriate bioindicator species to monitor soil health.
- 5) Assessing the economic benefits of using bioindicators as part of sustainable agriculture practices, including cost savings.
- 6) Study of annual weeds and short-lived perennials like Amaranthus and Polygonum as indicators of overgrazing
- 7) Survey to study the phosphorous deficiency crops and to implement measures to fix the phosphorus deficiency in soil and plants.

**Tree health assessment:**

- 1) Study of the species which are known to be associated with healthy, stressed or diseased tree species.

- 2) Effect of light pollution on the flowering and fruiting of trees.
- 3) Effect of various pollutions on the micro-ecosystem of the tree.

**School environment assessment:**

- 1) Study of air quality in various areas of the school premises.
- 2) Occurrence of pests and cleanliness status of the school premises.
- 3) Study of correlation between noise pollution and concentration of students.

**Society and urban ecosystem assessment:**

- 1) Effect of various environmental stress factors on animals like animal population dynamics, size, rate of deformities and disease occurrence, behavioural responses, biorhythm, sleep pattern, irritation, bioaccumulation, and biomagnification of pollutants etc.
- 2) Study of the effect of electromagnetic waves on human and birds.
- 3) Implementation of improving micro-ecosystems and/or biodiversity in the urban areas with measures like sustainable wet waste management, adding green spaces, increasing water seepage in ground, minimising concretization etc.
- 4) Effect of biological stressors on pets such as illness, disability, and injury.
- 5) Human activity impact on the local biodiversity and ecosystem.
- 6) Effects of noise, light, air, water, pollution on human and other organisms.
- 7) Study of impact on birds due to major threats like deforestation, the draining of wetlands, planting of non-native trees, the loss of open space etc.
- 8) Study of effects of occupational exposure to chemicals, dusts, radiation, and certain industrial processes.

**Water assessment:**

- 1) Water analysis and biodiversity in the water body.
- 2) Study of Eichhornia abundance indicating sewage and heavy metal pollution in water.
- 3) Survey of the groundwater indicators like Banyan tree, cluster fig, tamarind, etc., and to correlate it to the ground water details like depth, amount, quality, availability throughout year, vicinity to larger water bodies, etc.
- 4) Study of area-specific plants such as mangroves, grasses in swampy areas, cacti in dry areas, etc.
- 5) Study of termite infestation on plants or premises and corrective measures to reduce it.

**Agriculture health assessment:**

- 1) Study of presence of pest species and/or beneficial species on crops and determining crop health. Applying remedial measures like organic farming, cultivation of indigenous crops which are pest resistant, disease resistant, climate-smart, genetically diverse and sustainable, etc.

**Renewable energy consumption impact assessment:**

- 1) Study of impact of renewable energy sources / installations (such as wind or solar power) on local ecosystems and local wildlife populations.

**Conservation strategy assessment:**

- 1) Monitoring the health of endmangered species populations.
- 2) Monitoring the effectiveness of conservation efforts in protecting biodiversity.
- 3) Study of how and why the growing anthropogenic impact on nature and biodiversity decline can increase the

spreading of infectious diseases like monkeypox, COVID-19, AIDS, Ebola, Lyme disease, dengue fever, and Zika. Etc.

- 4) Study of role of alien species in biodiversity loss, species extinctions, causing risk to human health, food security, and livelihood. (Ex. Parthenium, eichhornia, water hyacinth.etc.)

**Health assessment:**

- Monitoring the impact of pollution or pesticides on health of humans and other organisms like bees. Ex. Bioaccumulation, biomagnification, longevity, physiological changes, diseases occurrence, abnormalities, etc.

**Climate change assessment:**

- Study of impact of different aspects of climate change on local biodiversity and local ecosystems.

**Marine ecology assessment:**

- Study of impact of various human activities on the marine biodiversity and mangroves.

**References:**

1. <https://www.google.com>
2. <https://en.wikipedia.org/wiki/Bioindicator>
3. <https://www.slideshare.net/chitranair16/bioindicators-ppt>

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