

Insects as bioindicator of environmental changes and pollution: Its monitoring and conservation

V Priya¹, Sunil Kumar Mandal¹, Vinod Kumar Dubey¹, Deepak Kumar Patel^{2*}, Shripati Dwivedi¹ and Alok Dube³

¹Dr Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar 848 125

²Bihar Agricultural University, Sabour (Bhagalpur), Bihar 813 210

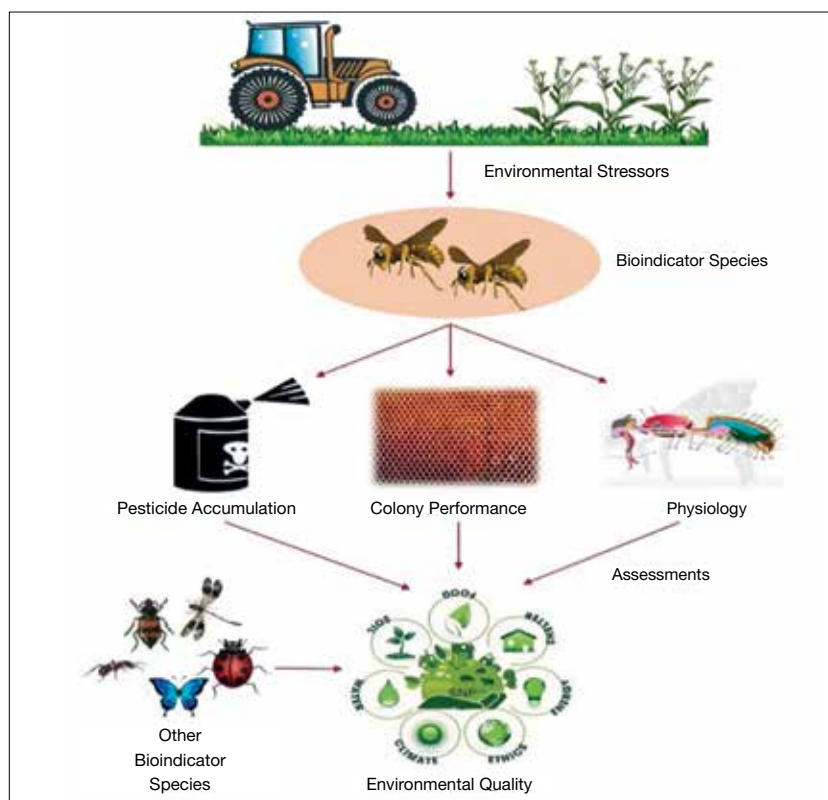
³ICAR-Indian Agricultural Research Institute, Pusa, New Delhi 110 012

A bioindicator is a living organism, such as an insect, a microbe, a plant, or an animal, used to monitor an ecosystem's health. In addition to being used to assess environmental health, environmental impacts of bio-geographic changes can also be assessed by them. As an indicator of the health of a biological system, each organic entity within it provides information about its surroundings, such as insects, which respond rapidly to environmental changes, are important biomarkers used to assess air, water, and soil quality, and as indicators of pollution. Environmental bioindicators can be obtained from many insect species, including several appropriate species for this group. As bioindicators and biomonitoring methods are becoming more popular, insects can be used to study the effects of external factors on ecosystems. These bioindicator insect species also aid in conserving the biodiversity of different species of flora and fauna and help the environment to keep them pollution free.

Keywords: Biodiversity, Bioindicators, Biomonitoring, Conservation, Environmental pollution, Insects

Biological indicators play an important role in assessing the environmental health and detecting changes in the environment, whether positive or negative, and their impacts on human society. A number of factors affect bioindicators, such as light transmission, water flow, temperature, and suspended solids. The use of bioindicators can provide information about the natural state of a region or how much contamination is there. The characteristics of a biosphere are basically defined by bio-organisms. It is these organisms that are termed bioindicators or biomonitors, both of which can vary greatly in their characteristics.

Bioindicators can be used to determine the quality of environmental changes taking place, while biomonitors provide quantitative information on the environment's quality. Biomonitoring also incorporates



Climate change indication by honey bee and other bioindicator

Table 1. Major characteristics of bioindicator species

Characteristic	Description
Easy handling	Most species require few efforts for their capture, except toxic species. The small size of samples helps in their capture and transport
Diversity of species and richness	There are four species of insects for every five animal species
Ecological faithfulness	Many species may have low tolerance to abiotic factors, which allows to link certain insect groups with certain habitats
Fragility to small changes	It allows the display of demographics or behaviour variables that can be measured or observed in the field that correlate closely with the preselected abiotics variables
Organism's response	Environmental change guilds to be identified

information regarding past aggravating factors and the impact of various factors. A variety of biological processes can be monitored with the objective of observing changes in health status over time and space, assessing the impact of specific environmental or anthropogenic stresses, and assisting in the viability of anthropogenic measures such as reclamation, remediation, and reintroduction. As part of the biological monitoring process, species diversity is used to determine the health of the environment. A loss of insects can negatively impact whole communities in an ecosystem, as they play a crucial role in many processes. As a result, it is crucial to understand how insects respond to human activity in order to support conservation policies and assess ecosystem functional consequences of human disturbances.

A bioindicator species approach to monitoring ecosystem

Wild habitats have a high degree of endemism, which contributes to the diversity and abundance of insect species. The effect of the environment on populations of generalist species, which form an important component of the food chain and are essential for pollination by plants. Many arthropod insects are used for bioindication because:

- Polyphagous predators (beetles and spiders) are the most frequently collected taxa, and are considered important biological controls.
- It is easy to collect data with a pitfall trap.
- Statistics can usually be

performed on catches that are large enough.

The environmental indicators consist of quantitative and qualitative parameters used to measure the environment's changes. They are used to investigate the complex dynamics of the environment by combining physical, biological, chemical, and human phenomena. A study of entomo fauna is conducted in order to determine how healthy ecosystems are, how productive they are, and how polluted and contaminated waters are. In order to transform and regulate ecosystems, it is crucial to identify bio-indicator species. A practical assessment of sustainability can be made by using bioindicators among these organisms to reflect their environment. Due to their diversity, indicator insects provide a means of assessing habitat differences on an acceptable fine scale and since the number of species they represent exceeds half. As environmental bioindicators, insect groups should have the characteristics presented in Table 1.

The characteristics of aquatic insect groups attributed to the use of bioindicators in land environments differ slightly from those of bioindicators in aquatic environments:

- Samples and identification of bioindicators are easy.
- They are highly sensitive to detecting early changes in their geographical area.
- Changes in the environment require quick responses.
- Every year, there are a few generations.
- Provide information about

the extent of environmental pollution or alteration without interruption.

Insects as bioindicators in different type of polluted ecosystems

Water pollution: Bioindicators of the aquatic environment can be derived from a variety of aquatic insects as mentioned in Table 2. It has been shown that odonata species (dragonflies) are highly sensitive to habitat changes, especially lakes and flooded drainage areas. It is stated that aquatic insects can serve as indicators of water quality.

The tolerance to metals of aquatic organisms is attributed to the formation of metallothionein (MTs) by many species. This organism may be able to provide clues about its tolerance to metals if MT levels are a measure of metal tolerance, or possibly about toxic agents that contribute to environmental stress. Hylobates species, however, are suitable for bioindicating cadmium and mercury pollution. They can also work as metals pollution bioindicators, although they are less commonly used.

Soil pollution: The presence of land insects is a good bioindicator of various kinds of environmental change (Table 2). About 20% of arthropod diversity are coleopterans, which contribute to soil quality, population regulation of other invertebrates, energy flow, and soil structure which confirms the high potential of beetle species (Coleoptera: Scarabidae) as environmental indicators.

The carabid beetle (Coleoptera: Carabidae) is an important predator that monitors pollution caused by oil, sulphur, herbicides, CO₂, insecticides, and radioactive phosphorus. Within urban areas and in proximity to industrial areas, some lepidopteron groups are used to measure carbon dioxide concentrations and heavy metal pollution levels. A study was conducted on pupae of different geometridae and noctuidae species i.e., *Coenonympha pamphilus* to confirm the effects of copper, iron, nickel, cadmium, and sulphuric acid used in fertilizers. An ant's ability to

Table 2. Insect bioindicators from aquatic and terrestrial environments and their role in monitoring

Order/Family	Common names	Biomonitoring	Habitat
Odonata	Dragonflies, Damselflies	Water quality	Aquatic
Gyrinidae, Hydrophilidae, Notonectidae, Dytiscidae, Vellidae	Predaceous diving beetles, Backswimmers, whirligig beetles	Due to high adaptive capacity	Aquatic
Ephemeroptera, Plecoptera	Mayflies, Stoneflies	Due to high adaptive capacity	Aquatic
Halobates	Ocean-Skaters	Cadmium and lead	Aquatic
Coleoptera (Scarabaeidae)	Beetles	Forest and agricultural crops	Land
Coleoptera (Carabidae)	Beetles	Biological control, oil, sulphur, herbicide, CO ₂ , insecticides pollution	Land
Lepidoptera	Moths, Butterflies	Heavy metals, CO ₂ pollution, and environmental changes	Land
Collembola	Spring tails	Heavy metal pollution, pesticide pollution, and acidification of water	Land
Formicidae	Ants	Degraded and reforested areas recovery	Land
Diptera (Sarcophagidae)	Flies, Mosquitoes	Heavy metals	Land
Diptera (Syrphidae)	Flies, Mosquitoes	Affected by diversity reduction	Land
<i>Apis mellifera</i>	Domestic bees	Chemical environmental changes	Land

detect soil quality is used as a bio-indicator. Several ecosystems can use it as an environmental indicator due to its high sensitivity to human impact. The ants presented a strong resistance to pollutants (Radioactive and Industrial Pollutants) that may be because only about 10% of individuals fall outside, the rest are exposed to the harmful pollution effect. Some ant groups, *Myrmica* spp. and *Temnothorax* spp. have potential as biological indicators of soil conditions, crop management and assessment systems for plantations in agro-ecosystems.

Due to the lack of ecological knowledge about many groups of flies, Diptera can be used as bio-indicators only under certain conditions. In spite of this, certain fly, *Chrysoma megacephala* and *Musca domestica* species can be considered good biomarkers of environmental change. Several metals, asbestos fibres, and waste chemicals can be detected by sarcophagidae as environmental pollution indicators. Insecticide and herbicide sensitivity can vary widely among different species of flies. Some flies' species

should be treated with caution when used as chemical indicators for soil contamination.

Insect bioindicators in agriculture and forestry

Plant species on cultivated or reforested lands have been shown to be highly diverse in terms of insect species. Additionally, such species have demonstrated greater ecological stability due to intense competition for resources, which prevents a few dominant species from dominating an ecosystem.

Agricultural ecosystems: Changing microclimates, foraging activity, and resting locations, agrochemical use, and interaction with other species all affect food availability. Agricultural lands are predominantly monocultures. An unbalanced environment is reflected in the high number of defoliators and sucking insects in these areas. Biodiversity is reduced in simple agricultural systems because fertilizers and chemicals destroy many insects that are biological control agents. It is common to find Hymenoptera communities

in agricultural areas. Pollination of crops and wild plants is carried out by them. Moreover, many insects in society act as biological control agents by serving as predators or parasitoids.

It is essential to adopt environmentally friendly practices in agricultural areas. Depth control can lead to layer destruction, where decomposers (Collembola and Coleoptera) are active. It is possible to increase insect diversity by increasing the conditions for bacterial growth and decomposition through the rational application of soil correction, fertilization, and crop residue incorporation.

Forest ecosystems: In order to maintain ecological balance, native vegetation, which has a high insect diversity hormonally, is replaced by homogeneous plantations, which have low insect diversity and fragile ecological balance. The result is a prevalence of harmful insect species, with frequent population explosions, especially defoliator Lepidopteron. It is common for reforestation to be carried out in soil that is deficient in nutrients and to be located in water-stressed areas that are highly susceptible to insects' attacks during certain times of year. It is possible that aggressive and dominant insects will flourish during this period.

Insects as bio-indicator of environmental pollution

A variety of insects can be used to detect pollution in the environment as bioindicators (Table 3). Several pollutant concentrations have been measured by ants in forests and disturbed ecosystems have been monitored using ants. There are multiple advantages of using bees as bioindicators, including their versatility and efficiency. Their uses include monitoring trace metals in urban environments, radioactivity following the Chernobyl disaster, pesticides and herbicides, and industrial wastes. The Gerridae are suitable for the detection of different types of iron and manganese, but some bees are able to accumulate nickel and lead. Social wasps and the genus *Polistes* are among the

top predators in the food chain, so they are exposed to bio hazardous conditions.

Other insects (Termite and Aphids) as bioindicator of environmental pollution

Termites are important decomposers in land ecosystem as a result of its activity, soils become more water-retentive and a greater amount of soil productivity occurs. They are involved in the decomposition and incorporation of organic soil materials in forest ecosystems. They are not always noticed in agricultural ecosystems, pastures, and reforestation areas since they nest underground and they are only detected by the plant damage they cause. Aphids are pollution indicators when they feed on hosts exposed to high levels of carbon dioxide, since they show an increase in population density in these environments.

SUMMARY

For environmental monitoring, bioindicators are essential. In order

Table 3. Insects used as environmental pollution bioindicators

Insect	Biomonitoring	References
Bees	Trace metals, radioactivity, pesticides, herbicides and industrial pollutions	Chowdhury <i>et al.</i> 2023
Ants	Pollutant concentration at Australia	
Larvae (Chironomidae)	Iron and manganese concentration	
Genus Polistes (Wasp)	Lead pollution	

to be considered a bio-indicator, it must have certain characteristics like richness, diversity, species, and ease of handling, ecological faithfulness, fragility, and a good response to minor environmental changes. Insects have all of them. However, according to the environment, some species are more able to adapt to these changes than others.

Changes in water environments affect odonata species more strongly. Ephemeroptera, heteroptera, plecoptera, and coleoptera have a high degree of adaptability.

Several species of Coleoptera are bioindicators. e.g., beetle (Scarabidae) in forest and agricultural cultures. There are

some insects in the Diptera and Lepidoptera groups that serve as indicators for heavy metal pollution.

Trace metals (radioactivity, pesticides, and herbicides) are monitored by bees in urban environments. Using carridae, different levels of iron and manganese can be detected. In conclusion, this article found that insects have many potential representatives for environmental bioindicators, such as Coleopterans, Dipterans, Lepidopterans, Hymenopterans, Hemipteran, and Isopterans.

*Corresponding author email:
dkpbhu9915@gmail.com

HANDBOOK OF INTEGRATED PEST MANAGEMENT

To reverse the loss of environmental resources and also to reduce biodiversity loss, the Government of India has Integrated Pest Management (IPM) as part of the National Agricultural Policy. Integrated Pest Management emphasizes the growth of a health crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. IPM is not new – mechanical, cultural and biological tactics were used by farmers for hundreds of years before chemical pesticides became available. Besides, there are IPM techniques that have been developed more recently and are effective in suppressing pests without adversely affecting the environment.

The task of spreading the message of IPM across is tough due to poor awareness about the subject among people in line-departments as also among the farmers. The information on integrated pest management as a whole is scattered. This *Handbook* comprehensively deals with all the aspects of integrated pest management in field crops, horticultural crops under traditional,



protected systems. Information on basic strategies and tactics of different methods of management including mass production of biocontrol agents, IPM policy and pesticide registration is provided in comprehensive form.

The *Handbook of Integrated Pest Management* comprises 82 chapters which are well written in lucid language with crispy sentences by the renowned scientists. The role of IPM is elucidated with different pests like *Trichogramma*, *Bacillus thuringiensis*, *Nomuraea rileyi* etc. and agricultural crops like rice, wheat, maize, sorghum, pearl millet, pulses, soybean, rapeseed mustard, groundnut, minor-oilseed crops, sugarcane, cotton, jute and mesta, potato, vegetable crops, fruits, grapes, citrus, banana, pomegranate, coconut etc. This *Handbook* will provide information of available useful technologies to educate on how to reduce or judiciously use chemical pesticides, safeguard ourselves from chronic poisoning, save the National environment while also reducing input costs and raise farmers' income. This compilation will be useful to teachers, students, trainers, line-department personnel and policy makers.

TECHNICAL SPECIFICATIONS

No. of pages : i-x + 768 • Price : ₹ 1500 • Postage : ₹ 100 • ISBN No. : 978-81-7164-179-6

For obtaining copies, please contact:

Business Unit

Directorate of Knowledge Management in Agriculture
Indian Council of Agricultural Research
Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012

Tel : 011-25843657, Fax 91-11-25841282; e-mail : bmicar@gmail.com

SCAN QR Code to
Purchase Online

