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Bioindicators as The Natural Indicator of Ecosystem Health: A Review

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ABSTRACT

Bioindicator are living organisms that give 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 behavior, or it could even die. Phytoplanktons, zooplanktons, mosses, lichens, tree bark, tree rings, leaves, benthic macroinvertebrates, frogs, toads, fishes, microbes, etc., act as bioindicator. Bioindicators are utilized to screen the quality of the natural ecosystem. They are used for assessing environmental health and biogeographic changes taking place in the environment. Lichens are sensitive to air or industrial pollution. Phytoplankton and zooplankton retort rapidly to any alterations in nutrient changes in water bodies indicating the growing nutrient pollution. Benthic macroinvertebrates and fishes are sensitive to water pollution. Microbes are often used to identify prospective areas for oil and gas occurrences.

Keywords: *Bioindicators, Phytoplanktons, Zooplanktons, Benthic macro invertebrates.*

INTRODUCTION

Bioindicators include biological processes, species, and communities and are used to assess the quality of the environment. Variations in the ecosystem are often related to anthropogenic disturbances (*e.g.*, pollution, deforestation) or natural stressors (*e.g.*, drought, late spring freeze), although anthropogenic disturbances are the primary focus of bioindicator research. Some organisms are very sensitive to pollution in their environment (Rosenberg and Resh, 1993). So, if pollutants are present, the organism may change its morphology, physiology or behavior, or it could even die. This situation will generate loss in biodiversity which disrupt aquatic food chains and food webs leading to the disturbance of the ecosystem and will originate many harmful causes to thousands of living beings including, animals, human beings and birds in environment (Islam and Sinha, 2012).

Bioindicator species effectively indicate the condition of the environment because of their moderate tolerance to environmental variability. The use of bioindicators, however, is not just 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. There are a certain factors which govern the presence of Bioindicators in environment such as transmission of light, water, temperature, and suspended solids. Through the application of Bioindicators we can predict the natural state of a certain region or the level/degree of contamination (Khatri and Tyagi, 2015).

Based on the studies of many ecologists, a species should exhibit a broad set of characteristics to be considered as good bioindicators. (i) Species or combination of species provides measurable response and the response rapidly reflects the whole population/community/ecosystem response, when the situation is even repairable. (ii)

Taxonomically well documented, relatively stable despite moderate climatic and environmental variability and, life history well understood. (iii) Easy and cheap to survey and can be reliably identified, using routine laboratory equipment.

Bioindicator may be classified in to three categories (a) Plant indicator (b) Animal indicator and (c) Microbial indicator. Plants are used as very sensitive tools for prediction and recognition of environmental stresses. The presence or absence of some specific plants or other vegetation provides ample information about the health of environment. Phytoplanktons, diatoms, algae, lichen, bryophytes etc. are used as plant indicators. The change in animal populations may be a result of the relationship between populations and food sources. Animal indicators help in detecting the amount of toxins present in the tissues of animals (Khatri and Tyagi, 2015). Benthic macroinvertebrates, mollusks, frogs, toads, fishes *etc.* used as animal indicators. Microbes are often used to identify prospective areas for oil and gas occurrences.

MATERIALS AND METHODS

This is a review paper based on the results of many previous research works in the fields of air and water pollution taking aquatic plants and animals. The paper summarizes the state of knowledge of the different topics.

RESULTS AND DISCUSSION

Bioindicators need not only to indicate the long-term interaction of several environmental conditions, but also react to a sudden change of the important factor(s). There are several alternations for indicators of biomonitoring in lake, pound, streams, rivers, and sea however benthic macro invertebrates, periphytons and fishes are the most frequently utilized. The natural change, taxa are utilized to show the impacts of natural surrounding changes, or environmental change. They are used to detect changes in natural surroundings as well as to indicate negative or positive impacts. They can also detect changes in the environment due to the presence of pollutants which can affect the biodiversity of the environment, as well as species present in it. The condition of the environment is effectively monitored by the use of bioindicator species due to their resistance to ecological variability (Table 1). Roy and Gupta (2010) utilized molluscs *viz*., gastropoda and bivalvia to determine the pollution level in river Barak and its tributaries. A total of 16 (sixteen) taxa were recorded in the twelve sampling sites during the period of study. The molluscan community was represented by two classes, *viz.*, Gastropoda and Bivalvia. Among the gastropod species, *Brotia costula* (Rafinesque, 1833) episcopalis (Lea) was the most ubiquitous. The bivalve fauna was less rich with 3 species only. Of these, *Lamellidens marginalis* (Lamark, 1819) was the most common. Islam and Sinha (2012) used benthic macro invertebrates to detect water quality of Burhi Gandak river: North Bihar. In this biological assessment, the diversity, density and distribution of benthic macro invertebrates at family level were used for identifying pollution level. Benthic macro invertebrates are reliable indicators because they spend all or most of their lives in water, are easy to collect and differ in their tolerance to pollution. In this study, out of identified 42 families of benthic macro invertebrates; 6 families in phylum mollusca, 5 families in phylum annelida, and 31 families in phylum arthropoda were recorded in 4 locations including 16 sampling sites on the bank of Burhi Gandak river (Table 2). The

abundance and composition of benthic macro invertebrates were found low. The most dominant and pollution tolerant taxonomic group was mollusca with 60.55%, Diptera (Chironomidae) with 11.90% while pollution sensitive benthos ephemeroptera with only 7.31% of abundance were found which shows not acceptable quality of river water (Islam and Sinha, 2012). Only 47.17% of total benthic macro invertebrates in the winter season while 52.83% of total benthic macro invertebrates in the summer season were calculated. The result was probably due to the lowest volume and the highest temperature of water body during summer season (Islam and Sinha, 2012). Zooplanktons are microscopic animals living near to the surface of the water body. They are poor swimmers, instead relying on tides and currents as a transport mechanism. They feed upon phytoplanktons and detritus and provide a vital food source for fish. They also play an important role as bioindicators and help to evaluate the level of water pollution. Khalifa *et al*., (2015) showed that the zooplanktons' density was the highest in the rainy season, while it reduced in summers due to high temperatures. Copepods form the dominant group of all the zooplanktons, followed by Cladocera, rotifer, and Ostrocoda. Phytoplanktons have been used for successful observation of water contamination and are a useful indicator of water quality (Singh *et al*., 2013). *Euglena gracilis* is a motile, freshwater, photosynthetic flagellate. Although Euglena is rather tolerant to acidity, it responds rapidly and sensitively to environmental stresses such as heavy metals or inorganic and organic compounds. Cynophyta, a type of phytoplankton, is one particularly powerful bioindicator which is known to indicate rapid eutrophication of water bodies such as reservoirs, lakes, *etc*. via the creation of bloom formations (Thakur *et al*., 2013). *Wolffia globosa* is an important tool for showing cadmium sensitivity and also used for indicating cadmium contamination. Phytoplankton absorb nutrients from water for use in growth, and remove ammonia nitrogen from water, which is particularly important in lessening concentrations of this potentially toxic metabolite. Kshirsagar (2013) utilized algae as a bioindicator to determine water quality of river Mula from Pune City. Authman *et al*., (2015) used fish as bioindicator for the effects of heavy metals (Al, Cd, As, Cr, Cu, Fe, Pb, Hg, Ni) pollution. The presence or absence of certain plant or other vegetative life in an ecosystem can provide important clues about the health of the environment. Lichens and bryophytes (liverworts) are frequently used to monitor air contamination. Both, lichens and bryophytes are powerful bioindicators of air quality on the grounds that they have no roots, no fingernail skin, and acquire all their supplements from immediate introduction to the climate (Dudani *et al.*, 2015). Environmental stress can be indicated by the disappearance of lichen in forests, as caused by changes such as increases in the level of sulfur dioxide (SO_2), pollutants of sulfur and nitrogen (N_2) (Khatri and Tyagi, 2015). Zooplanktons like *Alona guttata*, *Mesocyclops edax*, *Cyclops*, *Aheyella* are zone-based indicators of pollution (Hosmani, 2014). Amphibians, particularly anurans (frogs and toads), are increasingly used as bioindicators of contaminant accumulation in pollution studies. Anurans absorb toxic chemicals through their skin and their larval gill membranes and are sensitive to alterations in their environment. They have a poor ability to detoxify pesticides that are absorbed, inhaled, or ingested by eating contaminated food. Frogs are basically influenced by changes that take place in their freshwater and terrestrial habitats. Microorganisms have a rapid rate of growth, and react to even low levels of contaminants and other physicochemical and biological changes. From a research perspective they give important signs of environmental change (Hosmani, 2014).

Table 1
Types of Plants and its indications

Names of Plants		Indications	References
Phytoplanktons	Charophytes	Quality of water	Uttah *et al.*, 2008
	Selanastrum	Water pollution	Uttah *et al.*, 2008
	Wolffia globosa	Contamination of cadmium	Uttah *et al.*, 2008
Algae		Generally enrichment area	Kshirsagar, 2013
Euglena gracilis		Organic pollution in lakes	Hosmani, 2014
Lichen		Sensitive to air pollution	Dudani *et al.*, 2015
Bryophyta		Pollution by a ccumulation of metals, nutrient enrichment area	Whitton, 2013
Trees bark *(Cassia fistula*)		accumulation of air contamination from road traffic	Janta and Chantara, 2017

Table 2
Types of Animals and its indications

Names of Animals			Indications	References
Benthic macroinvertebrates	Phylum Mollusca	Gastropoda *(Snails)*	Pollution tolerant and nutrient enrichment area	Islam and Sinha, 2012
		Pelecypoda *(Bivalva)*	Pollution sensitive, high O_2 enrichment area	Islam and Sinha, 2012
	Phylum Annelida	Oligochaeta *(Worms)*	Pollution tolerant, high CO_2, nutrient enrichment area	Islam and Sinha, 2012
		Hirudinea (leeches)	Pollution tolerant, high CO_2, nutrient enrichment area	Islam and Sinha, 2012
	Phylum Arthropoda Class Insecta	Ephemeroptera *(Mayflies)*	Pollution sensitive, high O_2	Islam and Sinha, 2012
		Plecoptera *(Stone fly)*	Pollution sensitive, high O_2	Islam and Sinha, 2012
		Trichoptera *(Caddis fly)*	Pollution sensitive, high O_2	Islam and Sinha, 2012
		Odonata *(Dragonflies)*	Pollution tolerant, nutrient enrichment area	Islam and Sinha, 2012
		Hemiptera *(Aquatic bug)*	Moderate water pollution	Islam and Sinha, 2012
		Coleoptera *(Beetles)*	Pollution sensitive, high O_2	Islam and Sinha, 2012
		Diptera *(Chironomidae)*	Pollution tolerant, high CO_2, nutrient enrichment area	Islam and Sinha, 2012
Zooplanktons			Pollution sensitive,	Khalifa, 2015
Rotifers *(Wheel animals)*			Moderate water pollution	Solanki *et al.*, 2015
Frogs and toads*(Anurans)*			Correlation with nutrients	Simon *et al*., 2011
Fishes			Heavy metal sensitive, disturbance in gill, lungs, skin	Authman *et al*., 2015
Birds			Sensitive to the disturbance of food and ecosystem	Lodhi *et al.*, 2017

CONCLUSION

Bioindicators are good indicators of their environmental quality. They are helpful, objective, straightforward, and reproducible. Bioindicators can be utilized at various scales, from the cell to the environmental level, for assessing the changes taking place in a specific biological community. Bioindicators unite biological, physical, chemical factors, and are utilized as an important part for evaluating health status of water bodies.

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