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# Environmental Monitoring and Impart Assessment

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***Abstract – I do not intend to elaborate the subject of biological monitoring of the state of the environment (bioindicators) in this chapter. I would rather restrict the subject to basic concepts of environmental monitoring. As a result of population growth, rapid industrial and technological development, urbanisation and unjudicious planning without due regard to sustainable development, there have been induced a variety of changes iii the environment. Human activities induce such changes in the environment in the form of pollution and perturbation that cause widespread damage to the living organisms in the biosphere The result is the disruption of ecological balance, a growing threat to the entire life support system which is rapidly lacing extinction.***

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## INTRODUCTION

In every sphere of human endeavor, the use of biological systems provides an elegant device as these do not disrupt the stabihty of natural ecosystems A few examples would make the point clear I3ioenergy is proving gradually as good alternative to nonrenewable sources of energy causing serious pollution problems. Biofertilisers are becoming popular over chemicals in agriculture. For control of diseases, chemicals used s pesticides in agriculture are being replaced by biocontrol agents.

In order to assess the changes caused by human activities, effective and reliable monitoring systems are required to recognise and predict hazardous effects Life-as the best indicator of environment Biological methods can be successfully applied in predicting the impact of human activities particularly of pollutants well in advance since they present effective and reliable method of evaluating the effect of anthropogenic substances on living. organisms. Thus microbes, plants, animals, cell organelles, organs, individuals, populations, biotic communities and ecosystems show different levels of sensitivity and can besuecessfully employed as ecological indicators (bioindicators) to assess and predict environmental change in a timely manner.

Thus organisms, chiefly plants. species, communities or even system serve as ‘a measure or index (indicator) of [he environment. If plants serve a indicators, they are called plant indicators. Each response is the effect of some factor or fact or complex (interacting factors) acting as a cause and is, therefore the indication of this factor. It is thus evident that every plant is a product of the conditions under which it grows and is therefore, a measurement of environment. Dominant species in an area are most important indicators, as they receive the full impact of the habitat for over longer periods. Consequently. plant communities are more reliable indicators than individual plants. Plants arc indicators of conditions, processes and uses. Large species serve as better indicators than small species: usually 'steno' species serve much better indicators than 'eury' species. Numerical relationship between species, populations and whole communities are more reliable than single species. Some of the obvious eases where plants and to some extent animals also, serve as indicators of some characteristic type of environmental conditions are as follows:-

1. **Indicators of potential productivity of land -** Forests serve as good indicators of land productivity. For example. vegetative growth of trees like species of Quercus (Q.marilandica. Q. stellata) is comparatively poor on loc land or sterile sandy soil than the normal soil in which they grow under natural conditions.

2. **Indicators of agriculture.** Native vegetation of a particular region is the safe criterion of agricultural possibilities. Thus, plants growing under natural conditions provide informations on capabilities of land for crop growth than those obtained through meteorological data or soil analysis.

3. **Indicators of climate.** Plant communities characteristic of a particular region provide information on the climate of that area. For instance, evergreen forests indicate, high

rainfall in winter as well as summer; sclerphyllous vegetation indicate heavy rainfall in winter and low during summer: grasslands indicate heavy rains during summer and low during winter; xeorphytic vegetation indicate a very low or no rainfall in the year.

4. **Indicators of soil type and other soil characteristics.** Luxuriant growth of some taller and deeply rooted grasses like Psoralea indicates a sandy loam type of soil, whereas the presence of grasses as Andropogon indicates sandy soil. Rumex acetosella indicates an acid grassland soil, whereas Sperrnacoce stricta the iron-rich soil in the area. Plants like Chrozophora rottleri, Heliotropium supinum and Polygonum grow better in low-lying lands. Shorea robusta, Cassia obtusifolia, Geranium sp. and Impatiens si. indicate proper aeration of soil. Grasses like Saccharum spontaneum prefer to grow in poorly- drained soils. Plants as Artemisia tridentata, Kochia versrita, Salicornia utahensia and S. rubra indicate saline soil, cappesris spinosa and Carissa spinarum indicate intense soil erosion.

5. **Indicators of fires.** Some plants as Agrostis hiemalis, Epilobium spicatum. Pitium contorta, Populus termuloides, pteris aquilina and Pyronema *confluens* (fungus) dominate in areas destructed by fires. *Pteridium spp.* in particular in4icate burnt and highly disturbed coniferous forests.

6. **Indicators of petroleum deposits.** Some protozoans as *Fusilinds .indicate* petroleum deposits in the area,

7. **Indicators of adequate oxygen in water.** Burrowing may fly *(Heragenia* sp.) indicates proper oxygen regimes in the water.

8. **Indicators of pollution.** Plants like *Utricularia, Chara, Wolffia* prefer to grow in polluted waters. Bacteria, like *Escherichia coli* also indicate water pollution. Presence of diatoms in water indicates pollution by sewage. Movement of fish like *Catla catla, Labeo goniu, L. bata, L. rohita* and *Natopterus natopterus* away from the water indicates industrial pollution of water.

9. **Indicators of overgrazing.** Annual weeds and short-lived perennials like *Amaranthus, Chenopodium* and *Polygonum* etc. grow better in overgrazcd areas Frequent visits of the areas by animals as cattle, horses, sheeps, goats etc. also ‘indicate that the area is under intense grazing.

Biological methods of monitoring may provide information about the state of environment due to their following characteristic features at different levels (i) microbes, plants and annuals have the ability to accumulate a hazardous substance occurring in the environment They may thus indicate the presence of such a substance. (ii) life processes of different organisms can be used to evaluate the action of. environmental pollution and that of a given pollutant. (iii) changes in the pollution of species and in the structure of ecosystem can indicate the level of environmental deterioration.

Biological systems as indicators of the environment, therefore, have a remarkable potential in forecasting of disasters, prevention of pollution, exploration and conservation of natural resources, all aiming at a sustainable development with minimal destruction of the biosphere.

**Biological Monitoring Programme**

Realizing the need of biological monitoring, the International Union of Biological Sciences (IUBS), in its XXI General Assembly, held in Ottawa, Canada in 1982, decided to initiate a worldwide programme for identifying and applying biological indicators in environmental mi monitoring particularly to evaluate the effects of hazardous substances on ecosystems. The IBUS recognising the importance of Bioindicators Programme constituted an International Steering Committee headed JProfessor 3. Salanki of Hungary. The objectives of this programme are as follows: (i) to encourage scientists, as well as scientific bodies to develop and improve methods indicative of hizardous substances occurring in the environment. (ii) to collect information on existing methodology of bioindicators. (iii) to promote exchange of experience between different laboratories to help dissemination of recent knowledge among different countries. (iv) to provide literature about bioindicators including different reference lists, general discription of methods and practical manuals suitable for distrubution to interested bodies. (v) to promote interdisciplinary and international cooperation in standardizing and extending the use of agreed methods. (vi) to stimulate scientific bodies to encourage the presentation of new results concerned with bioindicators at international meetings and (vii) to organise special regional or international symposia, workshops and seminars in cooperation with national bodies or other organisations on the methods, new results and their application.

Keeping in view the increasing importance of bioindicators in environmental monitoring, the Indian National Science Academy (INSA). New Delhi in association with IUBS organised an International Symposium on Biological Monitoring of the State of the Environment (Bioindicators) as a part of its Golden Jubilee Year Celebrations. from 11-13 October, 1984 at New Delhi.

**Bioindicators and Environmental Monitoring**

Bioindicators of soil, water air pollution provide information for dcveloping suitable programme for biomonitoring. Bioinindicators provide a practical wav of assessing the health of environment. The term bioindicators covers a wide spectrum of organisms serving as indicators of environment. The most rational way of the use of biological systems as indicators of environment is to employ those organisms which in their presence or absence and in all features of their phenotype and physiology, serve as an index of their environmental status. Undoubtedly, they indicate the level of pollution, but more important is the fact that they provide a clear insight into the composition of their substratum. Thus both the positive and negative facets of the environment can he monitored through biological systems. A bioindicator actually indicates the general toxicity of the environment, without telling the exact physical or chemical factors responsible for this toxicity. The appropriate physical and chemical methods are to be supplemented to understand the exact chemical responsible for pollution.

There are a variety of biological systems which can be used as indicators of harmful anthropogenic substances. The IUBS programme divided these systems into following six groups: (i) Microbiology. (ii) Botany. (iii *Zoology,* (iv) cell Biology and Genetics, (v) Comparative Physiology and (vi) Hydrobiology.

We shall consider each of the systems briefly here.

**[I] Microbial systems**

Microbes are rapid detectors of environmental pollution both in water. soil. There are microbes, specifically sensitive to some substances while others take part in decomposition of pollutants. The elimination (of sensitive spp) or abundance (tolerant and involved in breakdown of pollutant) of species can indicate changing environments. Alteration of microbial communities and reduction of species diversity can be the result of the presence of specific toxic agents. Microbial muds from continental and intercontinental water bodies serve as ideal tools for detecting several compounds including sulphur. The detection of polar lipids of archeohacteria in petroleum belts and sediments is an elegant momtoring system.Solmanella typhyimurium, other bacteria and fungi as Neurospara and Aspergillus provide excellent device for monitoring genctic effects of physical and chemical agents. Several microbes are used in assessment and prediction of changes in marine environment induced by human activities. These include E. coil, Vibdo spp, Aerononas sp, Pseudomonas, Clostridiun, Streptococcus etc. Cyanobacteria are 'used as bioindicators of soil pesticides. For instance Nostoc microscopicum, Haplosiphon welwitshii and H. confervaceus indicate the pollution of Dithane, Deltan, Aldrex, BHC-, Rogor, Phorate etc.

Some filamentous fungi, yeasts, actinomycetes and bacteria ire used to monitor oil pollution (oil spillage). Scolecobasidium, Mortierella spp, Humicola, Verticillhicnz spp. are able to utilise waste oil. Fedorak et a! (1984) isolated about 74 yeasts and 224 filamentous fungi from marine water and sediment samples. These included Penicillium spp, candida quillerinondii and Aureobasidium pulluians, which utilise oil fractions.

**[III] Lower plants**

Both, from pollution as well as survey of resources, (different groups of plants indicate the nature of the environment. The susceptibility or resistance towards a substance in the environment varies with species. For instance, lichens due to their susceptibility and resistance to different environmental effects, are ideal monitoring agents. There are some lichens which can thrive only in the unpolluted air whereas others are resistant even to the most polluted systems. The wide variety of lichens including different species of Lecanora are good indicators of a broad spectrum of environment. rhe presence of $SO_2$ and fluorine in atmosphere is indicated by lichen thalli. Even the dead thalli are capable of absorbing fluorine and heavy metals including lead Lichens are also utilised for survey of long life nucleids like cesium 137, strontium 30, released from nuclear explosions.

Various algae are excellent monitors of environment. Ulva and Enteromorpha, are used in monitoring the water quality of estuaries. Heavy metal pollution of water is monitored by algae as Cladophora and Stigeolonium, the former is completely absent, whereas the latter shows abundant growth in waters polluted with heavy metals.

Chlorella is used to monitor toxic substances in water bodies. Some algae, as Duniella teritolecta Skeletonema costatiun, Criosphaera canerae, Amphidium carterac, Cyclotella ciyptica Paylova lutheri etc. are used as indicators of oil pollution (oil spillage). "Moss bags", epiphytc lichens and mosses have been used for minotoring air pollution. They accumulate heavy metals.

**[III] Higher plants**

Various higher plants serve as bioindicators Sensitive species air employed to detect and monitor specific air pollutants Tolerant (indicator) species are used to determine the incidence of particular soil condition. Studies on plants have more often been directed specifically to monitoring heavy metals in waters. There is extensive leterature on higher plants as indicators of air and water pollution. Different species have been used to detect and monitor gaseous (as $SO_2$, $O_3$**.** nitrogen oxider) as well as heavy metal pollutants (Al. Ca. Co. Cu. Zn, Gd, Pb, I 1g. Mo, Mn, Ag). The Zinc tolerance of *Anthoxanthum* spp, copper tolerance of *Agrostis.* lead tolerance of *Festuca* and cadmium tolerance of

*Impatiens* are well known examples. These planis are not only indicators but also as pollutant scavangers. Studies are very useful in locating new areas of mineralisation.

A wide sped rum of phenolypic. metabolic and anatomical changes in the plant system refleet the nature of the compounds to which the plants are exposed. The weathered flakes of tobacco or chlorotic flakes of pine needle are good examples of ozone damage. The collapse. glazing and bronzing of leaf cells are products of damage by peroxyacetyl nitrate.

Several physiological and anatomical parameters are taken into account. For example, inhibition of photosynthesis and enolascs is associated with fluroine damage. Bleaching of perianth and stamen injury are indicators of mercury poisoing. The nature of stomata, pigmentation chlorosis and bleaching are generalised effects through bioindicators. Activities of several metabolites and enzymes are excellent indicators of environmental effects. Tiagi and Aerv ( 1985 ) have presented a list of some of lie well established plants as indicators of heavy metals.

**[IV] Animal systems**

Individual species or whole community provide data on accumulation of chemicals in animals accumulation occurs to different extents in different organs. Accumulation of chemicals within food chains and consequently higher levels of toxicity in human food stuffs are indicated by selecting a suitable species for routine study.

Fish *Daphnia,* silver carp etc. are used to monitor heavy metal and pesticide pollution levels in water. Zooplanktons as rotifers and cladocerans arc used as indicators of freshwaters. Earthworms are good bioindicators of soil radiactive pollution.

**[IV] Aeroallergens**

They incxlude aerial flora and fauna. Air is medium of transport of flying animals, germs of infect ion diseases, plant and animal parts, fungal spores. pollengrain etc. The monitoring of airbonc pollen and spores and related microphytoplankton such as trachieth, cuticle, algal filaments, insect scales and wings has received special attention of aerobiologists. mainly for its bearing on human allergy and plant pathogenicity. Pollen grains are pollutants causing biopollution. Pollen gains are considered as omnipresent (occurring everywhere around the globe) and thus good bioindicators in mentioning programmes. Nair (1085) presented an account of biomonitoring of airborne plant materials.

**[VI] Human system**

Blood and urine alongwith others are used as exposure to toxic compounds. However, such an analysis bristles with the Limitation of monitoring capacity being restricted to exposures, On the other hand human hair from head, can trap metallic vapour and dust over a long period of time due to their affinity with hair protein. Thus samples as old as 2000 years could be successfully analysed.

**[VIII] Cell biology, genetics and comparative physiology**

Cellular and sub-cellular components, even chromosomes. Adapted to specific environmental conditions form an excellent parameter for bioindicators. Both short and long-term test systems have been developed in vitro as well as in vivo to monitor changes caused by different environmental agents. Grover et al (1985) presented an account of monitoring environmental chemicals by chromosomal aberrations in plants.

Many animals show behavioural responses following the detection of. environmental changes by their sense organs. A chemical may influence the functioning of endocrine, nervous. muscular, cardiovascular and excretory system. Such changes may be investigated at morphological, biochemical or physiological levels and can indicate the presence of toxic substances.

Details of environmental monitoring may he found in SCOPE-1 (1971), SCOPE-3 (1973) and IUBS-INSA symposium (1985).

**Environmental Impact Assessment**

**Development,** agricultural and industrial lies at the heart of a nation. For a nation to progress socially, economically as well as politically development processes in different fields are very necessary. This has been true and the super powers could do this at tremendous rates, the Third world is in the process of such developments. This is one side of the coin. Let us also have a look to another side of the coin. What are the costs of such development, not in terms of money but equally or rather more valuable in terms of its impact on our environment. The two ie. development and environment are inseparably 1inked to each other. Any development process is bound to have its impact on the environment.

If we trace the history of human being, it should be clear that there had been tremendous environmental impacts of industrialised societies Agriculture. industry and mining had very harmful impacts on our invironment. Such impacts led to degradation of our land, forests, water, air, and biological diversity by release of noxious chemicals and other factors.

Industrialisation had been a mixed blessing. There was considerable economic growth and increase in GNP per capita and overall standard of living. However, all the development had been at a tremendous environmental cost. Man has virtually reached a stage when natural resources could not be exploited further and development will have to be achieved without destruction of environment.

In our country, in the post-independent period, our ideas were dominated by developmental growth and we did not have a culture of pollution control. Even late Pandit Jawaharlal Nehru wrote in 1957 "We have many large-scale river valley projects which are carefully worked out by our engineers. I wonder however, how much thought is given before the project is lunched. to having in ecological survey of the area and to find out what the effect to the drainage system or to the flora and fauna of that area. It would be desirable to have such an ecological survey of the e areas before the project is launched and thus avoid an imbalance of nature' The total insensitivity at the bureaucratic/administrative level, which persists still has given the nation a very heavy backlog of pollution and ecological degradation. They look immediate money in destruction of environment, and not in conserving it We must reverse this picture. There is huge backlog of our 40 years of negative environmental impacts of developmental work. These are to be set right.

It is desirable to have an idea of the possible impacts of any developmental plan it is going to have on our environment. Fortunately, adequate legislation could be brought into force to make proper assessment of ill such environmental impacts.

The objective of Environmental Impact Assessment (EIA) is to ensure that development is sustained with minimal environmental degradation. The Ministry of Environment and Forests, Govt. of India has been assigned the respossibility for carrying out environmental impact assessment of developmental projects in various sectors such as multipurpose river valley and irrigation projects, thermal and atomic power, industries, mining, ports and harbours transport etc.

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