

## Ecology in India

The study of ecology and environmental science has assumed great significance, particularly during the second half of the 20th century. While ecology deals with the study of structure and function of nature, environmental science with somewhat vague boundaries, is primarily concerned with how humanity affects and in turn is affected by other living organisms and the non-living physical environment. Environmental science has to be strongly biocentric; the holocoe-notic environment is the object and ecology is the science that deals with it. Ecology therefore must be at the core of any environmental science programme. Ecology provides the most scientific approach and methodology to understand and evaluate the present day environmental crisis, and to find ways and means to resolve the crisis so as to ensure a better tomorrow for the human race. Resolution of burgeoning environmental problems is not possible without a thorough understanding of ecological principles, and therefore appropriately trained ecologists (both generalists and specialists) will be required increasingly. The new generation of ecologists will require the capability to predict, plan and manage the environment and resources.

From a small beginning, ecology has emerged into a frontline science by the turn of the 20th century. From the conventional regional floristic and vegetation studies the switch over to ecosystem approach in the late fifties and early sixties, the concerted worldwide productivity studies under UNESCO's International Biological Programme (1964-74) and then incorporation of 'man' as part of biosphere in

UNESCO's Man and the Biosphere (MAB) Programme followed by inclusion of geosphere also in the International Geosphere Biosphere programme, have shaped ecological researches to a great extent. Widespread environmental degradation and catastrophic episodes have generated serious concerns and environment-friendly growth in agriculture, forestry, urban and industrial systems by holistic management methods



Ramdeo Misra (1908-1998)

has been advocated. On the international scene, from the 1972 Stockholm Conference on Human Environment to the 1992 Earth Summit in Rio de Janeiro and through activities of UNEP, the United Nations have taken periodic stock of the situation and given directions for the future.

A national seminar on 'Ecology in India: Retrospect and Prospect' was organized by the Centre of Advanced Study in Botany, Banaras Hindu University on 12-13 March 1999. Eminent scholars who have actively contributed to different aspects of ecology were invited to this seminar to review the progress of the subject in India and to outline the future directions required. Major issues discussed in the seminar were: (i) structure, functioning and management of major ecosystems such as forest, grassland, savanna, agro-ecosystem, wastelands, river, and lakes; (ii) sustainability of natural resources; (iii) conservation and monitoring of biological diversity, damaged ecosystems; (iv) ecology of noxious weeds; (v) causes and consequences of global change; (vi) socio-economic issues in environmental management; etc. Both oral and poster presentations were made.

The seminar was inaugurated by Y. C. Simhadri, Vice-Chancellor, Banaras Hindu University, who emphasized the role of higher education to promote sustainable development and environmental protection. Simhadri also highlighted the fact that environmental education at the university level is necessary for students to apply ecological principles to analyse environmental issues. While dedicating the seminar to the memory of late Ramdeo Misra, J. S. Singh highlighted contributions of Misra who laid the foundations of ecology and environmental science in the country. He was aptly called 'Father of Indian Ecology' by the ecologists world over. Misra breathed his last on 25 June 1998 in New Delhi and India

has lost one of her most illustrious scientists.

Misra was born on 26 August 1908 in a village of District Jaunpur and had his early education at Varanasi, and obtained his B Sc and M Sc degrees with honours from the Banaras Hindu University. The year 1937 proved a milestone from where onwards ecology in India showed sustained development and continuous diversification. This year marked the return of Misra to India, after his postgraduate studies with W. H. Pearsall, at the Wray Castle, UK. Misra pioneered ecological studies on low-lying lands, ravines, ponds and herbaceous plant populations during the period 1937 to 1946 at the Banaras Hindu University. He actively pursued both field and experimental ecology, and in the process, established the now world-renowned and oldest centre of ecology at this University. Among the significant observations made during this early phase were the demonstration of the alternation of hydrosere and xerosere in low-lying areas and the first experimental report of population differentiation in plants.

Misra moved to Saugar University in 1946, and soon a strong centre emerged there for researches on synecology of forests and grasslands. He returned to Varanasi in 1955 and occupied the prestigious chair of botany at BHU. He soon built a strong school in ecology, attracting students from all parts of the country and some even from abroad. He not only laid the deep foundations of the subject in India, but over the next decades fostered ecology to become a major discipline for teaching and research in traditional departments. His book *Indian Manual of Plant Ecology*, coauthored with G. S. Puri, became the first text available in the country in 1953. Misra imbibed the essentials of contemporary British traditions of habitat approach, Zurich-Montpellier concept of phytosociology, Clementsian approach of dynamic vegetation, and Turesson's approach of genotypic response, and blended them with his original thinking. Delivering the Presidential Address on 'The Status of Plant Communities in the Upper Gangetic Plain' to the Indian Botanical Society at New Delhi in 1959, he questioned the validity of the then prevalent community concepts. In his Presidential Ad-

dress 'Environment, Adaptation and Plant Distribution' to the Botany Section of the 46th session of the Indian Science Congress in 1959, he integrated the habitat adaptations with varying genotypic and phenotypic plasticity of plants in response to environmental conditions. Early focus of this school was on autecology of herbaceous plants, especially the edaphic basis of population differentiation and on synecology of grasslands, especially the grazing effects. Among the notable contributions made at that time are the demonstration of ecotypic differentiation associated with soil calcium in *Euphorbia thymifolia*, analysis of seasonal distribution and photoperiodic response of distinct *Xanthium strumarium* populations, and elucidation of succession of wall flora.

Misra founded, jointly with late G. S. Puri, the International Society for Tropical Ecology in 1956, and its international journal, *Tropical Ecology*, which began publication in 1960. Misra founded the National Institute of Ecology and the *International Journal of Ecology and Environmental Sciences*.

During the early 1960s, the Varanasi School under the guidance of Misra began studying grasslands and forests in an ecosystem perspective, emphasizing primary production and biogeochemical cycling. The work on production ecology coincided with the launching of the International Biological Programme in 1964. These studies provided a turning point in ecological researches in India, and created a tremendous wave of research in this direction throughout the country. It was in this period that hypotheses were proposed to account for the opposite trophic biomass structure in large aquatic systems, diversity-productivity relationships in grasslands and promotory effect of moderate herbivory on grassland productivity and diversity. Also, in dry tropical forests rapid nutrient cycling and contribution of fine roots to ecosystem function were emphasized, and controlling effect of seasonality and litter chemical quality on litter decomposition was shown. These findings and concepts percolated internationally. The Ecology Summer School organized in 1966, and the *Ecology Work-Book* produced for the School, had tremendous impact on the spread of ecology and environmental

science in other parts of the country. Many teachers and would-be researchers received first-hand training in hitherto unavailable ecological techniques and concepts.

The first MAB research programme in India was launched by Misra at Varanasi in 1975. Misra played a key role in the International Biological Programme and the UNESCO's MAB Programme. He was the first Vice President of the International Association of Ecology (INTECOL), and one of the Vice Presidents of the first Bureau of the International Coordinating Council of UNESCO-MAB where he continued to represent India for many years. The country paper for India which was presented at the Stockholm Congress of World Governments in 1972 by the then Prime Minister, late Indira Gandhi, was developed under the guidance of Misra who then served on the National Committee on Environmental Planning and Coordination (NCEPC). The Stockholm paper presented a clear thinking of the Indian government on long-term environmental problems and provided an impetus to the cause of environment. The NCEPC paved the way for creation of a new independent Department of Environment which later assumed the status of a Ministry.

In recognition of his services to the country, Misra was honoured with the Sanjay Gandhi Environment Award by the late Prime Minister, Indira Gandhi. He was elected a Fellow of the National Academy of Sciences of India, Indian National Science Academy, and the World Academy of Arts and Science. He received the Birbal Sahni Gold medal of the Indian Botanical Society, Jawaharlal Nehru Gold Medal of the M.P. Vigyan Academy, and the Swami Pranavanand Saraswati Award of the University Grants Commission, New Delhi for Environmental Science. For several years, he was a Member of the Jury of Institut de la vie Prize (Paris), and also served on the Editorial Boards of *Agroecosystems and Applied Ecology Abstracts*, besides many Indian journals. He was associated with numerous national and international organizations serving on their various committees in different capacities.

Today, ecology in India owes its presence in all Indian universities to the foresight and untiring efforts of Misra

who contributed to its development and growth at a time when ecology was not only unknown but was also not considered to be science. He trained numerous young researchers by organizing training courses and influenced many more through his lectures. After his retirement also, he continued to work at the Banaras Hindu University as an emeritus scientist, and was later made an Emeritus Professor. Misra continued to take active interest in teaching and research, and to provide counsel to the various organizations he founded, until a couple of years ago when his health failed him. It is only befitting that this seminar was held at the home base of Misra and was dedicated to his memory.

The seminar discussion was initiated by R. S. Tripathi on retrospects and prospects of population ecology in India. The studies on population-interaction have engaged the attention of ecologists and agricultural scientists in this country for quite some time, the focus being on resource competition studies between crop and weeds, and grasses and legumes. Tripathi also focused on the population responses of species to various ecological factors such as density-increase, herbivory, inter-specific competition, allelopathy and density-independent factors including microsite-characteristics with a view to discerning the mechanism of plant population regulation. Most of the ecological research findings are based on short-term observations without adequate emphasis on year to year variability. Since several ecological phenomena occur on a time scale of decades, or even centuries, the short-term observations are not able to distinguish between cyclic changes and long-term unidirectional changes. This makes long-term ecological observations important. K. B. Reddy presented a long-term study (of 21 years) on changes taking place in phytosociology of roadside vegetation of the Chennai-Calcutta highway between Guntur and Vijayawada. Most changes in vegetation were limited to nonpalatable aggressive annuals with very little change in palatable grasses. One interesting change observed was initial rapid colonization and later replacement of *Parthenium hysterophorus*, a noxious invader, by other species along the roadside.

Understanding of ecological processes is essential for anticipating and ameliorating the environmental effects of human activities. Analysis of ecological processes at the ecosystem level is a prerequisite to the understanding of the functioning of ecological systems in relation to perturbations, so that mechanistic ecosystem modelling can be pursued. H. N. Pandey highlighted the role of fine litter, fine roots and microbial biomass in restoring soil fertility of degraded forest ecosystems of north-east India and examined the changes that take place in physico-chemical properties and nutrient mineralization in soil during forest regrowth. Structure, functioning and management of a variety of silvicultural ecosystems of Chotanagpur region of Bihar was the focus of O. N. Pandey and R. Kumar. S. K. Tripathi and K. P. Singh analysed the response of forest and savanna to N and P enrichment. Savanna vegetation was shown to respond more rapidly to nutrient enrichment than the forest. However, the responses were retained for longer periods in the forest than in the savanna.

Over the years, the Himalayan lakes have been subjected to considerable ecological stress by way of intense landuse, urbanization and poor management of watershed. As a consequence, the lakes are undergoing undesirable changes such as shrinkage of water area, reduction in depth and water volume, siltation, deterioration of water quality, accelerated eutrophication, decline in biodiversity and loss of recreational amenities. D. P. Zutshi, in his overview on ecology and management of Himalayan lakes, examined the present ecological state of some important Himalayan lakes and evaluated various approaches being used for their conservation and management.

Globally, about 10 million square km area consists of hyper arid or true desert region. An overview of desertification in semi-arid and arid regions of western India was presented by A. N. Pandey. It was reported that consistent depletion of clay particles and macroaggregates of soil results in disorganization of soil structure during the course of desertification. Simultaneous loss of organic substances with deterioration of ecosystem reinforces the disorganization of soil structure. The persistent decrease in

N and P and an increase in Na, K, Ca and Mg during the course of desertification results in an entirely different proportion of soil nutrients than that at the reference forest ecosystem. Soil salinity increases with deterioration of ecosystem. Pandey emphasized that vegetal cover is necessary to check the loss of clay minerals and organic substances through soil erosion which, in turn, will maintain soil structure and prevent desertification. It was felt that there is an urgent need to study and monitor soil processes in order to check further deterioration of soils in fragile desert ecosystems.

The importance of Central Himalayan forests and practical aspects involved in their conservation was the focal theme of presentation by S. P. Singh. These forests are subjected to chronic disturbance, with different properties and impacts than those of acute form of disturbance generally described in literature. Singh emphasized the fact that forest policies fail to recognize differences between these disturbances, resulting in failure of species regeneration, and in continued forest degradation in spite of a ban on tree cutting which inhibits the formation of gaps in forest canopy, so important for regeneration of many species. According to Singh, establishing economic enterprises based on non-timber forest products holds promise to unite forest conservation and economic growth.

Understanding the effect of ecological complexity (or of changes in ecological complexity) on ecosystem function including ecosystem stability has remained an intractable problem. Ecological complexity may affect not only the routine ecosystem functioning but also the system response to extreme conditions. The ecological complexity of the protected areas with particular emphasis on linkages at landscape and ecosystem levels has a great research potential. Environmental destruction in the Third World countries is mainly because people are forced to exploit natural resources on a massive scale in order to try to raise their living standards quickly. Use of biodiversity and degree of dependence of human population on local biodiversity in different locations need be quantified. E. Sharma emphasized enterprise-based biodiversity conservation in protected areas by

giving an example of work done around Khangchendzonga National Park in Sikkim. Shardendu and Reema Kumari demonstrated how creative methods including designing of popular, small and constructive tools related to local socio-economic conditions can be used for environmental management. Role of these creative methods to generate awareness regarding local environment was also discussed. Participants felt that taxonomy and systematics are frequently undervalued as far as research and education are concerned. Both disciplines are indispensable to any scientific endeavour aimed at elucidating ecological complexity and biodiversity.

Agroecosystems are important particularly for India where it is a major landuse class. A presentation on sustainability of a disease-free agricultural system with integrated approach by Bhatnagar and Reddy, demonstrated the importance of identifying a cropping system suitable for the growth of desired micro-organisms so that a suitable and in-built disease suppressive system can be achieved. In another talk on productivity and nutrient status of mustard under varying weeding conditions, Chakhiyar *et al.* showed that there was 36% fruit production loss due to weed competition. C. B. Pandey and D. K. Sharma presented a case study on above- and below-ground tree/crop competition in a traditional agroforestry system in a sub-humid climate of India. Their study on influence of *Acacia nilotica* on the growth and grain yield of rice crop indicated that *A. nilotica* enriches the soil under its canopy with organic C and N. Reduced light due to tree canopy to the understory crop along with reduced N availability result in reduction in the crop density, above-ground biomass, and grain yield.

Restoration ecology has started playing a key role in bringing back normal ecosystem structure and functioning on drastically disturbed or altered sites. Successful restoration of a damaged ecosystem requires a thorough understanding of such fundamental ecological processes as nutrient cycling, succes-

sion, competition and predation, and of interaction of biotic and abiotic factors. It was felt that identification of methodologies for the restoration of degraded ecosystems and biological productivity, diversity and stability of the impacted ecosystem is an important area of research. S. B. Chaphekar presented a success story on restoration of a stone quarry outside Pune where principles from environmental engineering, horticulture and biotechnology were involved in landscaping, plantation, drainage, water purification using root zone technique, recycling of water and recycling of mineral nutrients through composting of harvested weeds. A. Roy and K. P. Singh presented observations on the vegetation development on blast furnace slag dumps. S. C. Srivastava presented techniques of biological reclamation of manganese and coal mine spoil through an integrated biotechnological approach (IBA) involving amendment of mine spoils with domestic and industrial wastes (FYM, pulp and paper mill wastes and press mud from sugar industries), mycorrhiza and biofertilizers (*Rhizobium* and *Azotobacter*). Mine drainage contributes to the metal load in water bodies which can be removed by the use of micro-organisms. L. C. Rai *et al.* presented techniques developed for removal of Fe and Cu by immobilized *Microcystis* packed in continuous flow column system.

J. S. Singh's group presented the results of in-depth studies on rehabilitation of mine spoils. Biomass, productivity, nutrient cycling and soil characteristics in plantations of selected native and exotic tree species on mine spoil at the Jayant project were presented. More than 30 species were tested and graded for growth and restoration potential. *Pennisetum pedicellatum* and *Stylosanthes* spp. introduced as nurse crops had significant effect on the growth of trees and improvement of habitat. Intercropping with leguminous trees improved growth performance of nonleguminous trees. Native leguminous trees were found to be better than exotic leguminous trees in improving

the physico-chemical and biological properties of the spoil.

Plantation of green belts by industries is now obligatory as per regulations of the government. Chaphekar and Madav emphasized that plantation-species, density, area to be covered, etc. need to be considered on a case to case basis, to bring originality to the resulting greenery, in addition to the basic functioning of green belts as pollution sinks. They presented a case study of a coastal thermal power station where climate, soil, inter-tidal zone, proximity of sea and resultant gusty winds, crops and orchards in the vicinity, availability of water and manure and amount of flyash generated were taken into account for choice of species for plantation.

Moving from species, communities and ecosystems, the focus of ecological research zeroed on global processes. In future, an assessment of the magnitude and likely impact of climatic and associated changes on species and ecosystems is needed. This will lead to the development of capability to take advantage of positive effects and mitigate negative effects of global change through management. J. S. Singh's group presented the results of methane flux measurements from natural and derived ecosystems. The results showed that the long-term methane uptake rates are conditioned by the soil N and C levels, while the seasonal variations are largely controlled by soil moisture. Both the CH<sub>4</sub> efflux in flooded rice fields and CH<sub>4</sub> oxidation in dryland rice were found to be variety-dependent. Participants felt that the effects of increasing CO<sub>2</sub>, N-deposition, acid rain, ingress of salinity, etc. on species populations, communities and ecosystems are some of the priority areas for future research. It was emphasized that fluxes of greenhouse gases in relation to deforestation and agricultural practices need to be quantified.

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A. S. Raghubanshi and J. S. Singh,  
Centre of Advanced Study in Botany,  
Banaras Hindu University, Varanasi  
221 005, India.