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India's Contributions to Ecology: Ecological Studies in Mumbai

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ABSTRACT

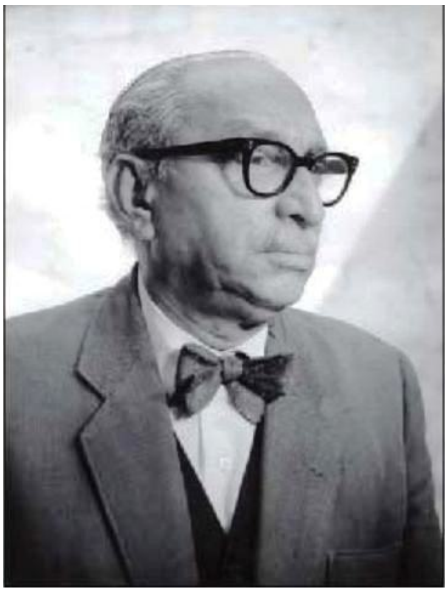
Teaching and research in Plant Ecology started in erstwhile Bombay at the then Royal Institute of Science in 1935 after Dr F.R. Bharucha joined there upon returning home after studying at the Cambridge University in U.K. and obtaining his D.Sc. from Montpellier University in France. The research covered vegetation in several parts of the Indian subcontinent, taking a new approach of phytosociological, ecological and phytogeographical aspects. With the passage of time, new generation researchers at the Institute shifted to urban ecological studies such as plants and vegetation with reference to air and water pollution, land degradation, etc. which was inevitable in the densely populated and industrial-commercial '*urbs prima'* of India. Research for eco-restoration also attracted scientists who launched multidisciplinary environmental projects.

Key Words: Bharucha; Navalkar; Shankarnarayan; Meher-Homji; Phytosociology, Air Pollution; Phytogeography; Mangroves; Ecorestoration; Bioclimatology

THE BEGINNING OF INDIAN ECOLOGY

Dudgeon (1920) is often credited to have published the first ecological study- that of the Upper Gangetic plain- in the country. This was soon followed by an ecological study of Deccan grasslands (Burns and Chakradeo 1921). However, relatively very little is known of the significant contributions to ecological research and education in the pre-independence India by Indian scientists and institutions. This article summarises the contributions from a School of ecology established in Bombay (now Mumbai) in 1935.

Teaching and research in Plant Ecology started at the Royal Institute of Science, Bombay, in 1935 with the joining of Prof. Faredoon Rustamji Bharucha who returned to India after his ecological studies in Cambridge with Prof. H. Godwin (Godwin and Bharucha 1932, Godwin et al. 1932; also Braun-Blanquet et al. 1931) and obtaining his D.Sc. degree from University of Montpellier in France for his work on phytosociology of a Mediterranean plant community with Prof. J. Braun-Blanquet (Bharucha 1933). This marked probably the beginning of research and teaching in the discipline in India. Prof. Bharucha's research was mainly in the then emerging field of Plant Sociology. Various plant communities from Bombay, Western Ghats and Rajasthan were studied along with stress on edaphic conditions (Bharucha and Navalkar 1942, Sheriar 1950, Bharucha



Prof. F.R. Bharucha (4 May 1904-30 March 1981) and Dubhash 1951, 1954, Bharucha and Satyanarayan, 1954, Shankaranarayan 1956, Bharucha and Meher-Homji 1952.)

BRANCHES IN ECOLOGICAL RESEARCH

Eco-physiology of mangroves growing in saline habitats, their morphological peculiarities, growth habits, distribution in Peninsular India and zonation with reference to tidal movements were studied for the first time in the country, by his student, B.S. Navalkar (Bharucha and Navalkar 1942).

Prof. Bharucha assessed nutritive value of fodders and emphasized the role of trace elements in the soil. As most gypsum mines were no more in the country post-independence, Prof. Bharucha's application of the plant indicator concept in locating the "Gypsophytes" in Rajasthan was of particular significance.

One of his most notable contributions is on crassulacean metabolism. He brought out, for the first time, that the same plant species may behave differently in terms of storage and reconversion of their metabolic products, under tropical and temperate conditions (Bharucha and Joshi 1957).

He also showed that the plants growing on rocks and calcium-rich substrata survive the precarious habitats because of their ability to absorb and retain elements like calcium and iron in large quantities and secrete organic acids in a complimentary way (Satyanarayan 1954).

Prof. Bharucha's research on nitrophilous vegetation has received wide acclaim. He showed that plants growing on habitats replete with decaying organic matter show an adaptive metabolic behavior. The characteristic nitrophytes and their organs show luxuriant growth proportional to the amount of nitrate available from the substratum, as demonstrated by his students (Sheriar 1950, Dubhash 1950, Bharucha and Dubhash 1951, 1954).

Biogeography and Bioclimatology

Bharucha, jointly with his student Dr V.M. Meher-Homji, proposed a classification of Indian vegetation based on precipitation / evaporation indices derived from modified Rohwer's formula of evaporation. They supplemented vegetational criteria and statistics of distribution of taxa with modern biometeorological parameters, in order to assess the degree of aridity/humidity (Bharucha and Meher-Homji 1956).

Systematic Ecological Studies of the Great Indian Desert sponsored by the UNESCO led to the outcome that included an important argument that the climate of the desert was not getting more arid (Bharucha and Meher-Homji 1952). The Report proved to be a pioneering attempt to study the desert conditions in detail and paved the way for many more studies aimed at understanding and taming the deserts in Indian sub-continent and elsewhere.

Meher-homji (1956) made several contributions to the field of Bioclimatology in the Indian Subcontinent. His important contributions include an original classification of both forest types and climates with the proposal of an Index of Aridity-Humidity, the concept of a Probable Year than an Average Year in Climatology, the importance of Regime (season of occurrence of rains) in explaining distribution of species, degree of Mediterraneity in the sub-continent, probable links between deforestation and hydrological cycle and the vegetational history.

The aerial photographs used by the military during World War II were successfully employed by him to map the vegetation, under the leadership of Prof. Gaussen at the Institute of Vegetation Cartography in France. His D.Sc. thesis titled, 'Bioclimates and Vegetation of the Indian Subcontinent and Their Analogous Types in the World' was published as a book by the University of Toulouse, France (Gaussen et al. 1978) and was widely acclaimed. His main contributions include maps of the vegetation of Peninsular India and a range of regional vegetation features.

Based on the fossil record, Meher-Homji built up a climo-vegetational history of the country, particularly during the Holocene period. He concluded that pollen markers in such studies were not fidel indicators of aridity-humidity changes of climate in Rajasthan.

Conservation of Ecosystems

Vegetation studies of Western Ghats, Palnis and Nilgiri mountain ranges helped in clearing doubts about the climax status of the Shola (Montane forests) and hill-top savannas (grasslands). His studies of scrub jungles in coastal Coromandel region of Tamil Nadu and Andhra Pradesh revealed abundance of medicinal and economic plant species. His arguments based on meticulously carried out field studies had significant role in the conservation of Silent Valley forest in Kerala, Pichavaram mangroves in Tamil Nadu, relocation of airport site in Pondicherry and a stretch of mangroves in the crowded city of Bombay (now Mumbai).

Urban Environmental Studies

The retirement of Prof. Navalkar retirement in 1959 created a gap in ecological research activity in the Institute of Science, Bombay. It was eventually filled by his student, S.B. Chaphekar. Environmental conditions in the city had changed tremendously over a couple of decades, thanks to intense industrial and construction activity in the rapidly expanding urban spread, increasing human and vehicular population, etc. As a result, Chaphekar changed tracks from forest ecology (the forest studied by him is now part of the Sanjay Gandhi National Park) to urban ecological studies. Increasing human population led to shrinking institutional and laboratory space and experimental area to a great extent. Urban ecological studies based mainly on field surveys supported by minimal laboratory work had to be planned and executed. Ruderal vegetation in the city showed several changes from what Prof. Bharucha's students had reported in 1950s. Roadside vegetation was shrinking but calcicolous and nitrophillous vegetation occupied construction sites and backyards respectively. Importantly, large areas suffered from severe air pollution stress as indicated by foliar injury on trees and shrubs.

Air Pollution and Plants

Repeated surveys of residential-cum-industrial areas (the old textile mills region in central Bombay) revealed severe pollution due to gases and particulates. The industrial belt of Chembur in eastern suburb was one of the worst affected due to concentration of fertilizer factory, oil refineries, thermal power plant, and more; hence labeled as 'Gas Chamber'. Air quality monitored by an NGO of scientists in the city revealed the presence of SO_2, NOx, HF, and SPM. Episodes of accidental leakages of chlorine and ammonia were also reported. Acid rains were also detected in Chembur in the beginning of rainy season. (Chaphekar 1972, 1978, 1982).

A three month long phytomonitoring experiment wherein standardized *Commelina benghalensis* plants were exposed to ambient air in different parts of the city, showed that along with industrial pollution, vehicular emissions were also great contributors to pollution in urban environment. It was so especially along roads connecting the dockyard area and major road junctions. Even pristine sea-front area in the southern city suffered due to heavy traffic load on the boulevard called Marine Drive. Sunflower leaves clearly showed increasing trend of dust deposition with progress of dry season (Chaphekar and Boralkar 1979, Chaphekar et al. 1980) and pollution absorption capacity (Giridhar and Chaphekar 1983, 1987). Based on these studies, and by combining field observations with controlled fumigation experiments in specially fabricated chambers, Chaphekar developed protocols for preparing pollution maps of the city (Chaphekar 1995a). His students continued similar work in other areas like Raigad and Ratnagiri districts, as also in New Bombay (Navi Mumbai). Another student found *Tithonia* sp. (Family Asteraceae) as a very sensitive monitor for air pollution (Chaphekar 1995).

Green Belts

Not satisfied with making surveys to detect and quantify to some extent, status of air pollution in the city, Prof. Chaphekar looked for ways to justify the newly popular slogan, "Grow Trees and Reduce Pollution". He tested several plant species, seasonal and perennials , for their sensitive and tolerant behaviour. Based on the information collected, he recommended species for plantation in different areas in urban-industrial regions (Chaphekar 1995b).

Several research projects were sponsored to him by industries like Rashtriya Chemicals and Fertilizers, Hindustan Petroleum Corporation, etc. to recommend tree plantation strategies for their premises. Ministry of Environment & Forests invited Prof. Chaphekar to coordinate a national project on Plants and Air Pollution, conducted from six research centres, aimed at understanding nature of Plant-Air Pollution interactions and arrive at plantation strategies in the country. Central Pollution Control Board commissioned him, along with two scientists from Nuclear Power Corporation. and Atomic Energy Regulatory Board, to suggest plantation strategies to cover industries and roadways in all parts of the country. The Report "Guidelines for Development of Green Belts" (Chaphekar et al. 2000) was published by the sponsors and is followed by several industrial establishments and concerned government agencies like highways authorities.

Water Pollution

Another major pollution problem, that of surface waters, getting polluted due to industrial effluents like heavy metals came into sharp focus in seventies-eighties of last century. Changes in vegetation, from diverse species composition to a single tolerant species was found to be the result of heavy metal contaminated water of river Kalu, receiving effluents from a number of industries in the vicinity. *Pycreus macrostachyos,* accumulated heavy metals like mercury, lead, cadmium, copper and zinc, alone occupied vast stretches of river banks near the confluence with industrial effluent stream, showing population dynamics in favour of pollution accumulator species in polluted environment (Chaphekar et al. 1973). Buffaloes grazing on this sedge yielded milk in which the same metals were detected. Intensive studies of water, mud, grasses and sedges, as also milk samples from animals grazing in the area, in collaboration with State Water Pollution Control Board, pointed to the potentially serious consequences of food chain contamination, and prompted corrective actions by the Government.

Land Degradation and Eco-Restoration

While regulations were being formulated and implemented for control of air and water pollution, degradation of land was neglected for long, leading to increasing area under derelict land. In a space-starved city, even derelict land was not available for purposes other than construction or dumping of waste. When enlightened authorities of a Municipal Corporation approached for restoration of an abandoned 6 ha stone quarry, it was an opportunity to learn on site, problems on the fringes of a growing city. Water stagnated in the quarry land was a rich habitat for mosquito breeding and diseases in the neighbourhood residents. A combination of de-silting and de-weeding, employing phyto-remediation method for influent gray waters, along with systematic plantation on excavated silt, led to formation of a water bird habitat and a recreation park for residents from neighbouring hutments. A huge stone quarry on an island in Mumbai harbor area, though surveyed ecologically and for its restoration potential, couldn't however be worked on, thanks to the world heritage status of the Elephanta caves on the island (Lattoo 1987).

Littoral Vegetation

Deteriorating coastal ecosystems were (and still are) visible at many places in and around the city which is formed by fusion of seven islands over the past three centuries. Environmentally conscious industrialists launched their own programmes for improving green cover in coastal areas through plantation of mangroves. Development of nursery techniques for a variety of mangrove species was undertaken by Prof. Chaphekar's students, along Thane creek at. Vikhroli in suburban Mumbai (Chaphekar and Deshmukh 1987, 1997). The effort resulted in, not only conservation of tens of acres of coastal land with a cover of diversity-rich mangrove vegetation, but also helped subsequently in forming protective mangrove cover to 14 sq. km. coastlines along two creeks in Dahanu, a coastal village in North Maharashtra (Deshmukh et al. 1997).

Stabilization of Toxic Waste

Environmentally conscious industrial establishments, often coaxed by Environment Ministry, other regulatory bodies and sometimes even NGOs, led to engagement of outside help, including academicians, for finding and trying solutions to their specific environmental issues. It was an era in which Environmental Consultancy as a profession was in an infant stage. Prof. Chaphekar, with his students researching for their degrees, successfully completed a number of industry-sponsored research-cum-action projects, that have benefitted industries and helped several of his students become self-employed environmental professionals after getting their degrees. .In this approach of combining research with problems on ground, he was inspired by the work of Prof. A.D. Bradshaw of Liverpool University. The latter visited some of the degraded sites around Mumbai and Zawar Mines near Udaipur, for working out suitable strategies for research and restoration. One such project of immense educational value and research and action potential, was a heavy metal mining project in the Aravallis. After extracting zinc and lead from the ore, the tailings discarded formed a huge lake with some 24 ha surface area, about 12-15 m deep. Trees couldn't survive on the tailings, in spite of good care and the toxic tailings had to be covered in a sustainable way. A combination of planting local grass, locally available farm-yard manure, strict watering regime were worked out with on-site experimentation . After a couple of years, green grass cover protected the tailings from wind and water erosion (Chaphekar et al. 1986, 1988).

After the experience with toxic Zn-Pb mine tailings, stabilization of fly ash from a thermal power plant was relatively easy, though very important for the establishment. It was generally accepted that coal was the dirtiest fuel all the way from mining to fly ash formed after burning it. This particular 500 MW power plant was located in Dahanu, a coastal village famous for a number of sapota (*Manilkara sapota)* orchards that would have suffered if the fly ash problem was not sorted properly.

CONCLUSIONS

This School has been generating and nurturing scientists and teachers in plant ecology since the subject was introduced in the country. Phytosociology, autecology, edaphic conditions and plant growth, biogeography and bioclimatology have been active areas of research in the past. When urbanization has become an irreversible way of life, urban ecology studies, aimed at finding ecology-based solutions to environmental issues, are inevitable. This School, located in a space-starved city with all types of environmental problems, has been developing ways to combat those problems. At the same time, long term solutions to the problems to global issues are not overlooked. Students from this School, after specialized training in leading global research centres, are involved in Taming of Deserts, Conservation of Biodiversity, Sacred Groves and Biosphere Reserves, Genetic Resources, Improvement of Crop Productivity, meeting challenges of Climate Change, etc., apart from attending to local and regional environmental problems.

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