Water and Biodiversity: An Overview

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Introduction

In the International Year of Water Cooperation (2013), it is quite appropriate to reflect back on the linkages between water and biodiversity on the occasion of the International Day for Biological Diversity. Life had its origin in water and it diversified first in water. Water provided the inexhaustible source of hydrogen for the synthesis of complex molecules by the earliest form of prokaryotic organisms that were anaerobic. The origin of chlorophyll and photosynthesis facilitated the splitting of the water molecule utilising the solar energy and the generation of oxygen that paved the way for the evolution of higher forms of life on land (Keddy 2007). Water is the most abundant substance on the earth. It is the source of all oxygen in the atmosphere and through its global cycling influences the distribution of elements as well as the climate on the earth. It sustains life which cannot exist without it. The relationships between water and biodiversity (the total diversity of living organisms) are multi-dimensional, and when human species is brought into play in the nature's functioning, the water-biodiversity interactions become more varied and complex.

Water affects directly and indirectly different facets of biodiversity. In an area, the amount of water, the duration and timing of its availability and its physical and chemical biota, their distribution and abundance as well as most of the structural and functional attributes of various organisms. At the same time, biodiversity influences water throughout its cycle through processes of interception, uptake, transp-iration, interference with movement, alteration of the physical and chemical characteristics, etc.

However, I do not intend to discuss these complex interactions, their disruption by human interventions and their bearing on human lives. Humans evolved on land and developed their culture and civilizations by drawing heavily on the relatively small fraction of freshwater flowing through the rivers. Today, the dependence of humans on freshwater has grown and diversified to such an extent that we readily forget a large proportion of the Earth's biodiversity that exists in water and relies exclusively on water for its survival. We also forget the benefits that we continue to derive from the functioning of this segment of biodiversity and without which our own survival will be at risk. During the past two decades, numerous publications have focused on the distribution and importance as well as the plight of biota (plants, animals and microorganisms) in rivers, lakes, wetlands and other inland water habitats. I have also written extensively on the aquatic biodiversity at different geographical scales (within India, Asia and even global) in many publications which are again listed at the end. Therefore, I shall restrict here to a brief overview in the Indian context only to highlight the extent of our ignorance and the uphill task of its conservation. The text is condensed from my earlier reports which include extensive references to the published literature. Hence, I refrain also from padding up the text with many references.

Aquatic Habitats and Aquatic Biota

The inland aquatic ecosystems include rivers, streams, springs, lakes, lagoons and estuaries, and various human made habitats as reservoirs, canals and tanks/ponds. India has an extensive network of major, medium and minor rivers together with their tributaries

which cover practically the entire country except for the western arid region of Rajasthan desert. Natural lakes are rather few and mostly confined to the Himalayan belt. India is influenced by the monsoon and experiences seasonal rains followed by prolonged dry periods. The monsoon behaviour is highly unpredictable. Therefore, since historical times, surface runoff has been impounded to create thousands of reservoirs and tanks, particularly in the arid and semi-arid regions. River flows were also diverted for irrigation (as in the Indus Valley). In recent years large dams have been constructed creating multipurpose reservoirs. Natural wetlands such as floodplains, marshes and swamps (including mangroves) have been eliminated or converted to agriculture and aquaculture. Today, a large proportion of aquatic habitats is man-made (e.g., extensive network of canals, wastewater drains, reservoirs, fishponds and paddy fields) and intensively managed. The aquatic habitats also include roadside ditches and abandoned quarries, etc. besides the coastal mangroves, estuaries, lagoons and backwaters.

The biodiversity of these aquatic habitats comprises of organisms across the entire biological spectrum – from microorganisms to mammals. Where it is easy to categorise most of them as aquatic or terrestrial, the distinction is complicated by the fact that a large number of plants and animals use the two kinds of habitats partly, at different times of their life cycle and for different resources. Amphibia, large proportion of birds, and majority of insects fall in this category. At least from a conservation viewpoint, I consider all those animals which depend (not simply use) on the aquatic habitats or its resources at any time in their life cycle, as aquatic (Gopal and Junk 2000).

India's Aquatic Biodiversity

Floristic Diversity

The floristic component of aquatic biota is dominated by algae in open deep waters whereas higher plants (macrophytes) dominate the shallow water areas. There are also many bacteria and fungi and also a few bryophytes.

Despite several detailed systematic accounts of a few groups of algae published by the ICAR, the total algal flora of India has never been estimated. A preliminary estimate puts the Indian algal flora (excluding marine forms) at about 1800 species of which about two-thirds are the blue-green algae. It is however difficult to assess the actual numbers because of differences among algal systematists on the identity of species. For example, the number of species recognised within *Charophyta varies* from 61 to over 400. In many cases, hundreds of subspecies and forms are recognised within a species (e.g., *Scenedesmus species*) or treated as distinct species by others. Similarly, the total species richness of higher aquatic vegetation in India was estimated only recently by Cook (1996) who described about 800 species of aquatic and wetland plants from India at elevations below 1000 m. The total number of species exceeds 1250 by including the Himalayan region where most of the temperate species also occur. It is noteworthy that Khullar and Sharma (1989) and Pande *et al.* (1991), in their assessment of aquatic pteridophytes of western Himalaya, include species which are not usually considered as "aquatic" but may indeed be wetland species. Thus, the available estimates suggest that the aquatic (and wetland) flora (including algae) constitute more than 15% of the India's total estimated floristic diversity.

Faunal Diversity

According to the estimates published by the Zoological Survey of India (Anonymous 1991), about 16,500 species i.e., >20% of the total fauna (78,000 species) in India is aquatic, and majority of this is freshwater. Among the major and better known groups, there are about 300 Rotifera, 285 Mollusca, 100 Cladocera, 100 Ostracoda, >300 Copepoda, 742 fishes, and about 1000 Aves. A large proportion of Insecta which constitute more than 40% of the Indian fauna, have their larval stages in aquatic habitats.

However, these figures for faunal diversity are grossly underestimates for two major reasons. First, most of the wetland and open water habitats have not yet been fully explored. Second, there are no systematic keys for the identification of most of the groups of invertebrate fauna, particularly insects whose only larval and pupal stages occur in aquatic habitats. Their identification to the level of a species is extremely difficult, and there are very few specialists in the country.

Despite the growing importance of these organisms in monitoring water quality, these organisms remain ignored. Fishes and birds are among the best known groups of animals.

Endemism and Threatened Species

Endemism is a common feature of Indian biodiversity. Yet, endemism among algae is not documented. Among the aquatic vascular plants, more than 60 species are known to be definitely endemic to India. A highly interesting group is the family Podostemaceae with more than 20 endemic species which occur in highly specialised habitats under the falls and on rocky beds of rivers in Kerala, Maharashtra, Karnataka and northeast India. Many species are native of the Indian subcontinent. Many aquatic/wetland plant species are endangered or threatened, and a few (*e.g.*, *Aldrovanda vesiculosa* Linn.) are believed to have become extinct.

Among the known fauna, there is a fairly large number of species endemic to India; e.g., more than 10% of the rotifers and more than 40% of freshwater molluscs are endemic. Many species, particularly among fishes, turtles, crocodiles and birds are threatened or endangered (Anonymous 1991, WWF-India 1993, Dehadrai *et al.* 1994). The status of planktonic Crustacea and aquatic insects is very dificult to assess because the surveys are inadequate and most taxa are generally identified to the generic or family level only. India's National Aquatic Animal - the Ganges River dolphin (*Platanista gangetica*) is an endangered species (Sinha 1997).

Microbial Biodiversity

Despite the fact that microorganisms play a critical role in the functioning of nature, especially through the process of decomposition and the cycling of nutrients and other minerals, the microbial diversity remains least explored. Although the bacterial populations are often reported from polluted waters (such as MPN or fecal coliforms) only rarely are they identified or referred to specific taxa. Reports of fungi in lakes, ponds and rivers are rare.

Genetic Diversity

There is very little information about the genetic diversity among aquatic plant and animal species, except fishes (Dehadrai and Ponniah 1997). There is likely to be considerable genetic variability among the widely distributed species among all groups of aquatic organisms.

Distribution of Biodiversity

Species richness is one of the major considerations in recognising the importance of an area for conservation. The aquatic habitats exhibit a wide range of species richness although the total biodiversity of an aquatic system has never been inventorised. Quite often the aquatic habitats, especially shallow water habitats are dominated by only one or few species. Adjacent aquatic habitats often exhibit large differences in their species composition and abundance of various taxa. Algal species alone contribute substantially to the total richness. Shukla and Anjum (1991) recorded 577 algal species from River Ganga at Kanpur only but reports from other stretches of River Ganga recorded less than 60 species (Krishnamurti *et al.* 1991). Similarly, one study recorded 138 species from Dal Lake (Kashmir) whereas most of the reports indicate an average of less than 50 species. The macrophytic species richness also varies from total absence (Lake Sambhar) or few species (Lake Chilka) to several hundred species (Keoladeo National Park and Loktak Lake). The species richness of fishes, birds and other fauna is also very high in many aquatic habitats. For example, there are more than 330 species of birds but fewer fishes in Keoladeo National Park, 64 fish species and 116 species of birds in Loktak lake, and 217 fishes and 160 birds in Lake Chilika.

Human Use of Aquatic Biodiversity

Humans depend heavily upon the aquatic biota for food, fiber, fodder, timber, and numerous other needs. Rice and Fish (including prawns) sustain large human populations. Many other plants (lotus, trapa, Ipomoea) and animals (frogs, prawns, mollusks) are also important sources of food. Large number of aquatic plants are of high medicinal value, and some (e.g. *Vetiveria*) provide essential oils. Reeds, cattails and sedges, besides jute, are important sources of fiber. The woody plants in aquatic habitats as floodplains, river banks, and in mangroves are important sources of timber and fuelwood.

Though some algae cause nuisance, majority of them plays an important role in the food chain of fishes. Bluegreen algae with the ability to fix atmospheric nitrogen, are an important nitrogen source especially in the paddy fields. Many algae have also been shown to have medicinal value and some like *Spirulina, Chlorella* and *Scenedesmus* are a rich source of protein for humans as well. The saline alga, Dunaliella is an important source of carotenes. Whereas some aquatic organisms (mosquitoes, snails) are seen as vectors of human disease causing organisms, other such as leeches have also been used in medicine.

Loss of and Threats to Aquatic Biodiversity

Aquatic biodiversity of inland waters is increasingly threatened by many anthropogenic factors. Ever increasing human population places a direct pressure on the limited resources through increasing demand for meeting the basic needs (e.g., for drinking and agriculture) as well as the cultural needs (e.g., waste disposal). However, real threats come from the anthropogenic activities that cause biophysical changes in and around aquatic ecosystems, and the policies that govern these activities aimed at economic development (Gopal 2005).

For aquatic environments, alterations in the hydrological regime constitute the most important cause of loss or degradation of habitats that threaten or even eliminate aquatic biota. Diversion of river flows by constructing dams and weirs (barrages), construction of embankments, and modification of surface runoffs in many ways by human activities in the watershed directly change the water regimes and hence, the aquatic flora and fauna. These are accompanied by changes in the amount of sediments and nutrients transported to the water bodies. Deforestation, agriculture and urbanization of the watersheds right up to the headwaters of most rivers contribute to the already high sediment load of the rivers. Natural aquatic habitats have been degraded and transformed extensively by conversion to paddy fields and aquaculture farms Aquatic habitats are further lost by drainage and landfill to reclaim land for other land uses, particularly agriculture and extension of urban settlements. Eutrophication and pollution from toxic substances are the next most important threats to aquatic biodiversity. Despite huge investments in diversion and treatment facilities for domestic sewage and industrial effluents, especially in the Ganga basin since 1985, wastes continue to be discharged into rivers and lakes with only partial or no treatment. The intensive agriculture dependent upon heavy use of agrochemicals (fertilizers and pesticides) is a major source of eutrophication and pollution as the agrochemicals find their way into surface waters with the runoff, subsurface flows and periodic floods.

Exotic invasive species, such as water hyacinth, *Salvinia molesta, Ipomoea fistulosa*, etc. are a major threat to the aquatic biodiversity. Water hyacinth has become an agent of habitat destruction. Several introduced fishes have become nuisance in numerous water bodies throughout the country, affecting native biodiversity (Dehadrai and Ponniah 1997). Often overexploitation of biological resources (fishing, plant harvest, grazing) is also common and impinges on aquatic biodiversity.

However, more serious threats from the socio-cultural changes, inappropriate economic development and policies, and the growing pressures of globalization, generally receive little attention (Gopal 2005, Gopal *et al.* 2008, Polunin *et al.* 2008). I would like to reiterate what I wrote few years ago. The policies related to the management of the country's water resources are the primary threats to the aquatic biodiversity. Corporatisation of water resources treating them as an economic good is starting to endanger the over-exploited and severely abused rivers, lakes and wetlands. The anchor at an international conference in Nepal, succinctly summarized the situation in the words, 'humans make the deserts bloom and rivers dry'. The policy- and decision makers fail to appreciate the long-term consequences of their short-sighted policies as the technocrats continue to suggest technological solutions to all kinds of problems. The requirements of water for the maintenance of goods and services provided by the aquatic ecosystems are currently totally ignored.

Conservation

Conservation is often considered synonymous to total protection and exclusion of all human influences. A distinction must be made between different kinds of

ecosystems - between terrestrial and aquatic systems as well as within the aquatic systems between the deep water systems and the wetlands - and the precise goals and objectives of conservation. Total protection may result in such changes in the habitat which are detrimental to the particular species or ecosystem functions. Wetlands differ from the deep water systems in that the former experience larger water level changes. Wetlands, particularly those in the tropics and subtropics, have for millennia interacted with humans and large grazing animals. Many of the values assigned to specific wetlands are often the product of these interactions and any interference with them results in a loss of values, including biodiversity values. Such impacts are exemplified by the well known Keoladeo National Park at Bharatpur where drastic changes in the vegetation and fauna have occurred following total ban or grazing and removal of biomass as fuel or fodder.

Conclusion

Our knowledge of biodiversity and its functioning in aquatic ecosystems is extremely poor. It requires serious and urgent efforts towards detailed taxonomic studies of all biota and preparation of identification keys for all groups of organisms especially arthropods. Aquatic microbial diversity and its role in the ecosystem functioning have to be accorded high priority. While a better understanding of the aquatic biodiversity will take some time, urgent steps are required to ensure that the aquatic habitats are not degraded further by anthropogenic activities *in situ* or in their watersheds.

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Greylag Geese, Patna Wildlife Sanctuary (Photo credit : Neeraj Srivastava)