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Ecological Health of Wetland Ecosystem: An overview

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Abstract

Wetlands are unique, productive ecosystems where terrestrial and aquatic habitats meet. Wetlands play a critical role in maintaining many natural cycles and supporting a wide range of biodiversity. Wetlands can also contribute to the wellbeing of the community by acting as urban green spaces which provide aesthetic appeal, landscape diversity and recreational opportunities. Globally wetlands are under threat due to altered hydrology, destruction of vegetation, fragmentation, dumping of waste, being drained and other anthropogenic reasons. Wetlands provide numerous ecological goods and services but are under tremendous stress due to rapid urbanization, industrialization and agricultural intensification. An inventory of wetlands of any region is a pre-requisite for their conservation and management. One of the aims of monitoring is to provide information for ecological assessment, which can provide early warning of changes that could negatively affect species or ecosystems.

Keywords: Avifaunal diversity, ecological health, indicator taxa, macrophytes, wetland.

Introduction

Assessments of wetland ecosystem health play an important role in the development of robust protection and use strategies for wetlands that integrate ecological and socio-economic aspects (Wu et al, 2018). Wetlands are amongst the most productive ecosystems on the Earth (Ghermandi et al., 2008), and provide many important services to human society. Wetlands are frequently described as the kidneys of the earth because of the wide range of environmental functions and ecological benefits.

Wetlands are unique, productive ecosystems where terrestrial and aquatic habitats meet. Wetlands play a critical role in maintaining many natural cycles and supporting a wide range of biodiversity. They purify and replenish our water, and provide the fish and rice that feed billions. They serve as a natural sponge against flooding and drought, protect our coastlines and help fight climate change. Bursting with biodiversity, wetlands are a vital means of storing carbon. Wetlands are also tremendously productive ecosystems that provide a myriad of services to society worldwide (CBD Press brief, 2015). Wetlands are a critical part of our natural environment. They protect our shores from wave action, reduce the impacts of floods, absorb pollutants and improve water quality. They provide habitat for animals and plants and many contain a wide diversity of life, supporting plants and animals.

Ecological health of wetland ecosystem

'An increased understanding of the functioning of wetland systems has led to the realization that good wetland management benefits both wetland ecosystem health and human health. This affects people in all social, economic and geographic categories. Although this is a complex correlation, immediate multisectoral action is essential in order to minimize the risks and maximize the benefits to human health and well-being of good wetland management.'

This was the consensus reached by the 80 members of the global development, aid and conservation communities who discussed these issues at a symposium entitled 'Healthy Wetlands, Healthy People' held in Shaoxing, People's Republic of China, on 8 November 2007, and hosted by Wetlands International and the People's Government of Shaoxing City. Participants noted that 2008 would be the UN International Year of Sanitation.

The slogan 'Healthy wetlands, healthy people', which was also the theme of the 10th meeting of the Conference of the Contracting Parties (COP10) in 2008, implies an interaction between wetland ecology and management and the health of people, with consequent social and cultural interactions between people and wetlands. This is seen as an extension of the multi-disciplinary approaches adopted through the Millennium Ecosystem Assessment (2005) and subsequent global assessments that have addressed human well-being and ecosystem services. The linkage between ecosystem services and human health is consistent with the Ottawa Charter for Health Promotion, which recognized as prerequisites for health: peace, shelter, education, food, income, a stable ecosystem, sustainable resources, social justice, and equity (World Health Organization, 1986).

Ecosystem services from wetland ecosystem

Ecosystem services have been described by the Millennium Ecosystem Assessment (2005) as "the benefits that people receive from ecosystems" and they are broadly categorized as provisioning, regulating, cultural, and supporting services. By incorporating ecosystem services within ecological character (Ramsar Convention, 2005a), the Ramsar Convention has explicitly recognized the links between the components and processes and the services provided by wetlands. Wetlands provide numerous ecological goods and services but are under tremendous stress due to rapid urbanization, industrialization and agricultural intensification, manifested by the shrinkage in their area extent, and decline in the hydrological, economic and ecological functions they perform.

Wetlands can also contribute to the wellbeing of the community by acting as urban green spaces which provide aesthetic appeal, landscape diversity and recreational opportunities. The interactions between people and ecosystems have received more attention in recent years with the Millennium Ecosystem Assessment (2005) providing an assessment of the consequences for human well-being of ecosystem change. The Assessment was based on synthesized information and it added value to existing scientific information rather than generating new primary knowledge. In this manner it established with high certainty that as a result of human actions the structure and functioning of the world's ecosystems changed more rapidly in the second half of the twentieth century than at any other time in human history. A major consequence of these changes is that biodiversity globally is being depleted at an accelerating rate, with wetlands amongst the most adversely impacted ecosystems (Revenga et al., 2000; Dudgeon et al., 2005; Falkenmark et al., 2007). Changes in land cover and use have resulted in major transformations in wetlands with substantial gains for human well-being and health from the production of food, but there are concerns whether this is sustainable (Foley et al., 2005).

Many ecosystems have been managed as though they were disconnected from the wider landscape, with scant regard for maintaining the ecological components and processes that underpinned their ecological character (Molden et al., 2007). The consequences of such approaches include the loss of fisheries, loss of storm protection and nutrient retention, with negative feedback on food and fibre production. Human health has also suffered, for example, directly through increased prevalence of insect-borne disease or through changes in diet and nutrition or the loss of ecosystem properties that control erosion and ameliorate floods (Corvalan et al., 2005a,b). Poor people in rural areas who use ecosystems directly for their livelihoods are likely to be the most vulnerable to such changes in ecosystems (Millennium Ecosystem Assessment, 2005).

Wetlands in India

India, with its varying topography and climatic regimes, supports diverse and unique wetland habitats (Prasad et al., 2002). Ramsar Convention on Wetlands, which is an international treaty signed in 1971 for national action and international cooperation for the conservation and wise use of wetlands and their resources, defines wetlands (Article 1.1) as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". So as per the Ramsar Convention definition most of the natural water bodies (such as rivers, lakes, coastal lagoons, mangroves, peat land, coral reefs) and manmade wetlands (such as ponds, farm ponds, irrigated fields, sacred groves, salt pans, reservoirs, gravel pits, sewage farms and canals) in India constitute the wetland ecosystem. Only 26 of these numerous wetlands have been designated as Ramsar Sites (Ramsar, 2013). However, many other wetlands which perform potentially valuable functions are continued to be ignored in the policy process. As a result many freshwater wetlands ecosystems are threatened and many are already degraded and lost due to urbanization, population growth, and increased economic activities (Central Pollution Control Board, 2008). Lack of conformity among government policies in the areas of economics, environment, nature conservation, development planning is one reason for the deterioration of these water bodies (Turner et al., 2000). Urban wetlands have not always been valued and many have a history of degradation and today many still face problems of ecological damage and loss (Zedler and Leach, 1998; Standish et al., 2013; Hettiarachchi et al., 2015).

Indicator species

Indicator Species (IS) are living organisms that are easily monitored and whose status reflects or predicts the condition(s) of the environment where they are found (Landres et al., 1988; Bartell, 2006; Burger, 2006). In 1919 Hall and Grinnell were among the first to use the indicator concept by associating plant and animal species to particular 'life zones' (i.e., large geographic areas with similar structural and compositional characteristics). Wetland vegetation plays an important role in improving water quality through extraction and/or filtering of pollutants (e.g., nitrates) and amelioration of pathogens including coliform bacteria and faecal streptococci (Ghermandy et al., 2007; Verhoeven et al., 2006; WWDR, 2006).

Waterbirds as bioindicators

Waterbirds are bioindicators of wetland ecosystems, because they quickly respond to any changes in vegetation composition and water level fluctuation as compared to other animals (Siriwardena et al., 1998; Kerbs et al., 1999). "Waterbirds" refers to the bird species that entirely depend on wetlands for a variety of activities such as foraging, nesting, loafing, and moulting. Waterbirds have been shown to track environmental variations, at short (months) and long (years) temporal scales, and at both species and community levels (Nudds, 1983; Amat et al., 1985; Guinet et al., 1998; Abraham and Sydeman, 2004; Almaraz and Amat, 2004; Rendón et al., 2008). Second, because many species are top predators and several contaminants often accumulate along the trophic chain, such species may be used as indicators of changes occurring at lower trophic levels (Burger and Eichhorst, 2005). And third, either the waterbirds themselves or their prey are exploited by humans (e.g., hunting and fisheries), so that hunting bags of waterbirds may be indicative of productivity in nesting areas or breeding parameters of birds may inform on fish stocks (Einoder, 2009).

Birds are sensitive to both direct and indirect environmental influences. They can indicate changes in: vegetation extent, pattern and structure (Finch, 1991), standing water extent, depth, duration and seasonal frequency (Wakeley and Roberts, 1994), water quality (Hoyer and Canfield, 1994) and disturbance (Craig and Barclay, 1992). Birds are therefore valuable as ecosystem change indicators because they often respond to cumulative effects of environmental influences on the system (Sekercioglu, 2006). Birds are affected both directly and indirectly by hydrologic changes. Species that are likely to be the most sensitive indicators of water levels might be those that(a) nest along water edges, (b) feed on mudflats (e.g., shorebirds), (c) require a particular combination of wetland hydroperiod types in a region (Kantrud and Stewart, 1984).

Vegetation distribution and its dependency by animals, especially avian population facilitates significant ecological interactions (Monyet al., 2018). Resources, especially the dependent nature of faunal communities over the producers of floristic components are require to be monitored (Jha, 2013). Particular characteristics of the waterbody including the vegetation in and around the waterbody, as well as bank material, make them unique, and the bird assemblages are probably dependent at different times and in various cycles on this assortment of environments. This suggests that to support species diversity and local livelihoods, enough land must be set aside to allow for redundancy in waterbody types so that if one type is lost, others with similar characteristics would be able to maintain the same species assemblage (Mistry et al., 2008).

The ecological health of any wetland ecosystem is mainly based on the existence of avian fauna, which forms the terminal links through establishing several aquatic food chains. In response to this phenomenon, birds' habitat preference for their stay reflects the prevailing ecological conditions of the wetland ecosystem (Gaston and Fuller, 2008).

Habitat diversity

Habitat diversity plays a pivotal role in wildlife management, especially to its conservation. The pivotal role of floristic population in the wildlife conservation has been given due consideration by researchers (Bibi and Ali, 2013). The habitat determines the composition of avifauna in the wetlands. The macro-scale vegetation, in terms of whether the wetland is situated within flooded grassland or flooded forest, is the overriding factor influencing bird communities. Within flooded grassland habitats, birds are determined by the geomorphic characteristics of the waterbody and can be divided into bird communities of ponds and those of main river channel and associated waterbodies (Mistry et al., 2008).

The importance of habitat type for bird communities in wetlands ecosystem was studied by many workers viz., Davidar et al., 2001; Gillespie and Walter, 2001; Kessler et al., 2001; Waltert et al., 2005; Rompré et al., 2007. In particular, characteristics of floristic diversity, composition and structure have been associated with tropical bird species richness and composition (Freifeld, 1999).

Discussion

The ecological quality of the lake water i.e., whether it is oligotrophic or eutrophic (on the basis of nutrient content), its pollution status can be determined by indicator species. Indicator species are very much sensitive and responsive to subtle changes of their environment. The change in diversity and abundance of these indicator species are used to assess the influence of various pressures. Sammiah and Singh (2004) mentioned the species diversity of waterbirds as pollution indicator. Macroinvertebrate organisms are another faunal community in wetland ecosystem. They have body size greater than or equal to 0.5 mm. They are the primary consumers and determine the secondary productivity. They are important food source of the avifauna. Natural adequate macrophytes and macroinvertebrate diversity clearly indicate high primary and secondary productivity. Roy et al., (2011) reported positive correlation between bird density and gross & net primary productivity. Prakash and Sharma (1995) found the feeding behaviour of aquatic birds in relation to the population density of macrophytes, molluscs, insects and fishes. Macrophytes are important as producer organisms of the ecosystem. They determine the primary productuvity on which the whole faunal species must depend. Besides food source, submerged macrophytes are specially important as they are used as the roosting sites of migratory birds (Ray et al., 2011). Patra et al*.,* (2010) indicated positive impact of submerged macrophytes on avifaunal abundance.

The excretory materials of the birds are rich in phosphate and other nutrients. These are partially digested products and are in readily available form. So, nutrient addition directly increases GPP and secondary production. Thus birds can play significant role in increasing their own density. Patra et al., (2010) found positive correlation between phosphate content increase (due to avifaunal defecation and addition of guano) & bird density in Santragachi jheel. Manny et al., (1994) reported about nutrient additions by waterfowl to lakes and reservoirs & the positive impact of this on primary productivity.

Pollution leads to over enrichment of nutrients. In this case, invasive floating macrophytic species such as *Eichhornia sp* get the chance to overpopulate within very short time. They also act as pollution indicator here. Their excessive growth can create problem by two ways. i) water surface gets totally covered. Sunlight cannot penetrate properly. Photosynthesis becomes lowered. Gross primary production (GPP) also becomes lowered accordingly. Reduced primary production directly lowers secondary production. Ultimately food availability for the birds would be scarce. (ii) excessive floating vegetation limit the proper growth of other essential macrophytic population. Instead of floating invasive species birds roost on submerged macrophytes consequently reduction in food and site availability would reduce avifaunal diversity. Ghosh and Chattopadhyay (1994) worked on biological resources in Santragachi jheel lake in Kolkata. Patra *et al* (2010) found remarkable decline in avifaunal density in hypereutrophic site of Santragachi jheel. Ge et al., (2009) found a steady, negative correlation between vegetative cover and waterbird density.

Dale and Rutledge Connelly (2012) in the Special issue of Wetlands Ecology and Management stresses upon the research work on some aspects of wetland viz. first about constructing wetlands with the aim of retaining the ecosystem services and wetland value; second is about manipulating wetlands to restore or to maintain wetland function.

Conclusion: Need for an inventory to assess wetland ecological health

Wetlands are also ecologically sensitive and adaptive systems (Turner et al., 2000). Wetlands are biologically diverse and significantly much productive ecosystems and also form as the most fragile (Garg, 2015). Globally wetlands are under threat due to altered hydrology, destruction of vegetation, fragmentation, dumping of waste, being drained and/or filled for 'development', receiving contaminated storm water, exploitation and local extinction of fauna, invasion by feral animals and plants, excessive nutrient loading, pressure for recreation infrastructure and vandalism (Millennium Ecosystems Assessment, 2005; van Asselen et al., 2013; Davidson, 2014). An inventory of wetlands of any region is a pre-requisite for their conservation and management. One of the aims of monitoring is to provide information for ecological assessment, which can provide early warning of changes that could negatively affect species or ecosystems (Burger, 2006). Indicator species would aid in assessing the ecological health of a wetland ecosystem.

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