

Aquaculture In Mangrove Ecosystems of India : State-of-Art and Prospects

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Introduction

The mangrove vegetation spread over 0.35 million hectares (Saenger *et al.*, 1983) accounts for less than 1/10th of the extensive coastal ecosystems of India. It's an experience that the coastal ecosystems which are intricately diverse are equally high productive biotopes accounting for 60% of the world's seafood production, through capture and culture fisheries (Lie, 1983).

Mangrove Environment

Like most of the other coastal ecosystems, mangroves also have characteristic environmental and biotic features with varying magnitude of interaction. As an ecosystem, the mangrove habitat represents a transitional area between the terrestrial and marine zone and thus forms an integral part of the intertidal or littoral regime with the seaward expanse, at time, extending into subtidal, also. Here, besides the conventional air, land and water interaction, also in the action are the extremes of various interactions between the freshwater and the salt water and their impact on biota. Accordingly, mangroves associated with the mid and the upper reaches of an estuary are progressively more terrestrial in affinity and increasingly influenced by fresh rather than salt water tidal flooding (Kestner, 1963).

The magnitude of variability in the mangrove ecosystem is intriguing (Table 1). Effect of temperature in the mangrove ecosystem is three dimensional with distinct variations in space and time. While during the low tidal phase, the air temperatures are more effective than during the flood tide, depending on the tidal amplitude and the natural gradient, the water temperature also exhibit wide variations. The soil or interstitial temperature, in contrast, display range values of higher magnitude than the air and water temperatures.

The salinity variations are more pronounced and often more sudden in a mangrove ecosystem than in an estuary. However, the variability in salinity is maximum in interstitial water column, mainly because of high evaporation during low tide, coupled with the

Table 1. Annual cycle of environmental characteristics in a mangrove ecosystem

Parameter	Type	Maximum	Minimum
Temperature (°C)	Air	35.6	20.0
	Water	30.1	23.5
	Soil	32.0	25.2
Salinity (‰)	Water	30.4	0.12
	Soil	35.7	12.80
Dissolved (ml/l) Oxygen	Water	4.6	2.0
	Soil	3.1	0.54
Organic (mg/l) Matter (mg/g)	Water	18.33	3.19
	Sediment	52.92	8.68
Suspended (mg/l) solids	Water	960	44

retention of salts due to the structural peculiarities of the substratum. The dissolved oxygen content in the mangrove water column is relatively of a low magnitude, probably due to the presence of high oxidizable matter originating from mangrove litter (Teixeira *et al.*, 1969). Low oxygen tension, mainly due to high organic matter content and low capillary interspacing, is a redeeming feature of the interstitial water table.

High organic inputs from decaying mangrove foilage and debris combined with circulation, results in the formation of pools of high organic matter in the mangrove sediments. In contrast, the organic matter content in the mangrove water column (Table 1) is analogous to that of an estuary (Parulekar *et al.*, 1980). Extremely high values of suspended solids are invariably linked-up with land run-off, lack of vigorous water motion and the prevalence of fine silt particles. Development of substratum in mangrove ecosystem is mainly due to coarse silt or fine sand and with the addition of finer particles of silt and clay, the substratum becomes more cohesive (Kestner, 1963). While seaward fringes of a mangrove are muddy, the landward fringes are invariably sandy. Thus, the substratum in the mangrove environment having fine grained sediments with calcareous debris is characterized by high salt content, low oxygen and high organic content with the dominance of cellulose and lignin fractions.

Biotic components of mangrove environment with the possible exception of mangrove vegetation itself, is an admixture of marine, limnetic and terrestrial ecosystems. Being a composite of terrestrial,

estuarine and marine organism, numerous interactions between the biota of terrestrial and aqueous habitat, the mangrove vegetation and their environment, are on view (Chapman, 1974). Essentially an intertidal or littoral area, the mangrove ecosystem subjected to the lack of vigorous water motion, active sedimentation of fine particles and a relatively sheltered location with high detritus content, is a stressful habitat, which makes the biota either to adapt to the wide range of environmental variations or else, evolve, mode of life, that will minimize the adverse effects (Parulekar, 1984).

Though the species of terrestrial origin contribute more than 50% of the biota, the aquatic species are reported to be more important in the energetics of the mangrove ecosystem (Teal, 1962). Macnae (1968) in a classic review on the fauna and flora of mangroves in the Indo West Pacific region, has commented that there exists on all shores of mud or mixed mud and sand, a biota which is not found elsewhere and of which certain elements demand the shelter of vegetation. The faunal and floral elements are always found to be associated with mangroves.

While the floral aspects of mangrove ecosystem are relatively well studied, the faunal or zoological elements are usually understudied and disparantly presented (Plaziat, 1975). As mangroves are best developed under estuarine conditions, the productivity process, like in an estuary, are on a higher level of efficiency. The main contributors are of course the mangrove plants themselves, algal colonies on the pneumatophores and substratum, seagrass and phytoplankton communities in the associated bays, gullies and creeks (Hamilton and Snedaker, 1984.,

High natural productivity and shallow estuarine waters provide conducive environment for a wide variety of biota in different stages of life cycle. However, no correlation is reported to exist between the phytoplankton biomass, benthic biomass and exploitable fish yield (Pant *et al.*, 1980). It means that only a minor part of the large primary production is consumed directly by animals. Major part enters the mangrove food web as dead organic matter i.e. detritus which is either utilized within the mangrove environment or transported in degraded form into adjoining estuary.

From 7910 sq. km. area of Indian sector of Sundarban mangrove vegetation, a commercial fishery has been reported, sustained by as many as 87 species of fish which contribute almost 80% to the total estuarine fishery yield of India. However, it is established that the primary habitat of these species constituting the "so called" mangrove fishery, are the shallow bays, inlets and creeks that form an integral part of the estuary which also harbours the mangrove vegetation (Hamilton and Snedaker, 1984.) Recently, Achuthankutty

and Parulekar (1985) have also reported that out of 4 species of commercially important penaeid prawns in the coastal waters of Goa, only one species has its post-larval and adolescent stages of its life cycle in the mangrove ecosystem.

Aquaculture In Mangrove Ecosystems of India

Inspite of being a none-too-ideal aquaculture site, the mangrove ecosystem, mainly the estuaries and backwaters, fringed by mangrove vegetation, have long been used (Hora and Pillay, 1962) for the rearing and/or fattening of prawns, bivalves and finfishes. Though Ong (1982) has reported that the mangrove is nature's own aquaculture system with a number of advantages, several costly experiences have indicated that mangrove environments are not necessarily the optimum locations for maricultural ponds (Hamilton and Snedaker, 1984). Thus the aquaculture in mangroves, signifies a case of necessity prevailing over suitability.

For the past many centuries, the conversion of mangroves for paddy and coconut cultivation alongwith sitting of fish ponds, is in vogue in the coastal zone of India. Such areas, to name a few are "bheris" in West Bengal, "Chemeeen kettu" in Kerala, "gazani" in Karnataka, "khazan" in Goa and "khar lands" in Maharashtra and they reportedly cover an area of about 45,000 hectares (Parulekar and Dalal, 1978) and an annual yield of about 15,000 tons of prawn and 30,000 tons of bivalves, crabs and fishes (Palomares, 1985).

In the "bheris" of West Bengal, the production in rice-cum-brackishwater aquaculture is on an average 576 kg/ha of fish and prawn in 6 months and 2-4 tons/ha of paddy (Ghosh *et al.* 1985). In the "Chemeeen kettu" fields of Kerala, the production of shrimp and paddy is reported (Vannucci, 1984) to be 865 kg/ha/season and 500-1200 kg/ha/season, respectively. While dealing with the traditional methods of aquaculture in "khazan" lands of Goa, parulekar and Verlencar (1976) identified three type of fish farming, namely, "manas" or permanent fish pond; "mitache agar" or salt-cum-fish farming and paddy-cum-fish culture in mangrove dominated estuaries. Commonly cultivated species are *Penaeus monodon*, *P. indicus*, *Metapenaeus monoceros*, *Mugil cephalus*, *Chanos chanos*, *Eetroplus suratensis* with associated species like, *Lates calcarifer*, *Lutianus* sp. *Gerres* sp. and *Thenus* sp. While permanent fish pond had seasonal yield of 1065 kg/ha; the corresponding figure for paddy-cum-fish farming and salt-cum-fish farming was 830 kg/ha and 350 kg/ha, respectively. Profit margin varied from 47.7% in salt-cum-fish farming to 100% in permanent fish pond.

The general consensus based on the analysis of cost factors, pond management efficiency and annual production levels, has indicated that the disadvantages of sitting of large scale commercial

aquaculture ventures in mangrove areas outweigh the advantages and should be resorted to only in the absence of other options (Hamilton and Snedaker, 1984). However, the scientifically managed aquaculture operations in mangrove ecosystem are relevant to less developed and developing countries where considerations of minimum use of capital, simplicity of operation and low cost, low price product and a substantial effective demand, favours it (Sheperd, 1974).

In India, especially in the last decade, a number of experimental aquaculture farms, have been developed in the mangrove ecosystem or in estuaries lined with mangrove vegetation. However, only a few published accounts are available for evaluation. In a brackish water fish farm constructed by reclamation of mangrove swamp adjoining the Kakinada Bay (east coast of India), Dwivedi and Reddi (1977) have reported prawn and fish production, varying from 1390 kg/ha to 2220 kg/ha with prawns alone contributing, between 170 kg/ha and 264 kg/ha. Prabhu Matondkar (1978), while working on the culture of mullets and pearl spot in a fish farm surrounded by mangrove vegetation, observed a net increase in fish biomass of 803.34×10^3 gC, during the culture period (time of stocking to time of attaining the marketable size) and a high rate of return of 75% on the investment. Similarly, in the raft culture of green mussels (*Mytilus viridis* L.) in mangrove lined open estuarine farm in Goa, Qasim *et al.* (1977) have observed a high yield of 480 tons/ha/yr with a rate of return of 181% on the investment.

A resume of case studies, cited above, indicates that in specific cases of aquaculture in mangrove ecosystem of India, as elsewhere, economic and social benefits may outweigh management problems. Experiences in Thailand, Ecuador and Panama have shown that salt flats and other lands on the landward side of the mangrove vegetation are suitable for pond prawn culture (Hamilton and Snedaker, 1984). While any substantial increase in capture fisheries of India, is thought to be rather uneconomical, only other logical course of action for fulfilling the realistic demand of fish proteins, will be from culture fisheries or aquaculture and towards it mangrove vegetation, as an integral part of extensive coastal ecosystems of India, will offer scope for utilization. As rightly pointed by Qasim (1977) that if aquaculture is practised on proper lines, the present seafood production of India can increase several times within a few years and thus should be able to generate considerable employment potential in rural areas and substantially, boost national economy.

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