Ecology of Indian Estuaries: Part II—Ecology of Seagrass Bed of *Halophila ovalis* (Hook) in the Ashtamudi Estuary, SW Coast of India

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Standing stock of *H. ovalis* varies from 3.6-48 g.m \(^{-2}\) (dry) with the salinity range of 12.46-27.05 \(\times 10^{-3}\) and the flowering occurs during January. The inorganic nutrients of the overlying water in the seagrass bed show wide fluctuation. Correlation between density of plant growth and inorganic nutrients of overlying water and chemical and textural properties of the sediment is noted in the seagrass ecosystem.

Seagrass meadows are highly productive and dynamic ecosystems\(^1,2\). They are conspicuous and widespread biotopes in the shallow marine environment throughout the world producing a great amount of organic material and also offering a good substrate for a variety of epiphytic algae, diatoms and sessile fauna\(^3\). Eight species of *Halophila* Thouars have been recorded in the coastal waters of both temperate and tropical seas\(^4\). From India 6 genera comprising 9 species of seagrasses have been reported\(^5\). In India, incidence of *Halophila ovalis* Hook is observed along the coasts of Goa, Madras, Okha, Dwaraka and other places in Kathiawad\(^6\) and from the Ashtamudi estuary\(^7\). The present study pertains to some of the ecological aspects in relation to the standing stock of *H. ovalis* in the estuarine ecosystem.

Materials and Methods

Sampling was done at Kanjirakode, the interior most segment of Ashtamudi estuary (lat. 8°53'-9°2'N; long. 76°41'.76°51'E).

Monthly triplicate samples of seagrass were collected from June 1980 to May 1981 using a quadrat of 25 cm\(^2\) and the wet and dry weights were taken. Temperature, light penetration, pH, salinity, dissolved oxygen and inorganic nutrients (PO\(_4\)-P; NO\(_3\)-N; NO\(_2\)-N and SiO\(_2\)-Si) of the overlying water were estimated during the same period. Substrate samples were taken using a metal corer\(^8\) (6.6 cm. internal diam. and 21 cm long) covering a surface area of approximately 34 cm\(^2\) and a sediment volume of 718 cm\(^3\). A portion of sediment for chemical analysis was oven dried at 100-105°C overnight. The dried samples were ground and sieved through 0.5 mm and 0.5 g of the material was taken for the estimation of organic carbon\(^9\). Estimations of total phosphorus, total nitrogen and total potassium were also carried out\(^10\). Grain size analysis was done using international pipette method\(^11\).

Results and Discussion

In Fig. 1 biomass values of *H. ovalis* both by wet and dry weight basis are shown. Data on dry wt. m \(^{-2}\) are presented as standing stock following McRoy and McMillan\(^2\). The average standing stock of *H. ovalis* varied from 3.6 to 48 g.m \(^{-2}\) (dry) during June to Jan. The available data indicate that the standing stock of tropical, subtropical and temperate seagrasses such as magnocasterids and enhalids are in the range of 0.5-1.5 kg.m \(^{-2}\) (dry) and the parvozosterids, syringodiids and halophiilds are in the range of 100-200 g.m \(^{-2}\) (dry)\(^4\). These values are much higher than those noticed for *H. ovalis* in the present study.

Temperature variations of the overlying water in the seagrass bed area were between 28.4°C in Jan. and 32°C in June (Fig. 2). The minimum temperature in Jan. coincided with the peak biomass [322 g.m \(^{-2}\) (wet) and 48 g.m \(^{-2}\) (dry)]. The flowering of *H. ovalis* was noted during Jan. whereas in the Mandovi estuary\(^6\) the flowering season of *H. beccari* was during Sept. and Oct. with the temperature variation of 26-33°C.
Though the flowering is noticed during the lowest temperature period this value is not a limiting factor in the tropical areas. The present study and the studies on \textit{H. beccari} in the Mandovi estuary support this and the temperature variation in these areas is narrow unlike in temperate waters where temperature fluctuations affect the germination, seedling development, vegetative growth and reproduction.\cite{12}

Salinity of the seagrass bed area showed a fluctuation between 12.46 and 27.05 x 10^{-3}, the variations were gradual and regular with maximum value during premonsoon and the low values during the monsoon (Fig. 2). As a consequence of ecological differences during monsoon seagrass density varied from 5 to 25 g.m$^{-2}$ (dry). The influx of turbid freshwater affects the healthy growth of seagrass and even decay is noticeable. The influence of salinity lower than 28 x 10^{-3} is confined to flowering of many seagrasses in temperate waters\cite{13,14}, and these investigations were confined to coastal communities. In the present study the flowering is noted during postmonsoon period when the average salinity was relatively high.

Studies on the effects of suspended sediment on the growth of seagrass are scanty. The effect of suspended particulates on the light penetration is a major growth limiting factor of seagrasses\cite{15}. The values of light penetration varied between 0.61 and 1.99 m in the bed and minimum values were recorded during the monsoon and the decline in the standing stock was also obvious during the season. The turbid and polluted waters from the Kallada river enter the estuary with heavy loads of suspended particulates and this naturally prevents light penetration which would hinder photosynthetic activities. Maximum growth of \textit{H. ovalis} was noted during the postmonsoon and the premonsoon when the transparency was high.

$\textit{pH}$ varied only slightly with a minimum (7.4) in Dec. (Fig. 2). The oxygen content of the overlying water fluctuated between 3.05 and 11.5 ml.l$^{-1}$ between Oct. and April. The influence of $\textit{pH}$ and dissolved oxygen on the standing stock is apparently not significant. Seagrasses are capable of absorbing nutrients across the surface of the leaves or roots\cite{16} and therefore, the nutrient cycle is more complex. The inorganic phosphate and nitrate of the overlying water ranged between 3 and 11.5 \textmu g.at.l$^{-1}$ (in June and Oct.) and 1.62 and 15.9 \textmu g.at.l$^{-1}$ (in June and Dec.). Relatively higher values were obtained during postmonsoon period. The increase in the weight of standing stock is noted from Oct. and the flowering is encountered during this high nutrient period. The nitrite and silicate values showed a reverse pattern with higher values during monsoon and lower values during postmonsoon (Fig. 3).

![Fig. 2-Seasonal variations in physico-chemical factors of overlying water](image)

The organic carbon content in the sediments fluctuated from 6.45 to 11.55 mg.g$^{-1}$. An increase during postmonsoon period indicates that the role of allochthonous organic matter input is minimal and the increase may be from autochthonous sources mainly from the decomposition of macroalgae and seagrasses which are subject to stress and destruction during monsoon. This observation is supported by Gordon and Wetzel\cite{17} according to whom the inputs of organic matter through the decomposition of aquatic macrophyte are often greater than those from planktonic and allochthonous sources. The total nitrogen content in the sediments varied from 0.19 to 1.05 mg.g$^{-1}$ and relatively higher values were noticed during postmonsoon. The highest level in the bed was during postmonsoon when there was higher density of

![Fig. 3-Seasonal variations of inorganic nutrients of overlying water](image)
plant growth, an observation that agrees with that of McRoy and McMillan\textsuperscript{2} that nitrogen can also be absorbed across the leaves and so the bed could provide large amount of nitrogen. Total phosphorus and potassium in the sediments varied between 1.41-3.43 and 0.05-1.05 mg g\textsuperscript{-1} respectively. The substratum with rich autochthonous phosphorus (2.9, 2.23, 3.4 and 1.76 mg g\textsuperscript{-1}) and potassium (1.35, 0.05, 1.5 and 0.6 mg g\textsuperscript{-1}) during postmonsoon period may be the possible reason for the dense growth of plants.

Seagrasses alter the prevailing sedimentation process in a variety of ways, but the major effects are to increase the sedimentation rates, to concentrate preferentially to finer particle sizes, and to stabilise the deposition\textsuperscript{18}. The leaves of \textit{H. ovalis} with a film of fine sized sedimentary particles are noticeable throughout the year and this may be because of the mucilage on the leaves. The trapping of sediments by the leaves is the possible reason for the dense growth of plants. During the monsoon when the substratum in the meadow area was dominated by coarse sand (92.56\%) the plant density was low and during postmonsoon when the clay dominated the substratum the density of the seagrass was high. Moreover the percentages of silt and clay were considerably higher within the seagrass meadow than in the surrounding areas which showed an average 5.2\% of mud whereas in the bed the percentage of mud varied between 11.08\% and 12.89\% during monsoon and the postmonsoon respectively. Burrell and Schubel\textsuperscript{19} discussed the efficacy of seagrass in binding and stabilizing sediments with plant density, blade size and rhizome system. In the present study however, the density of plants was found to have little influence on the sediment binding. The influx of freshwater during the monsoon lowers the salinity of water, the river discharge brings in large loads of alluvium into the area. Thus it is seen that the physical factors play a crucial role in the biological cycle of this seagrass in this part of the estuary resulting in great destruction to this meadow.

The reestablishment and rejuvenation of the meadow occur only during postmonsoon when conditions are favourable for the lush growth with abundant nutrients in both ambient water and in the sediments. Under those conditions \textit{H. ovalis} flourishes when the overlying water is clear and exposed to sufficient sunlight for photosynthesis.

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References
5 Santapau H & Henry A N, \textit{A dictionary of the flowering plants in India} (CSIR, New Delhi) 1973, 198.