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Studies on Seagrasses in relation to some Environmental variables from Chilika Lagoon, Odisha, India

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Abstract

Chilika lagoon has been studied from different angle in different aspect by several authors. The seagrasses have not been studied from Chilika lagoon so far. Five species of seagrasses i.e. Holodule uninervis, Holodule pinifolia, Halophila ovalis, Halophila ovata and Halophila beccarii have been observed from four stations namely Rambha, Palur Canal, Samala and Nalabana Island during February 2013 to November 2013. The highest water temperature was observed to be 31.0 ^{0}C and lowest temperature was observed to be 22.0 ^{0}C in station -2 and station -4 in the month of April and November 2013respectively. The highest and lowest pH was observed to be 8.9 and 7.0 during June and November 2013 from station -4 and station -1respectively. Likewise, the highest dissolved oxygen was observed to be 8.6 mg/l in station -4 for the month of Septenber and the lowest dissolved oxygen was observed 3.4 mg/l in station -3 for the month of July 2013. The variation of salinity was observed to be 5.1 ppt to 20.6 ppt in station -2 and station -3 for the month of August and April. The highest total organic carbon was observed to be 1.6 mg/l in station -2 for the month March and the lowest total organic carbon was observed to be 1.01 mg/l in station -4 for the month of September 2013. The highest total suspended solid was observed to be 25 mg/l in station -4 for the month of August 2013 and lowest total suspended solid was observed 12 mg/l for the month of April, May, September and November 2013 in station -2, 3, 1 and 3 respectively. The highest total dissolved solid was observed 510 mg/l in station -2 for the month of February and the lowest dissolved solid was observed to 210 mg/l in station-4 for the month of July 2013. Likewise the variation of total hardness was observed to be 130 to 460 mg/l in station -2 and station -3 for the month of August and February 2013.

Keywords: Seagrass, environmental variables, Chilika Lagoon, India.

Introduction

India has a long coastline of about 8129 Kms and 8.5 million hectare of coastal expanse forming sheltered bays and lagoons supporting an array of various floral and faunal biodiversities. In India, seagrasses are found principally in Gulf of Mannar and Palk Bay, Kalpani and Kadmat Islands of Lakshadweep, Andaman and Nicobar Islands, Uppanar and Vellar estuary in Tamil Nadu and are new inhabitants to Chilika lagoon in Orissa[1]. They are called 'seagrass' because most have ribbon-like, grassy leaves, but none is a true grass. Seagrasses have roots, stems, leaves and also reproduces by pollination. The roots and horizontal stems (rhizomes), often buried in sand or mud, anchor the grasses and absorb nutrients. Leaves are usually green and attached on vertical branches which also absorb nutrients. There are about 57 species of seagrass found all over the world. Seagrasses are found in coastal waters from tropical to temperate regions. They are mainly found in bays, estuaries and coastal waters from the mid-intertidal (shallow) region down to depths of 50 or 60 meters. Most species are found in shallow inshore areas. Seagrasses inhabit all types of ground, from mud to rock. The number of sea grass species is greater in the tropics than in the temperate zones. Only two species, *Halophila ovalis* and *Syringodium isoetifolium*, occur in both temperate and tropical regions. Over 30 species can be found within Australian waters. The most diverse seagrass communities are in the waters of north-eastern Queensland and are an important part of the flora in the Great Barrier Reef region. Seagrass communities are one of the most productive and dynamic ecosystems. They provide habitats and nursery grounds for many marine animals which are discussed in the text. While these marine plants thrive in nutrient rich areas, the wrong mix of nutrients can be lethal if conditions persist for a long period. Direct human impacts are seen in areas where seagrass beds are dredged for piers, channels and other coastal development[2]. The beds stabilize sediment and help to maintain high water quality by filtering out nutrients from terrestrial inputs, trapping sediment, recycling nutrients within the ecosystem and sequestering carbon. They also serve as enormous nurseries for hundreds of species of commercially important fin fish and shell fish. In addition to this it helps in ecotourism, coastline protection and in the production of global commercial fisheries. In a global perspective point of view India has also sea grass beds which are few and inadequate. Today, India is home for more than fifteen species of seagrasses found in different coastal areas of Eastern, Southern and Western parts of India. Most of the species are found in healthy numbers along the Southeast coast (which is the Gulf of Mannar and the Palk Bay), coast of Tamil Nadu, and the sporadic islands of Lakshadweep and Andaman and Nicobar. The most important

location for seagrasses in India is the Gulf of Mannar Biosphere Reserve, which is estimated to have more than 13 of its species. The most common species of seagrasses found in India are: *Cymodocea rotundata, Cymodocea serrulata, Cymodocea, Thalassia hemprichii, Halodule uninervis, Halodule pinifolia, Halophila beccarii, Halophila ovata, Halophila ovalis*. Seagrasses are known to flourish in coastal areas that have good salinity levels, clear waters, adequate sunlight, and minimal strong water currents. The coastal belt of India is favorable for the seagrasses as it provides the optimal conditions for the growth and survival of seagrass. Large regions and a major stretch of coastlines of the country are still unexplored for sea grasses. As brief list of Seagrass species in India as well as in Chilika lagoon is depicted in table-1.

Five species of seagrass are found in the Chilika lagoon these are *Halophila beccarii, Halophila minor, Halophila ovalis, Holodule pinifolia and Halodule uninervis*. Seagrasses can form extensive monospecific strands or areas of mixed strands, such areas are known as Seagrass meadows or beds[3,4]. These grasses like plants are usually found in beds or meadows patterns on mud or sand in shallow waters[5,6]. A seagrass bed is a complex ecosystem. It is an important source of primary production. It provides food and shelter for marine fauna and provides nursery grounds for juveniles. In addition, the seagrass ecosystem helps in stabilizing nutrient cycles, enriching bottom sediments and improving water quality. It also protects shorelines from erosion by storms and waves[7-9]. Five species of seagrasses are found in 6 stations of Chilika lagoon, East coast of India. The main threats to seagrasses of Chilika lagoon includes natural hazards (storms, floods etc), and human disturbances including dredging, inappropriate fishing, anchoring, coastal constructions, coastal aquaculture etc. Because of these threats, an appropriate action plan for sustaining seagrass management is required immediately. For such conditions, it is required to identify and locate the seagrass species in various stations of the Chilika lagoon for future seagrass sustenance and further research on them. Seagrasses acts as a shelter, breeding and nursery ground for many juveniles fin and shell fishes. These are not only helping for the enhancement of biodiversity in and around the locality but also reduce turbidity and water quality. The green sea turtles and some endangered species utilize seagrass leaves as their food. The seagrasses after their death decompose and they provide food for the microscopic organism. Seagrasses are very sophisticated plant which cannot tolerate higher salinity and murky water. It is used as raw material for paper making and also used for making fertilizers. Besides this these are used as fodder and also used to make soil fertilize by decomposition. A little research work has been done on the identification and distribution of various types of seagrasses found at different stations of Chilika lagoon but no study has been done on water quality parameters with respect to distribution of sea grasses .Therefore the present work is attempt on the studies on the Seagrasses with respect to some hydrological parameters from Chilika lagoon, Orissa.

Study Area: Chilika is the largest brackish water lagoon of India as well as of Orissa state. It is in latitude of 19º28'-19º54' N and longitude of 85º05'-85º38' E (figure-1). It stretches over three districts namely Puri, Khurda, and Ganjam. The pear shaped, low latitude tropical lagoon owes its shape to the presence of delta of the Mahanadi river in northern part, the rocky hills of the Eastern Ghats and a barrier spit separating the lagoon from the Bay of Bengal. It is the largest tropical lagoon in Asia and the largest lagoon in India and having unique physiography. The lagoon is separated from the sea by a sand bar formed by the waves and wind in the fore-shore area. The sand bar acts as a barrier island between the lagoon and the sea. The lagoon is connected to the sea by a narrow, zigzag channel which opens into the Bay at Arakhakuda. Recently, one artificial mouth has been opened near Sipakuda by Chilika Development Authority in September, 2000 and another mouth has naturally opened during August, 2008 near Gabakunda. The morphology of Chilika lagoon suggests that it can be divided into four sectors such as northern sector, central sectors, southern sectors and outer channel. Each sector is having its own unique hydrographic features. Northern sector having typical low salinity waters due to strong influence of distributaries of Mahanadi and several small fresh water streams that join the lagoon. Southern sector having higher salinity and central sector have variation in salinity level. The outer channel is influenced by the Bay water. The study area was surveyed in different seasons, viz., pre-monsoon, monsoon and post-monsoon (February, 2013 to November, 2013) from four selected sites, namely, Rambha light House, Palur canal, Samala Island, Nalaban Island. Rambha light House is located southern sector of the lagoon situated at latitude of $19^0$31'27'' North and longitude of 85^0 07' 5'' East which is about 50 km from Berhampur University campus. Salinity is generally slightly higher as compared to other two sectors. This station is having muddy bottom and water depth varies from 67cm to 102 cm. Palur Canal is located extremely southern sector of Chilika lagoon and it connected to Bay of Bengal by a narrow stretch of channel. It is popularly known as Sahaeeba canal which is situated at latitude of $19^0$28' 35'' North and longitude of 85^0 08' 26''East. This station is having sandy clay bottom and the water depth varies from 40cm to 48 cm. Samala Island is located in middle of southern and central sector of latitude of 19^0 33' 51'' North and longitude of 85^0 9' 93'' East of average water depth 65 cm to 95 cm. Nalaban Island is located in central sector which cover about 25 sq. km of average water depth 60 to 72 cm present in latitude of 19^0 35' 51'' North and longitude of 85^0 17'29''East. This is a hillock with huge exposed hanging rocks. Nalabana Island, in Oriya language means a weed covered island. The island is covered with herb, shrubs, trees, creepers, aquatic plants and with the predominant species like *Phragmites karka*[11].

Materials and Methods

Seagrass sample and hydrological parameters were collected regularly at monthly interval of time for ten month starting from

February 2013 to December 2013. Seagrass were collected using quadrate sampling method of 1-1 square meter area. The physico-chemical parameters such as air temperature (AT), water temperature (WT), pH ,salinity, dissolved oxygen (DO), total organic carbon (TOC), total suspended solid (TSS), total dissolved solid (TDS) and total hardness (TH) were collected during monsoon, post monsoon, and pre monsoon seasons. Multiple samples were taken from each study site than the average has been calculated and cited. All samples were brought to the laboratory of P.G. Department of Marine Sciences, Berhampur University and the analysis was made using standard methods of APHA 2005.

Results and Discussion

Seagrasses are angiosperm flowering plants bearing roots. They possess their mineral from the nature of substratum to which they are firmly attached. The growth, reproduction and physiology of seagrasses are influenced by quality of water. During the field survey period we found five species of seagrasses inhabiting the Chilika Lagoon in different sectors. They are *Halodule uninervis*, *Halodule pinifolia*, *Halophila ovalis*, *Halophila ovata* and *Halophila beccarii* and their Latitude and Longitude are recorded by a Geo Positioning System (G.P.S) respectively. For their growth, proliferation development and reproduction, it depends on the hydrological condition of the area. Therefore, it is essential to study the hydrological condition of the area. The abundance of seagrass and their distribution in relation to some hydrological parameters were studied during February 2013 to November 2013 from four station of Chilika lagoon. The study was conducted for ten consecutive months from February 2013 and was ended in November 2013. The study was carried out in the different stations such as; station-1: Rambha, station-2: Palur canal, station-3: Somala, and station-4: Nalabana Island (figure-1). The parameters were considered for the water quality study from various stations were air temperature, water temperature, pH, dissolved oxygen, salinity, total organic carbon, total suspended solid, total dissolved solid and total hardness. The highest air temperature was observed to be 35^0C in station-2 for the month of May 2013 and the lowest air temperature was observed to be 23^oC in station-4 for the month of November 2013 (table-3). The highest water temperature was observed in station-2 for the month of April 2013 being 31^oC and the lowest water temperature was observed to be 22^oC in the station 4 for the month of November 2013 (table 3). The highest pH was observed to be 8.9 in station-4 for the month of June 2013 and the lowest pH was observed in station-1 being 7.0 for the month of November 2013 (table 3). Likewise, the highest dissolved oxygen was observed to be 8.6 mg/l in station-4 for the month of September 2013 and the lowest dissolved oxygen was observed to be 3.4 mg/l in station-3 for the month July 2013 (table 3). The highest salinity was observed to be 20.6 PPT in station-3 for the month of April 2013 and the lowest salinity was observed to be 5.1 PPT in station-1 and 2 for the month of August 2013 (table 3). The highest total organic carbon was observed to be 1.6 mg/l in station-2 for the month March 2013 and the lowest total organic carbon was observed to be 1.01 mg/l in station-4 for the month of September 2013 (table 3). The highest total suspended solid was observed to be 25 mg/l in station-4 for the month of August 2013 and the lowest total suspended solid was observed to be 12 mg/l for the month of April, May, September and November 2013 in station -2, 3, 1 and 3 respectively (table-3). The highest total dissolved solid was observed to be 510 mg/l in station-2 for the month of February and the lowest total dissolved solid was observed to be 210 mg/l in Station-4 for the month of July 2013 (table 3). Likewise the highest total hardness was observed to be 460 mg/l in station-3 for the month of February 2013 and the lowest total hardness was observed to be 130 mg/l in station-2 for the month of August 2013 (table-3). The water samples and the seagrass samples were collected systematically from four station of the Chilika lagoon and were brought to the laboratory for further analysis. The seagrasses were washed and taken for identification using different literature and books.

Key to the Identification of Seagrasses from Chilika lagoon: Halophila beccarii (figure-2): Division- Magnoliophyte, Class-Lilliopsida, Order-Alismatales, Family-Hydrocharitaceae, Genus-Halophila, Species-*beccari.* It is a monoecious plant having, rhizome. Root is present at each node. Lateral shoots are erect which can grow up to 2 cm long. *H. beccarii* was observed on the lower part of the eulittoral zone of the Chilika lagoon. The seagrass is associate with other seagrass species like H.ovalis and *Halodule pinifolia* in the sandy soil of the lagoon.

Identifying Characters: Leaves generally measures 6-10 cm. Petioles are appeared to be arranged in whorl with 2 scales at the base. Leaves are provided with prominent mid rib and there is no cross veins on the leaves. Inflorescence is solitary and flowers are auxiliaries in position. Perianth is transparent white and sepals are with darker midrib. The female flowers may measure up to 1.7 cm long and the ovary is oblong consisting of 2-4 ovules.

Ellipsoids to ovoid fruits have been observed with 1 to 4 seeds. Seeds are globose, reticulate, hard, reddish brown in color.

Halodule pinifolia (figure-2): Division- Magnoliophyte, Class-Lilliopsida, Order- Alismatales, Family-Cymodoceaceae, Genus-*Halodule*, Species-*Pinifolia:* It is a dioecious plant. The plant is supplied with rhizomes which are slender and branched. Creeping roots are present originating from each node. It is observed from sandy to muddy soil of the Chilika lagoon.

Identifying Characters: Leaves generally measures about 1-6 cm long and 1-5 mm width. Leaves are supplied with prominent midribs. Lateral ribs form lateral teeth on apex of the leaf. Flowers are sheathed with leaves. Sepals are not well arranged. The ovary ovoid with filiform terminal styles and later on becomes sub terminal or lateral during fruit bearing stage. Globose fruits with persistent lateral styles. Seed coat hard with ornamentations

Halodule uninervis (figure-2): Division- Magnoliophyte,

Class-Lilliopsida, Order-Alismatales, Family-Cymodoceaceae, Genus-*Halodule,* Species- Uninervis: These plants are dioecious. Creeping rhizome are present which are branched and moniliferous. Roots are generally unbranched at each node. Plants are generally abundant in sandy bottom of the lagoon.

Identifying Characters: Shoots generally measures up to 30cm long which are straight having 2□4 leaves in each branch. Leaves are linear, narrowed at base with sheath, entire margin with 3nerves. Midribs are conspicuous and lateral ribs are inconspicuous ending with good developed lateral teeth at the leaf top. Male flowers are sessile and enclosed in leaf sheaths. Ovary is ovoid in shape with 2□3 slender, smooth, terminal in style. Fruit is subglobose to ovoid, usually in pairs with persistent styles.

Halophila ovata (figure 2): Division- Magnoliophyte, Class-Lilliopsida, Order- Alismatales, Family- Hydrocharitaceae, Genus-*Halophila,* Species-*ovata:* It is a dioecious plant. Rhizomes are fleshy and unbranched. Solitary roots are present which measures up to 5- 6cm long provided with root hairs. It was collected from calm and shallow areas of Chilika lagoon. The plant populated in sandy surface to muddy bottom.

Identifying Characters: Leaves are usually paired at each node. Lamina is transparent, oblong and glabrous with 4-24 mm long petiole. Flowers are solitary and axillary in position which covered by spathes. Female flowers are sub sessile. Fruits are generally ovoid in nature with 20 numbers of seeds. Seeds are globose and beaked at both the ends. These are appeared to be white in young stage and becomes brown during mature.

Halophila ovalis (figure 2): Division- Magnoliophyte, Class-Lilliopsida, Order-Alismatales, Family Hydrocharitaceae, Genus *Halophila,* Species-*ovalis:* It is a dioecious plant which is branched supplied with creeping slander rhizomes. Single root is present provided with root hairs at each node of the rhizome. The species has been observed in northern as well as southern sector of the lagoon which are having different environment with salinity. The plants are abundant in coarse sands and muddy bottom of the logoon.

Identifying Characters: Leaves are supplied with paired long petiole at each node. The leaf with petiole may extend up to 5-13 cm long. Flowers are generally solitary and axillary in position covered by two spathes. Three tepals are present which are broad and elliptic in nature. Ovary is ellipsoid with 1□celled pointed apex. Ovoid to ellipsoid fruit supplied with 18□27 seeds. Seeds are globose in shape with white color when they are young and become brown when mature.

Discussion: The physical and chemical parameters obtained from the field surveys from Chilika lagoon are suitable for the proliferation of delicate species of seagrasses. The major factors for distribution, growth and variability of sea grass are the sediment, light, water depth, and salinity. Firstly, the sediment is considered to be the most important material for the survival of the seagrasses. The roots of seagrasses anchor to the sediment on which they grow, and obtain their nutrients from the sediments itself. The field observation and results shows that seagrasses colonizes benthic habitats that are most commonly characterized by soft substrates i.e. sand and mud. The inclusion of sediment structure, composition and stability of seagrasses related studies has a potential to contribute for a better understanding of the factors that affect nutrient dynamics, sediment geo-chemistry, eutrophication, substrate anoxia, sulphide toxicity, bioturbation and seagrass health. The Second important abiotic factor most required for survival of seagrasses is Light. Light is defined as the electromagnetic spectrum causing sensation of vision. It is the ultimate source of energy on which all food producing organisms depend. Light is divided into various parts in response to biological significance. Out of various parts, wavelengths between 400-760 nm are required for sustaining life and are known as visible light and others have a catastrophic effect. Using light obtained from sun plants convert inorganic matter to simple carbohydrates. When the light strikes the surface water, a part of total light is reflected back. Then the light entering the water also gets attenuated due to scattering, absorption. The fate of light also depends upon the transparency of water. Again the transparency of water depends upon stirring, riverine discharges and plankton productivity. The maximum depth limit for seagrass is determined largely by depth to which sufficient light intensity for sustaining plant growth reaches the bottom known as "Compensation depth". The minimum light requirement for seagrass has been identified at 10-20% of surface light, higher than other marine plants, presumably because of high photosynthetic demand to survive rooted in anoxic sediments. Below, the minimum light requirements, seagrass will die, as light intensity increases, seagrass growth will increase linearly. Different species of seagrasses have varying light requirements; the depth of distribution for many species may vary widely; a reduction in light reaching the substrate may vary Seagrass species composition by enhancing growth of species having low light requirements or may reduce depth of distribution. In shallow water and intertidal seagrass photosynthesis and production are inhibited by exposure to high light conditions. Such photo inhibition can prevent the proliferation of some species and result in a distribution that favors more high light tolerant species. Water depth is another major factor for assessing distribution and growth of gentle species of seagrasses. Greater the water depth not only reduces light and attenuates some light frequencies, but also increase the hydrostatic pressure on seagrass plants. Inhibition of photosynthesis in deeper waters; *Halodule uninervis* results from excessive hydrostatic pressure. Salinity is yet another factor in determining growth and distribution of seagrasses. Many studies from around the world have described changes in distribution and abundance in seagrasses and upper estuarine submerged macrophytes along spatial and temporal salinity gradients. Changes in different levels of salinity cause a decline in seagrasses. In Chilika, during field surveys conducted, we

found five species of seagrasses — *Halodule uninervis*, *Halodule pinifolia*, *Halophila ovalis*, *Halophila ovata* and *Halophila beccarii* (figure-2) in the stations of Rambha, Palur canal, Somolo, Nalabana, occurrence of *Halodule uninervis*, *Halodule pinifolia* and *Halophila ovata* from the lagoon are new. Prior to the opening of the new mouth of the lagoon, the most common seagrass recorded was *Halophila ovalis* that is more tolerant of low salinity and low light. However, after opening of the new mouth, it was found to exhibit good growth and gradually observed to spread even to deep-water zones. It was also found in the deep waters from the creeks of Krishna Prasad Island with prolific growth during post-monsoon months forming extensive meadows. The opening of the new mouth provided stable salinity regime with little fluctuations, improved water clarity, especially in post-monsoon and summer months, favorable for the growth of seagrass communities. This resulted in the proliferation of the seagrass beds into deep-water zones and appearance of species like *Halodule uninervis*, *Halodule pinifolia* and *Halophila ovalis* is a good sign to the plant diversity communities of the lagoon. The average water temperature ranged from 22^0C to 31^0 C corresponding to winter and summer month respectively. The average seasonal value of each station revealed that slightly higher value was observed near station-2 located in southern sector and this result is in agreement with result of Nayak *et. al*[12]. This may be due to degree of hotness and high evaporation of water and due to this temperature the sea grass seed may be germinated vigorously which is in partial agreement with the result of Kuo *et. al* 1990 [13] that some seed of seagrass *Phyllospadix iwatensis* had not germinated after 8 month when water temperature was $<10^0$ C but the seed was germinated when the water temperature reached $> 10^0$C in June and July in all the station. The variations of water temperature in different station from Chilika Lagoon were presented in figure-11.

The pH value showed that the lagoon water throughout the year remained alkaline. The pH in marine and brackish water system is always taken as a function of salinity. The result observed during the present study showed that the increase and decrease of pH followed the same trends as that of salinity (figure 11) which was reported earlier by Siddiqui *et. al*[14] and Nayak[15]. The Salinity value varied from 5 to 20 ppt. The low salinity value was observed during month of June to August in all the station and it could be attributed to large influx of fresh water from the river Daya, Bhargabhi and Nuna. The pattern of salinity distribution observed during present study is in general agreement with the result of Siddiqui *et. al* and Panda *et. al* 1989[14,16]. In condition of varying salinity[17] found that salinity was significant factor in lieu of growth of sea grass *Zostera marina* in summer when the light levels are high. The variations of salinity in different month with respect to different station were depleted which is shown in figure 11. The dissolved oxygen content of sea water exhibited very high degree of variation ranging from 3-8 mg/l. The high value of dissolved oxygen in lagoonal water could be co-related to the influence of the fresh water influx and release dissolved oxygen from the densely grown aquatic weed in lagoon. The present result of dissolved oxygen content can be comparable with the earlier observation of lagoonal system as reported by Nayak, 1998 and Asthana[15,18]. The variations of dissolved oxygen in different station in different season are presented in figure -11. The total organic carbon of lagoon plays a significant role in growth of seagrasses. In the present observation, the total organic carbon variation was from 1 to 1.09 mg/l and this result is in partial agreement with the result of Kamp *et.al* and Ward *et.al*[8, 19]. The variations of organic carbon in different station for different month from Chilika Lagoon are given in figure 11. The present study highlighted that the nutrient content of lagoon affected by the influence of fresh water as well as their replenishment from the sediment, as a consequences of salinity restoration. The further growth of seagrass shall be significantly in habited. Based on this result the present study can provide a guide line for the proper management strategy of lagoon system.

Conclusion

Seagrass is a vital indicator of coastal ecosystem and serve as spawning and nursery ground for a large numbers of fish and invertebrate species which play an important role in the food web of inshore ecosystem and provide a critical habitat for fish diversity. Six genus and 14 species belonging to two families are known from Indian coast. Despite a recent surge in research activity, studies on Indian sea grasses are scanty and inadequate. Large regions and a major stretch of coastlines of the country are still unexplored for seagrasses. From the above discussions, we conclude that the 5 species of Seagrasses inhabits the Asia's largest Salt water lagoon associating to its rich floral diversity. The lake also provides suitable conditions for the proliferate growth of Seagrasses. While seagrass meadows are declining globally, the meadows in Chilika have been expanding showing a very good sign of recovery of its ecosystem. The meadow, which was only 20 sq.km in the year 2000 (before the hydrological intervention), has expanded to 80 sq.km after restoration. Wild life experts are hoping the highly endangered dugong or sea cow could again visit Orissa's Chilika Lake. It is a great challenge to wetland planner and researcher to conserve and maintain a healthy habitat for the sea grasses. The expanding beds of seagrass growing in the shallow waters could be a critical requirement for the big marine animal. Thus, it has become imperative to carry out advanced study to monitor the seagrass meadows of Chilika, because the seagrasses of Chilika lagoon are valuable for future need. Now it is facing threat. Hence an appropriate management plan is needed urgently so as to reserve the biodiversity.

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Table- 1
Status of seagrasses found in India and Chilika lagoon

Family	Genus	Species	Authors
Hydrocharitaceae	*Enhalus*	*acoroides*	(Linn f.) Royle.
	Halophila	*beccarii*	Ascherson.
	Halophila	*minor*	(Zollinger) den Hartog
	Halophila	*ovalis*	(R.Brown) Hooker f.
	Thalassia	*hemprichii*	(Ehrenberg)Ascherson
	Halophila	*decipiens*	Ostenfeld
	Halophila	*ovata*	Gaud
	Halophila	*stipulaceae*	(Forsskal) Ascherson
Cymodoceaceae	*Cymodoceae*	*rotundata*	EhrenbergandHemprichexAscherson
	Halodule	*pinifolia*	(miki) den Hartog
	Halodule	*uninervis*	(Forsskal) Ascherson
	Syringodium	*isoetifolium*	(Ascherson) Dandy
	Cymodocea	*serrulata*	(R.Brown) Ascherson
Ruppiaceae	*Ruppia*	*maritima*	Linnaeus.

Source: Kannan *et. al* 1999, Patnaik, 2003[10,1]

Figure-1
showing study area, In clock wise direction; Station -1 Light House (Rambha), Station-2 Palur Canal (Southern Sector), Station – 3 Samalo and Station-4 Nala Bana Island (Central Sector)

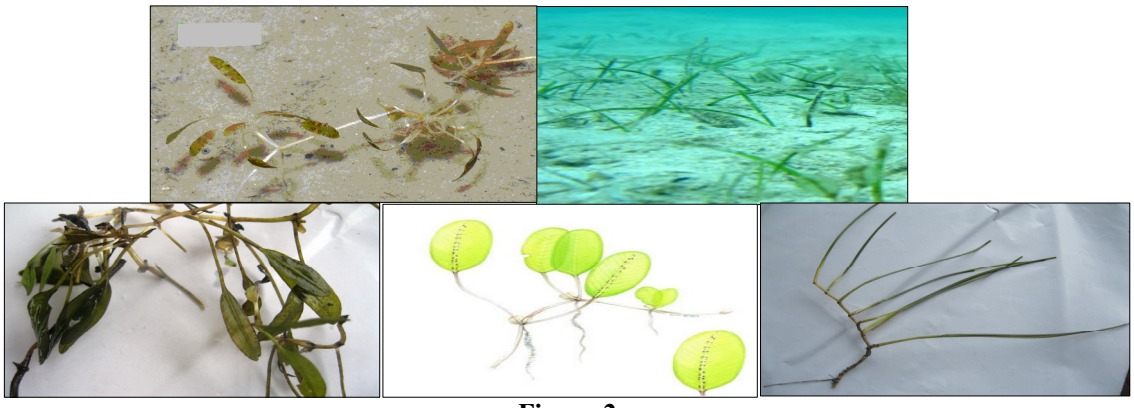

Figure-2
Seagrass species found in Chilika lagoon, In clock wise direction*; Halophila beccarii, Halodule pinifolia, Halodule uninervis, Halophila ovata and Halophila ovalis*

Table-2
Abundance and distribution of Seagrasses from different station of Chilika Lagoon

Station	Longitude	Latitude	Soil quality	Vegetation			
				A	M	L	T
Rambha	$19^0$31'27'N	$85^0$07' 5''E	clay	-	-	-	-
Palur canal	$19^0$28' 35''N	85^0 08' 26''E	Sandy clay	++			
Somala	19^0 33' 51''N	85^0 9' 93''E	clay	-	-	+	-
Nalabana	19^0 35' 51''N	85^0 17'29''E	Muddy clay	++			

A-Abundant, M- Moderate, L- Less, T-Trace

Table-3
Variation of Physico-chemical Parameters in Chilika Lagoon during February-2013 to November, 2013 from different Stations

Month	Station	A.T ˚C	WT˚C	pH	DO	Salinity	TOC	TSS	TDS	T.H
February	St.no-1	30	26	8.1	6	16.2	1.3	15	420	380
	St.no-2	31	27	7.8	7	16.8	1.4	13	510	450
	St.no-3	30	25	7.6	5.8	16.8	1.3	13	503	460
	St.no-4	30	26	7.9	5.6	16.2	1.2	17	430	340
March	St.no-1	32	28	8.1	5.3	18.4	1.5	14	430	350
	St.no-2	32	28	8.1	5.2	18.9	1.6	13	405	360
	St.no-3	33	27	8	5.1	18.6	1.2	15	407	380
	St.no-4	32	28	8	5.6	18.2	1.3	16	380	350
April	St.no-1	33	30	8.3	5.2	20.5	1.4	15	450	370
	St.no-2	34	31	8.4	5.3	20.3	1.3	12	460	360
	St.no-3	34	30	8.3	5.3	20.6	1.5	15	470	350
	St.no-4	33	29	8.2	5.6	19.5	1	15	460	380
May	St.no-1	34	30	8.6	4.2	19	1.2	13	430	360
	St.no-2	35	29	8.8	4.1	18.6	1.2	15	420	350
	St.no-3	35	29	8.2	4.2	18.6	1.3	12	410	354
	St.no-4	34	29	8.5	4.1	18.2	1.1	14	390	356
June	St.no-1	33.5	29	8.8	3.8	12.5	1.05	13	320	300
	St.no-2	32.5	29	8.5	3.6	12.6	1.03	14	335	290
	St.no-3	31.5	28	8.5	3.5	12.8	1.05	15	350	295
	St.no-4	31.6	28	8.9	3.6	12.5	1.06	13	328	310
July	St.no-1	29	26	8.8	3.8	6.5	1.2	20	218	180
	St.no-2	28	25	8.5	3.5	6.5	1.1	21	255	180
	St.no-3	29	26	8.3	3.4	6.9	1.1	21	220	150
	St.no-4	28	26	8.2	3.7	6.8	1.3	22	210	154
August	St.no-1	28	25	7.2	5.3	5.1	1.08	25	250	150
	St.no-2	27	24	7.2	5.6	5.1	1.09	21	240	130
	St.no-3	27.5	25	7.2	5.8	5.4	1.02	23	280	140
	St.no-4	26	23	7.1	5.2	5.4	1.06	25	250	150
September	St.no-1	28	26	7.3	8.2	9.5	1.05	12	300	200
	St.no-2	27	24	7.3	8.2	9.2	1.03	13	302	210
	St.no-3	26	23	7.4	8.5	9.2	1.02	14	300	200
	St.no-4	26	23	7.2	8.6	5.6	1.01	16	289	210
October	St.no-1	28	26	7.1	5.5	10.2	1.09	15	312	290
	St.no-2	26	24	7.6	5.4	10.3	1.08	17	325	290
	St.no-3	27	25	7.5	5.6	10.5	1.05	15	314	296
	St.no-4	25	23	7.5	5.9	10.9	1.05	14	290	300
November	St.no-1	25	23	7	5.1	10.9	1.2	14	220	300
	St.no-2	26	23	7.1	5.2	10.8	1.3	16	210	299
	St.no-3	25	23	7	5.1	10.8	1.2	12	214	296
	St.no-4	23	22	7.1	5.1	10.5	1.4	15	219	289

A.T= Air Temperature, W.T= Water Temperature, DO= Dissolved Oxygen, TOC= Total Organic Carbon, TSS= Total suspended Solid. TDS= Total Dissolved Solid, T.H= Total Hardness

Figure-11
Variation of physico-chemical Parameters in Chilika Lagoon during February-2013 to November, 2013 from different Stations

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