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Plant Ecology at Gulf of Cambay: A Review

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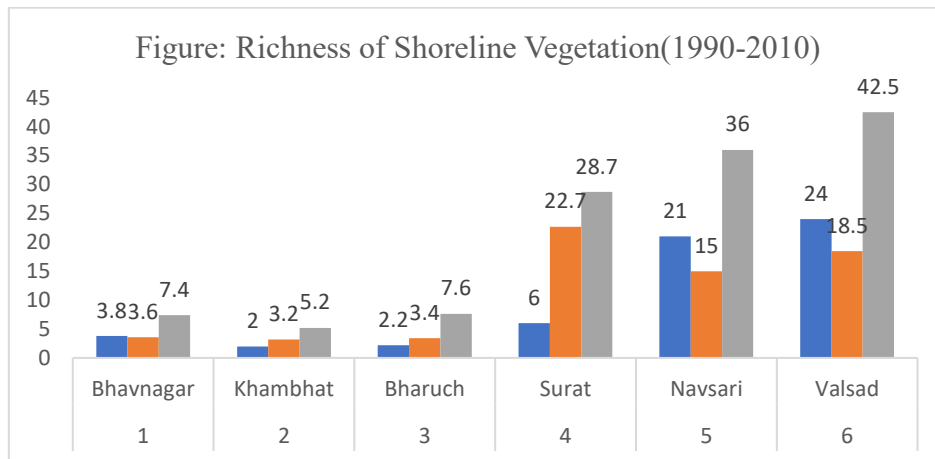
ABSTRACT: Coastal Ecology is a great area of active biodiversity on earth. It is a major part of productivity and also a major part to maintained biogeochemical cycle. Here the coastal ecosystem which we selected as our interest for the review work is very huge and affected by environmental and human made factors. Plant organisms like Coastal vegetation surviving in this area is such a great resilient power of ecosystem otherwise it could be eliminated easily. Area is highly influenced by soil, water and anthropogenic activities since many decades. Many mangroves species have been extinct and many are endangered. Coastal vegetation has been evaluated here to resist stress of salinity as well as heavy metals. The parts of plant excreted or eliminated such things by their plant parts seen easily. Here in this paper, we have disclosed biodiversity composition and their adaptation to be survived. The research completed by compiling diversity indices, soil and water parameters, species identification and different sampling methods utilised by many researchers. The data for research collected from many research papers published in this work from area like Bhavnagar, Khambhat, Surat, Bharuch, Navsari and Valsad coastal regions of Gulf of Cambay. We have identifying methods for identification of species composition.

KEYWORDS: Mangroves, Coastal vegetation, Species composition, Species diversity, Shannon-Weiner Diversity.

I. INTRODUCTION

The Gujarat state is habitated on the west coast of India between 20°06' N to 24°42' N latitude and 68°10' E to 74°28' E longitude, surrounded by the Indian Sea on the west which is most productive and functional ecosystems situated at transition zone like between land and sea in tropical and subtropical latitudes (Devi & Pathak, 2016). The Gulf of Khambhat is an extension by Indian Sea on the western coastal region of India, Gujarat approximately between latitude 20° 30' and 22° 20' N and longitude 71° 45' and 72° 45' E has Sabarmati and Mahi estuarine area nearly 5 km broad and extended towards south region of Surat coastal to Valsad coastal line. From north region to south region it is about 115 km in distance [39]. Extension of this Gulf approximately 3120 km² by mudflats with intertidal zones with rocky marine areas and sandy patches [33]. The Gulf of Cambay or Guulf of Khambhat is enriched by the constant sediments along with metals and minerals coming from major rivers such as Narmada, Tapi, Mahi, Sabarmati, Shetrunji and many minor rivers like Purna [77]. This major ecosystem comprising by many mangroves and mangroves associates, halophytes, estuaries, creeks, intertidal zones, mud flats, sandy land, rocks, island and human invasions. Coastal ecology is maintained by flora like mangroves and their associates, halophytes and also some grasses. Mangroves in a way of ecosystem services on earth has a great habitat where many animals breed and sea animals also developed. Identifying the vegetation composition of this region will help us to identify the niche also to understand the interactions between biotic as well as edaphic and climatic factors of the selected area. Here the area which we choose for the data research is Gulf of Cambay where mangroves are found along with their other associate plants and animals like if we say total 54 species of true mangroves and 60 mangrove associates worldwide have been found and also reducing due to anthropogenic or human activities [20]. By observing research data, we found that due to human related development, mangroves facing habitat loss and destruction, other highly developed and unusual invasive species as well as due to high population over exploitation and a course changes in climate change [86]. On earth mangrove forest cover is 1,46,500.00 km square of coastline [2]. In India total mangrove vegetation cover is 4,662.56 km square represents 0.14% of the total geographical area of India and 3% of Earth mangrove area. In India, Mangroves vegetation present in the latitude range 25° N and 25° S, including nine states with coastline, and 3 Union Territories [16]. In Gujarat coastal vegetation such like mangroves and associates cover is 1058 km square, which is the second largest area of tidal forest in India, next only to the Sundarbans (2155 km²) [64]. Like 43 percent is the largest mangrove richness in India is in Sundarbans, Bay of Bengal (Kathiresan 2018). We have some data collected from different research papers for the mangroves and mangroves

associates cover since decades [5, 33, 75]. Total mangrove cover at Gulf is with 52.46 km square for the period November 1999 (figure) [96].



Mangrove ecosystem is only the forest on earth where land, freshwater and marine water mixes to create great ecotone region resistant to high salinity, extreme tides, strong winds, high temperatures, low oxygen, and marshy soil [44]. Gujarat has two gulfs out of 3 major gulfs of India and the coastal area is found from south Gujarat (high rainfall area about 2500 mm) to north- west of Kachchh (low rain area about 250 mm only) has second largest area of mangroves in India (1058 km² square). About 99.4% mangrove forest area is represented by three mangrove areas; Gulf of Kachchh (15.2%), Gulf of Khambhat (10.1%) and Kachchh district including Kori creek (74.1%) and remaining 0.6% in Valsad and Navsari district [5, 39, 76]. It has been seen that varied ranges of tides, waves, cyclones, and currents in the sea could affect the physical as well as the biological conditions of the coastal ecosystem in area where clear cutting, hydrological changes, oil spills and climate change and more pressure on mangrove forests sites found [11]. In coastal vegetation mangroves are the species affected more because of coastal development projects and sever erosion, fodder and conversion of mangrove area to other forms of land use [4, 29]. Mangroves endlessly distressing by severe deprivation since 20 to 30 ages. Based on environmental studies degradation of mangroves and other coastal vegetation lengthwise with changes found in shoreline region, estuaries, mudflats, island, floodplains of Gulf of Cambay [73,33]. Such alteration can origin diminishes of flora and fauna of that habitat and so it is investigation topic to recognize the vegetation of the area at regular interval. Plants desired unchanging atmospheric state for its development. Constant and good atmospheric condition leads supreme growth of plants. India is the third richest country for mangrove biodiversity in the world, after Indonesia and Australia [82]. As per the review of [30] it is found that Mangrove ecosystems in the Philippines have been suffered from severe degradation attributable because of aquaculture industry during the last span, when the mangroves are converted for aquaculture purposes, various ecosystem services are traded for a single use. These changes can lead to further corrosion and the decline of various floral and faunal communities leading to drastic deviations in species composition and disruption of this vital life support system. Coastal vegetation like mangrove plants that can physiologically adapt to specific fluctuating environments, such like salinity, type of soil, and tides so that zonation is formed [11,30]. When we considered the data for species composition like some mangroves plant like *Avicennia marina* is found most overriding and dominating as well as rapidly growing species over the coastal line and covers the major area along the Gujarat coast while *Rhizophora mucronata* is very occasional to be found and also force to be disappeared from many sites which is found in reduction of mangroves species. Gulf of Cambay region where *Avicennia marina* is high in abundance which can withstand more harsh environmental conditions such as high salinity, high temperature etc [22, 59]. It is conceivable that higher thickness of *Avicennia marina* at Bhavnagar may reason for decrease in plant growth due to competition happens for getting less adequate or restricted resources [56, 105] Pollution creates huge role at coastal region of Gulf of Cambay like the region affected by ground water pollution, low level of dissolved oxygen (less than 4 mg per ml), high COD (greater than 50 mg per ml) like in Ankleshwar, Chorasi and Olpad of Surat coastal region where the TDS level is very high (3000-7000 mg per ml) [39]. High number of industries are present on Surat and Bharuch coastal area that constantly affecting mangroves vegetation. As per the study by different articles found that Gujarat had huge mangroves half a century ago but it was reduced by in 1970s. Even with fewer mangroves area at Gulf of Cambay reported to have rare mangrove species force be in endangered. By study of various research articles, it is initiate that *Avicenniaceae* is most dominant mangrove family. By research study it is also seen that heavy metal pollution

in the sea water and sediments has prolonged in recent days [51, 52, 53, 54]. Mangroves biodiversity and ecosystem are affected highly by abiotic factors [106]. Heavy metal infection in mangrove is a major disease which could be diagnose for the study of coastal vegetation. [65, 106]

II. METHODOLOGY

Study site and location of field work:

The research area is Gulf of Cambay coastline of Gujarat also known as Gulf of Khambhat (GOK). Study site is a great biodiversity region which is affecting by many natural and anthropogenically affected also having many species of mangroves and mangroves associates. Many rivers in this zone to sea water and so there could be a possibilities of freshwater mangroves species as well as chance of species extinction here. As per research study some freshwater mangrove species like *Heritiera fomes* and *Heritiera globosa* become endangered due to sedimentation, erosion and superfluous nutrients. *Heritiera globosa* is a rare species confined to western Borneo, while *Heritiera fomes* is more widespread in south Asia, but has experienced important declines in many parts of its range because of coastal areas affecting by storms, erosion, tidal waves, and floods [19, 28]. As per many researches the Coastal area of Gulf of Khambhat could be divided in to different major zones like Valsad, Navsari, Surat, Bharuch, Khambhat and Bhavnagar as well as some estuarine regions made by Mahi, Sabarmati, Purna and Par rivers are also selected for study purpose.

Selection of coastal vegetation for study:

High or sparsed patch of dense mangroves and associates found we selected for study purpose. Coastal vegetation which we considered for research purpose as well as selected to collect as data are approximately 1 km far from low tide region of sea side and towards the beach within 500 meters. True mangroves plants considered as well as the other angiosperms surviving with such plants or grown beside the mangroves are considered as mangroves associated.

Sampling and data collection:

As per the research study there could be a strip split plot sampling technique was used to determine the biodiversity or the species of mangroves and associates of the study area. Three 100-meter transects lines, which are by 30 meters apart from each other were arranged at in site which are at 90 degrees perpendicular to the baseline established along the coastline. A total of 5 quadrats measuring 10m x 10m were laid in each sampling site. Five quadrats were performed in each of the 100meter line transect with 10m distance between plots end to end [67].

Species composition and identification:

Species Composition and Identification could be done by as the local or ethnobotanical name of the mangroves and mangroves associates at coastal site in situ with the help of a local people of that region and was further classified taxonomically up to the species level by the help of taxonomical tool like “Monographs of Halophytes” as well as “Mangroves of Gujarat”, “Atlas of Mangrove” as well as field guide to mangroves done by many research scientist as well as taxonomical aid like herbarium at Gujarat Ecological and Research (GEER) Foundation and Botany Department of Gujarat University could be utilised.[7,11,31,45,96]

Species diversity and richness:

Main tool to identify species composition and saturation of particular area can be done by Species diversity or richness index was identified by using Shannon index (H), Simpson’s index of diversity (H’) by many research scientists. Both the indices help in quantitative explanation of mangrove’s habitat in terms of species distribution and evenness. Table 1 shows the standard categories of species diversity index (H’) [67]. Gini-Simpson and Lande’s similarity index are used to determine the similarity among the species. (Jost, 2006; Marino et al, 2019). For the research purpose we could also calculate Menhinick's Index (MN) for species richness as well as Pielou's evenness index (e) and Shannon evenness index to find out species evenness of mangroves particularly and understand the coastal vegetation of that specific region. By research we could compared similarities between two sites or more than two sited where opposite diversity richness found as well as research sites where species richness found nearly similar (Table).

Shannon-Weiner Diversity (H’):

$$H' = -\sum (p_i * \ln p_i), S / i=1$$

Where S = total number of species, pi is the proportion of individuals to the ith species expressed as a portion of the total cover and ln is the log base n [47, 94, 95]

Effective Number of Species (ENS) using Shannon Wiener index:

$ENS = e^x$

Where e is a constant with a value of 2.6818 and x = Shannon-Weiner species diversity value(H') (Shannon & Weaver 1963, Simpson 1949, Kerkhoff 2010).

Gini-Simpson index:

$$x = 1 - \sum_{i=1}^S p_i^2$$

Where S, is the total number of species, p_i is the proportion of individuals to the i th species expressed as a portion of the total cover and ln is the log base n.

Effective Number of Species (ENS) using Gini Simpson index:

$ENS = 1/(1-x)$, Where x is the Gini-Simpson index [67].

Lande's similarity index:

Lande's Index = $[1/(1-x_1)]/[1/(1-x_2)]$; where x_1 is the effective number of species in site 1 and x_2 is the effective number of species in site 2 [67]

Relative value	H' value
Very high	Greater than 3.50
High	3 to 3.49
Moderate	2.50 to 2.99
Low	2 to 2.49
Very low	Less than 1.99

Heavy metal analysis:

For analysis of certain heavy metals which are directly affected the growth of coastal vegetation samples could be collect from the sites where heavy sedimentation found, from the respiratory roots of mangroves and normal roots of some mangrove's associates. For metal analysis like Hg, As, Sb, Pb and Cd method could be use which was suggested by [3] as well as Mohammed et al. and [106].

III. RESULT AND DISCUSSION:

Many species of mangroves if we say in number then it could be more than 10 to 14 species have been identified and more than 15 species of mangroves associated also been identified by many research scientists in different coastal zones of Gulf of Khambhat. By many research paper it is proved that maximum number of mangroves species present in region like Piram Bet, Alang, Gogha of Bhavnagar, Kavi of Khambhat, Olpad, Hazira and Dumas of Surat, Karadi, Jalalpore, Gandevi, Bhat of Navsari and Jambusar, Aliyabet and Dahej of Bharuch, Magod and Umarsadi of Valsad are the good sites for future research study. There are 54 species of true mangroves and 60 mangrove associates worldwide and number of mangroves species reducing due to anthropogenic or human activities (Cudiamat & Rodriguez, 2017). As per the study of research papers at gulf of Khambhat some species of true mangroves which are of different families like *Avicenniaceae*, *Acanthaceae*, *Combretaceae*, *Euphorbiaceae*, *Rhizophoraceae*, *Sonneratiaceae*. True mangroves from *Avicenniaceae* and *Rhizophoraceae* families are high in number at Gulf of Cambay region. There could be a chance of new species found at the region and also many of species are in endangered or near to extinction. As per the study of research papers certain members of genus *Sonneratia* and *Limnizera* known to be in a probability to extinction in a status by the International Union of Conservation of Nature (IUCN) Red List (Duke, 2010). As per the study of research papers many mangroves associate are present at gulf of Khambhat like *Acacia nilotica* (L.) Del (Mimosaceae), *Aleuropes lagopoides* (L.) Pellegrin (Poaceae), *Anthrocneum indicum*, (Willd) (Chenopodiaceae), *Atriplex griffithi*, Moq. (Chenopodiaceae), *Chenopodium album* L. (Chenopodiaceae), *Clerodendron inerme* (L.) Gaertn. (Lamiaceae), *Cressa cretica* L. (Convolvulaceae), *Derris trifoliata* Lour. (Fabaceae), *Grewia subinequalis* DC. (Tiliaceae), *Halopyrum mucronatum* (Linn) Stapf (Poaceae), *Ipomoea biloba* Forsk. (Convolvulaceae), *Ipomoea pes-carpae* (Convolvulaceae), *Juncus maritimus*, Lam (Juncaceae), *Limonium stockisii* (Boiss.) (Plumbaginaceae) Kuntze, *Lotus garcinia*, *Salicornia bractiata* Roxb(Amaranthaceae), *Salsola kali*, *Spoprobolus maderaspatenus* (Poaceae), *Sporobolus verginicus* (L.) (Poaceae) Kunt, *Suaeda fruticosa* Frost(Amaranthaceae), *Suaeda meritima* (L.) Dumort(Chinipodiaceae), *Suaeda nudiflora* (L.) (Willd)) (Chinipodiaceae) Moq, *Trianthema triquetra*, Rottl(Aizoaceae) (Devi V. Pathak, 2016, Singh 2020).

IV. CONCLUSION

The gulf of Cambay (Khambhat) is a region where high biodiversity found of coastal vegetation as well as it is region where less sustainability of many true mangroves like *Acanthaceae*, *Combretaceae*, *Euphorbiaceae*, *Sonneratiaceae* still not found. Very high resistant power to survive in such condition found in family of true mangroves like *Avicenniaceae*, *Rhizophoraceae*. There could be a possibility of many stress resistant genes developed in such families. There could be the possibility of adaptation of plant parts of such region. There could another possibility of mutualism between soil microorganism for the survivance of only such mangroves plants in this region. There could be a possibility of finding role of heavy metals in particular location where mangroves are completely degraded and many more areas where due to presence of some micro and macro elements certain mangroves only grown there. There could be some relation might present between true mangroves and mangroves associates help for sustainability of true mangroves there. Direct and indirect role of some heavy metals could be major part for mangrove's length and diameter. Different indices could be help for the identification of species frequency and abundance as well as species relation and composition.

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