Thane Creek

A Status Report on Species Diversity in Relation to Conservation

Naoroji Godrej Centre for Plant Research

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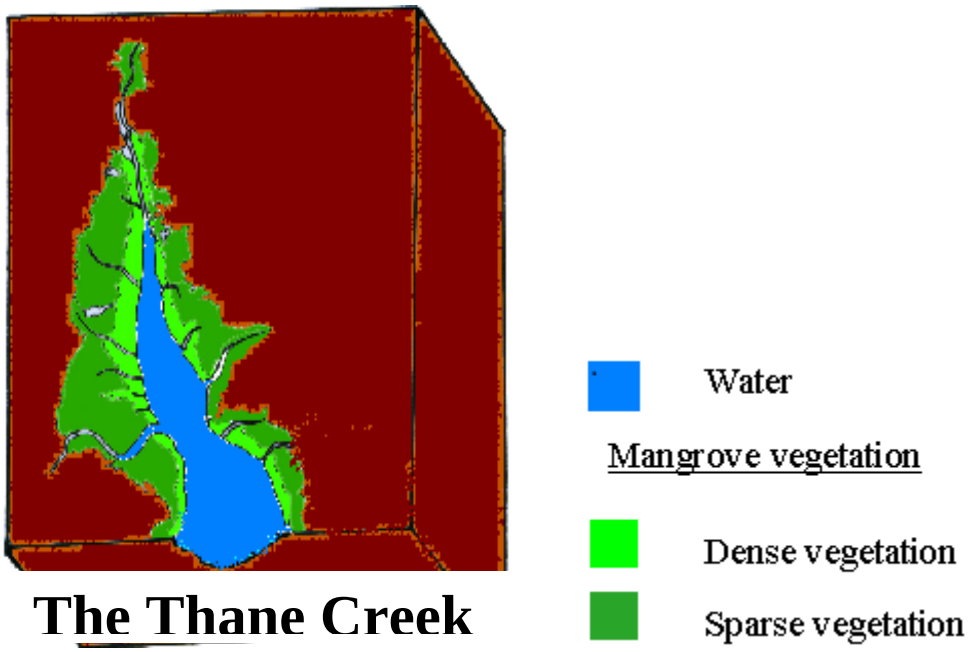
Chapter one

Introduction

Introduction

A creek is defined as an inlet of land where the seawater comes up regularly during the high tides and submerges vast areas known as inter tidal regions. Because of their unique physiography, creeks act as shelterbelts. The state of Maharashtra is very rich in having a number of creeks. There are about 58 such important creeks of different sizes present along the coast, on the western side of the state. Creeks play a vital role in the survival and livelihood of many human communities. Since immemorial times, the regions adjoining to creeks exhibited healthy and sustainable economies. Many factors contributed for such a scenario. One of the important factors that contributed from time to time for the wellbeing of the human communities of adjacent regions of the creeks is a very fragile plant community, called mangroves.

Mangroves are an unique plant community, found in the inter tidal regions of tropical and sub-tropical parts of the world. They grow luxuriant and attain maximum growth especially in the sheltered belts. A mangrove eco system does not necessarily mean a forest cover. In fact, it refers to various formations – arbores cent, bushy, and herbaceous and also the adjoining mud flats, which are devoid of any plant cover, but harbors many interesting forms of life. However, all these life forms share the ability to grow in saline and inundated environments and are adapted to multiple stresses that include high salinity and continuous flooding. In fact, the creeks with its mangrove formations represent one of the most complicated and highly evolved ecosystems of the world.



The Thane Creek

The mangrove ecosystems of creeks are complex as well as fragile and governed by different physical, chemical and biological elements. For a common man point of view, mangroves offer following useful roles. Many plant species are multipurpose. They are useful in boat preparation, honey production, local medicines etc. They are also habitat for many commercially useful species of fish, crabs, vertebrates and other fauna. The tree species are a major producer of detritus and a major contributor to offshore productivity. The roots of the plant community aids soil formation by tapping debris. Because of their unique root system and their habitat they selectively filters land runoff.

A comparison of the distribution of Indian mangroves reveals that more than 85% of the total mangrove areas are restricted to the West Bengal and Andaman & Nicobar Islands (Blasco, 1975). The East Coast has the advantage of having the major chunk of Indian mangrove areas as well as one of the richest mangrove diversity areas of the world. On the other hand, the West coast is less fortunate and left with lesser area under mangrove cover and less species diversity. Interestingly, Major mangrove cover of Maharashtra, which is also located on the West Coast, is distributed in the creeks.

The study conducted by Jagtap (1994) reveals that 79% of the mangrove cover of Maharashtra is distributed in 14 creeks, belongs to five districts of the state. Contrary to the West Coast, majority of the mangrove areas of East Coast are restricted to Delta regions of river mouths and estuaries. This is very important information for planning purpose. Since the studies suggest that Creeks on the West coast and Delta regions on the East Coast are diverse regions as far as mangroves are concerned.

Whatever may be the location, mangroves are a unique community, impossible to match because of their adaptations. They are an indiscrete community belongs to unrelated genera and families. The most distinctive of all these features is the vegetation and the associated fauna of the substratum or mudflats.

The leaf architecture, the root system, the reproduction abilities and the salt balancing of this unique plant community is unparalleled and evolved in aeons of time.

The life forms of mangroves are functionally similar in many aspects. They are not randomly distributed. Species occupy specific habitats. Their distribution has a pattern. Inter dependent organisms form complex food chains & food webs. Their life scape structure and relationships are complicated and difficult to understand.

It is believed that this unique community might have been evolved 70 million years before sometimes in the Miocene period even before the continental drift took place. It may be remembered that this particular group of plants showed a reverse evolutionary trend of going back to the sea from where early plants were evolved. Their occupational niche in growing in the transitional zone between the land and the sea is highly appreciable.

Traditional human communities understood the structure of creek ecosystems and relationships among different organisms better. They practiced many prudent and sustainable methods while harvesting creek ecosystems. Eventually, they reaped better harvests.

In fact, the present day mangrove ecosystems of the creeks are not really a climax or a stable type. They are passing through a variety of depredations. Most of the creeks, which offered suitable habitats to for a number of species, can no longer do that because the resources were not sustainably utilized. They are in most cases functioning as the dumping grounds or the sinks for vast and fast growing cities. The human modification of the system altered the major components and factors related to their stability. As a consequence the mangrove related resource base dwindled. The creek ecosystems in general and the mangroves in particular are under threat. A look into the list of threatened flora & fauna will give us a better picture about their status.

The coastal Ocean monitoring and Prediction system (COMAPS), a division of Department of Oceanography is functional since the year 1990. One of its major

observations based on the research data collected so far indicated that waters of the Indian sea are clean two km from the coastline except in the case of Mumbai where sea beyond five km clear.

In addition to this a recent CAMP (Conservation Assessment and Management Plan) exercise conducted at NIO (National Institute Of Ocenography), to identify the threatened species of mangroves (Ed. Rao, Molur & Walker -1997) recommended that majority of mangrove species (tree & shrubs) are facing some or other sort of threat and called for immediate conservation action. Groups of flora & fauna, number species assessed and number of threatened species assessed during the CAMP exercise is presented in Table-1.1

Table-1.1: Number of threatened species of mangrove ecosystems.

Group	Total no. of Species studied	Threatened species
Mangroves (Higher plants)	60	57
Mangrove Macro Algae	23	14
Mangrove Fishes	52	11
Mangrove Invertebrates	41	09

Source: Indian Mangrove Ecosystem Report Summary (Ed. T. Anand Rao, Sanjay Molur & Sally Walker , NIO, Goa 21-25 July 1997).

This is a serious concern to all of us. Many participants of the CAMP exercise felt that human interference and habitat loss are the two major threats to mangrove ecosystem and are a cause of concern.

Priority to this study another survey was conducted by NIO to identify the Marine Protected Areas (MPA) of Maharashtra & Goa states. The study was conducted under the stewardship of Dr. Untawale. A number of parameters (8) were studied to identify the MPA sites. Important criteria for identifying such sites is based on

1) Sensitivity of the ecosystem (How much it differs from rest of the areas)
2) Endemism
3) Economic importance & genetic variation
4) Human usage

At the end of the study, the following seven sites along the Maharashtra Coast (Map 1.1) were identified for MPA program.

1) Vengurla rock & Malvan open coast,
2) Devgad, Vijaydurg & Achra,
3) Ratnagiri & Purangad,
4) Kundalika estuary & Alibag coast,
5) Colaba,
6) Vikroli and
7) Mumbra- Diva region.

A brief account of the importance and diversity of these seven sites of MPA are presented in Table – 1.2

Another study in relation to Conservation of Biodiversity of the West Coast between Mumbai & Goa was conducted by Ecological Society, Pune. The World Wide Fund For Nature (WWF- India) sponsored project identified five potential biosphere reserve regions and 12 sites of special interest along the coasts of Maharashtra (Gole, 1997).

Both of these surveys have many commonalties. Thane creek, especially the Vikhroli mangrove swamp area (owned by Soonabai Pirojsha Godrej Foundation) was identified as one of the well preserved & biodiversity rich areas of Maharashtra state.

A pioneering study conducted by Mr. Sanjay Deshmukh (1990) for his PhD work was actually created a base for assessing and identifying the Vikhroli mangrove swamp areas of Thane creek and other mangrove areas of Mumbai & Thane districts. It must be borne in mind that mangrove study of Mumbai coast dates back to early years of 20^{th} century (Blatter, 1927 & 1928).

Conservation and sustainable utilization of an ecosystem is possible only when the structure and relationships are understood. All these years we forgot or conveniently ignored this basic principle. Most of the available research of mangrove ecosystem of creeks in India is group or taxon wise studies and therefore difficult for interpretation. A holistic approach is a need of the hour.

Keeping the existing needs in mind Naoroji Godrej Centre for Plant Research In collaboration with Soonabai Pirojsha Godrej Foundation promoted by Godrej group of industries and many other likeminded organizations such as BNHS, Bandodkar college, Thane, Botanical Survey of India, Zoological Survey of India and many individual scientists and students from different colleges and Institutes, studied the life scape diversity and structure of Thane Creek mangrove ecosystem. The present study is aimed

to quantify the diversity and understand the relationships of various groups organisms of Thane creek mangrove ecosystems. The details of the research studies are presented in the following chapters.

Map.1.1

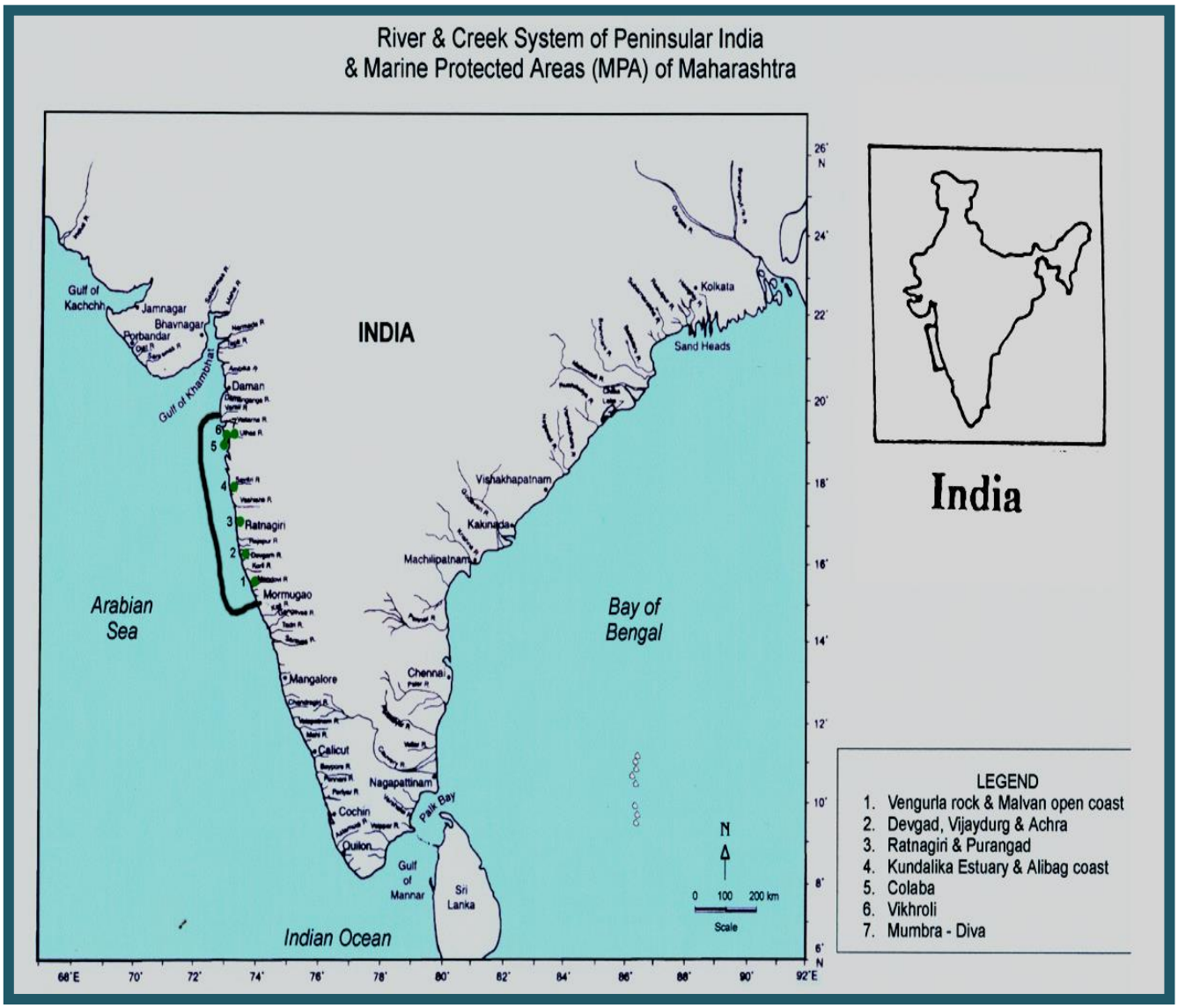


Table – 1.2. **Proposed Marine Protection Areas (MPA) & their biodiversity in Maharashtra.**

MPA locality	District	River	Important areas	Diversity
Vengurla & Malvan	Sindhudurg	Mandav	Kolamb creek Vengurla rock island Malvan open coast Kavya Dongar	Mangrove- 5 Algae – 49 Benthos -208
Devgad, Vijaydurg &Achra	Sindhudurg & Ratnagiri	Vaghotan	Achra creek Devgadh creek Vijaydurg open coast	Mangrove- 15 Algae – 25 Benthos -
Ratnagiri & Purangad	Ratnagiri	Muchkandi	Muchkandi river Shilwadi Purangad creek Shivgao creek Ratnagiri open creek	Mangrove- 12 Algae – 56
Kundalika & Alibag	Alibag	Kundalika	Kundalika estuary Revdanda fort	Mangrove- 5 Algae – 35
Coloba	Mumbai	--	Naval establishment TIFR area	Mangrove- 11 Algae – 64
Vikroli	Mumbai	Ulhas	Godrej & Boyce	Mangrove- 7 Algae – 2
Mumbra–Diva	--	Ulhas	--	Mangrove- 5 Algae – 3

* Source : Untawale et al, 1998 & Deshmukh, S, 1990.

Chapter Three

History

History

Prehistory is normally means pre-literate history (Kosambi, 1962). Prehistory of the study area (Thane & Mumbai districts) is almost devoid of any documented facts. The documented history mostly reels around rulers, religion & commerce. Information on mangroves is scattered. Available interpretations are piece meal with much exaggeration and less clarity.

The earliest known fact in history of the area belonged to the third century before Christ (B.C.225). They are engravings of Ashokan edicts on Basaltic boulders. The present study area was part of *Aparanta* or *Sunaparanta* ("the behind" or the Western land now known as Konkan).

The next known evidence available is about the dynasty of *Satavahans* or *Andhra bhrityas* who ruled the Konkan about B.C.100. The region witnessed the rise and fall of many dynasties. Notable among them were the *Abhiras* (A.D. 250), *Trikuta* or *Traikutakas* (name derived from three peaked mountain, A.D.415), *Chalukyas* (A.D.543), *Rashtrakutas* (A.D. 749) and *Silharas* (meaning food on rock).

The mediaeval period witnessed the fall of a local king Bimb to Muslim invaders (A.D.1318), which followed an era of invasions and plundering. Marco Polos account (1290) clearly indicates that the seas were infested with pirates. The whole region was also regularly ravaged by *Siddis* and Jesuits.

In the recent past, the Marathas, the Portugese and the British ruled the region.

It is noteworthy to mention that since pre historic times; a coastal fishing community colonized these islands first and survived the ravages of time and many calamities and invasions. These sea loving people known as *Kolis* are still intact without much cultural change. They worshipped natural objects such as trees and animals. Although, there are many interpretations about the origin of the word Bombay, to the study area, there is a strong evidence that the present name was originally derived from *Mumba-ai* or *Mumba Devi*, the local goddess of *Koli* community. In fact all the names of *vadas* or hamlets of the past are derived from tree or forest groves or some deities.

The Changing Pattern of Vegetation & wildlife of Thane creek and its surrounding areas.

The physical history of Bombay is the history of land reclamation. The early accounts of history reveal that the topography of the present day Thane creek and its

surrounding areas is considerably modified. Topographically the region was in fact part of a two major groups of islands. The islands were lush green, full of trees.

Kolis – in fishing mood

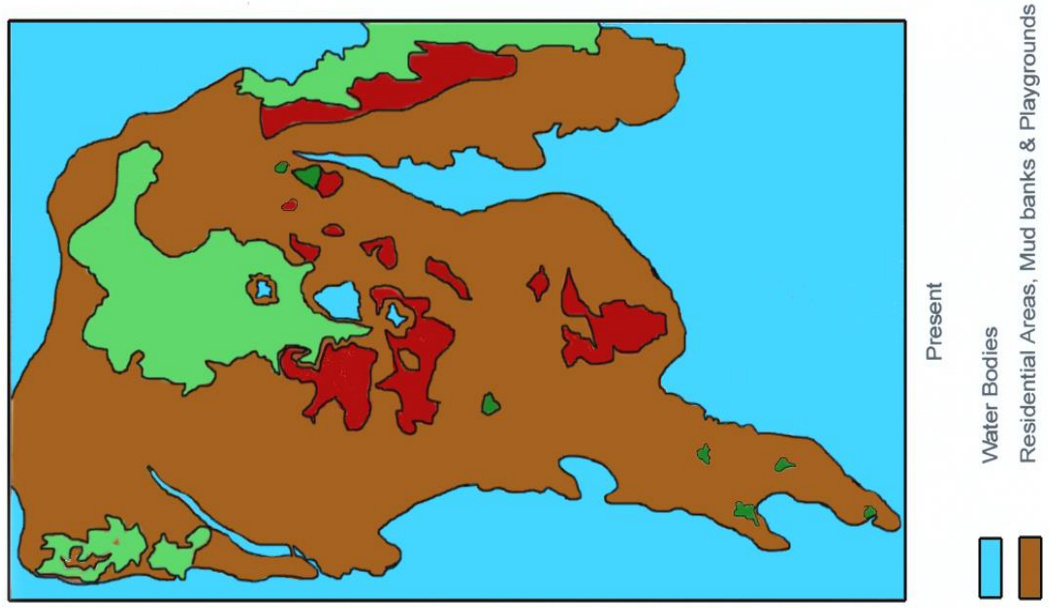
The islands were harboring many Coconut groves and Jack fruit trees. In fact the region was full of trees with tremendous species diversity (Jordanus & Odericus, 1321-1324 in Yules Cathay,I.68). The other common trees included *Mangifera indica* (mango), *Caryota urens* (forest palm), *Borasis* sp. (brab palm) and *Tectona grandis* (Teak). The reports also mentioned about the presence of a huge *Adansonia digitata* tree (baobab); the inter- tidal regions, the river banks and the lagoons were teemed with wild life. The shores of the islands were decorated with thick & luxuriant mangrove vegetation. Mangroves covered a larger part of the study area. There were many carnivorous animals such as black lions (needs confirmation, perhaps black leopards), leopards, lynxes roamed freely in the islands. The marshy habitat was home for rhinoceroses & crocodiles. There were numerous monkeys and baboons. There were also the reports (exaggerated) of bats as big as kites and rats (bandicoots) as big as dogs. There were no

horses but oxen & donkeys. They were used in agriculture and in transportation. Best accounts of these translations were available in the Gazetteers of Bombay (1986) & Thane (1986).

The best of all descriptions about the past status of the island vegetation appeared not long ago in a relatively popular journal (Asiatic Journal, 1838). A curious writer presented a beautiful summary of the past status of these islands. Following is the replica of the letter.

"Bombay harbor presents one of the most splendid landscapes imaginable. The voyager visiting India for the first time, on nearing the superb amphitheater whose wood –crowned heights and rocky terraces, bright promontories and gem-like islands are reflected in the broad blue sea, experiences none of these disappointments which is felt by all lovers of the picturesque on approaching the low, flat coast of Bengal, with its stunted Jungle. A heavy line of hill forms a beautiful out line upon the bright and sunny sky; foliage of the richest hues clothing the summits of these towering eminencies, while below the fortress intermingled with fine trees and the wharves running out into the sea, present altogether, an imposing spectacle, on which the eye delights to dwell."

Land reclamation for agriculture and for defense purposes contributed to the maximum destruction of wildlife and vegetation of the past. In modern times, urbanization & industrialization contributed to the maximum destruction of mangrove areas of Thane creek. The destruction is so much so that many species, which were mentioned in the earlier literature or travelers diaries, were, disappeared from these islands. A comparative list of wildlife mentioned in the ancient literature and its present status is presented in table- 2.1 and 2.2.


Present
Water Bodies
Residential Areas, Mud banks & Playgrounds

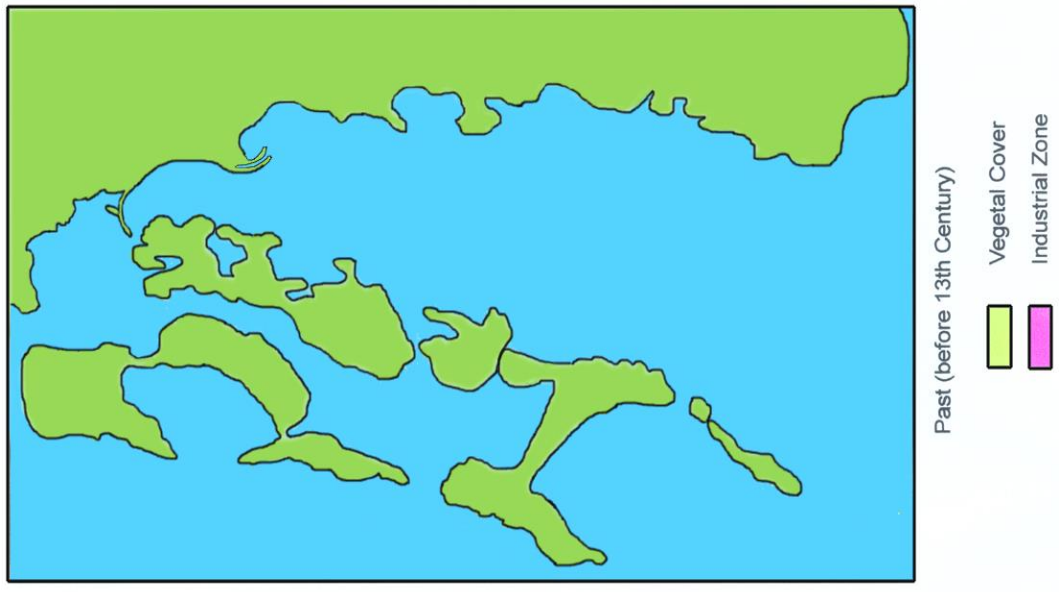

Past (before 13th Century)
Vegetal Cover
Industrial Zone

Table-2.1. Status of animals (extinct & threatened) of Thane creek and its neighboring areas.

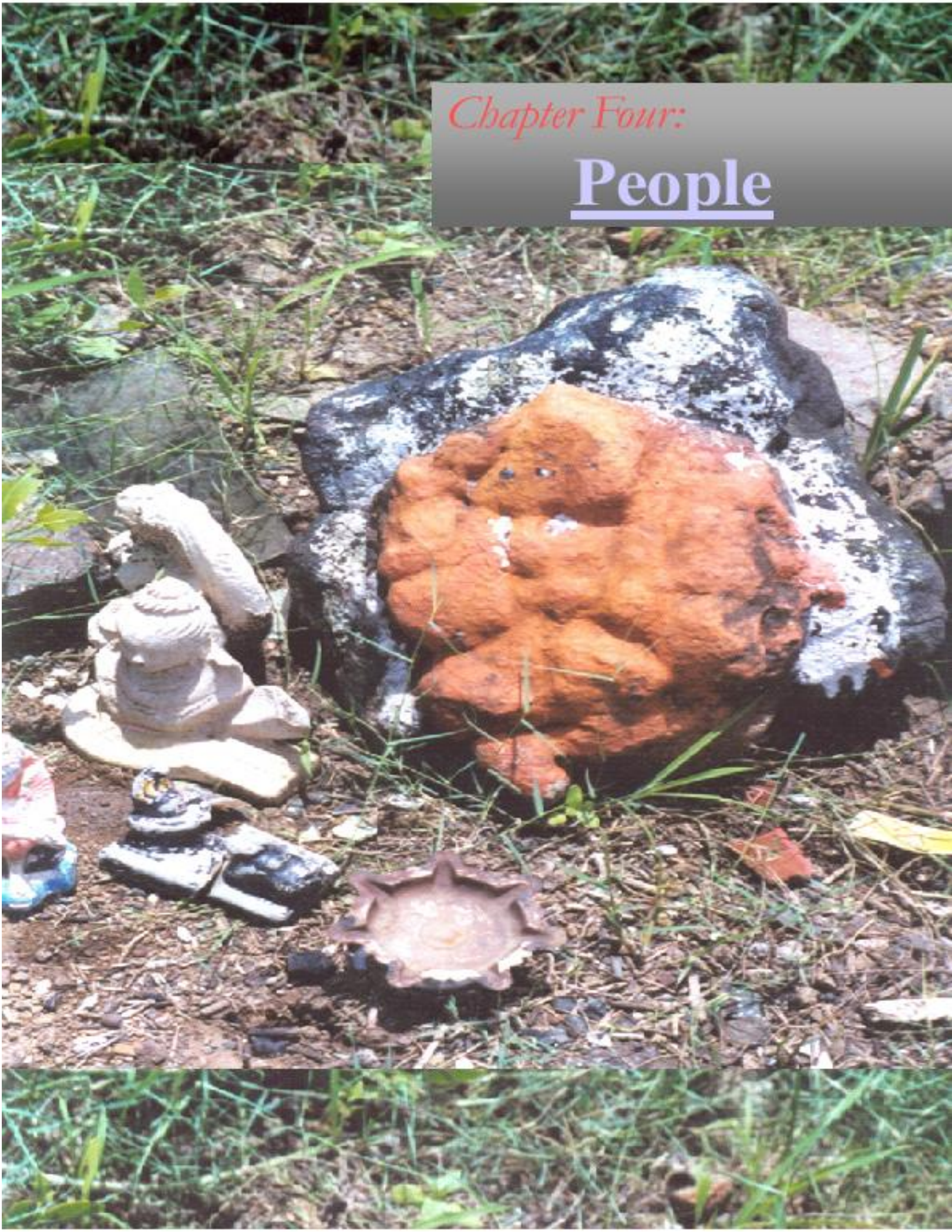
Common name	Scientific name	Past status	Present status	Reference
Rhinoceros	*Rhinoceros* sp.	Present	Absent	*Jordanus & Odericus, 1321 - 1324
Black lion	Not known (perhaps black leopard)	Present	Absent	*Jordanus & Odericus, 1321 – 1324
Leopard	*Panthera pardus*	Present	Common	*Jordanus & Odericus, 1321 – 1324
Linx	Felis *sp.*	Present	Absent	*Jordanus & Odericus, 1321 – 1324
Crocodile	*Crocadilus* sp.	Present	Absent	*Jordanus & Odericus, 1321 – 1324
Indian Python	*Pyhton molurus*	Present	Very rare	Vivek Kulkarni 1998.
Olive Ridely Turtle	*Lepidochelys Olivacea*	Present	Very rare	Giri, 2001
Green sea turtle	*Cheolonia mydas*	Present	Very rare	Giri, 2001

***Gazetteer of Bombay**

Table-2.2. Status of Plants (extinct & threatened) of Thane creek and its neighboring areas.

Common name	Scientific name	Past status	Present status	Reference
-	*Nypa fruticans*	Present	Extinct	Bonde, 1994
-	*Lumnitzera racemosa*	Present	Absent	Navalkar, 1951
Pussur	*Xylocarpus granatum*	Present	Absent	Cooke 1901-1908
-	*Kandelia candel*	Present	Absent	Navalkar, 1956
-	*Sonneratia caseolaris*	Present (doubtfull)	Absent	Blatter, 1905 Backer, 1951
-	*Bruguiera parviflora**	Present	Very rare	Navalkar, 1941
-	*Rhizophora conjugata**	Present	Very rare	Navalkar, 1941
-	*Rhizophora mucronata**	Present	Very rare	Navalkar, 1941

* Re introduced



Chapter Four:

People

People

People play crucial role in **natural resource utilization**. The natural resources of creeks such as mangrove forests, fishes, crabs and other marine foods are a common resource. Despite the fact that they are common resources, our survey indicates clearly that selective communities of people only harvest these resources. Naturally, **creeks are primary resource base** for many local communities. Fishing is their major occupation.

Kolis are the major community traditionally dependent on the Thane creek ecosystem for their sustenance. The *Kolis* follow fishing as their hereditary occupation. They are directly dependent on the creek ecosystem for food, shelter, medicine and a gamut of other uses. It is also recorded during the study that there are many other people who indirectly dependent or benefit from the system. It is practically difficult to exactly estimate the number of people dependent on the Thane creek ecosystem. Rough figures prepared from a crude survey reveals that about 20,000 *Kolis* are dependent on the Thane creek for their livelihood. About another 30,000 people belongs to other communities are indirectly dependent on the natural resources of Thane creek. These indirect benefactors include slum dwellers who regularly use mangrove resources for fuel and other purposes and also labour involved in drudging operations. These figures exclude Government and industrial employs.

Kolis are mostly mangrove dwellers. The Thane creek region is represented by four sections of Kolis. They are a) Thalkars, b) Gaonkars, c) Christiahn Kolis and nava-Hindus.

During the survey we have recorded 14 *Koli* settlements in different parts of Thane creek. Most of the *Koli* houses are distributed in closely constructed houses. The 14 *Koli* localities are as follows.

1) Thane, 2) Vitava, 3) Airoli, 4) Diva, 5) Talwali, 6) Ghansoli, 7) Kanjur,
8) Mulund, 9) Balkumb, 10) Kharegaon, 11) Vikhroli, 12) Turbhu,
13) Belapur, 14) Kujur.

Kolis- preparations for fishing

It is estimated that in India alone, **about 2.5 million tons** of marine fish are available within the 50m depth zone.

Documented history reveals that **fishing was one of the chief industries of Mumbai** during the pre-British period. Thane creek was one of the major fish and crab supply centers of Mumbai.

It is belatedly realized that Thane creek no longer yields commercially viable fish. The official records documented an alarming decline in fish catch, about **68% reduction** in the yield in a span of ten years ranging from 1980 – 1990. The natural resources of creek ecosystem are no longer renewable. They have been destroyed beyond the limit of sustainability. Experts opined many reasons.

The first explanation given is that all over the world, small scale fishing exceeds the sustainable capacity resulting in biological and economic over fishing in coastal waters (Ramakrishna, 1999). Thane creek is no exception.

The second opinion is that pollution is the major culprit for depleting fish, sea food and other natural resources.

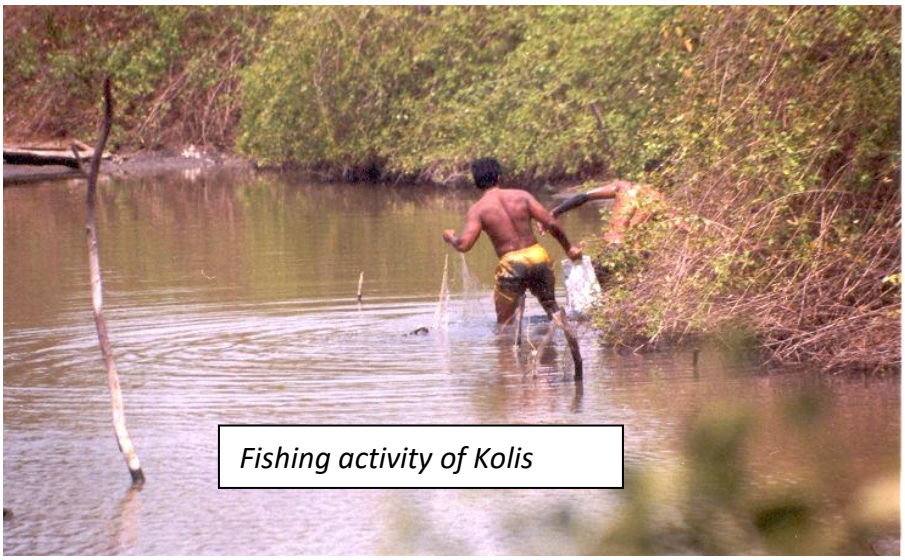
In the present study we have tried to carefully look into the reasons and what is really responsible for depletion of natural resources. To understand this we made

selective surveys, probed into the general lifestyles and interviewed fisher folks to understand their modes of fishing activities.

Sustainable utilization is the only option to ensure natural resources for future generations. The creek ecosystems have tremendous number of natural resources. All these resources are directly or indirectly dependent on the availability of mangroves. Many mangroves species and their associates are multipurpose species. It is very difficult to cover the resource utilization studies of all communities of people who are dependent on creek ecosystems with special reference to mangroves.

Kolis are one such community of people dependent on creek and mangrove ecosystems. Reaping the creek ecosystems is their heretical occupation. For generations they are engaged to harvest creek resources. Many research documents are available about the Kolis of Mumbai (Wilson, 1876; Sorley, 1933; Sethna, 1949, Punekar, 1959)

Kolis are a very simple community with strong cultural bondages. Most of the *Koli* settlements are isolated. They are situated along the creek near the sea shore, very closely to mangrove forests. A substantial percentage (45%) of the *Koli* families is nuclear (Punekar, 1959). During the enquiries we understood *Kolis* changed with changing needs and adapted to modernization. Even in the present times, most of the *Koli* life styles are simple and their natural resource utilization can be categorized as sustainable type.



Fishing activity of Kolis

An interesting feature of *Kolis* is the nature worship. Worshipping a tree or a forest god is commonly observed. All the *Kolis* worship god and offer prayers before going on for fishing. Deities range from stone gods to the photographs of Christ. They are kept under some back mangrove trees, near the Jetty sites. During the discussion we

were surprised to observe that many *Kolis* do not clearly recognize the different religions created by modern (primitive ?) man. The Christian *Koli*s prey to Hindu gods as well as Christ. They also celebrate all Hindu festivals.

Fishing is essentially a major employment generation occupation for *Kolis.* A variety of fishing techniques are used by *Kolis*.

The small and stunted mangrove forests of Thane creek are useless to provide wood for any type boat manufacturing. Boats are brought from other coastal regions.

The two most important requirements for fishing are a) boats, b) nets.
Kolis of Thane creek uses mostly three types of boats for fishing. Descriptions of the three types of boats used by the *Kolis* are as follows

1) ***Shipil***: It is a small hodi (boat), generally operated by two to three persons. A typical boat is elliptic - oblong shaped, 5.5-6m long X 1-1.2m wide. The boat is made from mango (*Mangifera indica*) wood. This variety of boat is the most common boat used by Kolis. It is a very useful boat for creek fishing and crab catching purposes. The present cost of the boat is about Rs. 20,000/- (It coasted Rs. 150-200 in late 1950's). The boat lasts for 15-20 years.

Shipil

2) ***Mothi Shipil***: Large *hodi* (boat). This type of boat is operated by 6-8 persons (preferably 8 persons). A typical boat is broadly-elliptic in shape, 12-12.5m long X4-4.5m wide. This boat is exclusively made of teak wood (*Tectona grandis*). The boats are either fitted with sails or mechanized. The mechanized boats are fitted with diesel engine. This type of boats are used frequently for deep water fishing, mostly in creek waters. The present cost of the boat is about Rs.1,50,000/- (it coasted Rs. 400/- in late 1950's).

3) ***Hora***: (Larger hodi (boat). This type of boat is opertated by 10-12 persons. They are fully mechanized. They are suitable for deep - water fishing. They are rarely found in creek waters. The price may vary depends upon the facilities. It is mostly made up teak wood. The cost ranges from Rs.12 lacks to 20 lacks.

The official estimates of the fishing boats in the Thane creek are 184. There are 17 mechanised and 167 non-mechanised boats operate in the creek. Table 4.1 presents regionwise distribution of fishing boats present in the Thane creek.

Shipil

Other than fishing boats there are other boats, which are exclusively used for dredging in the Thane creek. Kashala-Gaimukh region is reserved for dredging. About 4,000-5,000 workers dependent on dredging operations and about 400-500 mechanical boats work for this purpose. The officially permitted daily turnover is about 400 brass sand. The region generates an annual royalty of Rs. 60 lacks for the Corporation. The workers on the dredging boats belong to many other communities.

Table 4.1 Fishing boats Sensex of Thane creek (1998).

No.	Locality	Number of boats
1)	**Airoli**	30
2)	**Balkumb**	5
3)	**Diva**	41
4)	**Ghansoli**	33
5)	**Kanjur**	18
6)	**Kharegaon**	4
7)	**Mulund**	5
8)	**Talwali**	17
9)	**Thane**	3
10)	**Vitava**	28

- Source: Mumbai Port Trust (2000).

Another requirement for fishing is fishing-nets. We are amazed by the types of fishing and crab catching techniques used by Kolis and other communities. The type and shape of fishing nets are very important for type of fishing (a more detailed studies on types of boats and fishing nets are published by Gazetteers of Maharashtra). Generally fishing nets can be classified as two types. They are -

a**) fishing nets prepared from natural fibre from plants,**
b) synthetic nylon fishing nets.

A variety of plant materials were told, during the survey, were used for making fishing nets and other purposes. A list of plants suitable for fishing-nets is given below.

No.	Name of the species	Usage
1)	***Thespesia populnea***	fiber
2)	***Hibiscus tiliaceous***	fiber
3)	***Derris* sp.**	rope
4)	***Dendrocalmus* sp.**	erecting support for net & baskets
5)	***Lagneria* sp.**	Fish collection vessel

Using plant material for fishing was a thing of past. Except bamboo we have not noticed any other worth mentioning plant material being really used for fishing nets or any other related activity. Bamboos are costly. They are brought from far away places like Belapur. Each bamboo culm costs Rs.30/-. They are useful for only two years in saline waters. All types of nets made from natural fibre are taken over by synthetic nylon nets, locally called as *Pagara* or *vagara*. Bamboo culms are still used to erect the nets. As the water recedes fish that had come into creek are trapped in the net. Fish-catch of mechanized boats is carried out mostly during night apter 9pm. Torches made from tyres are burned to attract the fish. We have not recorded using of any plant material for stupyfying fish. A number of fish nets are used by the Kolis of Mumbai are listed below.

1) *Gholva*
2) *Khanda*
3) *Peri*
4) *Pongri*
5) *Vavri*

Another technique used for catching small fish is through a portable baited fish trap prepared with bamboo or cane. The trap is fixed at the inlet points of dug out ponds. During the high tide water with fish can enter through these traps. Once entered into the trap the fish cannot go out. The owner will catch the fish from the pond once in a ten days or fortnight.

Fishing is a very studious job, demands patience and hard work. The *Kolis* believe that fishing operations are totally dependant on god. All fishing operations are conducted after offering prayers to gods. Two fishing periods of twelve days each occur every lunar month. Fishing requires united effort of many men. The division of labour is perfectly organized. Fishing with the mechanized boats lasts for eight days.

The general survey to find out the attitude of Kolis (of 70 *Koli* youth) towards their profession revealed that 75%of the youth felt that they are not happy with their profession because of the difficulties. Due to lack of choice they opted this job. They are happy at the same time because fishing is still a lucrative business as compared to their professional skills and educational background. Most of the *Koli* youth also realize the disadvantages of working as an unskilled laborer.

During the survey it is realized that many individual *Kolis* with small boats prefer to collect Crabs to fish, as fish are not available in sufficient quantities for commercial fishing. Many species of fish are almost disappeared from many parts of the creek. Even if they are available they are not fit for human consumption because of heavy metal pollution. Moreover, crab catch is easier and economically more fetching.

The mud crab is the most preferred crab because of good demand in the local markets. It is also one of the common crabs of Thane creek. A *Koli*, after a days hunt can manage Rs. 750 – 1250/- worth crabs. Three species of crabs from Thane creek are used for food purpose. Crab catching is generally done along the banks or confluence places. Crabs are caught mostly three ways. They are

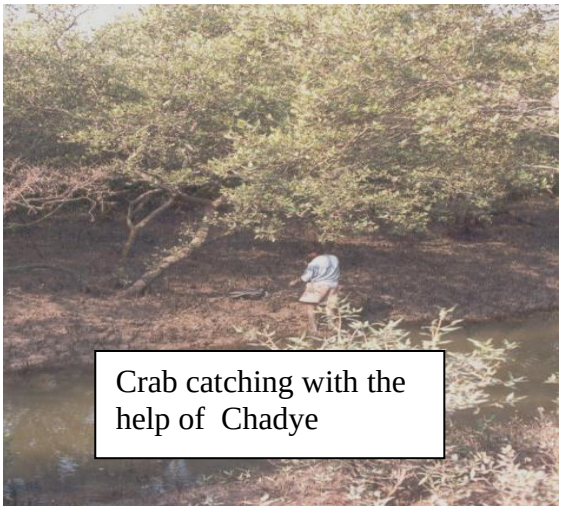
1) Using *Tokre* : The technique involves digging a pot shaped hole of one meter size into the soil near mud flats. A bamboo basket is inserted into the hole. Butchered goat or sheep ears are released at the bottom of the basket or they are fixed on a bamboo stick at the center of the hole. Crabs attracted to the food fall into the basket trap. The trapped catch is collected easily with the basket after some hours or next day morning.

2) Using *Chadye* or *Chapate* (Crab hooks): The most common way of catching crabs is with the help of a hook attached to a bamboo stick. Pieces of eel or ears of butchered goats or sheep are used as bite to attract the crabs. Single individuals scout around mangrove forests looking for ideal crab holes. The bamboo stick is poked slowly into crab holes. The crabs attracted for food and gets trapped easily. Identifying the right crab hole is learned with experience. This type of crab catching is done mostly in *Avicennia* forests. The technique is mostly used to catch *Scylla serrata*. This type of crab catching is done mostly by other communities other than Kolis. Each individual can fetch 1-4kilos of crabs per day.

*Kathkar*i community mostly uses this technique. The whole family engages in this sort of crab catching. The family gathers at one place after collection of crabs. Individual collections are put at one place. The elder among them divides the catch and share is allotted on hierarchical basis to the members of the family to take the catch to the market for selling.

3) Using *Gela*: It is a floating net attached to ring typed steel rod;mostly used in low lying waters to catch crabs. A long rope is attached to the other side of the ring. Floats made with thermo-coal are tied around the ring. *Kolis* mostly adapted this technique. Operations are done between rising and receding tides.

They take about 15-20 gelas on small boats. About two to three persons can catch about 30-150kg of mud crabs.



Crab catching with the help of Chadye

The Thane creek is also host for a number of people belongs to other communities. They are the people mostly living adjacent to the creek. They are casual visitors. Many of them come from nearby slums. They use tubes of truck tyres as floats. Fishing and crab catching are done only for sustenance.

Gela

We did not record manufacturing of charcoal or debarking of mangrove trees for *cutch* in the mangrove areas of Thane creek. However, we observed serious exploitation of mangroves for fire wood. Interestingly, fire wood collection is regularly done by slum dwellers living in the vicinity of mangrove areas. Their harvesting technique is very destructive in nature. Men from the adjoining areas go to the mangrove areas and partially cut or injure the trunk or big branches of the tree with a sickle or knife. Those branches are marked with some identification marks. This type of marking on injured parts of trees with symbols indicates the ownership and reduces the conflict between rival collectors. The injured parts will soon dry up and die. Because of heavy pollution this process is faster in Thane creek. Women periodically monitor the marked trees and collect the dried or fallen fuel wood. Drying of stems and branches takes place 30 –40 days after they were injured.

Kolis generally do not engage in this type of fuel wood collection activities. In fact they bitterly complained about loose law enforcement agencies. They are not allowed to collect fuel wood while others steal freely. During the entire survey period

we did not come across even a single technique adapted by fisher folks for fishing is destructive or unsustainable in nature.

Chapter two
Study Area

Study Area

The Thane creek is situated on the West coast of Maharashtra, between Mumbai and Thane districts. Geographically it is situated between 19^0 00' - 19^0 15' N latitude and 72^0 55' - 73^0 00' E longitude.

Thane creek is extended 26km northward from the Arabian Sea. The creek mouth is located on the South-West of Mumbai harbor where it joins Arabian Sea and its geomorphic head is located on the northern side near Thane, at the meeting point where a narrow connection of Ulhas River joins the creek.

Geology:

The entire study area is occupied by Deccan basalt flows. They are step-like or terraced type of geological formations. The basaltic flows are horizontally bedded. The traps attain their maximum thickness of 2,133 meters near Mumbai coast.

No minerals of economic importance are found in the study region. The rocks are generally used in construction. The important rock type quarried for construction work is granophyric trachyte (Gazetter of Mumbai & Thane, 1986).

Climate:

The climate of the study area is characterized by an oppressive summer, high humidity and heavy south-west monsoon. The mean annual temperature ranges from 22 ^{0}c to 30 ^{0}c. May is the hottest month. During summer days, the maximum temperature goes up to 40^0c. January is the coldest month. The temperature drops to 10 ^{0}c. The average rainfall of the district is 2293.4mm.

Humidity:

The creek harbors a humid climate in general. Mornings are more humid than the afternoons. Among the different months of the year, humidity is high between June – October. The relative humidity during these months is about 75 per cent. It even rises to 90% during rainy days. The humidity levels come down during other months. From November to February the relative humidity is between 50-65%.

Population:

The population of Thane district, as per the 1991 census, is 52, 49,126, which ranks third in the state. Due to developmental activities, there is a great increase in the human population of the district. The percentage decadal increase in the human population of the district, which was around 8.5% during 1901-11, is increased up to 56.5% during 1981-91. The population of the Mumbai district, as per the 1991 census, is 12 million.

East bank of the creek represents Thane district while the west bank represents Greater Mumbai district.

Thane creek is one of the biggest creeks in Asia. Apart from Sanjay Gandhi National Park, Thane creek mangroves are the only forests that are surviving in the Mumbai city. There are many sources of fresh water for the creek. Ulhas River is the largest source, followed by numerous drainage channels coming from various suburban areas of the cities of Mumbai, New Mumbai and Thane.

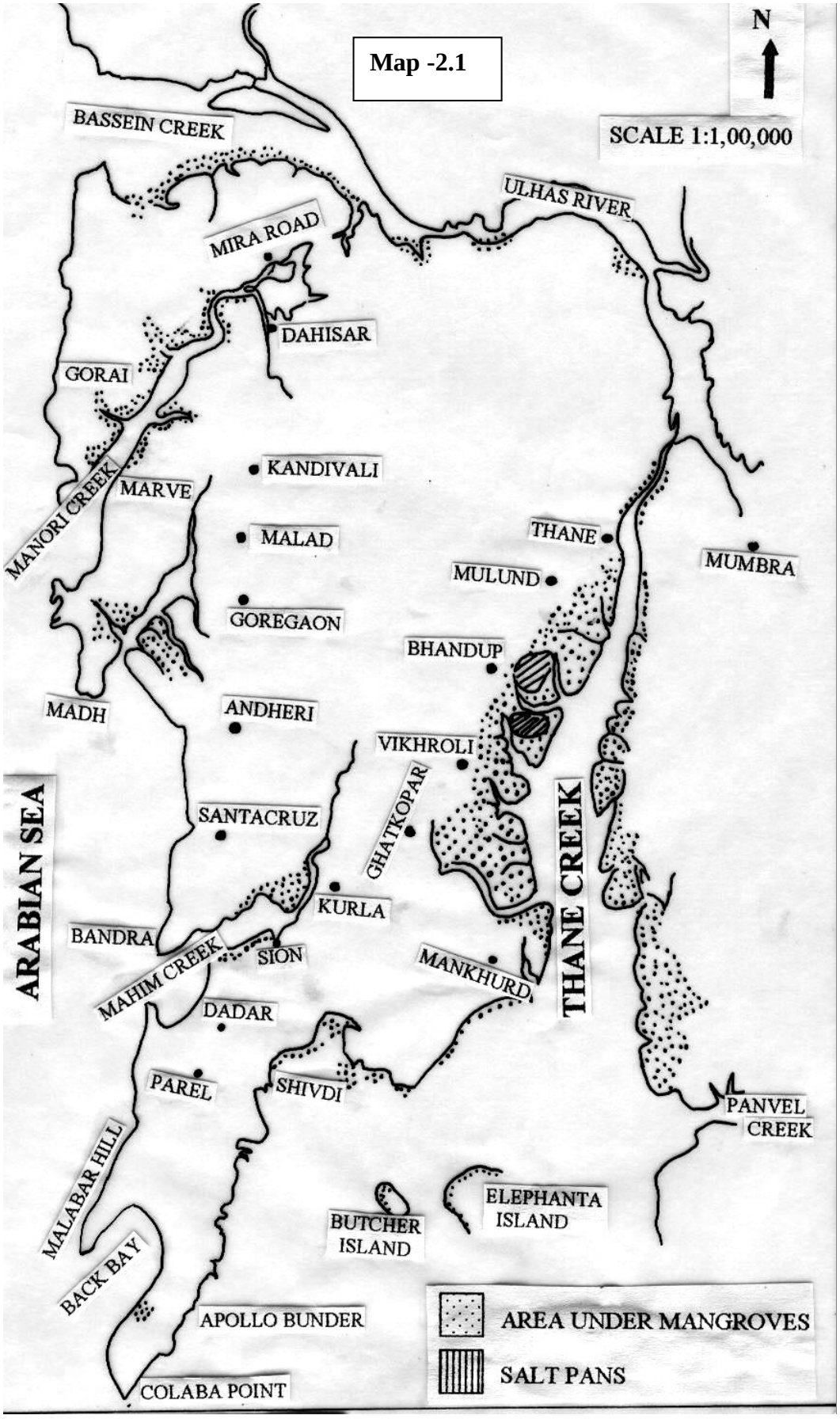
The Thane creek is surrounded by a few of India's largest industrial areas, viz. Thane-Belapur, Ghatkopar, Kurla, Vikhroli etc. All these industries continuously pour their effluents in the creek. There are two very big solid waste dumping sites at Deonar and Shivajinagar (Govandi) located on the western bank of the creek. Along with numerous other small and scattered dumping yards, they dump a huge amount of solid waste, bio-degradable as well as non-bio-degradable, into the creek, particularly after the spring tides. Hence today, Thane creek is considered as one of most polluted creeks of the country. The fish catch from the creek is reduced drastically because of marine pollution. Diversity of the fish catch is also reduced, as two to three species of fish are now available. The native fishermen of Mumbai used to depend on the creek for their livelihood. They are now looking for different business opportunities in the city because of decrease in the fish catch from the polluted Thane creek.

Areas selected for the study:

As the study should reflect the ecological status of the entire creek, various microhabitats, in the form of sampling stations were identified from the creek. Diversity of mangrove species varies according to their distribution as front mangroves and back mangroves with associate species. While selecting the stations, care has been taken to represent both the types. In addition to this, there is a consideration of arrays of pressure from natural and manmade processes while selecting the sampling stations.

Total area selected for the study is six hectares, spread over in six stations, each admeasuring one hectare (10,000m^2). Out of these six stations, three stations each have been selected from the mangrove areas is owned by Soonabai Pirojsha Godrej Foundation (SPGF) at Vikhroli and from the remaining areas are from the other parts of the Thane creek.

Names are given to sampling stations for the purpose of identification as well as the criteria for their selection which are presented in Table 2.1. The location map of these stations with reference to the creek is presented in 2.1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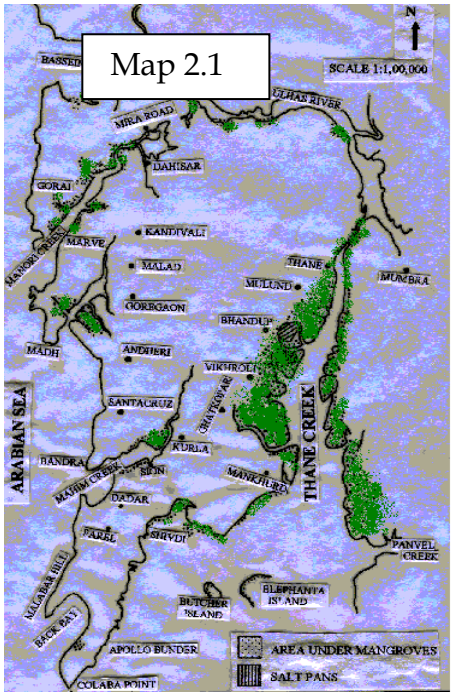
BHANDUP
MADH
ANDHERI
VIKHROLI
GHATKOPAR
ARABIAN SEA
SANTACRUZ
KURLA
BANDRA
SION
MAHIM CREEK
MANKHURD
THANE CREEK
DADAR
PAREL
SHIVDI
PANVEL CREEK
MALABAR HILL
ELEPHANTA ISLAND
BUTCHER ISLAND
BACK BAY
APOLLO BUNDER
COLABA POINT
AREA UNDER MANGROVES
SALT PANS



At each station, four permanent quadrates, each the size of 2,500m^2 were marked for the studies. Thus, a total of 24 permanent quadrates were laid down for purpose of the study. In each sampling station, the stems of mangrove trees within the quadrat area were marked with a circular band of color paint to demarcate the sampling area of the study area. Oil paint was used for marking the stems. Quadrates were drawn only in the areas covered by mangrove vegetation, i.e. in the supra-tidal region of the creek. Qualitative studies have been done by undertaking general surveys in the mangrove areas of the Thane creek.

The detailed description of each sampling station is presented in the proceeding text.

Table 2.1: **Details of sampling stations.**

Name of the Sampling Station	**Criteria for selection**
Vikhroli I: MMC Sewage Treatment Plant Site.	Partially protected, back mangroves.
Vikhroli II: Jetty site.	Partially protected, front mangroves.
Vikhroli III: Kanjurmarg nallah site.	Partially protected, front mangroves.
Mankhurd nallah site.	Disturbed area, front mangroves.
Talwali village site.	Disturbed area, back mangroves.
Vitava Island site.	Isolated island representing both the types of mangroves.

2.3 Description of the sampling stations

A] Stations from Vikhroli area The detailed description of each sampling station is presented in the proceeding text.
The detailed description of each sampling station is presented in the proceeding text.

1] <u>Vikhroli I</u>: MMC Sewage Treatment Plant Site

The station is located on the west bank of the Thane Creek. This is a well-protected old back mangrove patch, as evident from the tall trees with good canopy cover (Plate 2.1). This mangrove patch is surrounded by a number of *nallah*s. Estuarine water enters this area through these *nallahs* during high tides. During the other times these *nallahs* act as nothing but the drainage channels of decomposing sewage coming from the Vikhroli village. As a result biodegradable and non-biodegradable matter accumulates in these channels during the neap tide phases. These matters are flushed from channels by the gushing waters of spring high tides. Total submergence of the area takes place only during spring high tides. Spring high tide waters are found to be anoxic.

The striking feature of this area is the abundance of Pagoda Ant nests. Quite interestingly, in spite of good canopy, very few bird nests were observed in the area. There might have been some relation of presence of pagoda ant nests and absence of bird nests, which needs to be investigated in detail.

Six mangrove species viz. *Avicennia*, *Sonneratia*, *Excocaria*, *Ceriops*, *Aegiceras* and *Acanthus*, and four mangrove associates viz. *Salvadora persica*, *Derris* sp., *Clerodendron* sp. and *Sesuvium portulacastrum* are common in the area.

Patches of *Aleurops lagopoidis,* a typical mangrove grass is a very prominent feature of this area.

The length and width of Mudflats in the area are very short. Mud is very sturdy. Number of pneumatophores per unit area is very high; more than any other study area. This could be, possibly because of the anoxic conditions. During spring high tides, mollusks are found to climbing on tree trunks.

2] <u>Vikhroli II (</u>Jetty site):

This station is located on the west bank of Thane creek. The creek channel is very narrow. This channel is the release point of drainage channels from different parts of Vikhroli Industrial belt through which various kinds of effluents continuously released into the creek waters. Water is extremely polluted, showing dark color and emit smells of chemicals. Mangroves in this site are protected. They show a good canopy cover. The area gets submerged totally during the spring high tides.

Avicennia is the dominant mangrove species in this area. Besides, *Acanthus* belts are also common. A few plants of *Rhizophora*, which are introduced some time back, are growing well in this area. Except a few crow nests, bird nests are not observed in this area.

3] Vikhroli III (Kanjurmarg nallah site):

The station is located on the west bank of Thane creek. This area is situated at comparatively low level. Hence majority of the area gets submerged during neap high tides. Water level reaches two feet above the ground level during spring high tides. Black patches especially of oil and grease on the stems & branches of mangroves indicate tree height of submergence during the Spring high tide. Mud flats in this area are very soft, possibly because of longer water retention in the area.

Avicennia and *Acanthus* are the two species, which predominantly present in this area. So far, bird nests and pagoda ant nests are not observed in this area.

B] Stations from other areas of Thane creek

1] Vitava Island Site

The station is located on the east bank of Thane creek. At least two sewage outlets of Thane Municipal Corporation are located near the study area. Mangrove trees are very tall with good canopy cover. Cutting of wood for fuel is rampant in the area, which is evidenced by the presence of dried branches and wood logs spread all over the area. Mud flats are very long with extremely soft mud. According to local fishermen, widening of mudflats coupled with shallowing of the channel took place in last ten years because of solid waste dumping and siltation resulted from the construction of bridges on the creek.

The entire area gets submerged only during spring high tides. *Avicennia*, *Sonneratia* and *Acanthus* are the dominant mangrove species of this area. Bird nests are more in this area as compared to other sites.

2] Talwali Village site

The area is located at village Talwali near Ghansoli in the Thane – Belapur Industrial Zone, opposite National Organic Chemical Industries Limited (NOCIL) and Indian Petrochemical Corporation Limited (IPCL) factories, on the east bank of Thane creek. The Thane – Belapur Industrial Zone is one of the biggest chemical industrial zone of Maharashtra state. All along this zone, huge *Acanthus* belts have been formed due to the destruction of mangrove vegetation. Mud flats are long with soft mud. Front mangrove area is not accessible from land ward side because of thick belts of *Acanthus*. The area gets submerged during spring high tides only.

The Eastern side of the creek is reclamated for industries and housing. Mangrove areas are used for constructing crematorium.

3] Mankhurd nallah site

The station is located at village Mankhurd near Vashi Creek Bridge on Mumbai – Pune National High way, on the west bank of Thane creek. The area is located near High way near abandoned saltpans. The area is easily accessible by road, hence extremely degraded. Cutting of trees for fuel wood is very high as compared to other stations. As a result, mangrove species show extensive branching.. Trees are stunted. The area gets submerged totally during spring high tides. Bird nests are very rare.

The study area is located near Deonar Solid Waste Dumping Depot, biggest of its kind in India. During spring high tides enormous quantity of solid waste in the form of plastic bags, plastic bottles, electric bulbs and tubes, thermacol etc. enters the creek and gets trapped in mangrove bushes. *Avicennia* is the dominant species of this area.

Chapter Five

Sediment & Water Chemistry

Brackish Water and Mangrove Sediment Chemistry

The soils in mangrove ecosystem can be best described as sediments, since they are developed due to the process of accumulation of oceanic sediments at the edge of the creeks or creek lets and present themselves in the form of mudflats. This mud flat is the substratum, which supports the growth of mangrove plants.

Mangrove plants are also continuously exposed to tidal actions. Brackish water that flows through the mangrove ecosystems during the tidal action is utilized by the biota for various requirements. Hence, the chemical composition of brackish water and the sediments can influence the structure and development of mangrove vegetation to the greater extend. Therefore, brackish water and sediments can be considered as the major components of mangrove ecosystem. In the present study, an attempt has been made to study the chemical composition of brackish water and mangrove sediments by evaluating a few physico-chemical parameters.

Since, the seasonal variations are prominent in these components, the study has been replicated for three seasons, viz. pre-monsoon, monsoon and post-monsoon season.

Brackish water chemistry

Information on seasonal variations in the water quality in the mangrove environment is necessary to understand the implications of such changes on biogeochemical cycling of elements and productivity of mangrove ecosystem. In the present study, brackish water samples were collected during spring as well as neap high tides. In total six parameters have been evaluated. They are, pH, salinity, nitrates, phosphates, silicates and oil and grease.

In general, the Thane creek is considered as one of the most polluted creeks of the world. The creek receives enormous quantity of sewage and industrial effluents from the numerous industrial and residential establishments spread all along the stretch of the creek. Water, in all seasons, shows a characteristic dark color and stinking smell with a lot of turbidity. The native people do not prefer fishes caught from the creek, since they emit an obnoxious oily smell, even after cooking.

The following discussion deals with various physico-chemical characteristics of the brackish water from Thane creek.

1] Hydrogen ion activity (pH) :

The pH represents the intensity of the acid or alkaline conditions of any solution by means of hydrogen ion activity. The pH is the function of carbon dioxide-carbonate-bicarbonate system. This carbon dioxide makes the fresh water slightly acidic where as, in marine water, besides carbon dioxide many other salts are present which makes it alkaline. In estuaries and creeks, pH values are controlled by the fresh water influx and

biological productivity of the waters. In highly productive waters, high values of pH are observed during highly productive hours of the day.

The average pH values of brackish water collected during spring and neap high tides have been presented in Table 5.1. The table depicts that during pre-monsoon season, average values of pH of spring high tide waters range between 7.41 to 7.74 with the highest value of 7.88 recorded at Mankhurd and lowest value of 7.36, recorded at Vikhroli I station. In monsoon, average pH of spring tide waters varies between 7.29 to 7.67 with the maximum value of 7.71 recorded at Vikhroli III station and minimum value of 7.24 recorded at Vikhroli I station. In post-monsoon season, average pH of spring tide waters range between 7.61 and 8.05 with the maximum value of 8.57 recorded at Mankhurd station and the minimum value of 7.52 recorded at Vikhroli I station.

During spring high tides, maximum values of pH have been recorded in post-monsoon season. Neap tide waters do not show any particular trend; however, in general, pH values of neap tide waters are lower than the spring tide waters. According to Upadhyay (1988), high pH values in post monsoon are due to the influence of seawater penetration and biological activity while low pH values in monsoon season are because of the influence of freshwater influx and decomposition of organic matter carried by flood waters into the riverine system. In the present study, minimum values of pH have been recorded in Vikhroli I station, which represents a back mangrove patch having comparatively less seawater penetration. Das et al (1997) while studying hydrobiology of Mahanadi estuary reported high pH values in pre-monsoon and lowest pH values in monsoon season. In the present study, the highest values of pH post-monsoon can be attributed to the domination of fresh water over the marine water. In broader view, pH values recorded in the entire creek ranges between 7.29 and 8.05 i.e. with a little fluctuations. According to Martin (1970), extensive buffering capacity of the sea water allows only little pH changes to be pronounced normally. In enclosed portions biological activity can cause sizeable variations. Since, Thane creek is not an enclosed structure, pH fluctuation are not significant in magnitude.

2] Salinity:

Salinity is a function of chlorides present in the aqueous system. Chloride is a minor constituent of earth's crust, but a major constituent of most natural waters. Quantitatively, the most important source of chloride is the chloride transported in the atmosphere and carried to earth by rain or snow. All chloride salts are highly soluble. It is also relatively free from the effects of exchange, adsorption and biological activity. Hence, once water takes chloride in the solution it is difficult to remove it through natural processes. Chloride content of natural waters varies from 0.1 mg/L in arctic snow to 150,000 mg/L in brines.

Consideration of salinity is very important for the study of mangrove ecosystem because salinity is the limiting factor for the growth of mangrove plants. Mangrove species are adapted to the saline environment while other terrestrial species are not. This makes the mangroves free from the competition of other plant species within the

ecosystem. Although, the saline water is necessary for the optimal growth, mangroves need fresh water also. In the marine ecosystem, salinity is influenced by the influx of freshwater and thus salinity can be useful to judge the freshwater flow in the creeks. In general, salinity of marine water ranges between 3ppt to 40ppt.

The average salinity values of brackish water collected during spring and neap high tides have been presented in Table 5.1. The table reveals that in all the six stations during the pre-monsoon, salinity ranges between 15.36ppt and 38.74ppt with maximum value of 40.57ppt recorded at Vitava and the minimum value of 13.30ppt reported at Vikhroli I station. In monsoon, salinity values varies between 4.60ppt to 23.81ppt with the maximum value of 26.94ppt recorded at Mankhurd and minimum value of 3.62ppt recorded at two stations, viz. Vikhroli I and Vikhroli III. In post-monsoon, salinity values are found to be between 24.88ppt and 35.20ppt with maximum value of 38.06ppt reported at Vikhroli III and Mankhurd and minimum value of 25.5ppt reported at Vikhroli I station. In general, salinity values are found to be minimum in monsoon, while the highest salinity values have been reported in pre-monsoon season. Gouda and Panigrahy (1992) reported maximum values of salinity in pre-monsoon and lowest values in monsoon with unimodal annual oscillations in Rushikulya estuary. Murugan and Ayyakkannu (1991) attributed the non-monsoonal high values of salinity to high solar radiation, neretic water dominance and lack of fresh water inflow and the monsoonal minima to rain and fresh water influx. According to Medeiros and Kjerfve (1993), high salinity values during non-monsoonal months is because of the excessive evaporation and evapotranspiration by mangroves which was sufficiently large to overcome precipitation runoff and tidal ocean mixing. The present study corroborates their observations.

Amongst the six stations, Vikhroli I shows minimum salinity values while Mankhurd has maximum salinity values. The reason can be attributed to their locations in the oceanic system. Vikhroli I is a back mangrove patch. It receives water mostly through the *nallahs* coming from Vikhroli village carrying domestic as well as industrial effluents. This resulted is increase of freshwater influx rather than brackish water which results in decrease in the salinity. On the other hand, Mankhurd is located closer to the Arabian sea. Here, although freshwater enters through the *nallahs*, its influx is lower than that of marine water which results in increase in the salinity values. If bank to bank difference in salinity values is considered, the stations on the east bank of Thane creek, viz. Vitava and Talwali shows more salinity values than those on the east bank. Coriolis effect is known to cause deflection to the right for water traveling in the northern hemisphere. Hence lower salinity at the stations on the west bank (right bank) and higher salinity at the stations on the east bank is expected (Athalye, 1988).

Salinity values of samples collected during neap high tides found to be lower than that of spring high tides. This is also directly related to the influx of more marine water during spring high tides.

3] Dissolved oxygen (D.O):

Oxygen is the key requirement for any life to exist. Terrestrial life gets oxygen from the ambient air by means of respiration, while aquatic organisms like fishes, crabs, plankton etc. get oxygen which is dissolved in the water. As the amount of oxygen decreases, the life expectancy of aquatic organisms also reduced. Since, aquatic organism like fishes and plankton are the most important components of the mangrove ecosystem, dissolved oxygen assumes a lot of importance for the mangrove ecosystem. Oxygen is a parameter that reveals much about the metabolism of water and is used as an index of water quality, primary production and pollution. Federal Water Pollution Control Administration of USA has recommended 4mg/L DO as optimum level for coastal and estuarine waters (Metcalf and Eddy, 1979).

Sources of oxygen in the aqueous system are the diffusion from atmosphere and photosynthesis process of the green aquatic plants. Oxygen from air is absorbed by direct diffusion and agitation of surface waters by wind action and turbulence. The amount of oxygen that can dissolve in the brackish water depends upon temperature, surface area of the stream exposed and to some extend salinity of water. There is an inverse relationship between dissolved oxygen and temperature and salinity of brackish water. DO decreases at higher temperatures and salinity.

Average values of dissolved oxygen (DO) in mg/L in the brackish water collected during spring and neap high tides have been presented in Table 5.1. The table depicts that, DO values of the spring tide water collected during pre-monsoon ranges between 0 to 4.10mg/L with the maximum DO value of 5.60mg/L recorded at Vikhroli III while minimum DO value of 0mg/L reported at Vikhroli I. During monsoon, DO values found to be ranging between 0 to 2.08mg/L with the maximum value of 2.20mg/L reported at Vikhroli III and the minimum value of 0 recorded at Vikhroli I. During pot-monsoon, DO values vary from 0 to 2.68mg/L with the maximum value of 3.60mg/L reported at Vikhroli III and the minimum value of 0 reported at Vikhroli I. Water coming at the Vikhroli I station is found to be anoxic in all the three season because of excessive mixing of sewage. The stations located on the main channel, viz. Vikhroli III and Talwali shows higher values of DO due to the dominance of marine water over the fresh water. Also high rate of primary production by phytoplankton and benthic macro algae may be accounted for the higher concentration of dissolved oxygen in brackish water. Mankhurd, although located near the Arabian sea, it receives enormous load of sewage from the slum areas flourishing in the nearby areas. This has reflected in lowering the DO values. In general, neap high tide waters show more DO than the spring high tide waters.

4] Phosphate (PO_4):

Phosphates enter the aqueous system by the natural geochemical processes like weathering of mineral like apatite and by through the industrial and domestic effluents. Phosphates or their molecularly dehydrated forms, usually referred as polyphosphates, are important for sanitary engineers. Phosphates are considered as main causative agents of algal bloom and subsequent eutrophication of water bodies. Phosphate is one of the important nutrients which regulate the production in aqueous ecosystem. Study

of phosphorous helps to determine the state of primary production of the aquatic community. Phosphorous is used on a large scale in agriculture since it is one of the three most important nutrients of plants, others being nitrogen and potassium. Hence, the estuaries in agriculturally developed area receive large amounts of phosphates through land runoff as the agricultural fields are heavily fertilized. Generally, maximum permissible limit for the phosphate contents for the water to be considered as unpolluted is 0.09mg/L (Yentsch and Ryther, 1957).

The average phosphate values of brackish water collected during spring and neap high tides have been presented in Table 5.1. The table shows that average PO_4 values in pre-monsoon range between 0.005mg/L and 0.073mg/L with maximum value of 0.125mg/L recorded at Vikhroli I and minimum value of 0.003mg/L reported at Vikhroli II. In monsoon, PO_4 values vary between 0.001mg/L to 0.017mg/L with maximum value of 0.020mg/L observed at Vikhroli I and minimum value of 0.001 mg/L recorded at all the stations except Vikhroli I. In post-monsoon, average PO_4 values range between 0.006mg/L to 0.045mg/L with maximum value of 0.067mg/L reported at Vikhroli I and minimum value of 0.004mg/L recorded at Vikhroli III. In all the three seasons, PO_4 values are found to be maximum at Vikhroli I. The reason can be attributed to the flow of sewage water to this station through nallah coming from human settlements. In general, PO_4 values are low in monsoon season. Apart of Vikhroli I, the other station subjected to influx of sewage i.e. Vitava also shows considerable values of PO_4. Generally the variations in the phosphate concentration are attributed to their utilization by phytoplankton. According to Pomeroy et al (1965), the variations in the phosphate concentration of brackish water can be attributed to various processes like adsorption and desorption of phosphate and buffering action of sediments under varying environmental conditions. Balkrishnana Nair (1984) reported mean phosphate level in surface waters of Ashtamaudi estuary between 3.4 to 6.02 μg/L. Similar observation have been made during the present study.

5] Nitrates (NO_3):

Most of the nitrates in natural waters are derived from organic sources or from industrial and agricultural chemicals. Nitrogenous nutrients are added to the estuaries and creeks mainly by freshwater and terrestrial runoff during monsoon season. Inorganic nitrogen is present in an aquatic biotope as oxidizing nitrite (NO_2), nitrate (NO_3) and as reduced ammonia (NH_4), the most abundant being nitrate. Nitrogen is essential nutrient required for synthesis of protein. Hence its availability significantly affects phytoplankton growth in natural waters.

The average nitrate values of brackish water collected during spring and neap high tides have been presented in Table 5.1. The average nitrate values of the spring tide waters collected during pre-monsoon season varies between 0.4 mg/L to 2.10 mg/L with the maximum value of 2.30 mg/L recorded at two stations viz. Vikhroli II and Vikhroli III and the minimum value of 0 mg/L recorded at two stations viz. Vikhroli II and Talwali. During monsoon, nitrate values found to be fluctuating between 0.8 mg/L and 1.72 mg/L with the maximum value of 2.50 mg/L recorded at Mankhurd and the

minimum value of 0.62 mg/L recorded at four stations viz. Vikhroli I, II, III and Vitava. During post-monsoon, nitrate value are found to be ranging between 5.47 mg/L and 11.58 mg/L with the maximum value of 20.10 mg/L recorded at Vitava and the minimum value of 4.61mg/L recorded at Talwali. Neap high tide waters show an opposite trend as the maximum values are observed in pre-monsoon and monsoon season while minimum values are reported in post monsoon season. According to Raman and Ganapathi (1986), NO_3-N levels 0.014 mg/L and 1.26 mg/L indicate unpolluted and semi-healthy water conditions respectively. Here, it is quite evident that, the condition of Thane creek can be categorized as most unhealthy.

In general, nitrate values are maximum in post-monsoon and lower in pre-monsoon and monsoon season. Chandran and Ramamoorthy (1984) attributed low concentrations of nitrates in Vellar estuary during summer and early pre-monsoon season to the utilization of nitrates by phytoplankton and cessation of freshwater flow.

The maximum values of nitrogen are observed at Vitava. Here sewage pollution as well as pollution by industrial wastes is maximum as the municipal sewage outlets are located just opposite the mangrove patch where studies have been made. Higher nitrate values at Vitava can be attributed to these pollution sources. There are also a few agricultural fields in the vicinity, in the village Kharegaon. Hence possibility of nitrate coming through the runoff from these fields cannot be ruled out.

Balkrishnanan Nair (1984) attributed lower values of nitrates in sewage polluted regions to the low rate of replenishment during the degradation of organic matter and also possibly due to nitrate reduction. However, such conditions are not observed in the present investigation as the stations from sewage polluted areas shows nitrates in considerable amount. Considering the Thane creek environs, the sources of nitrates can be attributed to industrial effluents and domestic sewage.

6] Silica (SiO_3):

In the earth's crust, silica is the second most abundant element after oxygen. Because of its affinity to oxygen, in nature it occurs as dioxide (i.e. silica) and trioxides (i.e. silicates). Silica forms a major dissolved constituent in river water. It undergoes measurable changes during estuarine mixing, being influenced by some chemical and biological processes of the ambient water besides mere physical mixing. Presence of silicates in estuaries and in creeks is an indication of freshwater influx into the estuary. Silica is essential element for the growth of certain organism like diatom and radiolarians which secrete intricate shells made up of silica (Alam, 1992). According to Egge and Aksenes (1992), the availability of dissolved silicates is one of the important factors that can regulate the species composition of phytoplankton assemblage. Silicon is removed from water due to its biological utilization by diatom. When dissolved silicates are abundant, the component of diatom phytoplankton become dominant, whereas, when silicates become low, the non-diatom phytoplankton can dominate the algal community and decrease the relative importance of diatoms.

The average values of silicates from brackish water collected during spring and neap high tides have been presented in Table 5.1. The average values of silicates from the spring high tide waters collected during pre-monsoon season ranges from 3.75mg/L to 30.75mg/L with the maximum value of 34mg/L recorded at Vikhroli I and minimum value of 2.50mg/L recorded at Vikhroli II station. In monsoon, average silicate values range between 6.25mg/L to 59.50mg/L with the maximum value of 59.5mg/L recorded at Vikhroli I and the minimum value of 2.50mg/L reported at Mankhurd. In post-monsoon, average silicate values range between 16.25mg/L and 56.88mg/L with the maximum value of 68mg/L reported at Vikhroli I and the minimum value of 15mg/L recorded at two stations viz. Vikhroli II and Mankhurd. Silicate concentration of neap high tide waters is found to be more than spring high tide waters. Quadros (1995) reported the silicate values from Thane creek waters in the range of 0.56 to 34.82mg/L with monsoonal maxima. In the present study, the values are found to increase, specifically in post-monsoon period. Balkrishnan Nair (1984) reported such a high values of silicates, ranging between 15.47mg/L and 42.56mg/L, in the brackish surface waters of Ashtamudi estuary.

In general, silicate values are more in post-monsoon and monsoon season than the pre-monsoon season. Similar observations have been made by Gouda and Panigrahy (1992) and Chandran and Ramamoorthy (1984) in Rishikulya and Vellar estuary respectively. According to Chandran and Ramamoorthy (1984), low values of silica during summer or pre-monsoon sesaon are due to the dissolution of particulate silicon carried by the river water, the removal of soluble silicate by adsorption and co-precipitation of soluble silicon with humic compounds and irons.

Maximum values of silicates have been observed at Vikhroli I station. This indicates the dominance of freshwater which enters through the sewage flows at this station. Silicate concentration is considerable throughout the creek. This suggests the dominance of sewage throughout the creek. This is also corroborated by very low values of dissolved oxygen in the creek as reported during the present study.

7] Oil and grease:

Oil and grease enters the aquatic system through the industrial effluents and through the accidental leakage from the tankers carrying the petroleum products. Industries which use oil and grease and release them in their effluents are engineering and forging industries at large. Thane creek is surrounded by many medium and large scale industries. A large number of the industries use oils and greases as furnace oils as well as for lubrication. These effluents often reach into the creek. Besides these common pollutants, accidental oil spills occurring at Arabian Sea also contribute to the oil and grease content of Thane creek. Oil and grease are water insoluble and is lighter in weight than water. Hence they float on water when entered in creek channels. During spring high tides, this floating oil gets attached to mangrove tree trunks. As a result, after the spring high tides, mangrove stands on the main channel of the creek often shows a dark and continuous band of oil and greases. During spring high tides, it is observed that many benthic dwellers like crabs often climb on the tree trunk to escape

from the polluted waters. If water contains oil and grease, it can prove to be fatal for such benthic organism. Since removing the oil and grease from such a large expanses of creek is practically impossible because of the huge costs involved, prevention is the only alternative.

The average concentration of oil and greases of spring high tide water collected during spring and neap high tides have been presented in Table 5.1. The table indicates that during all the three season, there is a presence of oil and grease in considerable amounts. The stations such as Vikhroli I and II which are located on the *nallahs* joining the creek shows the maximum oil and grease content than the stations located on the main channel of the creek. Also, the stations located near the Arabian sea, like Mankhurd and Talwali, shows less contents of oil and grease than the stations like Vitava which are located away from the Arabian sea. This can be attributed to the wave action which forces the floating oil into the creek during the high tides. Hence, the mangrove vegetation and marine organisms from the interior areas of the creek are more prone to damage because of oil and grease.

Table 5.1 : Brackish Water Chemistry at Selected Stations in Thane Creek

Station : Vikhroli I : Spring Hide Tide

Sample No.	PH	Salinity (ppt)	DO (ppm)	SiO3 (ppm)	PO4-P (ppm)	NO3-N (ppm)	O&G (ppm)
Season I							
1	7.39	15.44	0	32	0.068	1.5	320
2	7.36	14.74	0	28	0.125	1.5	
3	7.39	17.97	0	29	0.060	1.5	200
4	7.49	13.3	0	34	0.039	1.5	
Average	7.41	15.36	0	31	0.073	1.5	260.00
Max.	7.49	17.97	0	34	0.125	1.5	320.00
Min.	7.36	13.30	0	28	0.039	1.5	200.00
Season II							
1	7.36	3.62	0	57	0.019	1.25	200
2	7.24	4.69	0	56	0.015	1.25	150
3	7.26	5.41	0	62.5	0.020	0.62	200
4	7.31	4.69	0	62.5	0.014	1.25	100
Average	7.29	4.60	0	59.50	0.017	1.09	162.50
Max	7.36	5.41	0	62.50	0.020	1.25	200.00
Min	7.24	3.62	0	56.00	0.014	0.62	100.00
Season III							
1	7.6	24.07	0	67.5	0.040	7.77	200
2	7.52	25.16	0	52.5	0.067	7.20	250
3	7.69	24.79	0	57.5	0.035	6.57	150
4	7.64	25.5	0	50	0.037	10.30	300
Average	7.61	24.88	0	56.88	0.045	7.96	225
Max	7.69	25.50	0	68	0.067	10.30	300
Min	7.52	24.07	0	50	0.035	6.57	150

Station : Vikhroli II : Spring High Tide

Season I							
1	7.79	31.6	1.2	2.5	0.003	0	120
2	7.7	35.91	1.4	2.5	0.006	0.8	
3	7.71	37.7	1.3	5	0.007	2.3	120
4	7.73	38.78	1.6	5	0.008	1.5	
Average	7.73	36.00	1.38	3.75	0.006	1.15	120
Max	7.79	38.78	1.60	5.00	0.008	2.30	120
Min	7.70	31.60	1.20	2.50	0.003	0.00	120
Season II							
1	7.48	20.48	1.5	12.5	0.002	0.62	150
2	7.52	22.29	1.7	12.5	0.001	1.25	200
3	7.47	22.63	1.6	12.5	0.003	1.25	200
4	7.51	20.48	1	15	0.002	1.25	150
Average	7.50	21.47	1.45	13.13	0.002	1.09	175
Max	7.52	22.63	1.70	15.00	0.003	1.25	200
Min	7.47	20.48	1.00	12.50	0.001	0.62	150
Season III							

1	7.85	32.32	0.6	20	0.014	5.245	200
2	7.87	29.09	0.4	22.5	0.014	6.5	150
3	7.85	36.64	0.5	27.5	0.016	5.245	350
4	7.84	31.26	0.5	15	0.012	7.0152	350
Average	7.85	32.33	0.50	21.25	0.014	6.00	263
Max	7.87	36.64	0.60	27.50	0.016	7.02	350
Min	7.84	29.09	0.40	15.00	0.012	5.25	150

Station : Vikhroli II : Neap High Tide

Sample No.	PH	Salinity (ppt)	DO (ppm)	SiO3 (ppm)	PO4-P (ppm)	NO3-N (ppm)	O&G (ppm)
Season I							
1	7.3	32.68	2.4	2.5	1.023	1.5	120
2	7.31	32.32	2.1	2.5	1.016	0.8	
3	7.29	33.75	2.6	7.5	1.356	1.5	80
4	7.31	32.32	2.5	5	1.428	0.7	
Average	7.30	32.77	2.40	4.38	1.21	1.13	100.00
Max	7.31	33.75	2.60	7.50	1.43	1.50	120.00
Min	7.29	32.32	2.10	2.50	1.02	0.70	80.00
Season II							
1	8.41	19.42	18	20	0.012	1.88	150
2	8.47	16.89	16.4	15	0.010	3.14	200
3	8.48	16.89	18.6	15	0.013	3.14	200
4	8.4	17.25	16.6	20	0.015	2.5	200
Average	8.44	17.61	17.40	17.50	0.012	2.67	187.50
Max	8.48	19.42	18.60	20	0.015	3.14	200.00
Min	8.40	16.89	16.40	15	0.010	1.88	150.00
Season III							
1	7.43	29.09	1.5	15	0.027	2.5	200
2	7.43	32.32	1.9	20	0.025	3.46	250
3	7.57	31.6	1.4	15	0.026	3.28	150
4	7.51	33.77	1.5	15	0.028	3.06	250
Average	7.49	31.70	1.58	16.25	0.026	3.08	212.50
Max	7.57	33.77	1.90	20	0.028	3.46	250.00
Min	7.43	29.09	1.40	15	0.025	2.50	150.00

Station : Vikhroli III : Spring High Tide

Season I							
1	7.71	31.6	5.6	7	0.0135	2.3	80
2	7.63	31.24	3.3	11.5	0.0190	1.5	
3	7.66	31.6	4.1	7.5	0.0075	2.3	40
4	7.51	30.88	3.4	7.5	0.0145	2.3	
Average	7.63	31.33	4.10	8.38	0.0136	2.10	60
Max	7.71	31.60	5.60	11.50	0.0190	2.30	80
Min	7.51	30.88	3.30	7.00	0.0075	1.50	40
Season II							
1	7.63	3.62	1.9	10	0.004	1.25	150
2	7.68	4.69	2	12.5	0.001	0.62	200

3	7.71	5.41	2.2	5	0.001	1.25	100
4	7.65	4.69	2.2	5	0.001	0.62	100
Average	7.67	4.60	2.08	8.13	0.001	0.94	137.50
Max	7.71	5.41	2.20	12.50	0.004	1.25	200
Min	7.63	3.62	1.90	5.00	0.001	0.62	100
Season III							
1	8.04	37.36	1.7	20	0.006	5.498	250
2	8.03	31.96	3.6	15	0.004	10.175	100
3	8.07	33.4	2.3	12.5	0.008	10.175	150
4	8.06	38.06	3.1	17.5	0.008	6.5	100
Average	8.05	35.20	2.68	16.25	0.006	8.09	150
Max	8.07	38.06	3.60	20	0.008	10.18	250
Min	8.03	31.96	1.70	12.50	0.004	5.50	100

Station : Vikhroli III : Neap High Tide

Sample No.	PH	Salinity (ppt)	DO (ppm)	SiO3 (ppm)	PO4-P (ppm)	NO3-N (ppm)	O&G (ppm)
Season I							
1	7.31	33.39	2.4	5	0.012	3.1	240
2	7.35	33.39	2.7	5	0.014	1.5	
3	7.3	31.24	2.4	5	0.014	3.1	120
4	7.3	31.96	2.4	5	0.015	0.8	
Average	7.32	32.50	2.48	5	0.014	2.13	180
Max	7.35	33.39	2.70	5	0.015	3.10	240
Min	7.30	31.24	2.40	5	0.012	0.80	120
Season II							
1	7.25	13.31	0.7	20	0.012	1.88	100
2	7.23	17.25	1.6	15	0.010	3.14	150
3	7.16	11.51	0.1	15	0.013	3.14	200
4	7.17	13.31	0.5	20	0.015	2.5	250
Average	7.20	13.85	0.73	17.50	0.012	2.67	175
Max	7.25	17.25	1.60	20	0.015	3.14	250
Min	7.16	11.51	0.10	15	0.010	1.88	100
Season III							
1	7.71	31.96	2	10	0.015	2.82	100
2	7.63	31.96	1.7	17.5	0.013	3.42	100
3	7.66	32.68	1.9	17.5	0.012	3.42	200
4	7.51	32.32	1.5	17.5	0.009	3.79	150
Average	7.63	32.23	1.78	15.63	0.012	3.36	137.50
Max	7.71	32.68	2.00	17.50	0.015	3.79	200
Min	7.51	31.96	1.50	10.00	0.009	2.82	100

Station : Vitava : Spring High Tide

Season I							
1	7.6	36.07	1.1	2.5	0.012	0.8	120
2	7.74	40.57	1.1	5	0.008	0.8	
3	7.55	39.91	1.1	5	0.010	0.8	160

4	7.55	38.42	1.4	5	0.009	0.8	
Average	7.61	38.74	1.18	4.38	0.010	0.8	140
Max	7.74	40.57	1.40	5.00	0.012	0.8	160
Min	7.55	36.07	1.10	2.50	0.008	0.8	120
Season II							
1	7.48	19.05	1.1	15	0.001	1.25	100
2	7.55	18.69	1.4	7.5	0.002	0.62	150
3	7.55	16.89	0.9	12.5	0.002	0.62	150
4	7.59	20.12	1.2	10	0.004	0.62	150
Average	7.54	18.69	1.15	11.25	0.002	0.78	137.50
Max	7.59	20.12	1.40	15.00	0.004	1.25	150
Min	7.48	16.89	0.90	7.50	0.001	0.62	100
Season III							
1	7.79	33.4	0.3	22.5	0.020	7.84	200
2	7.81	31.26	0.4	30	0.022	10.87	300
3	7.87	37.36	1	27.5	0.022	20.10	400
4	7.85	31.6	0.9	30	0.017	7.52	50
Average	7.83	33.41	0.65	27.50	0.020	11.58	237.50
Max	7.87	37.36	1.00	30.00	0.022	20.10	400
Min	7.79	31.26	0.30	22.50	0.017	7.52	50

Table (Contd.) **Station : Vitava : Neap High Tide**

Sample No.	PH	Salinity (ppt)	DO (ppm)	SiO3 (ppm)	PO4-P (ppm)	NO3-N (ppm)	O&G (ppm)
Season I							
1	7.79	23.67	2.6	34.5	0.029	6.2	120
2	7.75	25.41	3.5	41.7	0.027	6.2	
3	7.81	25.06	4.5	32	0.029	6.2	120
4	7.84	24.72	3.2	12.2	0.010	5.2	
Average	7.80	24.72	3.45	30.10	0.024	5.95	120
Max	7.84	25.41	4.50	41.70	0.029	6.20	120
Min	7.75	23.67	2.60	12.20	0.010	5.20	120
Season II							
1	7.5	2.54	4.2	30	0.028	1.88	200
2	7.63	1.82	3.9	32.5	0.029	3.79	250
3	7.68	2.18	5.2	20	0.028	2.5	200
4	7.83	2.54	9	30	0.030	3.79	200
Average	7.66	2.27	5.58	28.13	0.029	2.99	212.50
Max	7.83	2.54	9.00	32.50	0.030	3.79	250
Min	7.50	1.82	3.90	20	0.028	1.88	200
Season III							
1	7.65	31.26	2.3	32.5	0.03	3.04	250
2	7.6	32.32	2.1	22.5	0.03	3.28	150
3	7.59	31.6	2.1	27.5	0.03	4.108	200
4	7.6	31.6	2	30	0.03	3.52	200
Average	7.61	31.70	2.13	28.13	0.03	3.49	200
Max	7.65	32.32	2.30	32.50	0.03	4.11	250
Min	7.59	31.26	2.00	22.50	0.03	3.04	150

Station : Mankhurd : Spring High Tide

Season I							
1	7.67	38.06	0.4	5	0.004	0.8	120
2	7.67	34.11	0.4	5	0.004	0	
3	7.75	33.39	0.3	7.5	0.005	1.5	80
4	7.88	29.45	0.5	7.5	0.005	0.8	
Average	7.74	33.75	0.40	6.25	0.005	0.78	100.00
Max	7.88	38.06	0.50	7.50	0.005	1.50	120.00
Min	7.67	29.45	0.30	5.00	0.004	0.00	80.00
Season II							
1	7.48	21.2	0.7	7.5	0.001	1.25	150
2	7.47	24.79	0.7	2.5	0.001	2.5	100
3	7.51	26.94	1	7.5	0.001	1.88	150
4	7.53	22.29	1.2	7.5	0.006	1.25	100
Average	7.50	23.81	0.90	6.25	0.002	1.72	125
Max	7.53	26.94	1.20	7.50	0.006	2.50	150
Min	7.47	21.20	0.70	2.50	0.001	1.25	100
Season III							
1	8.57	33.32	0	15	0.007	5.372	200
2	7.77	31.96	0.5	22.5	0.008	4.993	250
3	7.85	38.06	0.6	22.5	0.009	5.6248	50
4	7.88	31.26	0.4	20	0.008	5.877	150
Average	8.02	33.65	0.38	20.00	0.008	5.47	162.50
Max	8.57	38.06	0.60	22.50	0.009	5.88	250
Min	7.77	31.26	0.00	15.00	0.007	4.99	50

Table (Contd.) **Station : Mankhurd : Neap High Tide**

Sample No.	PH	Salinity (ppt)	DO (ppm)	SiO3 (ppm)	PO4-P (ppm)	NO3-N (ppm)	O&G (ppm)
Season I							
1	7.34	34.47	2.8	2.5	0.014	3.1	160
2	7.3	34.47	2.8	5	0.009	3.1	
3	7.29	34.47	2.8	2.5	0.010	2.3	400
4	7.31	34.83	2.8	2.5	0.010	0.8	
Average	7.31	34.56	2.80	3.13	0.011	2.33	280
Max	7.34	34.83	2.80	5.00	0.014	3.10	400
Min	7.29	34.47	2.80	2.50	0.009	0.80	160
Season II							
1	7.23	3.62	0.4	30	0.030	3.14	200
2	7.23	10.79	0	25	0.020	2.5	100
3	7.2	9	0	20	0.023	5.06	150
4	7.17	6.13	0	20	0.023	3.79	150
Average	7.21	7.39	0.10	23.75	0.024	3.62	150
Max	7.23	10.79	0.40	30	0.030	5.06	200
Min	7.17	3.62	0.00	20	0.020	2.50	100
Season III							
1	7.77	33.77	2	15	0.027	2.5	150
2	7.47	33.04	2.5	20	0.025	3.46	100

3	7.51	33.77	2	15	0.026	3.28	200
4	7.51	32.32	2.1	15	0.028	3.06	200
Average	7.57	33.23	2.15	16.25	0.026	3.08	162.50
Max	7.77	33.77	2.50	20	0.028	3.46	200
Min	7.47	32.32	2	15	0.025	2.50	100

Station : Talwali : Spring High Tide

Season I							
1	7.41	33.39	3.4	17.2	0.017	0	120
2	7.45	33.03	4.7	15	0.016	0.8	
3	7.4	34.07	4.7	15	0.016	0.8	80
4	7.4	28.01	4.8	15	0.015	0	
Average	7.42	32.13	4.40	15.55	0.016	0.40	100
Max	7.45	34.07	4.80	17.20	0.017	0.80	120
Min	7.40	28.01	3.40	15.00	0.015	0.00	80
Season II							
1	7.51	17.97	1.9	17.5	0.003	1.88	200
2	7.53	21.2	2.2	12.7	0.003	1.25	200
3	7.48	20.48	1.9	7.5	0.003	1.25	150
4	7.51	18.69	3.7	12.5	0.001	1.88	150
Average	7.51	19.59	2.43	12.55	0.002	1.57	175
Max	7.53	21.20	3.70	17.50	0.003	1.88	200
Min	7.48	17.97	1.90	7.50	0.001	1.25	150
Season III							
1	8.01	35.19	1.7	42.5	0.013	6.19	200
2	7.96	32.68	1.2	32.5	0.013	5.56	250
3	7.96	33.04	2.5	27.5	0.013	4.61	150
4	8.18	32.32	0	25.5	0.011	7.02	300
Average	8.03	33.31	1.35	32	0.012	5.85	225
Max	8.18	35.19	2.5	42.50	0.013	7.02	300
Min	7.96	32.32	0.0	25.50	0.011	4.61	150

Sediment chemistry:

The nutrient economy of an aquatic ecosystem is mainly governed by the sediments. The productivity of estuarine ecosystems, which are known to be productive, depends upon the chemical constitution of the sediments. The sediments, where the dead organic matter gets deposited and also undergoes chemical and bacterial decomposition, acts as reservoir of nutrients under favorable conditions (DeSouza et al, 1979). Low lying alluvial coastal plains or downed valleys fringe by shallows, estuaries and deltas carrying waters rich in suspended matter and where marine coastal waters are not disturbed by strong dynamism, are ideal places for coastal accretion that is consolidated by mangroves (Vanucci, 1989). Sediment, besides providing all the necessary nutrients to mangrove plants, also affect the distribution, functional morphology and behavior of benthic organisms, which constitutes a large component of mangrove ecosystem. Sediments, which is also referred as substratum, can be classified into hard and soft substratum. Hard substratum is composed of a single material, such

as rock, hard skeletons like corals, wood or re-cemented sedimentary grains. Here organisms live mostly in attached form or in burrows. Soft substrata consists of sedimentary mineral grains, small organic particles derived from dead and decaying plants and animals (particularly organic detritus) and water. Chemically, these soft sediments are not homogenous with the depth below the sediment-water interface. Generally, sediments are reducing environments, devoid of oxygen, except for a surficial oxidized layer of a few centimeters or less. This zonation is generated as a balance between consumption of oxygen by benthic organisms and organic matter in sediments and pore water and the transport of oxygen from the overlying water into the sediments (Levinton, 1982). In mangrove sediments, under the anaerobic conditions below the surface, sulfate reducing bacteria produce hydrogen sulfide by reduction of organic sulfate from debris and reduction of sulfate in soil-water. This gas gives mangrove soils their pungent odour and also reduces iron compounds present in the soil to various hydrated ferrous sulfides to give the soils their characteristic dark colour (Lear and Turner, 1977).

The following text deals with the physico-chemical characteristics of mangrove sediments collected from the Thane creek.

1] Hydrogen ion activity (pH):

pH indicates the acidic or basic chemical reaction of the sediments. The pH values of sediment samples collected from the six stations have been presented in Table 5.2. The table depicts that, during pre-monsoon, average pH values vary between 7.29 and 8.23 with the maximum pH value of 8.39 recorded at Talwali and the minimum pH value of 6.92 reported at Vikhroli I. During monsoon, the average values of pH range from 7.07 to 7.70 with the maximum value of 7.85 recorded at Mankhurd and the minimum value of 6.90 recorded at Talwali. During post-monsoon, average pH values are found to be between 6.81 and 7.46 with the maximum value of 7.71 recorded at Vitava while the minimum value of 5.89 reported at Vikhroli I.

2] Salinity:

Salinity is considered as a limiting factor for the growth and development of mangroves as it affects the photosynthesis and respiration rates. Mangroves are considered as facultative halophytes. Their tolerance to saline conditions enables them to survive in environments which are unavailable to their principal competitors like terrestrial plants. Salinity or the salt concentration in the mangrove sediments depends upon evaporation, tidal flushing and fresh water inputs from rainfall, subterranean seepage and terrestrial run-off.

The salinity values of sediment samples collected from the six stations have been presented in Table 5.2. The table shows that, during pre-monsoon season, average salinity values vary between 6.71 ppt and 9.61 ppt with the maximum salinity value of 12.59 ppt observed at Vikhroli III and Mankhurd while the minimum salinity value of 4.34 ppt reported at Vikhroli I. During monsoon, the average values of salinity range from 2.14 ppt and 5.84 ppt with the maximum value of 10.44 ppt recorded at Vikhroli II

and the minimum value of 1.47 ppt recorded at Talwali. During post-monsoon, average salinity values are found to be between 5.59 ppt and 12.21 ppt with the maximum value of 14.74 ppt recorded at Vikhroli II while the minimum value of 5.05 ppt reported at Talwali. In general, it is observed that, the salinity values are minimum during the monsoon. Similar observation has been made by Deshmukh (1990) while studying the mangrove ecosystem of Vikhroli. This can be because of fresh water influx in the creek through various sources like precipitation and run-off. The Vikhroli I station which is a back mangrove area shows minimum salinity values. However, it is interesting to note that Talwali, although located on the main channel of the creek and also situated in the proximity to the Arabian sea, the sediment samples show less salinity values, minimum during monsoon and post-monsoon season. The reason can be attributed to the enormous land reclamation activities that are going on all along the east bank of Thane creek. Reclamation has almost altered the sediment composition of the area, which is corroborated by the presence of high percentage of sand in the sediments.

3] Organic matter (O.M.):

The important sources of organic matter in mangrove sediments are the decomposition of the mangrove foliage and other vegetative remains. Besides, the discharge of effluents from leather, fertilizer industries and also domestic waste into the creek also contribute substantially to the organic matter in mangrove sediments. Ramnathan (1997) reported that the organic matter content in the mangrove sediments is excess over the estuarine sediments due to the inherent biological productivity within the mangroves. Investigations on the organic matter in sediments indicate the extent of biological activity and indirectly the fertility of overlying seawater as well as status of pollution of the waters. Although, the organic matter is necessary for the plant growth, if present in excess quantity, acts as universal pollutants that affect the benthic organism.

The organic matter calculated from the mangrove sediments collected from six stations in Thane creek has been presented in Table 5.2. During pre-monsoon season, OM content varies between 2.88% and 6.47% with the maximum value of 9.88% recorded at Vikhroli I and the minimum value of 2.19% reported at Vikhroli III. During monsoon, the range of OM observed is from 3.54% to 5.87% with the maximum value of 7.96% recorded at Vitava and Vikhroli I and minimum value of 2.12% observed at Talwali. During post-monsoon, OM ranges from 3.57% to 7.06% with the maximum value of 9.40% recorded at Vikhroli I while the minimum value of 2.29% reported at Talwali. General trend indicates that OM values decrease in monsoon and again increase during post-monsoon with the maximum values observed in post-monsoon. This can be attributed to the decomposition litter fall contributing to the organic matter in mangrove sediments. Maximum values of organic matter are reported from Vikhroli I and Vitava station. This can be due to the presence of substantial mangrove cover in these stations. Comparatively lower values of OM at Mankhurd and Talwali are due to the absence of vegetative cover while lower values at Vikhroli II station can be due to the continuous wave action which flushes out the organic matter from the area.

4] Total nitrogen:

Nitrogen is one of the important plant nutrient. In mangrove sediments, source of nitrogen is the degradation of leaf litter and the other vegetative parts of the mangrove parts as well as degradation of other dead organisms. Besides, nitrogen can be added into the sediments from the domestic sewage and industrial effluents. Study of nitrogen and organic carbon is useful in identifying sediments containing excess nutrients because of contamination by domestic and agricultural waters (Michael Reddy, 1977).

The values of nitrogen calculated from the mangrove sediments of Thane creek are presented in Table 5.2. The table indicates that during pre-monsoon, average values of nitrogen range between 0.30% and 0.48% with the maximum value of 0.77% observed at Vikhroli I and the minimum value of 0.21% reported at Talwali. During monsoon, total nitrogen values found to between 0.24% and 0.59% with the maximum value of 0.59% recorded from Vikhroli I and the minimum value of 0.24% observed at Talwali. During post-monsoon, nitrogen values are ranging from 0.22% to 0.53% with the maximum value of 0.66% reported at Vitava and the minimum value of 0.19% observed at Talwali. Since Vikhroli I and Vitava stations are partially protected, the vegetation is thick with maximum litter fall. This could have contributed to the maximum values of nitrogen in these stations. On the other hand, Talwali is a station having only *Acanthus sp*. in dominance without any other tall trees. Hence the litterfall is limited in this station. This has reflected in minimum values of nitrogen. In general, maximum values of total nitrogen are observed during pre-monsoon and monsoon seasons while during post-monsoon values are found to be less. Higher values of total nitrogen in sediments during summer are probably due to the abundance of plankton in the overlying waters and increased quantum of silt and clay fraction in the sediments. (Reddy and Hariharan, 1986). Anthropogenic disturbances cause substantial damage to mangrove plants and also it can alter the composition of certain elements in the sediments. Kaly et al (1997) reported that in case of mangrove forests of Australia, undisturbed forests contained two to three times as much nitrogen and phosphorous than the disturbed forests. In the present investigation, total nitrogen calculated from the sediments of partially protected areas is more than that of collected from disturbed areas. However, quantitatively, there is not much difference.

5] Total phosphorous:

The important source of phosphorous in the mangrove sediments is the degradation of litterfall. Besides, domestic sewage also contribute substantially in increasing the phosphorous content of mangrove sediments. (Balkrishana Nair, 1984; Aston and Hewitt, 1977 and Sankaranarayanan and Panampunnayil, 1979).

The total estimated from the sediments of Thane creek is presented in Table 5.2. The table depicts that, during pre-monsoon, average values of phosphorous range from 0.006 mg/L and 0.012 mg/L with the maximum value of 0.030 mg/L recorded at Talwali while the minimum value of 0.001 mg/L reported at Vikhroli II. During monsoon, the

average values of phosphorous range between 0.008 mg/L and 0.024 mg/L with the maximum value of 0.145 mg/L observed at Vikhroli I and minimum value of 0.001 mg/L recorded at Vitava. During post-monsoon, average phosphorous values range from 0.013 mg/L to 0.021 mg/L with the maximum value of 0.125 mg/L recorded at Vikhroli II and the minimum value of 0.003 mg/L observed at Talwali. All along the creek, phosphorous contents off sediments are more in monsoon and post monsoon seasons. Higher values of total phosphorous during post monsoon period can be attributed to the addition of ferruginous material brought in by the river during the south-west monsoon period (Reddy and Hariharan, 1986). The stations such as Mankhurd, Vikhroli I and Vitava, which receives sewage in considerable amounts, shows higher values of phosphorous indicating its source from domestic and industrial effluents.

6] Sediment texture:

The texture of the mangrove sediments plays an important role in determining the distribution of benthic organisms. Also, texture can influence the incorporation of organic matter in the mangrove sediments. According to Rajamanickram and Setty (1975), clayey sediments offer larger surface for the adsorption of organic matter.

The percentage composition of the three soil separates viz. sand, silt and clay from the mangrove sediments is presented in Table 5.2. The table indicates that, in general, the sediments from the Thane creek mangrove areas are silty clay loam type at five stations. At Talwali, the sediments are loam type. The change in the sediment texture at Talwali can be attributed to anthrpogenic activities like land reclamation and dumping of solid waste near the creek. Seasonal fluctuation is not observed in case of sediment texture. Similar observation have been reported by Deshmukh (1990) in Vikhroli area.

In general, it can be concluded that the brackish waters of Thane creek shows alkaline nature. The waters are found to be anoxic or hypoxic throughout the year. A higher value of phosphates, nitrates and silicates in the water indicates the unhealthy condition of Thane creek due to influx of sewage. The creek also shows oil and grease in appreciable amount. Sediment samples collected from partially protected stations show maximum organic matter and total nitrogen due to litter fall. Total phosphorous levels in the sediments are also found to be more because of the sewage pollution of the creek. Sediment texture is silty or clay loam type at five stations while on the eastern site of the creek texture shows change because of maximum anthropogenic activities in the form of land reclamation. The present water and soil conditions of the creek are no longer suitable for mangrove regeneration.

Table-5.2: Sediment Chemistry at Selected Stations

Season I : Station : Vikhroli I

Sample No.	PH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	6.92	9.36	3.04	5.24	0.010	0.25	0.55	77.35	22.1
1.2	7.09	7.21	5.73	9.88	0.010	0.73	0.88	68.62	30.5
1.3	7.59	5.05	3.32	5.72	0.010	0.43	0.63	72.27	27.1
1.4	7.2	5.77	3.63	6.26	0.013	0.49	0.97	81.02	18.01
2.1	7.26	6.85	4.11	7.08	0.013	0.77	1.21	76.84	21.95
2.2	7.12	5.77	3.86	6.65	0.014	0.57	1.07	79.15	19.79
2.3	7.36	5.77	4.49	7.74	0.014	0.4	0.45	63.35	36.2
2.4	7.11	5.05	3.79	6.53	0.008	0.45	0.7	79.44	19.86
3.1	7.16	9	4	6.9	0.009	0.43	0.54	63.29	36.17
3.2	7.09	9.36	3.53	6.08	0.008	0.5	0.5	79.6	19.9
3.3	7	6.13	5.39	9.29	0.010	0.57	0.91	57.8	41.29
3.4	7.64	7.92	4.02	6.93	0.008	0.7	0.7	79.44	19.86
4.1	7.38	6.49	2.26	3.9	0.008	0.28	17.84	64.17	18.34
4.2	7.48	6.85	1.98	3.41	0.007	0.24	0.45	72.4	27.15
4.3	7.69	6.49	2.27	3.91	0.007	0.33	0.36	72.46	27.17
4.4	7.53	4.34	4.62	7.96	0.013	0.53	0.63	81.3	18.07

Min	6.92	4.34	1.98	3.41	0.007	0.24	0.36	57.80	18.01
Max	7.69	9.36	5.73	9.88	0.014	0.77	17.84	81.30	41.29
Mean	7.29	6.71	3.75	6.47	0.010	0.48	1.77	73.03	25.22

Season I: Station : Vikhroli II

Sample No.	PH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.83	9.36	2.91	5.02	0.007	0.42	0.97	72.02	27.01
1.2	8.01	7.56	2.78	4.97	0.008	0.39	0.15	72.62	27.23
1.3	8.1	10.08	3.03	5.22	0.008	0.33	0.7	69.51	29.79
1.4	8.22	11.15	2.88	4.96	0.008	0.33	0.3	69.79	29.91
2.1	8.09	6.49	2.62	4.52	0.008	0.33	0.38	69.74	29.89
2.2	8.21	7.56	2.69	4.64	0.004	0.33	0.37	56.93	42.7
2.3	8.08	8.28	2.53	4.36	0.002	0.31	1.09	69.24	29.67
2.4	8.17	9.36	2.91	5.02	0.001	0.38	0.73	69.49	29.78
3.1	7.9	7.92	2.24	3.86	0.003	0.35	0.81	69.43	29.76
3.2	7.99	6.85	2.5	4.31	0.007	0.38	0.6	72.29	27.11
3.3	8.05	6.83	2.05	3.53	0.009	0.32	0.27	72.53	27.2
3.4	8.07	10.79	2.69	4.64	0.008	0.25	0.2	72.58	27.22
4.1	7.81	6.13	2.62	4.52	0.008	0.36	0.27	72.53	27.2
4.2	7.99	7.92	2.05	3.53	0.007	0.35	0.16	72.61	27.23
4.3	8.01	7.21	2.59	4.46	0.010	0.39	0.11	72.65	27.24
4.4	8.1	9	2.69	4.64	0.008	0.4	0.15	72.62	27.23
Min	7.81	6.13	2.05	3.53	0.001	0.25	0.11	56.93	27.01
Max	8.22	11.15	3.03	5.22	0.010	0.42	1.09	72.65	42.70
Mean	8.04	8.28	2.61	4.51	0.006	0.35	0.45	70.41	29.14

Table (Contd.)

Season I : Station : Vikhroli III

Sample No.	PH	Salinity (ppt)	OC %	OM %	TotPO4	Total N	Texture		
							Sand %	Silt %	Clay %
1.1	7.56	7.56	1.27	2.19	0.008	0.29	0.2	66.53	33.27
1.2	7.47	10.08	1.91	3.30	0.008	0.35	0.62	69.57	29.82
1.3	7.66	7.21	1.43	2.47	0.012	0.31	0.12	59.93	39.95
1.4	7.4	12.59	1.33	2.30	0.015	0.38	0.3	69.79	29.91
2.1	7.57	10.08	1.98	3.42	0.012	0.32	0.43	63.36	36.21
2.2	7.49	9	1.77	3.04	0.009	0.31	0.26	79.79	19.95
2.3	7.59	8.28	1.64	2.83	0.008	0.29	0.46	59.73	39.82
2.4	7.55	10.08	2.05	3.53	0.006	0.32	0.38	59.77	39.85
3.1	7.6	9.72	1.64	2.83	0.007	0.33	0.16	63.53	36.6
3.2	7.58	10.79	1.43	2.46	0.010	0.32	0.12	59.93	39.95
3.3	7.55	11.51	1.39	2.40	0.009	0.29	0.43	90.51	9.05
3.4	7.6	9	1.95	3.37	0.006	0.33	0.16	59.89	39.93
4.1	7.67	8.28	1.64	2.83	0.008	0.39	0.22	59.87	39.91
4.2	7.55	11.15	1.95	3.37	0.007	0.38	0.28	59.83	39.89
4.3	7.89	6.85	1.77	3.04	0.008	0.45	0.13	44.39	55.48
4.4	7.5	11.51	1.55	2.67	0.006	0.35	0.12	49.94	49.94
Min	7.40	6.85	1.27	2.19	0.006	0.29	0.12	44.39	9.05
Max	7.89	12.59	2.05	3.53	0.015	0.45	0.62	90.51	55.48
Mean	7.58	9.61	1.67	2.88	0.009	0.34	0.27	63.52	36.22

Season I : Station : Vitava

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.38	8.28	3.22	5.55	0.007	0.35	0.6	69.58	29.82
1.2	7.61	7.92	3.41	5.88	0.006	0.33	0.5	69.65	29.85
1.3	7.39	9	3.48	5.6	0.009	0.39	0.38	69.74	29.89
1.4	7.31	6.13	3.44	5.93	0.008	0.46	1.57	68.9	29.53
2.1	7.69	8.28	2.37	4.08	0.007	0.33	0.7	49.65	49.65
2.2	7.61	9.36	3.1	5.34	0.008	0.33	0.38	79.7	19.92
2.3	7.7	7.56	2.84	4.9	0.008	0.33	1.44	68.99	29.57
2.4	7.46	9.36	3.48	5.6	0.002	0.39	0.78	81.18	18.04
3.1	7.71	8.64	2.65	4.57	0.008	0.35	0.38	59.77	39.85
3.2	7.5	7.56	3.41	5.88	0.007	0.24	0.6	69.58	29.82
3.3	7.68	7.56	3.51	6.07	0.007	0.35	2.23	78.22	19.55
3.4	7.35	8.28	2.53	4.36	0.002	0.38	1.77	68.76	29.47
4.1	7.34	8.64	2.59	4.46	0.012	0.36	1.63	68.86	29.51
4.2	7.37	7.92	2.59	4.46	0.012	0.31	0.93	69.35	29.72
4.3	7.34	7.21	2.21	3.81	0.008	0.31	1.17	69.18	29.65
4.4	7.62	7.92	2.94	5.07	0.012	0.32	2.27	68.41	29.32
Min	7.31	6.13	2.21	3.81	0.002	0.24	0.38	49.65	18.04
Max	7.71	9.36	3.51	6.07	0.012	0.46	2.27	81.18	49.65
Mean	7.50	8.10	2.99	5.10	0.008	0.35	1.08	69.35	29.57

Table (Contd.) **Season I : Station : Mankhurd**

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.71	6.49	1.9	3.27	0.006	0.29	0.2	36.29	63.51
1.2	7.57	6.49	1.92	3.31	0.008	0.31	0.84	44.07	55.09
1.3	7.46	8.28	1.61	2.77	0.007	0.33	0.42	45.27	54.32
1.4	7.36	9	2.28	3.93	0.008	0.28	1.44	39.42	59.14
2.1	7.67	5.41	2.31	3.98	0.006	0.31	1.48	39.41	59.11
2.2	7.83	5.71	1.42	2.45	0.006	0.29	0.64	39.75	59.62
2.3	7.67	6.13	2.2	3.97	0.006	0.36	7	29.79	69.51

2.4	7.39	7.92	1.96	3.38	0.007	0.32	0.85	45.07	54.08
3.3	7.35	7.92	2.06	3.55	0.007	0.32	1.26	62.84	35.91
3.4	7.39	8.28	1.36	2.34	0.008	0.26	1.44	49.28	49.28
4.1	7.34	6.49	2.09	3.6	0.007	0.26	0.92	54.04	45.04
4.2	7.53	7.21	1.98	3.41	0.007	0.28	0.7	49.65	49.65
4.3	7.45	8.28	1.42	2.45	0.007	0.24	0.85	49.57	49.57
4.4	7.26	12.59	2.94	5.07	0.008	0.35	1.61	39.35	59.03
Min	7.26	5.41	1.36	2.34	0.006	0.24	0.20	29.79	35.91
Max	7.83	12.59	2.94	5.07	0.008	0.36	7.00	62.84	69.51
Mean	7.50	7.59	1.96	3.39	0.007	0.30	1.40	44.56	54.49

Season I : Station : Talwali

Sample No.	PH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	8.21	6.49	2.45	4.22	0.011	0.29	10.48	49.73	39.79
1.2	8.16	5.77	2.06	3.55	0.007	0.24	8	55.2	36.8
1.3	8.31	5.77	2.6	4.48	0.022	0.28	10.05	59.96	29.98
1.4	8.39	6.49	2.4	4.14	0.026	0.28	7.39	55.57	37.04
2.1	8.15	7.21	2.68	4.62	0.012	0.31	10.41	59.73	29.86
2.2	8.18	8.28	2.93	5.05	0.030	0.32	13.97	47.79	38.23
2.3	8.08	9.36	3.22	5.55	0.027	0.36	11.43	53.14	35.43
2.4	8.24	9	2.57	4.43	0.018	0.31	11.61	61.87	26.52
3.1	8.31	7.21	2.65	4.57	0.003	0.24	5.06	60.42	34.52
3.2	8.23	7.56	2.85	4.91	0.007	0.32	4.89	60.52	34.58
3.3	8.24	9	2.68	4.62	0.008	0.21	7.51	64.74	27.75
3.4	8.2	7.21	3.33	5.74	0.008	0.4	11.01	59.32	29.66
4.1	8.29	6.49	3.44	5.93	0.003	0.35	6.74	62.18	31.09
4.2	8.25	9.36	2.88	4.96	0.007	0.32	8.11	51.05	40.84
4.3	8.21	9.36	2.96	5.1	0.004	0.26	4.33	69.58	26.09
4.4	8.18	8.64	2.91	5.02	0.006	0.29	1.93	62.41	35.66
Min	8.08	5.77	2.06	3.55	0.003	0.21	1.93	47.79	26.09
Max	8.39	9.36	3.44	5.93	0.030	0.40	13.97	69.58	40.84
Mean	8.23	7.70	2.79	4.81	0.012	0.30	8.31	58.33	33.37

Table (Contd.)

Season II : Station : Vikhroli I

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.47	4.69	4.2	7.24	0.017	0.56	0.29	85.07	14.64
1.2	7.41	2.54	2.33	4.02	0.016	0.57	0.11	81.73	18.16
1.3	7.09	2.54	4	6.9	0.145	0.56	0.26	79.79	19.95
1.4	7.15	2.9	3.73	6.43	0.008	0.56	0.27	81.6	18.13
2.1	7.11	3.62	4.62	7.96	0.013	0.6	0.2	81.65	18.15
2.2	7.51	2.54	3.67	6.33	0.012	0.6	0.26	78.8	20.95
2.3	7.23	2.9	1.85	3.19	0.011	0.57	0.16	81.68	18.15
2.4	7.35	3.98	3.43	5.91	0.019	0.57	0.24	79.81	19.95
3.1	7.15	3.26	3.16	5.45	0.011	0.56	0.37	74.72	24.91
3.2	7.3	3.26	2.92	5.03	0.015	0.57	0.12	79.9	19.98
3.3	7.29	5.05	4.14	7.14	0.013	0.56	0.13	65.47	34.4
3.4	7.11	1.82	4.26	7.34	0.009	0.56	0.24	72.56	27.21
4.1	7.34	2.18	3.61	6.22	0.052	0.71	0.2	81.65	18.15
4.2	7.25	3.62	2.83	4.88	0.011	0.67	0.11	81.73	18.16
4.3	7.32	3.98	3.4	5.86	0.015	0.63	0.16	81.68	18.15
4.4	7.41	4.34	2.33	4.02	0.015	0.63	0.25	76.38	23.36
Min	7.09	1.82	1.85	3.19	0.008	0.56	0.11	65.47	14.64
Max	7.51	5.05	4.62	7.96	0.145	0.71	0.37	85.07	34.40
Mean	7.28	3.33	3.41	5.87	0.024	0.59	0.21	79.01	20.78

Season II: Station: Vikhroli II

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.51	6.13	2.5	4.31	0.008	0.28	0.12	70.79	29.09
1.2	7.69	4.69	2.41	4.15	0.006	0.33	0.13	83.22	16.64
1.3	7.55	4.34	3.83	6.6	0.007	0.5	0.63	72.27	27.1
1.4	7.46	9	3.49	6.02	0.008	0.26	0.23	76.75	23.02
2.1	7.65	3.98	2.63	4.53	0.008	0.33	0.46	69.68	29.86
2.2	7.6	5.41	3.63	6.26	0.008	0.42	0.18	81.67	18.15
2.3	7.65	5.05	3.19	5.5	0.009	0.35	0.2	85.54	14.26
2.4	7.77	4.34	3.47	5.98	0.010	0.33	0.24	72.56	27.21
3.1	7.67	4.34	2.69	4.64	0.009	0.32	0.6	79.52	19.88
3.2	7.8	2.9	3.24	5.59	0.003	0.32	0.18	74.86	24.95
3.3	7.73	3.62	3.22	5.55	0.010	0.33	0.13	76.28	23.59
3.4	7.79	3.98	3.19	5.5	0.005	0.39	0.39	74.69	24.9
4.1	7.76	5.05	3.13	5.4	0.010		0.25	74.81	24.94
4.2	7.73	3.98	3.44	5.93	0.004		0.33	74.75	24.92
4.3	7.63	5.41	3.13	5.4	0.010		0.55	66.3	33.15
4.4	7.48	10.44	3.49	6.02	0.013		0.5	78.18	21.32
Min	7.46	2.90	2.41	4.15	0.003	0.26	0.12	66.30	14.26
Max	7.80	10.44	3.83	6.60	0.013	0.50	0.63	85.54	33.15
Mean	7.65	5.17	3.17	5.46	0.008	0.35	0.32	75.74	23.94

Table (Contd.)

Season II : Vikhroli III

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.02	7.21	2.47	4.26	0.008	0.25	0.09	81.74	18.17
1.2	7.05	8.28	3.04	5.24	0.004	0.12	0.24	72.56	27.21
1.3	7.02	6.13	2.32	4	0.008	0.15	0.29	72.52	27.19
1.4	7.09	8.28	3.16	5.45	0.006	0.26	0.22	72.57	27.21
2.1	7.11	5.41	2.52	4.34	0.011	0.25	0.15	74.89	24.96
2.2	7.05	7.92	2.42	4.17	0.009	0.19	0.25	63.47	36.27
2.3	7.09	6.13	2.64	4.55	0.011	0.28	0.29	72.52	27.19
2.4	7.11	7.21	2.72	4.69	0.004	0.33	0.11	72.65	27.24
3.1	7.05	3.62	2.27	3.91	0.011	0.25	0.24	81.63	18.14
3.2	7.05	3.98	2.64	4.55	0.005	0.25	0.13	74.9	24.97
3.3	7.09	5.05	2.25	3.88	0.007	0.31	0.12	83.24	16.65
3.4	7.05	3.62	2.4	4.14	0.001	0.33	0.29	63.45	36.26
4.1	7.11	3.98	2	3.45	0.035	0.32	0.24	69.83	29.93
4.2	7.15	3.98	2.27	3.91	0.012	0.36	0.13	66.58	33.29
4.3	7.03	6.13	2.25	3.88	0.012	0.32	0.08	74.94	24.98
4.4	7.11	6.49	2.2	3.79	0.012	0.32	0.25	81.61	18.14
Min	7.02	3.62	2.00	3.45	0.001	0.12	0.08	63.45	16.65
Max	7.15	8.28	3.16	5.45	0.035	0.36	0.29	83.24	36.27
Mean	7.07	5.84	2.47	4.26	0.010	0.27	0.20	73.69	26.11

Season II : Station : Vitava

Sample No.	pH	Salinity (ppt)	OC %	OM %	TotPO4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.71	4.34	3.26	5.62	0.008	0.56	0.77	93.29	5.94
1.2	7.79	7.56	3.11	5.36	0.010	0.52	0.54	81.37	18.08
1.3	7.71	6.49	4.62	7.96	0.011	0.52	0.32	79.74	19.94
1.4	7.78	6.49	3.2	5.52	0.009	0.54	1.34	88.79	9.87
2.1	7.63	3.98	3.73	6.43	0.008	0.52	1.44	88.7	9.86
2.2	7.69	5.05	3.58	6.17	0.015	0.52	1.96	88.24	9.8
2.3	7.71	2.54	3.67	6.33	0.001	0.56	3	89.69	8.97
2.4	7.63	4.34	2.87	4.95	0.006	0.56	1.07	89.04	9.89
3.1	7.51	2.9	3.37	5.81	0.015	0.54	0.75	62.91	15.73
3.2	7.58	2.9	2.69	4.64	0.008	0.54	0.93	89.16	9.91
3.3	7.73	3.98	3.31	5.71	0.004	0.5	0.6	89.46	9.94
3.4	7.71	5.41	2.63	4.53	0.015	0.5	0.18	79.86	19.96
4.1	7.75	2.9	3.11	5.36	0.009	0.5	0.6	79.52	19.88
4.2	7.74	7.21	3.7	6.38	0.006	0.54	1.38	88.76	9.86
4.3	7.71	3.98	2.9	5	0.010	0.56	1.28	88.85	9.87
4.4	7.79	5.77	3.23	5.57	0.007	0.5	0.27	91.42	8.31
Min	7.51	2.54	2.63	4.53	0.001	0.50	0.18	62.91	5.94
Max	7.79	7.56	4.62	7.96	0.015	0.56	3.00	93.29	19.96
Mean	7.70	4.74	3.31	5.71	0.009	0.53	1.03	85.55	12.24

Table (Contd.)

Season II: Station: Mankhurd

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.69	3.98	1.8	3.1	0.045	0.42	1.5	54.41	44.09
1.2	7.69	3.62	2.25	3.88	0.012	0.39	2.15	60.79	37.06
1.3	7.6	5.41	2.08	3.59	0.014	0.42	0.6	54.22	45.18
1.4	7.57	5.05	2.58	4.45	0.013	0.42	1.7	44.68	53.62
2.1	7.75	3.26	2.99	5.15	0.012	0.39	0.97	63.02	36.01
2.2	7.75	4.34	3.02	5.21	0.016	0.39	3.87	65.42	30.71
2.3	7.57	5.05	3.11	5.36	0.135	0.38	1.43	62.72	35.84
2.4	7.55	5.05	2.58	4.45	0.012	0.38	2.95	58.23	38.82
3.1	7.85	2.18	2.36	4.07	0.011	0.38	0.63	63.23	36.13
3.2	7.66	4.34	2.5	4.31	0.012	0.42	0.78	63.14	36.08
3.3	7.59	4.34	2.66	4.59	0.009	0.38	0.62	88.02	11.36
3.4	7.63	3.62	2.5	4.31	0.011	0.39	1.52	39.39	59.09
4.1	7.78	2.54	2.25	3.88	0.010	0.42	0.7	69.51	29.79
4.2	7.56	4.34	2.66	4.59	0.012	0.42	0.78	63.14	36.08
4.3	7.7	2.18	3.02	5.21	0.011	0.38	0.43	72.41	27.15
4.4	7.52	4.69	2.55	4.4	0.011	0.38	0.52	82.72	16.75
Min	7.52	2.18	1.80	3.10	0.009	0.38	0.43	39.39	11.36
Max	7.85	5.41	3.11	5.36	0.135	0.42	3.87	88.02	59.09
Mean	7.65	4.00	2.56	4.41	0.022	0.40	1.32	62.82	35.86

Season II: Station: Talwali

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.58	2.18	1.83	3.15	0.013	0.18	38.33	24.67	37
1.2	7.44	2.18	2.28	3.93	0.011	0.26	26.91	45.68	27.41
1.3	7.59	1.82	1.23	2.12	0.014	0.21	21.38	58.96	19.65
1.4	7.5	1.82	1.91	3.29	0.016	0.18	27.3	54.53	18.18
2.1	7.46	1.82	2.57	4.43	0.012	0.31	24.24	58.92	16.84
2.2	7.47	2.18	1.57	2.71	0.014	0.25	20.03	49.98	29.99
2.3	6.9	2.18	3.28	5.65	0.016	0.49	18.92	63.06	18.02
2.4	7.73	2.54	2.25	3.88	0.015	0.32	17.99	54.67	27.34
3.1	7.61	2.54	1.91	3.29	0.015	0.19	24.05	59.07	16.88
3.2	7.56	2.54	2	3.45	0.015	0.22	26.4	46	27.6
3.3	7.58	1.82	2.62	4.52	0.014	0.19	6.37	46.82	46.82
3.4	7.58	2.54	1.8	3.1	0.015	0.28	27.31	54.52	18.17
4.1	7.54	2.18	1.85	3.19	0.015	0.25	24.99	50.01	25
4.2	7.69	1.47	1.23	2.12	0.017	0.17	20.71	59.46	19.82
4.3	7.65	2.18	2.31	3.98	0.017	0.19	22.24	55.54	22.22
4.4	7.38	2.18	2.25	3.88	0.027	0.19	58.82	20.59	20.59
Min	6.90	1.47	1.23	2.12	0.011	0.17	6.37	20.59	16.84
Max	7.73	2.54	3.28	5.65	0.027	0.49	58.82	63.06	46.82
Mean	7.52	2.14	2.06	3.54	0.015	0.24	25.37	50.16	24.47

Table (Contd.)

Season III : Station : Vikhroli I

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.35	6.13	3.47	5.98	0.017	0.43	0.85	63.1	36.06
1.2	7.34	5.41	3.75	6.47	0.015	0.38	0.81	72.14	27.05
1.3	7.09	5.77	3.32	5.72	0.020	0.43	1.66	71.52	26.82
1.4	7.21	6.49	3.25	5.6	0.015	0.43	1.05	79.16	19.79
2.1	6.9	9.72	4.96	8.55	0.012	0.52	2	71.28	26.73
2.2	6.92	8.28	4.43	7.64	0.013	0.49	2.13	78.29	19.57
2.3	6.89	7.56	4.71	8.12	0.019	0.49	3.75	71.75	26.91
2.4	6.95	9.72	5.05	8.71	0.012	0.52	1.57	80.53	17.9
3.1	7.02	7.92	2.88	4.97	0.014	0.36	0.73	91.95	8.39
3.2	7.08	8.28	2.97	5.12	0.012	0.42	1.17	79.07	19.77
3.3	7.01	7.92	2.79	4.81	0.014	0.43	1.44	78.85	19.71
3.4	6.92	6.13	3.13	5.4	0.017	0.43	0.89	59.46	39.64
4.1	6.02	9.72	5.24	9.03	0.016	0.54	1.54	78.77	19.69
4.2	5.89	8.28	5.45	9.4	0.018	0.52	1.66	62.58	35.76
4.3	6.1	8.28	5.33	9.19	0.017	0.49	2.11	78.31	19.58
4.4	6.21	9	4.8	8.28	0.018	0.49	0.85	82	18.15
Min	5.89	5.41	2.79	4.81	0.012	0.36	0.73	59.46	8.39
Max	7.35	9.72	5.45	9.40	0.020	0.54	3.75	91.95	39.64
Mean	6.81	7.79	4.10	7.06	0.015	0.46	1.51	74.92	23.85

Season III : Station : Vikhroli II

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.34	11.87	2.97	5.12	0.014	0.32	0.48	82.93	16.59
1.2	7.33	12.59	2.79	4.81	0.014	0.32	1.35	71.75	26.91
1.3	7.35	11.87	3.04	5.24	0.014	0.33	0.6	79.52	19.88
1.4	7.37	11.87	3.13	5.4	0.016	0.32	0.5	79.6	19.9
2.1	7.55	7.92	2.94	5.07	0.014	0.35	1.69	58.99	39.32
2.2	7.51	14.02	3.01	5.19	0.010	0.35	1.88	78.49	19.62
2.3	7.54	10.44	3.1	5.34	0.015	0.35	0.63	72.27	27.1
2.4	7.59	10.44	2.85	4.91	0.014	0.33	0.78	81.18	18.04
3.1	7.09	14.74	3.28	5.65	0.016	0.4	1.49	82.09	16.42
3.2	7.08	14.38	3.47	5.98	0.014	0.35	0.97	79.22	19.81
3.3	7.05	13.66	3.13	5.4	0.014	0.35	1.81	78.55	19.64
3.4	7.05	12.59	3.04	5.24	0.012	0.39	1.75	68.78	29.48
4.1	7.25	12.59	3.1	5.34	0.015	0.35	0.6	79.52	19.88
4.2	7.24	12.59	3.32	5.72	0.008	0.32	0.5	69.65	29.85
4.3	7.26	11.87	4.45	7.67	0.013	0.32	0.67	81.27	18.06
4.4	7.26	11.87	2.88	4.97	0.013	0.35	0.95	81.04	18.01
Min	7.05	7.92	2.79	4.81	0.008	0.32	0.48	58.99	16.42
Max	7.59	14.74	4.45	7.67	0.016	0.40	1.88	82.93	39.32
Mean	7.30	12.21	3.16	5.44	0.013	0.34	1.04	76.55	22.41

Table (Contd.)

Season III : Station : Vikhroli III

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	6.94	11.51	3.47	5.98	0.015	0.4	4.78	77.91	17.31
1.2	6.92	10.79	3.5	6.03	0.016	0.39	3.68	70.05	26.27
1.3	7.01	11.15	3.59	6.19	0.015	0.39	1.48	78.82	19.7
1.4	6.98	11.51	3.25	5.6	0.011	0.39	7.33	75.82	16.85
2.1	6.96	10.79	3.16	5.45	0.015	0.4	8.49	66.56	24.96
2.2	6.96	10.79	3.16	5.45	0.011	0.42	9.06	63.66	27.28
2.3	6.91	11.87	3.22	5.55	0.018	0.43	1.85	68.71	29.45
2.4	7.02	11.15	3.28	5.65	0.017	0.4	2.78	79.55	17.68
3.1	6.98	12.59	2.79	4.81	0.022	0.39	1.19	74.11	24.7
3.2	6.97	11.51	2.88	4.97	0.023	0.39	2.78	68.05	29.17
3.3	6.91	10.79	2.85	4.91	0.125	0.39	3.72	77.03	19.26
3.4	7.02	11.51	2.97	5.12	0.008	0.39	1.75	68.78	29.48
4.1	6.92	13.31	3.16	5.45	0.007	0.42	1.42	71.7	26.89
4.2	6.95	10.79	3.28	5.65	0.014	0.42	12.43	71.8	15.77
4.3	6.97	11.51	3.53	6.09	0.010	0.42	1.57	78.74	19.69
4.4	6.91	11.51	3.19	5.5	0.013	0.4	1.83	78.54	19.63
Min	6.91	10.79	2.79	4.81	0.007	0.39	1.19	63.66	15.77
Max	7.02	13.31	3.59	6.19	0.125	0.43	12.43	79.55	29.48
Mean	6.96	11.44	3.21	5.53	0.021	0.40	4.13	73.11	22.76

Season III: Station: Vitava

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.63	5.05	4.18	7.21	0.018	0.66	2.11	68.52	29.37
1.2	7.61	6.49	4.21	7.26	0.018	0.54	1.48	78.82	19.7
1.3	7.63	7.21	4.03	6.95	0.018	0.63	1.63	78.69	19.67
1.4	7.71	6.13	4.34	7.48	0.020	0.63	1.9	68.67	29.43
2.1	7.42	9	3.9	6.72	0.016	0.57	2.17	53.36	44.47
2.2	7.41	6.85	4.03	6.95	0.013	0.57	1.22	71.84	26.94
2.3	7.43	7.92	3.81	6.57	0.024	0.59	2.17	78.26	19.57
2.4	7.41	7.21	3.72	6.41	0.016	0.57	1.83	68.72	29.45
3.1	7.46	6.13	3.94	6.79	0.015	0.6	1.4	80.67	17.93
3.2	7.45	7.21	3.81	6.57	0.020	0.63	1.96	78.43	19.61
3.3	7.47	7.92	4.03	6.95	0.016	0.63	1.56	78.76	19.69
3.4	7.46	7.92	3.69	6.36	0.016	0.57	5.59	75.53	18.88
4.1	7.32	9.36	3.87	6.67	0.020	0.52	1.4	78.88	19.72
4.2	7.29	7.21	4.03	8.95	0.026	0.54	1.4	71.71	26.89
4.3	7.31	7.21	4.21	7.26	0.023	0.54	1.67	78.66	19.67
4.4	7.34	8.28	3.72	6.41	0.022	0.52	2.38	68.33	29.29
Min	7.29	5.05	3.69	6.36	0.013	0.52	1.22	53.36	17.93
Max	7.71	9.36	4.34	8.95	0.026	0.66	5.59	80.67	44.47
Mean	7.46	7.32	3.97	6.97	0.019	0.58	1.99	73.62	24.39

Table (Contd.)

Season III : Station : Mankhurd

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.41	6.85	2.73	4.71	0.012	0.32	11.27	35.49	53.24
1.2	7.4	7.56	2.63	4.53	0.013	0.31	4.49	38.2	57.31
1.3	7.42	8.64	2.88	4.97	0.013	0.35	2.12	62.29	35.59
1.4	7.39	6.85	2.7	4.65	0.012	0.32	1.49	44.78	53.73
2.1	7.49	8.28	2.7	4.65	0.013	0.29	1.17	53.22	45.61
2.2	7.49	7.56	2.85	4.91	0.014	0.33	1.56	49.22	49.22
2.3	7.41	7.56	2.66	4.59	0.013	0.29	4.3	60.9	34.8
2.4	7.51	8.28	2.57	4.43	0.015	0.29	1.94	58.84	39.22
3.1	7.26	8.64	3.16	5.45	0.015	0.36	1.12	65.92	32.96
3.2	7.25	8.64	3.01	5.19	0.015	0.35	1.48	39.41	59.11
3.3	7.25	7.56	3.28	5.65	0.014	0.33	1.56	49.22	49.22
3.4	7.3	7.92	3.22	5.55	0.014	0.33	2.17	53.36	44.47
4.1	7.35	7.56	2.82	4.86	0.012	0.33	1.17	65.89	32.94
4.2	7.36	7.92	2.7	4.65	0.012	0.33	1.48	39.41	59.11
4.3	7.36	7.92	2.94	5.07	0.014	0.33	1.52	44.76	53.72
4.4	7.39	7.56	2.97	5.12	0.016	0.29	1.52	59.09	39.39
Min	7.25	6.85	2.57	4.43	0.012	0.29	1.12	35.49	32.94
Max	7.51	8.64	3.28	5.65	0.016	0.36	11.27	65.92	59.11
Mean	7.38	7.83	2.86	4.94	0.013	0.32	2.52	51.25	46.23

Season III: Station: Talwali

Sample No.	pH	Salinity (ppt)	OC %	OM %	Total PO_4	Total N (ppm)	Texture		
							Sand %	Silt %	Clay %
1.1	7.04	6.85	1.43	2.47	0.007	0.19	28.99	40.58	30.43
1.2	7.01	5.77	1.33	2.29	0.013	0.24	10.8	49.55	39.64
1.3	7.05	5.77	1.55	2.67	0.008	0.24	13.49	51.9	34.6
1.4	7.05	5.41	2.05	3.53	0.011	0.25	17.22	55.19	27.59
2.1	7.06	5.77	2.63	4.53	0.013	0.26	10.86	62.4	26.74
2.2	7.02	5.05	2.7	4.65	0.010	0.26	21.09	52.6	26.3
2.3	7.05	5.77	2.66	4.59	0.005	0.19	12.37	48.69	38.95
2.4	7.02	5.05	2.48	4.28	0.014	0.19	18.07	49.16	32.77
3.1	7.13	5.77	2.05	3.53	0.003	0.24	12.5	58.33	29.17
3.2	7.12	5.77	1.95	3.36	0.015	0.24	12.86	52.28	34.86
3.3	7.09	5.41	2.23	3.84	0.010	0.22	17.25	55.17	27.58
3.4	7.15	5.41	1.7	2.93	0.006	0.21	11.2	62.4	26.74
4.1	7.3	5.41	2.08	3.59	0.065	0.24	12.28	43.86	43.86
4.2	7.28	5.05	2.17	3.74	0.011	0.21	12.5	58.33	29.17
4.3	7.35	5.77	1.98	3.41	0.008	0.21	16.39	58.53	25.08
4.4	7.31	5.41	2.14	3.69	0.009	0.19	13.99	57.34	28.67
Min	7.01	5.05	1.33	2.29	0.003	0.19	10.80	40.58	25.08
Max	7.35	6.85	2.70	4.65	0.065	0.26	28.99	62.40	43.86
Mean	7.13	5.59	2.07	3.57	0.013	0.22	15.12	53.52	31.38

Chapter Six

Vegetation

Vegetation

The present chapter mainly deals with the vegetation and ecology of the mangroves of Thane creek. The different components studied during the survey have been presented in the following text.

In India, the term “mangroves” is used as a carpet word. It includes a variety of other formations such as arborescent, bushy, herbaceous and also regions such as mud flats without any true mangrove cover (just because of its position - adjoining to mangroves forests) but occupied by grasses and other species are also described as mangrove areas.

In a true sense Mangroves are Tropical forests (occasionally they are extended to sub-tropical regions). They are comparable to Salt marshes of temperate latitudes. Mangrove forests are not merely areas covered with salt tolerant flowering plants but includes a gamut of other groups of wild life that thrives in these regions and is dependent on mangrove vegetation.

Luxuriant mangrove vegetation is found in places where the mangroves are protected from tidal actions or cyclonic winds. Hence, the best mangrove forests or vegetation is found in creeks, estuaries and lagoon areas. A number of factors are known to limit or control the mangrove vegetation, in addition to the protected character of the coast line.

The mangroves are predominantly Evergreen forests. However, there are exceptions, especially in the case where the vegetation, which grows along the fringes of rivers exhibit varying proportion of deciduous species.

Before going into the details of any discussions on the mangroves of Thane creek, it must be remembered that the present day vegetal cover is only a fraction of the cover which this creek harbored a few centuries ago. The Mumbai coast had enjoyed luxuriant vegetation till 1670. Presently, the creek harbors small stretches of mangrove vegetation. The present vegetation represents only the remnants of the past.

The mangroves of Mumbai region, in particular Thane creek, are victims of anthropogenic interference. Most of the mangrove areas are reclamated for urban housing complexes and Industrial belts. Nowhere do we really find pristine or virgin forest areas. They are ravaged from time to time. The natural dynamism of the creek ecosystem is in great shambles. The woody elements, which are respected because of their high productivity, fail to regenerate. Everywhere there is a regressive trend. Vegetation is discontinuous., trees are

stunted, and branches are lopped regularly for fuel. Most of the present day mangrove areas are monopolized by *Avicenia* spp., *Excoecaria agallocha* and *Acanthus illicifolius*. All these species are considered as pioneers.

Despite this grim scenario, the mangroves of Mumbai are well studied by botanists of the past. Woodrow (1897) was considered pioneer in Mumbai mangrove studies. His study on plants of a Bombay swamp recorded 79 species. Blatter (1905) studied the mangroves and their biology. The study enumerated 14 species occur in the Bombay presidency. Burns (1910) studied the floristics of the sea shore vegetation and reported 17 species along the sea shore. It was also reported by the same author that environment is the limiting factor.

Among the vegetation studies, Mumbai region is one of the well explored regions of Maharashtra coast. Thanks to the efforts of many botanists and naturalists. A number of contributions particularly by Navalkar (1940, 49, 51, 56, 5 9, 74), Bharucha & Navalkar (1942), Navalkar & Bharucha (1948), Blasco (1975) Deshmukh (1995), Shah (1964), Cooke (1967), Billore (1972), Blasco (1975), Deshmuks (1990), Kothari & Rao (1994), Chapekar & Deshmukh (1996) helped much to understand the vegetation of Mumbai mangroves.

Vegetation:

The mangrove vegetation of Mumbai coast has its own interesting features and uniqueness. Two species of *Salvadora - S. persica* & *S. oleoides*, both of which are characteristic to ancient mangals are commonly distributed in the mangrove areas. Another interesting feature is the presence of patches of grass lands in drier regions of lee ward side. These patches are exclusively dominated by *Aeluropus lagopoides* (L.) Trin*.,* a creeping grass belongs to the family Poaceae.

Despite our through search we could not collect any epiphytic or parasitic species on mangroves. The mangrove areas are also devoid of Ferns. Palms are totally absent from the west coast. Like any other regions of the West Coast, halophytic species belongs to the families of Stericuliaceae and Meliaceae are totally absent in Thane creek.

Mangrove Forest Cover:

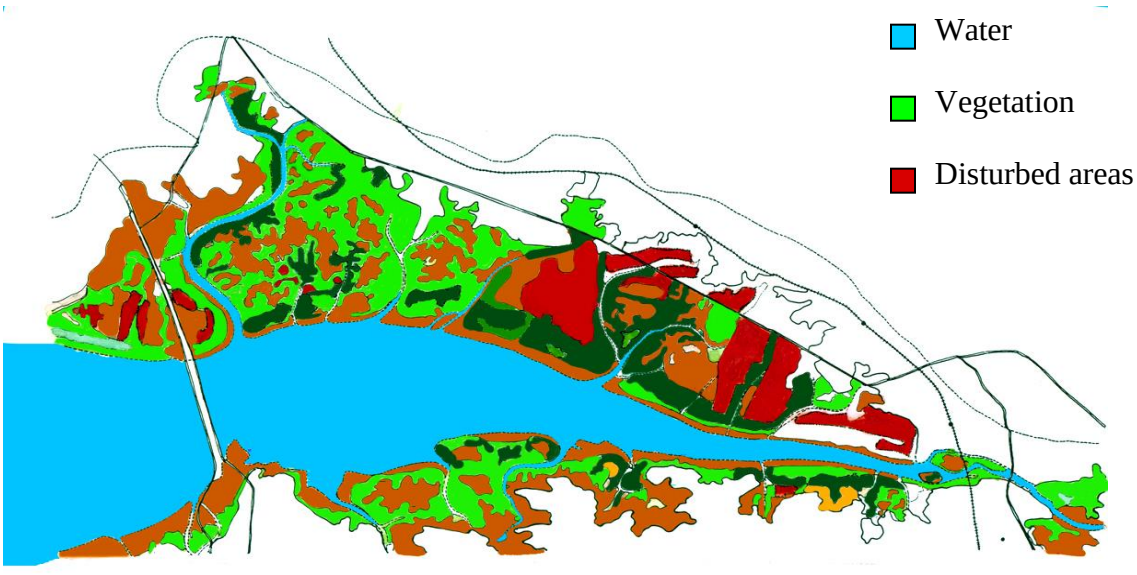
Quantification of mangrove forest cover of Maharashtra started with Waheedkhan (1957). Since then a number of estimates are published in different journals. They estimate differ greatly. Most of these values seems to be crude estimates. The following table gives changing estimates from time to time.

Table 6.1: Mangrove forest cover estimates of Maharashtra.

No.	Area in	Reference
1)	248.7 sq.km	Waheedkhan (1957)
2)	62,208 hectares	Sidhu (1963)
3)	20,000 hectares	Blasco (1977)
4)	108 sq.km	State of Forest Report (1999)

The total mangrove area of the Thane creek is only about 14.37 km^2 area. The Satellite imagery studies of Thane creek reveal an alarming decrease of mangrove forests. The study conducted by Chandrashekar (2000) for Thane Municipal Corporation calls for a greater concern and immediate action. In a decade of time ranging from the year 1989 to 2000, mangrove forests showed a depletion of 69.60% cover. Their area is reduced from 14.68 km (1989) to 3.56 km in the year 2000. Mangroves are seen only in certain pockets. They are found only along the creek, Kalwa, Diva and Mumbra regions of Thane Municipal Corporation area.

Same is the case with other parts of Thane creek. The satellite imagery studies are being carried out by Dr. Majumdar and his team at IIT. Their study also expressed similar concerns about mangroves of Thane creek (unpublished data). A mangrove patch of approximately 750 acres belongs to Soonabai Pirojsha Godrej Foundation is the only mangrove region of Thane creek which is still intact with minimum human disturbance. The mangrove dominated areas of the Thane creek, interpreted through satellite imageries are presented in the picture.1



Picture –1: Land use pattern along the Thane Creek

According to Champion & Seth (1968) mangroves are one of the seven type-groups of tropical forests. They are categorized as Littoral & Swamp forests. These forests are mainly evergreen, of varying density and height, but always associated predominantly with wetness. They are considered moist tropical seral formations. Ecologically this type-group is sub divided into five categories. But for the purpose of present study we will be concerned only with two categories. They are as follows:-

Forest types:

1) Littoral forests (beach or dune forests): Mostly found on coastal sand.
   Ex. *Erythrina indica, Casuarina equistifolia*, *Calophyllum inophyllum. Ipomea sp.*

2) Tidal swamp forests: Mostly found on estuarine mud. Many species of Rhizophoraceae are almost confined to this division.

   Sub division (a): Mangrove scrub (salt water forests, more or less dense forests of very low average height, often 3-6m. high.).

   Ex. *Avicennia alba, A. marina, A. officinalis, Sonneratia alba, S. apetala, Excoecaria agallocha, Acanthus ilicifolius*, local patches of grass.

   Sub division (b): Mangrove forests (Typically closed evergreen forests Adapted to survive on tidal mud which is permanently wet with salt water. Stilt roots are very typical). Only two places of Thane creek really comes under this type of vegetation. They are Vikhroli mangroves (Property belongs to Godrej & Boyce) and an isolated patch of mangroves of Vitava island, near Thane bridge. Mumbra-Diva is another interesting area of Mumbai coast which harbours such type of vegetation.

   Ex. *Avicennia marina, Sonneratia apetala, Salvadora persica, Salvadora oleoides*.

Quareshi (1957) has suggested a slightly modified version of classification, based on succession. He classified the mangrove vegetation into three groups. Thane creek exhibits following regions and species when classified according these groups.

1) **Swampy mangroves:** Occur below high tide level and covered by tides twice a day. Total area under such category is very less, may not cross even two square kilometers area.

   Characteristic species: A*vicennia marina, A. officinalis* .

2) **Tidal mangroves:** Occurs in areas covered by spring tides only and also during storms. Large tracts of mangroves of Thane creek fits under this category. Approximate area under this group may range somewhere between 10-12 square kilometers.

   Characteristic species: *Avicennia* spp., *Sonneratia apetala* & *Acanthus illicifolius*.

3) **Colonizers:** Forms mostly associates and other salt tolerant species. Ecologically they are non-littoral. A very large track, comprising mostly reclamated areas falls under this group. It is difficult to calculate how much area is under this group.

   Characteristic species*: Thespesia populnea, Salvodora* spp*. Aeluropus lagopoides, Sesuvium portulacstrum Suaeda* spp. etc.

Mangrove Zonation:

One of the outstanding features of the mangroves is their characteristic Zonation. A number of factors have been identified to control the mangrove zonation. Recent ecological studies in the Mumbai region reveal that sedimentation is a serious problem which is considerably accelerated for lost 3-4 decades (Atlee et al. 1998). This directly affects the mangrove zonation. Due to heavy siltation in mangrove regions many species of Rhizophoraceae such as *Rhizophora, Brugeria* and *Ceriops* disappear. This is because of insufficient availability of water.

The original zonation patterns of Thane creek mangrove species is difficult to interpret. Whatever patterns we observe presently are in fact modified by anthropogenic factors. However, a careful observation clearly reveals that all marshy creeks and reclamated areas of Mumbai show the strong presence of mangroves and other halophytic species. This means that mangroves were original occupants of such regions.

The zonation pattern is generally simple because of less diversity and more disturbances. Whole mangrove floristic pattern of Thane creek is dominated by species of

Avicennia. Out of the three *Avicennia* species, which are found in the Thane creek *A. marina* is more ubiquitous than any other species. The back mangrove areas are literally dominated by thorny *Acanthus illicifolius.*

Table – 6.2: Flowering plant species diversity of Mumbai coast & Thane creek mangrove ecosystem.

Type	Number of species
Mangorves	16
Associates	7
Halophytes	49

Diversity:

The living world of creek ecosystems is amazingly complex and diverse. Diversity literally means variety of life. Diversity is expressed and estimated in many ways. A variety of parameters and devises are used to quantify species diversity. During the present study, only one group of plant kingdom i.e. flowering plants is studied to understand their diversity. The study was mainly dealt with species richness (number of species & individuals), frequency, density, abundance and IVI of all the sampling stations. Other information such as total number of species per hectare area, wood volume and diversity indices are presented in Table --- .
The second most adapted plant group to mangrove ecosystems is Algae. Diversity of Algae is estimated by means of the species and biomass. During the present study we made a check list of all Algal species reported from Mumbai so far. It is worth noting that three major groups of plant kingdom - the Gymnosperms, the Pteridophytes and the Bryophytes are totally absent from Thane creek.

Thane creek is also rich in fungal and phytoplankton diversity. The fungi is represented by 24 species and the phytoplankton especially the diatoms are represented by about 33 species. The lichens are represented by only one species.

The station wise results of the flowering plant diversity studies are as follows.

Station 1 : Vikhroli - I (MMC Sewage treatment plant site)

Vikhroli – I is a partially protected back mangrove area.
The area receives sea water only during high spring tide. It means that the area gets submerged only once in a fortnight.
The area belongs to Soonabai Pirojsha Godrej Foundation and is well protected from human interference.
For the purpose of study, it is kept uneder partially protected category sites.
Of all the studied areas of Thane creek Vikhroli –1 is found to be the most diverse area. Number of species are more. In all, six mangrove species representing five families are observed at this station. Besides, seven species of mangrove associates are also recorded from this staion. They are - *Salvadora persica*, *Aeluropus lagopoides, Sesuvium portulacastrum, Derris trifoliata*, *Sphaeranthus africanus*, *Thespecia populnea,* and *Ipomea biloba*.

Avicenia marina is the most dominant species. The other common tree species found in this staion is *Excoecaria agallocha.*

This is the only station in the quadrat study areas, where *Derris trifoliata*, a leguminous climber is found growing luxuriantly.
Number of plants per hectare is less. This is mainly due to two reasons.
a) More mature tree species, hence sparse distribution.
b) Presence of many immature individuals.

In general, the station is represented by 3011 individual plants per hectare area. Plant height varies between 3.26 and 5.71 m. while DBH varies from 2.99 cm to 6.63 cm.

Total Wood volume (54918 m^3/ha) is found to be less as compared to other stations. The richness indices are found to be slightly lower than Station-4 (Vitava island), because of higher generic diversity than species diversity.

The species diversity is found to be maximum (Diversity index - 1.20) in this area as compared to other sampling stations.

Average length of pneumatophore is 9.14 cm and average number of pneumatophore per square meter area is 62.41, which expresses the anoxic conditions of the sediments.

The growth of seedlings is found to be maximum here. Total number of mangrove plants in various growth stages as recorded from this station is presented in Table – 6.1

Table 6.1: Station – I, Total number of mangrove plants (individuals)

Plant Species	Total No. Of plants	Saplings (< 30cm. High)	Plants (<2.5cm, diameter at breast height)	Dead plants
Acanthus illicifolius	1441	**	**	**
Aegiceras corniculatum	81	**	**	8
Avicennia marina	1072	301	283	48
Bruguiera cylindrical	135	28	579	49
Ceriops tagal	21	26	104	6
Excoecaria agallocha	261	44	26	**
Salvadora persica	**	**	100	**
Sonneratia apetala	**	**	19	3

Station –1 (Vikhorli – 1) Profile diagram

AL: *Acanthus illicifolius*; AM: *Avicennia marina*
SA: *Sonneratia casiolaris*; DT: *Derris trifoliata*

Station 2 : Vikhroli II (near Jetty site)

Vikhroli – II is a partially protected front mangrove area.

This station receives sea water during neap high tides. The whole quadrat study area gets submerged under water.

The study area is well protected from human interference. This station is located at the confluence of *nallahs* coming from Vikhroli and Ghatkopar suburbs of Mumbai . Both these nallahs carry huge quantities of sewage from residential and industrial areas into the creek.

For the purpose of study, the quadrat study area is kept under partially protected category sites.

Vikhroli-II is one of the least diverse areas among the different studied areas. The diversity index is minimum (0.45). The whole tree canopy is literally dominated by *Avicennia marina.* The two other species, which are found in negligible number, are – *Aegiceras corniculatum* and *Excoecaria agallocha*. In total, seven mangroves species are recorded from the study area.

This station records highest number of plants per hectare among all the studied areas – 3387 individuals. This is possible mainly because of secondary succession.

The results showed that a single tree species – *Avicennia. marina* literally monopolized the whole region (2832 plants/hectare).

Density and abundance values for the *Avicennia marina* are found to be maximum (708 each). This directly effected the other parameters such as decrease in DBH and plant height (4.79 cm and 4.02 m respectively). This observation coincides with the observations made by Sukardjo and Kartawinata (1979) and Selvam et al (1991).

The total wood volume caliculated comes to 81033 m 3/ha.

Open areas are selectively occupied by *Acanthus illicifoliu*s, which forms patches wherever conditions are suitable. *Salvadora persica* is predominantly common in back mangrove area. The regeneration of seedlings is more but their survival rate is found to be very low due to the pollution of brackish water. This leads to anoxic condition of sediments, which has resulted in increase in number, and height of pneumatophores in the mangrove area (average number of

pneumatophores per square meter area - 93.95 and average height - 11.52 cm). Selective tree cutting for fuel wood is also observed during the study.

Total number of mangroves plants observed in the area is presented in Table 6.2.

Table 6.2: Station– II, Total number of mangrove plants (individuals).

Plant Species	Total No. of plants	Saplings (< 30cm. high)	Plants (<2.5cm, diameter at breast height)	Dead plants
Acanthus illicifolius	551	**	**	**
Aegiceras corniculatum	3	312	**	**
Avicennia marina	2832	469	393	1045
Bruguiera cylindrical	**	207	**	**
Excoecaria agallocha	1	1	**	**
Salvadora persica	**	8	**	**
Sonneratia casiolaris	**	52	**	**

AL: *Acanthus illicifolius*; AM: *Avicennia marina*
SA: *Sonneratia casiolaris*;

Station 3 : Vikhroli III

Vikhroli –III: The station – 3 is a partially protected front mangrove area.

The whole study area is a low-lying area and gets submerged under sea water regularly. It is situated on the main channel of the creek and represents partially protected area. It is well protected from human interference mostly because of mud flats. Interestingly, this study site is the least diverse station among all the studied areas. The species diversity is almost negligible.

The vegetation within the quadrat area is dominated by a single species of *Avicennia (Avicennia marina)*. The study area is represented by tall trees because of inaccessibility. Average canopy is 5.2m. high.

However, this station is very important with reference to the biomass or wood volume of the vegetation. The total wood volume of the sampling station is 165714 m^3/ha. Average DBH is 6.8 cm.

IVI value for *Avicennia marina* is found to be maximum at this station among all the studied stations (300).

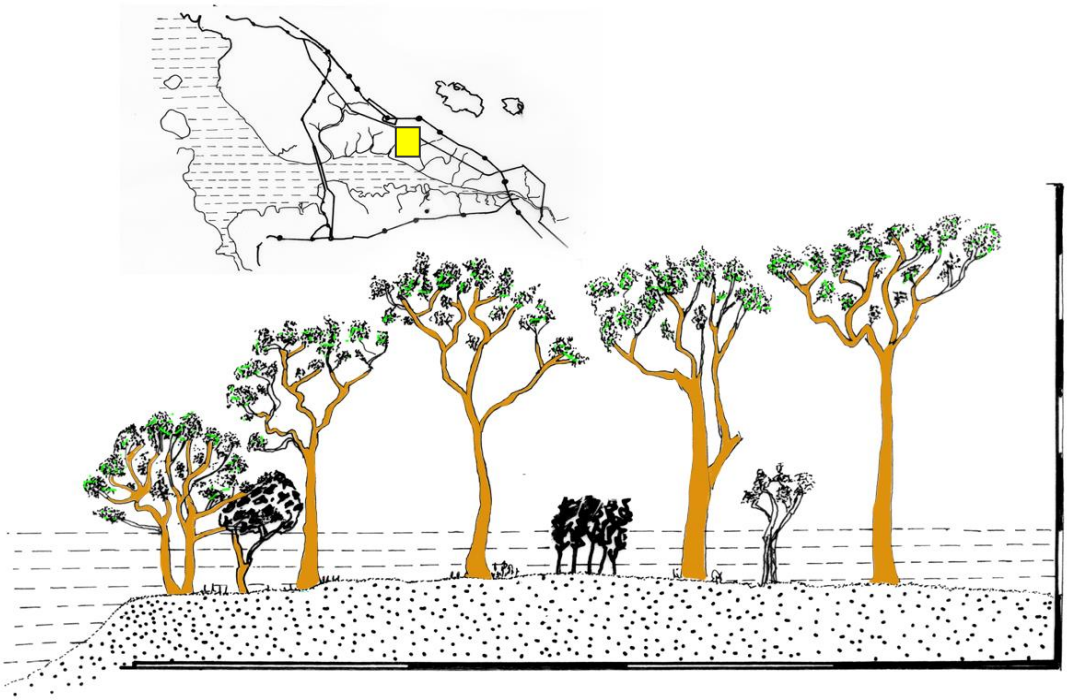
The average length of pneumatophore is found to be 10.5 cm while their average number is 80 per square meter.

Total number of mangroves plants observed in the area is presented in Table 6.3.

Table 6.3: Total number of mangrove plants.

Plant Species	Total No. of plants	Saplings (< 30cm. high)	Plants (<2.5cm, diameter at breast height)	Dead plants
Avicennia marina	777	1692	393	588
Bruguiera cylindrica	**	2	**	**
Sonneratia caseolaris	**	3	**	**

Station 3 : Vikhroli III – Profile



AL: *Acanthus illicifolius*; AM: *Avicennia marina*
SA: *Sonneratia casiolaris*;

Station 4 : Vitava island

Vitava island: This station is a geographically isolated island of approximately 20 ha area. The whole island is a front line mangrove area. The study area is well protected from human interference because of natural isolation. For the study purpose it is kept under the partially protected sites.

The study area is the innermost part of the creek from where seaward mixing of tidal water is difficult and freshwater in the form of municipal sewage gets mixed through various outlets. However, the island supports dense and diverse mangroves, dominated by *Avicennia marina*. Continuous exposure to tidal regime restricts mangrove vegetation at this station.

Six mangrove species are recorded from this area with diversity index of 0.96. Density and abundance for *Avicennia* is found to be highest (343.5 each) among all sampling stations. *Sonneratia apetala* form the sub dominant vegetation with IVI values of 30.89 and 41.33 respectively.

Though the number of plants per hectare area is less (2487 plants/ha) with average height 3.62m, the wood volume is found to be moderate due to maximum DBH value (av. 4.60cm).

Salvadora persica is the only associate observed at the station The average length of the pneumatophore is observed to be 11.03 cm while their average number per square meter is 72.

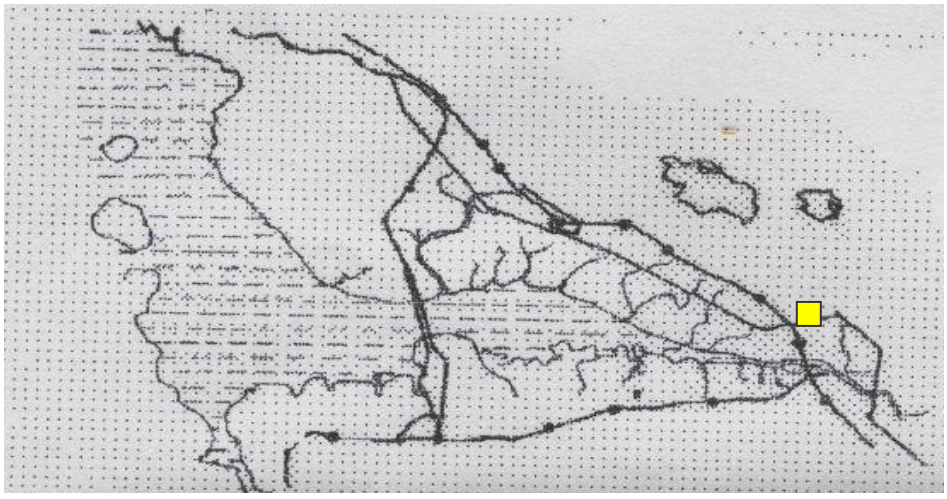
A thin layer of oil is found to cover the soil surface and pneumatophores in all the occasions we visited this island for the study purpose.

Plant wilting is more frequent on this island than any other studied sites. *Avicennia marina* is the commonest victim of wilting.

Total number of mangroves plants observed in the area is presented in table 6.4.

Table 6.4: Station – IV. Total number of mangrove plants				
Plant Species	Total No. Of plants	Saplings (< 30cm. high)	Plants (<2.5cm, diameter at breast height)	Died plants
Acanthus illicifolius	884	**	**	**
Aegiceras corniculatum	2	570	**	7
Avicennia marina	1374	244	526	91
Avicennia officials	157	**	**	**
Bruguiera cylindrical	**	236	**	7
Excoecaria agallocha	2	**	**	**
Sonneratia apetala	68	22	36	9
Sonneratia caseolaris	**	178	**	**

Station 4 : Vitava island – Profile diagram



AM: *Avicennia marina*

Station - 5 : Talwali village

Station – 5: This station represents one of the highly disturbed areas of Thane creek. The study area is located on the east bank of the creek and is categorized as disturbed site. The area is not protected. The study area gets regularly submerged under neap high tide.

The whole mangrove area is in fact very large, approximately with a kilometer width from the creek. *Acanthus illicifolius* replaced all the other species. True mangroves are very rare. Human interference is severe. Destruction of original mangroves for wood and fuel could be the major reason for depletion of mangroves from this region.

The entire region of the east bank near Talwali village is dominated by of *Acanthus illicifolius.*

Diversity is very absent in the quadrat study area because of a single species domination. Biomass generated by this plant is insignificant.

Average height of the *Acanthus illicifolius* is 1.25 m.

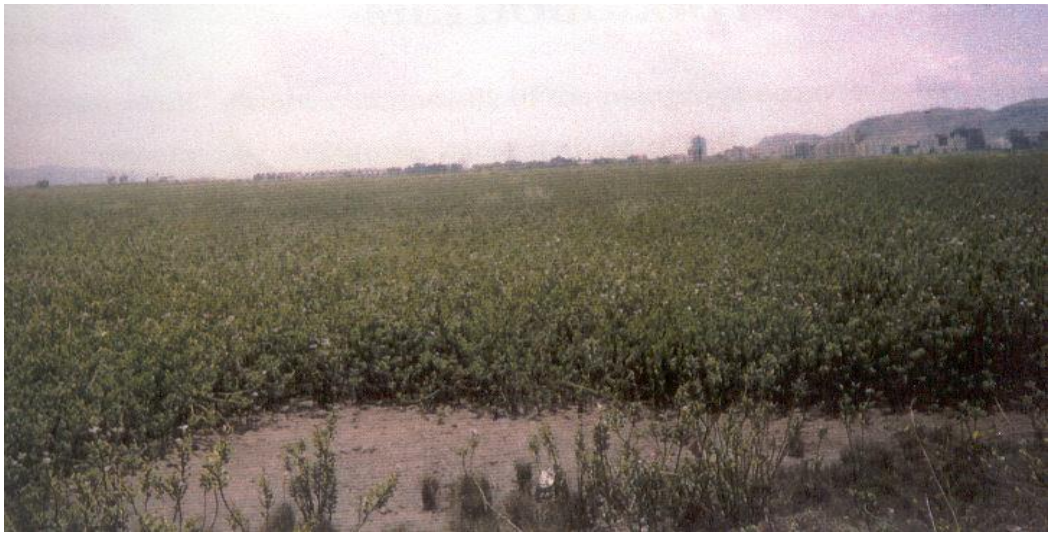
The study area is also represented occasionally by stunted or crooked mangrove tree species such as *Avicennia marina* and *Bruguiera cylindrica*. But their presence is very insignificant. Towards the village side a number of other species, mostly associates like *Cleredendron enermi, Salvadora persica, Excoecaria agallocha* and *Tylophora sp.* are found confusingly growing without any particular pattern.

The agricultural farms, mostly reclamated mangrove areas show a strong presence of salt tolerant Poaceae and Cyperaceae members.

Total number of mangroves plants observed in the area is presented in Table 6.5

Table 6.5: Station – V. Total number of mangrove plants.				
Plant Species	Total No. of plants	Saplings (< 30cm. high)	Plants (<2.5cm, diameter at breast height)	Died plants
Acanthus illicifolius	8000	**	**	**
Avicennia marina	**	48	**	**
Ceriops tagal	**	6	**	**
Excoecaria agallocha	**	**	26	**
Sonneratia apetala	**	34	**	**

Station-5: Talwali village – Profile diagram



AL: *Acanthus illicifolius*; AM: *Avicennia marina*

Station 6 : Mankhurd

Station – 6: The study area is an unprotected front mangrove patch.

Most of the potential mangrove areas on the lea ward side are reclamated for salt pans, housing and cultivation of agriculture crops. *Avicennia marina* is the only single mangrove tree species predominantly occurs in the whole region. Species richness is poor.

It is interesting to note that this region is located exactly on the other side of the Vikhroli. Despite its position as front mangrove area, it harbours only three species. Diversity is very poor. Tall trees are almost absent. There is a regressive trend of succession. Highest degree of biotic or human interference is observed in this area. The post monsoon season shows germination of other plants *like Excoecaria, Bruguiera* or *Sonneratia apetala* which fail to survive due to lack of proper habitat. Development of pneumatophore is also found to be affected due to human related interference. It is evidenced from the studies that their number is found minimum (27 per sqaure meter) and their length is also comparatively reduced (6.81 cm).

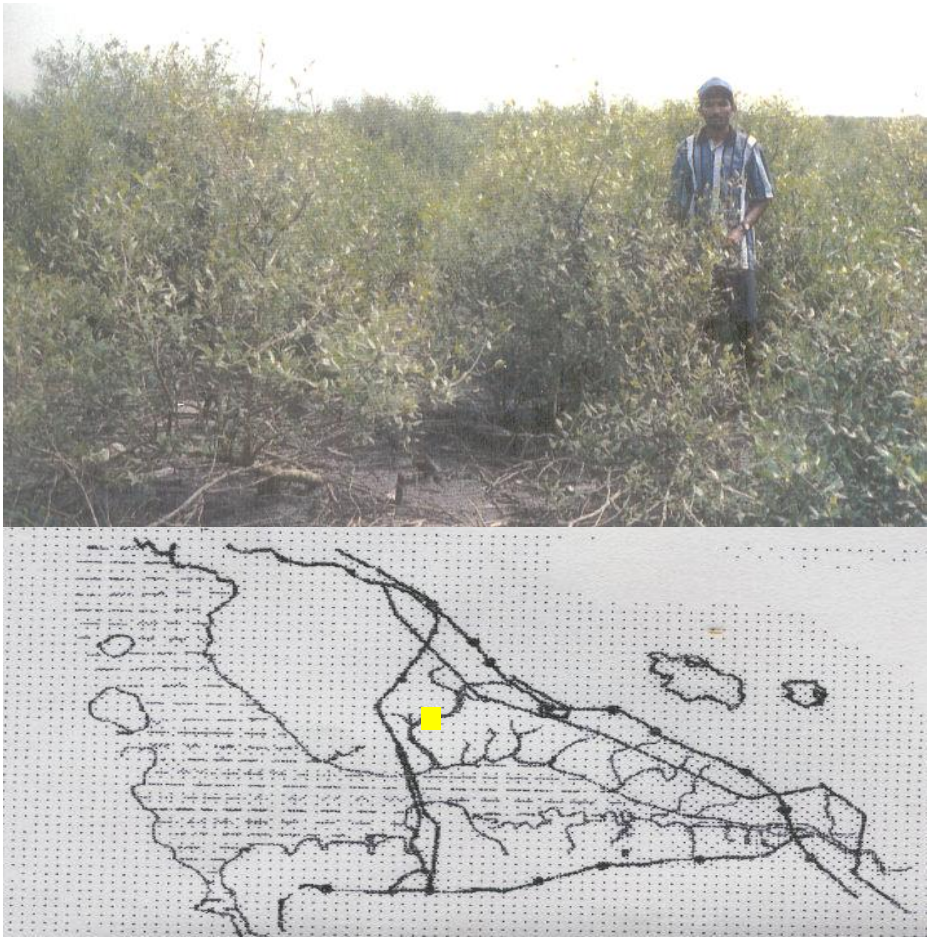
The salt pans are occupied by associates and salt tolerant plants like *Sueada nudiflora* , *Clerodendron innermi*, *Salvadora persica, Cayratia trifolia, Ipomea* sp.*, Ipomea separia*, *Blumea malcolmii, Alternanthera triandra, Aleurops lagopoides, Vitis sp.* etc. Total number of mangroves plants observed in the area is presented in Table 6.6.

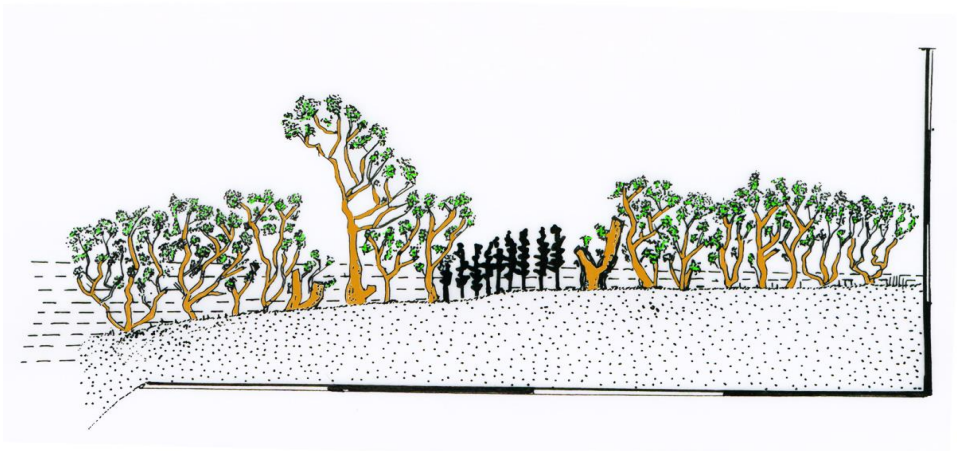
Table 6.6: Station – VI. Total number of mangrove plants

Plant Species	Total No. of plants	Saplings (< 30cm. high)	Plants (<2.5cm, diameter at breast height)	Dry plants
Avicennia marina	**	517	9177	**
Bruguiera cylindrical	**	1	**	**
Sonneratia caseolaris	**	2	**	**

* The table shows the absence of plants having DBH more than 2.5 cm and hence is insignificant with reference to biomass generation.

Station 6 : Mankhurd – Profile diagram





AL: *Acanthus illicifolius*; AM: *Avicennia marina*

The following inferences can be made from the diversity studies of mangroves.

As far as mangrove floristics is concerned, Thane creek exhibits a good diversity of species.

It is difficult to distinguish exactly the presence of front mangroves and back mangrove areas even with the help of remote sensing satellites. However, whatever ground surveys made during the study clearly indicates the absence of any noteworthy front mangroves in the Thane creek. When one carefully looks into the diversity of species many of the so called mangrove regions of Thane creek are devoid of any worth mentioning mangrove diversity.

Avicennia marina, the most ubiquitous tree species found in the mangrove areas of Thane creek is facing a serious crisis from a variety man made problems.

The most crucial problem in future years will be not simply protection but creation of suitable habitat. The habitat factor may solely control the future strategies of mangrove conservation of thane creek. All-important activities such as survival, growth, reproduction and germination are directly dependant on habitat. The mangroves of Thane creek are at a receiving end. Their natural habitat is fast disappearing.

In general, it can be concluded that, on the east bank of the Thane creek, *Avicennia marina* is dominant while *Acanthus ilicifolius* is dominant on the west bank. Species diversity and species richness is maximum in the partially protected area. Within the stations from partially protected areas, species diversity is maximum in back mangrove areas. No endemic species have been reported from the study area.

In case of disturbed areas like Mankhurd and Talwali, the total number of plants per hectare is much more than the number of plants in all the four partially protected areas. But the number is found to be insignificant in terms of biomass as they are showing stunted growth in case of *A. marina* and herbaceous nature in case of *Acanthus illicifolius.*

In the partially protected area, the average height of mangrove plants ranges from 2.7m to 5m. with the average DBH ranging between 2.99cm and 6.08cm. Although, the species diversity is maximum in back mangrove areas (Vikhroli I), the wood volume is found to be greater in front mangrove areas (Vikhroli III). This can be attributed to the increase in salinity, since the station is located on the main channel of the creek. The salinity is the limiting factor for the mangroves. The areas, which frequently receive marine water, showed less diversity. Because of protected habitat, most pollution tolerant and better adopted species like *Avicennia marina* grows

luxuriantly and hence contribute a good wood volume in the ecosystem. *Avicennia marina* has wide limits of tolerance for most of the factors.

Habitat structure influences the regeneration of mangroves. The partially protected Vikhroli I station shows maximum survival of seedlings due to less human interference coupled with rich organic matter and low salinity level of sediments. At Vikhroli III, seedlings survival rate is minimum, may be due to less supply of fresh water needed for the establishment of mangrove seedlings.

The comparison of IVI values obtained in the present study with those obtained by Deshmukh (1990) is presented in Table – 6.7.

Table 6.7: Decadal changes in the IVI of some mangrove species.

Species	IVI values		Species	IVI values	
	Deshmukh 1990	Present study		Deshmukh 1990	Present study
Avicennia marina	154.32	157.29	*Aegiceras corniculatum*	31.42	10.13
Bruguiera cylindrical	17.78	5.88	*Sonneratia apetala*	7.67	5.14
Ceriops tagal	21.7	4.43	*Excoecaria agallocha*	15.11	12.88

The table reveals that, over the years, IVI values of *Avicennia. marina* has been increased while that of other species has been decreased. The comparitive documentation of the past and present status hints that *Avicennia. marina* has better adopted itself to the rampant changes that includes pollution in the Thane creek's marine environment while other species are not able to keep pace with the changes and hence they are gradually vanishing from the area. Their habitat is either damaged or reduced significantly in recent years. As a result, populations of these species are also reduced**.**

Chapter Seven

Mangrove flora

Chapter Eight

Associates & Halophytes

Mangrove Associates

Botanical name: ***Aeluropus lagopoides*** (L.) Trin.

(= *Dactylis lagopoides*, *Aeluropus villosus* Trin. ex C.A. Mey., *A. repens* (Desf.) Parl.

Vernacular name*: Dola - gavat*

Family: **Poaceae**

Habit: Herb, up to 25cm long.

Flowering: January – December.

Pollination: --

Key characters for identification: Tufted annual; creeping; leaves lanceolate, acuminate, up to 4.0 X 0.2cm; heads globose; flowers densely crowded, florets unawned, 0.5- 2 X 0.5 across; anthers white.

Ecology: Abundant in mangrove areas.

Distribution: Asia

Uses: Fodder grass.

Threatened category: Endangered.

Botanical name: ***Clerodendrum inerme*** Gaertn.

Vernacular name: --

Family: **Verbanaceae**

Habit: Large shrub; up to 2.5m tall.

Flowering: November - January

Pollinators: Insects

Fruiting: November – March.

Key characters for identification: Evergreen; leaves glabrous, opposite, elliptic or obovate, 3-7 X 1-3cm; flowers white, in few flowered axillary racemes, usually 3-9 flowered; peduncles 3-6cm long; flowers white, corolla tube glabrous outside, hairy inside, 3-3.5cm long; lobes sub equal; filaments very long, hairy at the base, exerted; style long exerted; stigma acutely two lobed; fruit a drupe, seated at the base of an enlarged, persistent, and veined calyx; when ripe separates into 4 woody pyrenes.

Ecology: Occasional along the borders of high water mark regions.

Distribution: Many parts of the world at low altitude regions.

Uses: Often planted as a hedge plant.

Threatened category: Endangered.

Botanical name: ***Salvadora persica*** L.
var. wightiana (Planch. ex Thw.) Verdc.
(= *S. persica* non L.)

Vernacular name: Kharjal, Pilu, Pilva, Khakan, Khatan.
English name: Tooth brush tree.

Family: **Salvadoraceae**

Habit: A large shrub or a small tree; up to 10m tall.

Flowering: January – March.

Pollinators: Insects (flies)

Fruiting: January – June.

Key characters for identification: Evergreen; wood whitish-yellow; bark rugose; branches drooping; leaves pale green, somewhat fleshy, ovate, elliptic lanceolate, base acute or rounded, 3-7 X 2-3.5; flowers small, greenish-yellow, pedicelled, in axillary and terminal compound lax panicles; corolla deeply cleft, persistent, 3mm long, reflexed; drupe 3mm long, globose, smooth, red when ripe.
*Leaves broader than *S. oleoides*

Ecology: More frequently in old mangrove patches. The Mumbai mangroves areas differ floristically from other parts of Southern India by the large-scale presence of *Salvadora* spp.

Distribution: Asia, Africa

Uses: The leaves are edible and eaten as a salad.
The pungent leaves are favorite fodder of cattle.
The leaves are considered to be tonic to the liver, analgesic, useful in nose troubles, piles, leucoderma, inflammation, strengthen the teeth. The twigs of the branches are considered as best tooth brushes. In fact, the tree in Iran and other regions is called as tooth brush tree.
In Ayurveda the decoction of the bark of the stem is given internally to to cure low fever, and tonic in amenorrhoea.
The leaf paste is applied externally in rheumatism.
The fruit is sweet, aphrodisiac, improves appetite.
The seed oil is digestible and used in Ayurveda to cure *vata*.

Threatened category: --

Botanical name: ***Thespesia populnea*** (L.) Soland. ex Corr.

(=*Hibiscus populneus* L.)

Vernacular name: Bhendi, Paras bhendi, Paras pimpal, Paras kazada, Bhendi-kazed.

Family: **Malvaceae**

Habit: Moderate sized tree; up to 12m high.

Flowering: Almost throughout the year.

Pollinators: Birds, bats & insects.

Fruiting: Throughout the year.

Key characters for identification: Evergreen; leaves entire, not lobed, broadly ovate, base deeply cordate, apex acuminate, 8-13 X 6.5-12cm; glandular pores present in the intercostal spaces on the lower surface; pedicles 1-5cm long; flowers cupular, yellow with pale purple base, 6-8cm long; color of the flower changes from yellow to purple within 24 hours after opening, nectar glands of the flowers are usually present on the basal parts of the petals; stigma is elongated and longitudinally grooved; fruit indehiscent; capsule globose; seeds ovoid, channeled along the back.

Ecology: Common along the sea shores; often planted.

Distribution: Asia, Africa & Australia

Uses: Young flowers and buds are eaten either raw or cooked. Leaves are used as cattle fodder. Bark fiber is used for ropes and twines. Seed oil is used for illumination.
The wood is fine grained and tough and has been used as gun stocks and cart-wheels, boat building furniture, musical instruments and tool handles.
Seed oil and mashed bark are considered medicinal. Oil is used to cure cutaneous diseases. Mashed bark is used as poultice for wounds.

Threatened category: --

Botanical name: ***Pentatropis nivalis*** (J.F.Gmel.) Field &Wood

(=*Pentatropis cynanchoides* R.Br., *P. spiralis* (Forssk.) Decne, *Asclepias spiralis* auct.non, Forssk.)

Vernacular name: Ambarvel.

Family: **Asclepiadaceae**

Flowering period: January – October.

Pollinators: Insects.

Fruiting: April – November.

Key characters for identification Stem twining; densely pubescent when young, glabrous at maturity; leaves petiolate, fleshy, opposite, glabrous above, pubescent beneath, ovate, oblong, elliptic, 0.5-4.2X 0.3-2.7; flowers axillary in 4-7 flowered umbellate cymes, 8-13mm long; pedicles 4-11mm long; calyx deeply divided, pubescent; corolla lobes laterally compressed, divided to the base, apex curled or reflexed; corona uniserrate, five-lobed, triangular, base rounded, 8.5X2.5mm ; follicles usually single, 3cm long.

Ecology: Occasional in back mangrove patches.

Distribution: Asia, tropical Africa.

Uses: --

Halophytes

Botanical name: ***Atriplex stocksii*** (Wight) Boiss

Vernacular name: --

Family: **Chenopodiaceae**

Habit: Undershrub, up to 45 cm high.

Key characters for identification: Monoecious; stems and branches white; leaves alternate, fleshy, elliptic oblong; male flowers ebracteolate with 3-5 sepals; female flowers 2-bracteolate without sepals; fruit a membranous urticle rarely adnate to the seed, enclosed in large bracteoles.

Flowering: October – January.

Pollinators:

Fruiting: --

Botanical name: ***Blumea obliqua*** (L.) Druce

(= *B.amplectens* Dc., *B. pubiflora* D.C., *Erigeron obliquum* L.)

Vernacular name: Burambi

Family: **Asteraceae** (Compositae)

Habit: Herb (up to 60cm high). In Flora of the Presidency of Bombay (by Cook) the variety maritima is described as a littoral species, shrub, glandular, about 150cm high.).

Flowering: Throughout the year.

Pollinators: --

Fruiting: Throughout the year.

Key characters for identification: Dichotomously branched; stems yellowish, puberulous. Leaves lanceolate, elliptic oblong, margins serrate-dentate, auricled, base half amplexicaul to obtuse, velutinous, 0.5-5X 0.2-2cm; inflorescence is a paniculate racemes; heads 6-10mm diameter; involucar bracts hairy on dorsal surface, reflexed at maturity, often tinged with

purple, 1-8mm long**,** longer than the florets; corolla of bisexual florets tubular , yellow, 5-lobed, 4-5mm long; achenes dark brown, not ribbed; pappus yellowish white, 3-4mm long.

Ecology: A maritime species. Prefers open places.

Distribution: Tropical & sub tropical Asia.

Uses: Aromatic.

Threatened category: --

Botanical name: ***Caesulia axillaris*** Roxb.

Vernacular name: Maka.

Family: Asteraceae

Habit: Succulent herb, up to 60cm high.

Key characters: Prostrate or sub erect; leaves alternate, lanceolate, margins distantly serrulate, 22-14 X 0.1-2.4cm; heads homogamous, sessile, axillary,1-1.3cm across; florets white; anthers black, bases sagittate; achenes winged.

Flowering: September – June.

Pollinators: --

Fruiting: Octobe - June

Threatened category: --

Botanical name: ***Cayratia trifolia*** (L.) Domin

(= *Cayratia carnosa* (Lam.) Gagnep., *Vitis carnosa* Wall ex. Wight & Arn., *Cissus carnosa* Lam., *C . obtusifolia* Lam., *C. trifolia* L., *C. cinerea* Lam., *C. crenata* Vahl ex DC.).

Vernacular name: Ambet - vel, Tsjori-valli

Family: **Vitaceae**

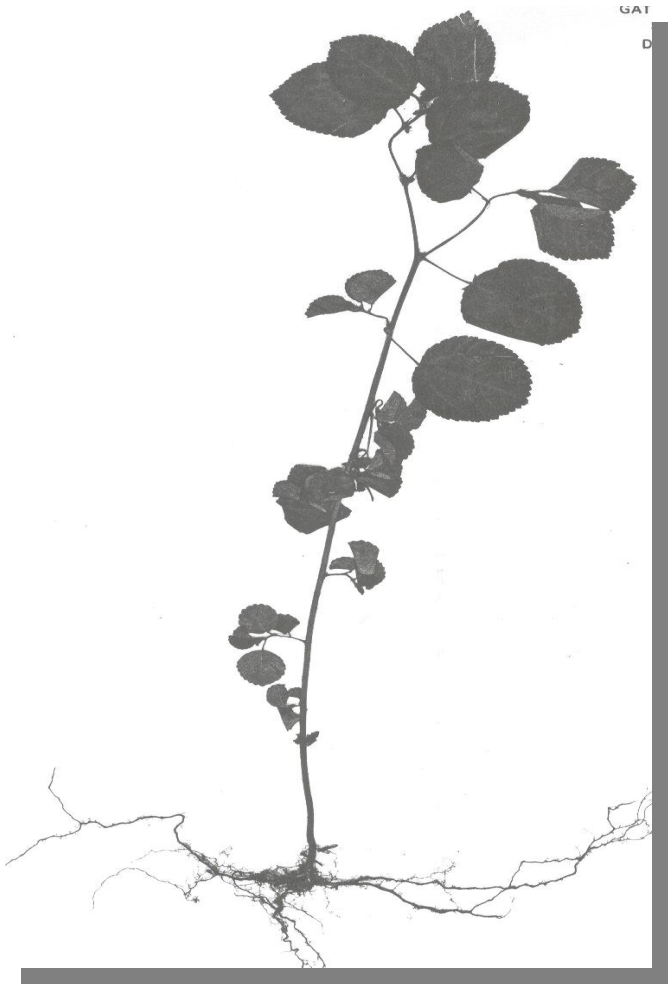
Habit: Herbs, up to 2m long; often with a climbing tendency.

Key characters for identification: Stems scandant, compressed, young parts densely pubescent; leaves 3-foliate; leaflets thick, stalked, round - ovate, round, crenete serrate, 4-6 X2-3cm; tendrils simple; calyx saucer – shaped; petals 4, hooded; disk 4lobed; berry black; smooth, 2-4 seeded.

Flowering period: June – September.

Pollinators: Insects,

Fruiting period: August -October



Botanical name: ***Corchorus aestuans*** L.

(= *Corchorus acutangulus* Lam.)

Vernacular name: --

Family: **Tiliaceae**

Habit: Undershrub, up to 55cm high.

Key characters for identification: Leaves ovate, serrate, base rounded 3 – 9 X 2.5 – 4.5cm; flowers yellow, in leaf - opposed cymes; petals spathulate; capsules 6-angled; three of them angles winged; seeds dark brown.

Flowering period: October – November.

Pollinators: --

Fruiting period: November-December

Botanical name: ***Cressa cretica*** L.

Vernacular name: K*ardi, Lona, Chavala, Rudanti*.

Family: **Convolvulaceae**

Habit: Dwarf under shrub, 15-38cm long.

Key characters for identification: Stem and branches silky-hairy; leaves subsiile, ovate, 3-6 X 1.5-2.5mm; flowers white or pink; corolla 5mm long, divided half way down; lobes reflexed; styles 2, free; stamens exerted; capsule 4-5mm long; seeds usually solitary.

Flowering: November – January.

Pollinators: --

Fruiting: November – February.

Ecology: Common in cultivated fields.

Distribution: Tropical & sub-tropical Asia.

Uses: In Unani & Ayurveda the leaves of the plant are used as aphrodisiac, enriches blood, useful in Asthma & urinary discharges.

Botanical name: ***Glinus lotoides*** L.

(= *Mollugo hirta* Thunb.)

Vernacular name: Kotrak, Dasar-sag.

Family: **Molluginaceae**

Key characters for identification: Herbs (up to 20cm long), prostrate, rosulate, spreading, softly hairy. Leaves opposite, hairy, elliptic or obovate, 1-3 X 0.8-1.5cm . Flowers greenish white turns

to pinkish white at maturity, 3-8 in axils. Stamens 10. Ovary 5 lobed, style almost absent, stigmas 5 . Capsules ovoid, 5 valved, 0.6cm long. Seeds appendaged.

Flowering: October – May.

Botanical name: ***Glinus oppositifolius*** (L.) A.DC.

(= *Mollugo oppositifolia* L., *M. spergula* L.)
Vernacular name: --

Family: **Molluginaceae.**

Key characters for identification: Herbs (up to 25cm long), prostrate, creeping, dichotomously branched. Leaves whorled, linear lanceolate, oblanceolate. Flowers white, in axillary fasicles. Stamens 3. Styles 3. Capsule, ellipsoid, 0.5cm long Seeds appendaged with a white scale.

Flowering: January – June.

Botanical name: ***Heliotropim indicum*** L.

Vernacular name: Bhurundi

Family: **Boraginaceae**

Habit: Herb or undershrub (up to 4-feet high).

Description: Branches coarse, hirsute, spreading, ascending. Leaves ovate, elliptic or ovate-oblong, 3-8 X2-4cm, petiole winged. Flowers in dense scorpioid cymes, white or bluish-white, sessile. Fruits deeply bifid, deeply 4-ribbed. Nutlets, beaked and angled.

Flowering: April - June

Pollinators:

Fruiting: Almost throughout the year

Key characters for identification: Leaves more than 4cm long. Fruits 4-beaked.

Ecology: A weed.

Distribution: Asia, Africa & America.

Uses: Leaf paste is applied to wounds, ulcers, boils and stings of insects.

Botanical name: ***Ipomea marginata*** (Desr,) H. Manitz

(= *Ipomea maxima* non (L.f.) G.Don ex Sweet, *I.sepiaria* Koen ex Roxb.

Vernacular name: Amti-vel

Family: **Convolvulaceae**

Key characters for identification: Twiners (up to 4m long) . leaves ovate-cordate. Flowers pale pink or white. Corolla funnel shaped, 2.5-4cm long.

Flowering period: August – January.

Botanical name: *Malachra capitata* L.

Vernacular name: Ran-bhendi, Ran-ambadi.

Family: **Malvaceae**

Habit: Under shrub (up to 160cm high).

Description: Stems coarse, hispid. Leaves, lobed angled, entire, base cordate. Petioles 4-6cm long. Involucre leaves variously lobed, teethed with a white spot at the base and two opposite ciliate appendages. Stiff bristles are present on the margins. Flower yellow. Seeds smooth, brown black.

Flowering: August – December.

Pollinators: Insects.

Fruiting: September - January

Key characters for identification: Leaves often angled, less lobed. Staminal tube antheriferous outside. Branches of the style twice as many as the carpels.

Ecology: A weed.

Distribution: Introduced from Brazil. Naturalized in India

Uses: Stem fibre is used for cloth, twines and ropes.

Botanical name: ***Operculina turpethum*** (L.) S.Manso

(= *Ipomoea turpethum* (L.) R.Br., *Merremia turpethum* (L.) Shah & Bhatt).

Vernacular name: Dudh kalmi, Nisottar.

Family: **Convolvulaceae**

Key characters for identification: Climber (up to 6m long). Stems with milky juice, long twiny, angled and winged. Leaves ovate-oblong, lobulate, 6 – 12X 3 - 8cm. Bracts pinkish. Corolla white, sub campanulate, 6cm long. Capsule enclosed in the brittle sepals, almost 3cm diameter.

Flowering period: Almost through out the year.

Botanical name: ***Peganum harmala*** L.

Vernacular name: Harmal.

Family: **Zygophyllaceae**

Habit: Under shrub (30-90cm high).

Description: Dichotomously or corymbosely branched. Leaves alternate, 5-7.5cm long. Flowers white, solitary on sub terminal leaf opposed pedicles, 2-2.5cm across. Petals 4-5, elliptic oblong. Stamens 12-15. Capsules globose, deeply lobed.

Flowering: October – December.

Pollinators: --

Fruiting: October – January.

Key characters for identification: Dichotomous branching. Flowers white. Stamens 12-15.

Ecology: Common in drier parts.

Distribution: Asia

Uses: Seeds are considered laxative, useful in weaknesses of muscles, brain, rheumatism, relieves asthma and chronic bronchitis.
In Unani medicine, the smoke inhalation is believed to relieve tooth ache, and pain In the liver. The decoction of the leaves is given for rheumatism. The powdered root mixed in mustard oil, is applied to the hair to kill vermin & lice. The seeds powder is taken internally as remedy for tape worm.
The seeds are narcotic and are taken for indigestion, and to cure jaundice, hiccough, hysteria & gall stones.
Plant kept in room repels mosquitoes.
Seeds yield a red dye.

Botanical name: ***Pentanema cernuum*** (Dalz.) Ling

(= Vicoa cernua Dalz.)

Vernacular name: --

Family: **Asteraceae**

Key characters: Herbs (up to 50cm high). Branches sparsely pubescent. Leaves alternate, petiolate, serrate, acuminate. Peduncles drooping. Heads yellow, heterogamous, 10-18mm diameter. Involucre bracts with long filiform or recurved tips, hairy. Ray florets yellow, 3-toothed at apex, pappose. Achenes oblong, sparsely hairy.

Flowering: November – February.

Threatened category:

Botanical name: ***Pluchea arguta*** Boiss.

Vernacular name: --

Family: **Asteraceae**

Key characters for identification: Shrub(up to 1m tall). Soft & fleshy when present near sea. Upper parts glandular- pubescent. Leaves glandular pubescent, pungently serrate or lobulate. Heads sub solitary, purple , 0.8 –1.2cm across.

Flowering: January – February.

Threatened category: --

Botanical name: ***Phyla nodiflora*** (L.) Greene

(= *Lippia nodiflora* (L.) A.Rich, *Verbena nodiflora* L.)

Vernacular name: Ratoliya, Jalapimpali, Gour Mundi.

Family: **Verbenaceae**

Habit: Herb (Creeper)

Description: Stems sub quadrangular, prostrate, rooting at nodes. Branches nearly covered with white hairs. Leaves opposite, spathulate, margins coarsely serrate, 0.8-3.5 X 0.4-2cm. Flowers in globose –ovoid or cylindric spikes, white, bluish or lilac tinged. Corolla 0.2-0.3cm long upper lip erect, bifid, lower lip 3-lobed, the middle lobe the largest. Fruits, globose-oblong, enclosed by calyx

Flowering: Throughout the year

Pollinators: Insects

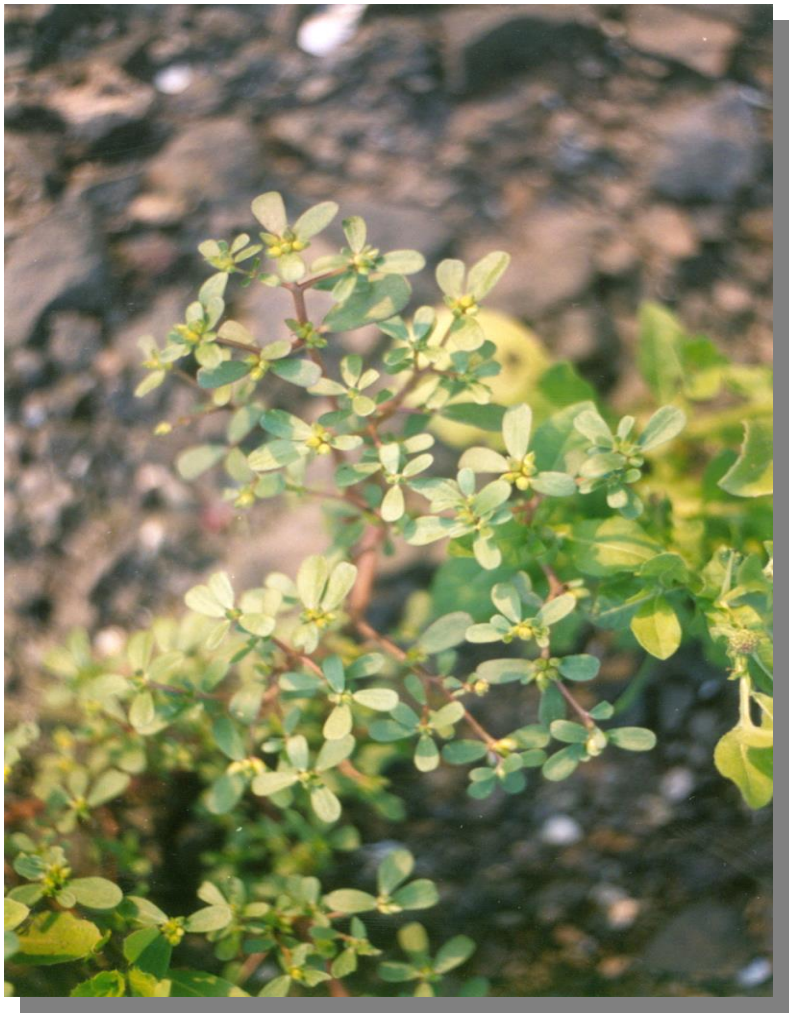
Fruiting: Throughout the year.

Key characters for identification: Prostrate herb, Calyx deeply 2-lobed. Flowers white, bluish or lilac tinged.

Ecology: Moist situations.

Distribution: Tropical & Sub-Tropical parts of the world.

Uses: In Unani medicine the plant is used to cure fevers, colds and urinary concretions.
In Ayurveda the species is believed to be useful in curing the diseases of heart, blood, ulcers, wounds, asthma, bronchitis, burning sensation, improves the taste and loss of consciousness.
Chutney made from the leaves and fruits is eaten to relieve the irritation of internal piles.
A poultice composed of the fresh plant is a good maturant for boils.



Botanical name: ***Portulaca oleracea* L.**

Vernacular name: Ghol, Mhoti ghol, Kurfah.

Family: **Portulacaceae**

Key characters for identification: Herbs (25cm long), fleshy, prostarate. Stems reddish or reddish brown. Leaves alternate or subopposite, ovate, obovate, rounded. Flowers in sessile heads. Petals obovate, yellow, 5-6. Stamens 8-12. Style partite (3-8). Capsule enclosed in petals, operculate. Seeds many, black.

Flowering: Through out the year.

Uses: Plant is edible. Delicious soup and salads are prepared from the herb.
The whole plant is also used for a variety of medicinal uses. It is used to cure scurvy, liver diseases, spleen, kidney bladder, cardio-vascular diseases and dysentery.
In homoeopathy and folk medicine it is used as a blood purifier.

Botanical name: ***Ricinus communis* L.**

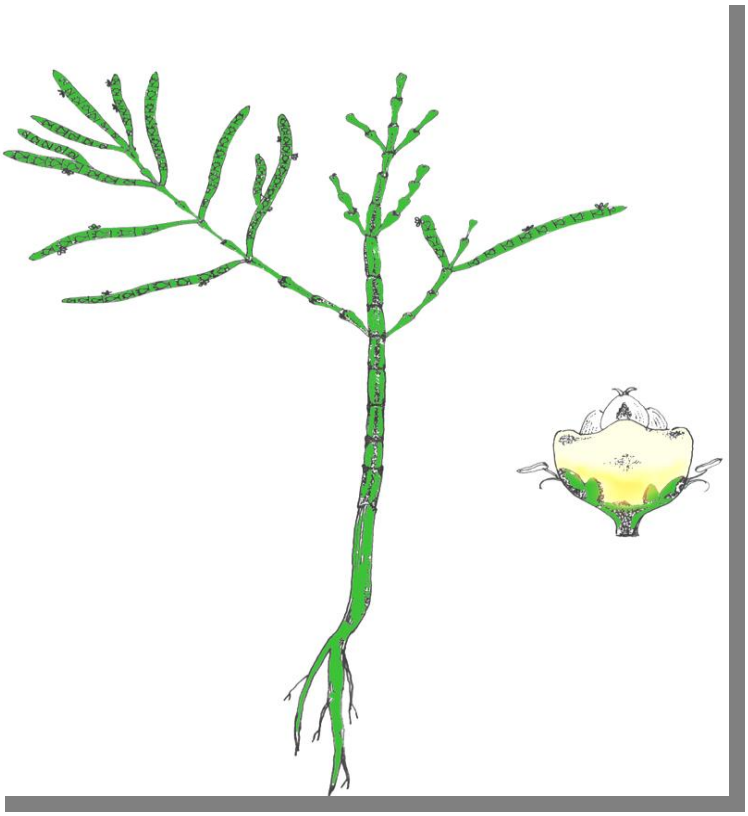
Vernacular name: Erand

Family: **Euphorbiaceae**

Key characters for identification: Large shrub or a small tree; (up to 3m tall). Naturalized. Stems green or reddish. Leaves palmately lobed.

Flowering period: Almost through out the year.

Uses: The castor bean plant. Seeds are a source of castor oil. Leaves are used as insecticides



Botanical name: ***Salicornia brachiata* Roxb.**

Vernacular name: Machul

Family: **Chenopodiaceae**

Habit: Shrub (Up to 80cm high).

Description: Fleshy, branched, jointed, joints 6-12mm long, slightly dialated, 2-toothed, leafless. Flowers in slender cylindrical spikes, present in the axils of scaly bracts, hermophroidte, 3-nate. Fruit is a compressed urticle. Seeds pale brown**.**

Flowering: November - December

Pollinators: --

Fruiting: November – January.

Key characters for identification: Fleshy. Leafless. Flowers sunk in cavities in successive joints.

Ecology: Occuring in salt marshes along the sea coasts

Distribution: Tropical Asia.

Uses: Young shoots are eaten after pickling.
Plants are considered good camel feed.
The ashes are used to cure itching.

Threatened category: Lower risk – near threatened.

Botanical name: ***Salsola foetida*** Del.

(= *Salsola spinescens* Wight)

Vernacular name: Lanan, Ellakura.

Family: Chenopodiaceae

Key characters for identification: A large shrub (up to 1.5m tall.). Leaves small, minute, fleshy. Inflorescence of short cylindrical spikes. Bracts fleshy, broadly ovate. Perianth white, shining. Stigmas 2, recurved.

Flowering: November – December.

Botanical name: ***Sesuvium portulacastrum*** L.

Vernacular name: Daula, Dhapa

Family: **Aizoceae** (Ficoideae)

Habit: Herb (creeping).

Description: Stems prostrate, succulent, rooting at the nodes. Branches glabrous, red. Leaves, opposite, linear or spathulate –oblong, 2.5-5 X 0.5-1cm . Flowers solitary. Calyx deeply –5 lobed, purplish outside, rosy within. Stamens many, filments red. Ovary usually red. Styles-3. Capsule enclosed within a persistent calyx.

Flowering: November – December.

Pollinators: --

Fruiting: November- January.

Key characters for identification: Calyx purplish outside, rosy within. Ovary 3celled.

Ecology: Prefers open coastal areas. Common in degraded mangrove areas.

Distribution: Tropical & subtropical parts of Asia.

Uses: The plant is eaten as a vegetable.

Threatened category: Endangered.

Botanical name: ***Sopubia delphinifolia*** (L.) G. Don

Vernacular name: Dudhali

Family: **Scrophulariaceae**

Key characters for identification: Herbs (up to 80cm high). Stems quadrangular, grooved. Leaves opposite, pinnatisect with filiform segments, 2.5-4cm long. Flowers rose coloured with a dark

purple spot on the lower lobe, 2-3.5X 0.3-0.4cm across. Calyx strongly ribbed. Corolla funnel shaped.

Flowering period: August – November.

Botanical name: ***Sphaeranthus africanus*** L.

Vernacular name: Sweta Gorakhmundi.

Family: **Asteraceae**

Key characters: Herb (up to 75cm high). Erect, aromatic. Stems compressed, winged. Leaves sessile, decurrent, sub entire to minutely dentate. Glomeruli not more than 1cm across. Peduncles pubescent. Heads white very rarely purple, globose, 0.5-1cm across. Involucral bracts obovate-spathulate, rounded and glabrous.

Flowering: Almost throughout the year.

Threatened category:

Botanical name: ***Suaeda fruticosa*** **Forssk**.

(= *Chenopodium fruticosum* L., *Salsola fruticosa* L.)

Vernacular name: Moras, Ushuk-lani

Family: **Chenopodiaceae**

Habit: An under shrub (up to 60cm high).

Description: Leaves fleshy, sub sessile, oblong, ellipsoid. Flowers hermophrodite, bracteoles membranous, slightly denticulate margins. Fruit subglobose, stigmas 3, short.

Flowering: November – December.

Pollinators: --

Fruiting: November – January.

Key characters for identification: Flowers hermaphrodite, Stigmas-3, flowers axillary, 1-3 nate, bracteoles with toothed margins.

Ecology: Found growing in alkaline soils.

Distribution: Asia, Africa & America.

Uses: The plant is eaten by camels. It is recommended for treating water logged & saline soils. The leaves are applied as poultice to opthalmia.
The wooly excrescences of the plant, mixed with oil (empyreumatic) is used to cure the sores of camel.
* The plant is also reported to produce persistent black diarrhoea and death in sheep.

Threatened category: ---

Botanical name*: Suaeda maritima* (L.) Dum.

(= *S.nudiflora* Moq., *Salsola indica* Willd.)

Vernacular name: Moras, Lana, Lani, Muchola.

Family: Chenopodiaceae

Habit: Under shrub (up to 70cm high).

Description: woody stems with numerous branches, leaves fleshy, narrowly linear, 2-3 X 0.5-1cm. Floral leaves very small. Flowers in globose clusters. Bracteoles ovate membraneous. Perianth segments covering the uritcle, rounded. Stigmas-2. Seed obliquely ovoid, smooth, shining black.

Flowering: May.

Pollinators: --

Fruiting: May – July.

Key characters for identification: Stigmas-2. Seed obliquely ovoid.

Ecology: Common along the mud-flats and salt marshes.

Distribution: Pantropical

Uses: The green leaves are eaten as a vegetable.
It has also been reported to fix sand along the sea-shores.
The plant is also incinerated to produce an impure Sodium carbonate.

Threatened category: Endangered.

Botanical name: ***Syzygium caryophyllatum*** (L.) Alston

(= *Myrtus caryophyllatus* L., *Eugenia corymbosa* Lam., *E. caryophyllaea* Wight)

Vernacular name: Bhedas, Nimbuli, Ranlavang.

Family: **Myrtaceae.**

Key characters for identification: Large shrub or a small tree (up to 5m tall). Leaves glabrous above, inconspicuously dotted below, obovate, 4-10 X 2-5cm. Flowers white, 0.4-0.6cm across. Inflorescence of laxy trichotomous cymes, branches quadrangular. Calyx 4, cup shaped. Petals 4, white. Fruit dark purple or black, globose, 0.8 -1cm long.

Flowering: March – October.

Botanical name: ***Tamarix indica*** Willd.

(= *Tamarix gallica* var. indica (Willd.) Cooke, *T. gallica* auct. non L., *T. troupii* Hole).

Vernacular name: Jhavrajhad, Lai, Jhau.

Family: **Tamaricaceae**

Key characters for identification: Large shrub or a small tree (up to 3m tall) with pendulous branches. Leaves small, scale like. Flowers pinkish, bisexual, crowded in racemes. Stamens 5. Ovary trigonous, styles 3. Capsule pink, trigonous.

Flowering period: November – May.

Botanical name: ***Vigna dalzelliana*** (O. Ktz.) Verdc.

(= *Phaseolus. dalzellii* T.Cooke, *P. pauciflorus* Dalz.)

Vernacular name: Ran - mung

Family: **Fabaceae**

Key characters for identification: Herbaceous twiners (up to 1m long). Stems & branches hairy. Leves trifoliate. Leaf lets ovate, 8-15 X 4-7cm. Flowers yellow, 0.5 -1cm long. Calyx hairy Pods 3-4cm long, cylindric.

Flowering period: September – December.

Botanical name: ***Cyperus compressus*** L.

Vernacular name: --

Family: **Cyperaceae**

Key characters for identification: Herbs(upto 35cm high). Stems tufted, trigonous with rounded smooth angles. Leaves basal, linear, one nerved. Inflorescence of simple umbels, often with a sessile head at the fork. Rays 3-6. Spikelets compressed, yellow when ripe, 1.2-1.8X0.8cm, 20-40 flowered. Stamens 3, anthers yellow. Stigmas 3. Nuts broadly obovoid, triquetrous, yellow turns dark brown at maturity.

Flowering: July – December.

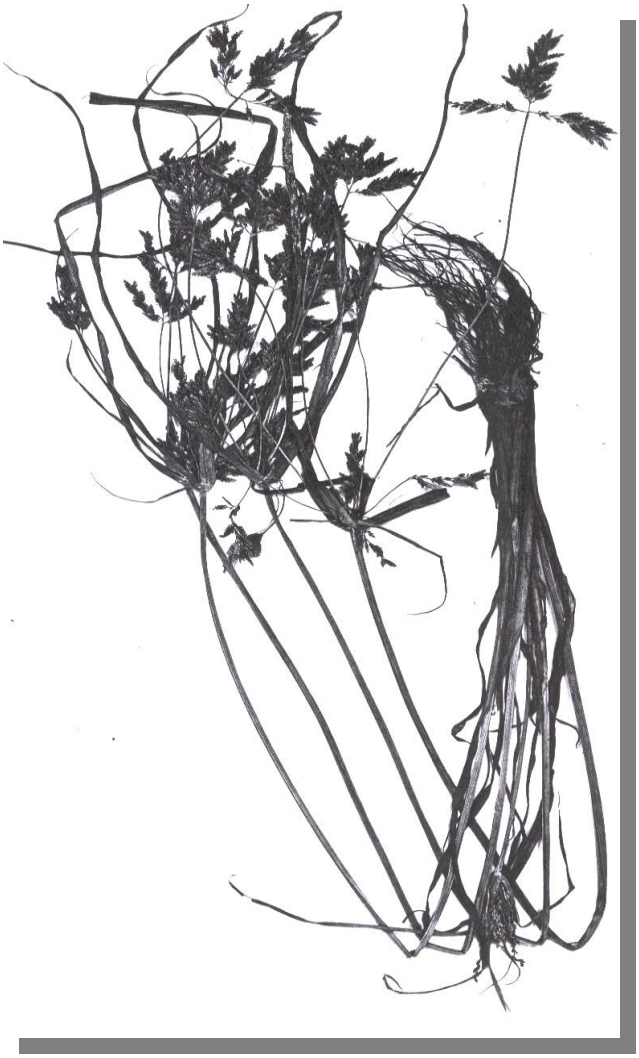
Botanical name: ***Cyperus alulatus*** Kern

(= *Cyperus iria* var. rectangularis Kuekenth, *C . rectangularis* (Kuekenth.) Bennet).
Vernacular name: --

Family: **Cyperaceae**

Key characters for identification: Herbs (up to 25cm high). Leaves 12-16cm long. Inflorescence of compound umbels. Spikelets reddish or greenish yellow, 0.4-X0.2cm. Nuts brown, 1mm long, spiculate.

Flowering: July – November.



Botanical name: *Cyperus iria* L.

Vernacular name: --

Family: **Cyperaceae**

Key characters: Herb (up to 60cm high). Stems tufted, triquetrous. Leaves basal, as long as the stem, 110-18 X 0.1-0.5cm, acuminate. Inflorescence terminal, compound umbel. Umbellules irregularly fascicled. Spikelets yellow, greenish yellow (pale brown ?), 0.5-1.0X 0.3cm. Nuts as long as glumes, obovoid, triquetrous, brown or black, 0.1cm long.

Flowering: Almost throughout the year.

Botanical name: ***Cyperus rotundus*** L.

ssp. **rotundus**

ssp.**tuberosus** (Rottb.) Kuekenth.

Vernacular name: Moth, Belgondhara, Motha, Nagar-motha

Family: Cyperaceae

Key characters for identification: Herbs (4-50cm high). Stoloniferous. Tubers hard, fragrant. Stems triquetrous at the top. Leaves linear, 10-18cm long. Inflorescence is of simple or compound umbel. Spikelets reddish brown, compressed, 10-50 flowered. Glumes with 5-7 nerves, deep or reddish brown. Stamens 3. Stigmas 3. Nuts broadly obovoid, trigonous, greenish, turns to greyish black, 0.15cm long.

Flowering: Almost through out the year.

The tubers are considered highly medicinal in Ayurveda. Rhizomes yield an essential oil which is used in cosmetics, perfumery and as insect repellent.

Botanical name: ***Fimbristylis dichotoma*** (L.) Vahl.

(= *Fimbristylis diphylla* Vahl.; *F. annua* R&S. var. pauci-spiculata Blatt. & McC. ; *F. diphylla* var. annua (R.&S.) C.B.Cl.)

Vernacular name: --

Family: **Cyperaceae**

Key characters for identification: Herbs (up to 15cm high). Leaves usually shorter than the stems. Inflorescence a laxly compound umbel. Glumes reddish brown. Stamens 1-3, Style 2-fid, recurved, densely villous in the upeer part. Nuts, pale staw coloured or white with 6-9 broad tuberculate ribs.

Flowering: July – April.

Botanical name: ***Fimbristylis ferruginea*** (L.) Vahl

Vernacular name: --

Family: **Cyperaceae**

Key characters for identification: Herbs (15-70cm high) Leaves absent or very rarely few, narrowly linear, 1-15cm long. Inflorescence simple or subcompound umbels, of few spikelets. Spikelets reddish brown, mall upto 1.5cm long. Glumes ferrugineous, pubscent. Stamens 2-3. Stigmas2. Nuts pale straw coloured, obovoid or sub orbicular, compressed, obscurely reticulate, smooth, narrowly margined all around0.1-1.2cm long.

Flowering: August – February.

Botanical name: ***Fimbristylis ovata*** (Burm.f.) Kern.

(= *Fimbristylis monostachyos* (L.) Hassk., Carex ovata Burm.f.)

Vernacular name:--

Family**: Cyperaceae**

Key characters: Herb (up to 40cm high), densely tufted. Leaves crowded on the swollen base, shorter than the stems. Sheaths with scarious margins. Spikelets glabrous, pale-straw coloured, globose-ovoid, 1-2, 0.6cm long. Glumes reddish brown. Stamens 3, anthers yellow. Stigmas 2. Nuts not enclosed in an urticle, pyriform, coarsely tuberculate 0.2-0.3 X 0.15-0.2cm.

Threatened category: --

Botanical name: ***Fimbristylis polytrichoides*** (Retz.) Vahl

Vernacular name: --

Family: **Cyperaceae**

Key characters for identification: Herbs (up to 30cm long). Stems leafy, trigonous at base. Leaves as long as or longer than the stem, trigonous or terete. Spikelets solitary. Glumes pale straw-coloured or almost white, minutely apculate, membranous with a narrow central band. Stamens flattened, white, membranous , 1-3. Stigmas 2. Nuts 0.08-0.1X0.055cm, sessile, compressed, biconvex, yellow, dotted with white spots.

Flowering: August – October.

Botanical name: ***Fimbristylis tetragona*** R.Br.

Vernacular name: --

Family: **Cyperaceae**

Key characters: Herb (15- 35cm high). Stems densely tufted. Leaves absent. Sheaths brown. Rachilla thickly studded with deep tetragonal pits. Spikelets brown or yellow, 0.3-0.5cm long. Stamens 2 , filaments almost black, flattened. Style hairy, as long as nut. Stigmas 2. Nut sub cylindric, curved, conspicuously stiptate, 0.1cm long.

Flowering: August – March.

Botanical name: ***Scirpus affinis*** Roth.

(= Scirpus maritimus var. affinis (Roth) C.B.Cl., ; *Bolboschoenus maritimus* ssp. affinis (Roth) T. Koyama)

Vernacular name: --

Family: **Cyperaceae**

Key characters for identification: Herbs (up to 15-60cm). Creeping rhizomes bear tubers. Stems tufted, triquetrous, Leaves many, keeled, narrowly linear, 8-18cm long. Inflorescence terminal or sub terminal, umbellate, rays unequal. Bracts leaf like, 3-5. Spikelets reddish – brown, cylindric, 1-2 X 0.5-1cm. Glumes strongly brown, keeled, bifid at the apex. Hypogynous bristles un equal, 3-6. Stamens 3, Stigmas 3. Nuts obtusely trigonous, 0.3cm long.

Flowering: August – December.

Botanical name: ***Diplachne fusca*** (L.) P. Beauv.

Vernacular name: --

Family: Poaceae

Key characters for identification: Herbs (up to 1m high). Leaves flat or convolute, up to 10cm long. Panicles 10-17cm long, branches spike like. Spikelets 8– flowered (4-10 ?), laterally compressed, pedicellate, 0.5-0.8cm long. Glumes muticus, hairy. Lower glume oblong-lanceolate. Upper glume broader, ovate-oblong. Stamens 3.

Flowering: August – February.

Botanical name: ***Eriochloa procera*** (Retz.) C.E.Hubb.

(=*Eriochloa polystachya* Hook.f.; *E. ramosa* O. Ktze.)

Vernacular name: --

Family: **Poaceae**

Key characters for identification: Herbs (up to 150cm high). Creeping. Stems densely tufted, nodes hairy. Leaves linear, linear - lanceolate, acuminate up to 25cm long. Ligule with a villous ridge. Panicles pedunculate. Peduncles short. Panicles 10-12cm long. Spikelets silvery, loosely imbricate, shortly pedicellate solitary or 2nate. Lower involucore glume absent. Upper involucre glume silky hairy, obscurely 3nerved. Grains oblong or ellipsoid-oblong.

Flowering: August – January.

Botanical name: ***Paspalum paspalodes*** (Michx.) Scribner

(=*Paspalum distichum* auct non L.)
Vernacular name: --

Family**: Poaceae**

Key characters for identification: Herb (up to 45cm high). Stem many nodded, sheathed throughout. Leaves distichous, sheaths bearded at mouth. Racemes upto 9cm long. Spikes 2-nate, pedunculate, dorsally flattened, 2-4cm long. Lower glumes absent, upper glumes with a distinct midnerve, covered with a short pubescencealmost white, 3.5mm long. Grains ellipsoid –oblong.

Flowering: August – January.

Botanical name: ***Paspalidium punctatum*** (Burm.f.) A. Camus

(=*Panicum punctatum* Burm.f.)

Vernacular name: Petnar

Family: Poaceae

Key characters for identification: Herb (upto 1m high), floating, rooting at lower spongy nodes. Leaves linear, acute or acuminate, up to 23cm long. Ligule a ridge of hairs. Inflorescence 10-20cm long. Spikes 2-4cm long. Glumes 4, lower glumes well developed. Upper glume half the length of upper lemma or more, granulate, white. Upper lemma rugulose, acute. Spikelets yellowish, in 2 rows, turgid.

Flowering: August – November.

Botanical name: ***Paspalum vaginatum*** Swartz

Vernacular name: --

Family: **Poaceae**

Key characters for identification: Herbs (upto 2.5-15cm high), prostrate stems, creeping, rooting at inter nodes. Leaves 5-8cm long. Spikes 2 nate, pedunculate, 2.3-4cm long. Spikelets ovoid-oblong. Upper lemma concave, middle nerve of lower lemma faint.

Flowering: July – October.

Botanical name: ***Pseudanthistiria heteroclita*** (Roxb.) Hook.f.

Vernacular name: Phulada

Family: Poaceae

Key characters for identification: Herbs (up to 60 cm high). Tufted. Leaves 7-15cm long. Peduncles of pseudo-racemes, glabrous. Spikes spathaceous. Spikelets 0.3-0.4cm long.

Flowering: July – October.

Botanical name: ***Setaria pumila*** (Poir.) R. &S.

(=*S. pallide-fusca* (Schumach.) Stapf & C.E. Hubb. ; *S. glauca* non (L.) P.Beauv.)

Vernacular name: Kolara, Bindi, Kolu, Kolwa.

Family: **Poaceae**

Habit: Herb (up to 20-60cm high) .

Description: Tufted, lower nodes rooting. Leaves 3-11 X 0.2-0.5cm, acuminate, flat with scabrid margins, ligule with a ridge of hairs. Inflorescence a false spike, cylindrical, dense, 1.5-5.0 X 0.3-0.7cm, bristles antrorsely barbed, spike lets ovoid, ellipsoid, 0.2-0.3cm, involucel 6-12, pale or reddish-brown, glumes-4, upper lemma rugose. Grains dorsally or plano-convex.

Flowering: July – November.

Pollinators: --

Fruiting: July – December.

Key characters for identification: Spikelets subtended by an involucre of bristles, leaves flat, bristles of involucel with spreading or erect teeth. Inflorescence a false spike or spike like raceme. Bristles antrorsely barbed.

Ecology: Common in open grass lands and in cultivated fields.

Distribution: Tropical, Sub-Tropical regions and warm temperate regions of the world.

Uses: Weed. Used as cattle fodder.

Botanical name: ***Sporobolus helvolus*** (Trin.) Th.Dur. & Schinz.

(=*Sporobolus glaucifolius* Hochst. ex Steud.)

Vernacular name: --

Family: Poaceae

Key characters for identification: Herb (up to 60cm high). Stolons slender, rooting at nodes. Leaves tapering to a filiform tip. Panicles pale yellowish white, 4-12 X 0.5-2.0cm long Spikelets

greenish brown. Involucral and floral glumes almost similar. Glumes 3. Floret 1. Grains ellipsoid, 0.05cm long.

Flowering period: August – December.

Botanical name: ***Sporobolus maderaspatanus*** Bor

(= *Sporobolus orientalis* Kunth.) .

Vernacular name: --

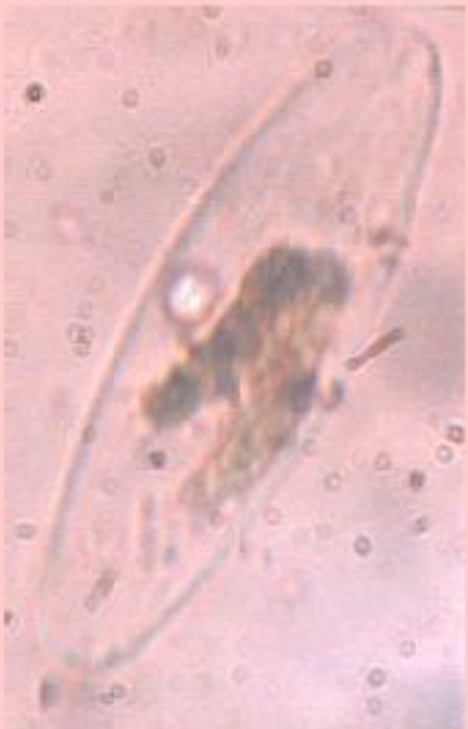
Family: **Poaceae**

Key characters for identification: Herbs (up to 50cm high). Stems rooting at nodes. Branches and flowering stems geniculate below. Leaves scaberulous, 3-16 X 0.2—0.4cm. Panicles 3-10cm long. Spikelets un awned, terete, upper involucral glume about equaling the floral glume.

Flowering: August – December.

Chapter Nine

Algae & Phytoplankton



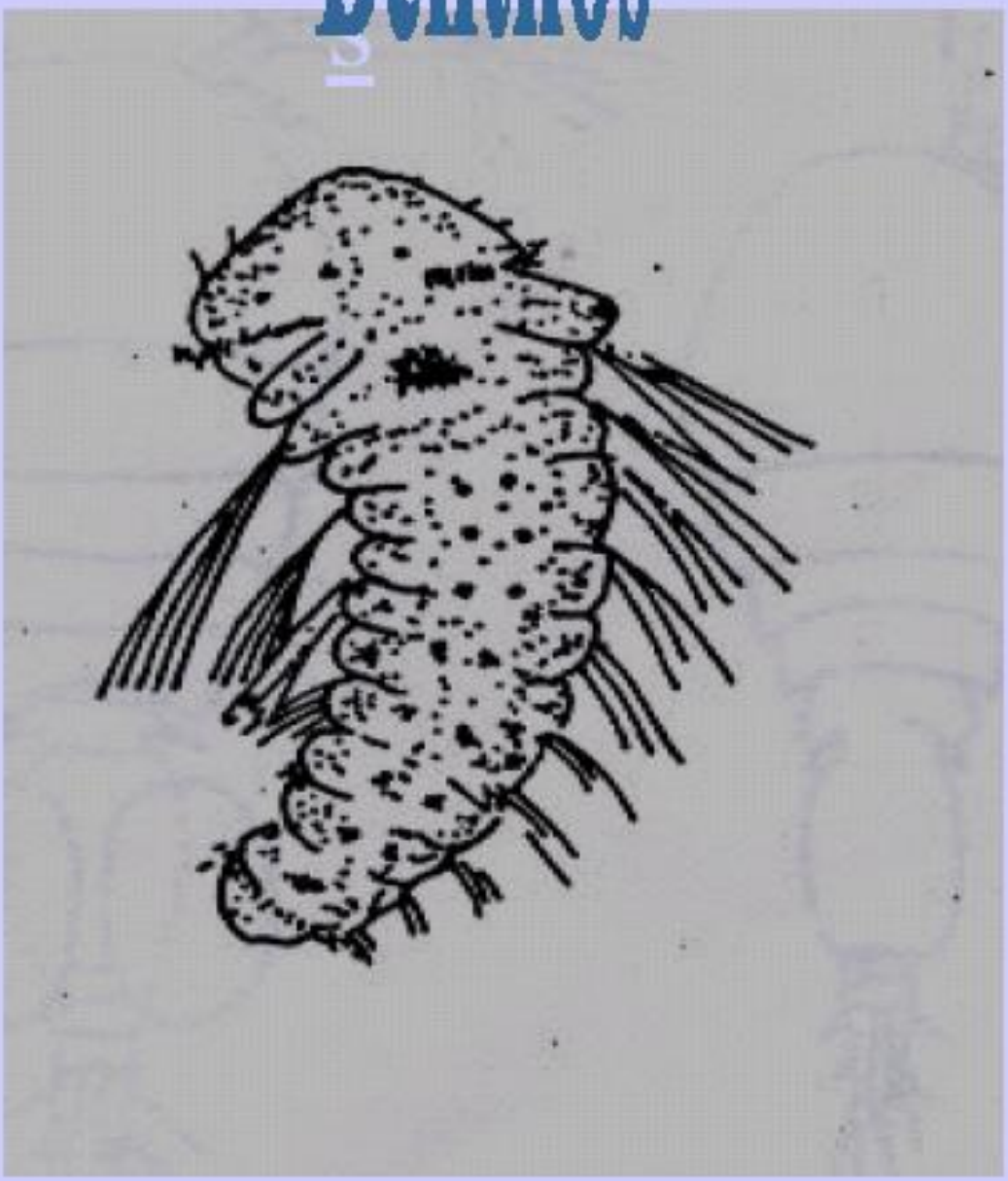
Chapter Ten

Fungi

Fauna

Chapter Eleven

Benthos



Chapter Twelve

Arthropoda

Chapter Thirteen

Mollusca

Chapter Fourteen

Pisces

Chapter Fifteen

Reptiles

Chapter Sixteen

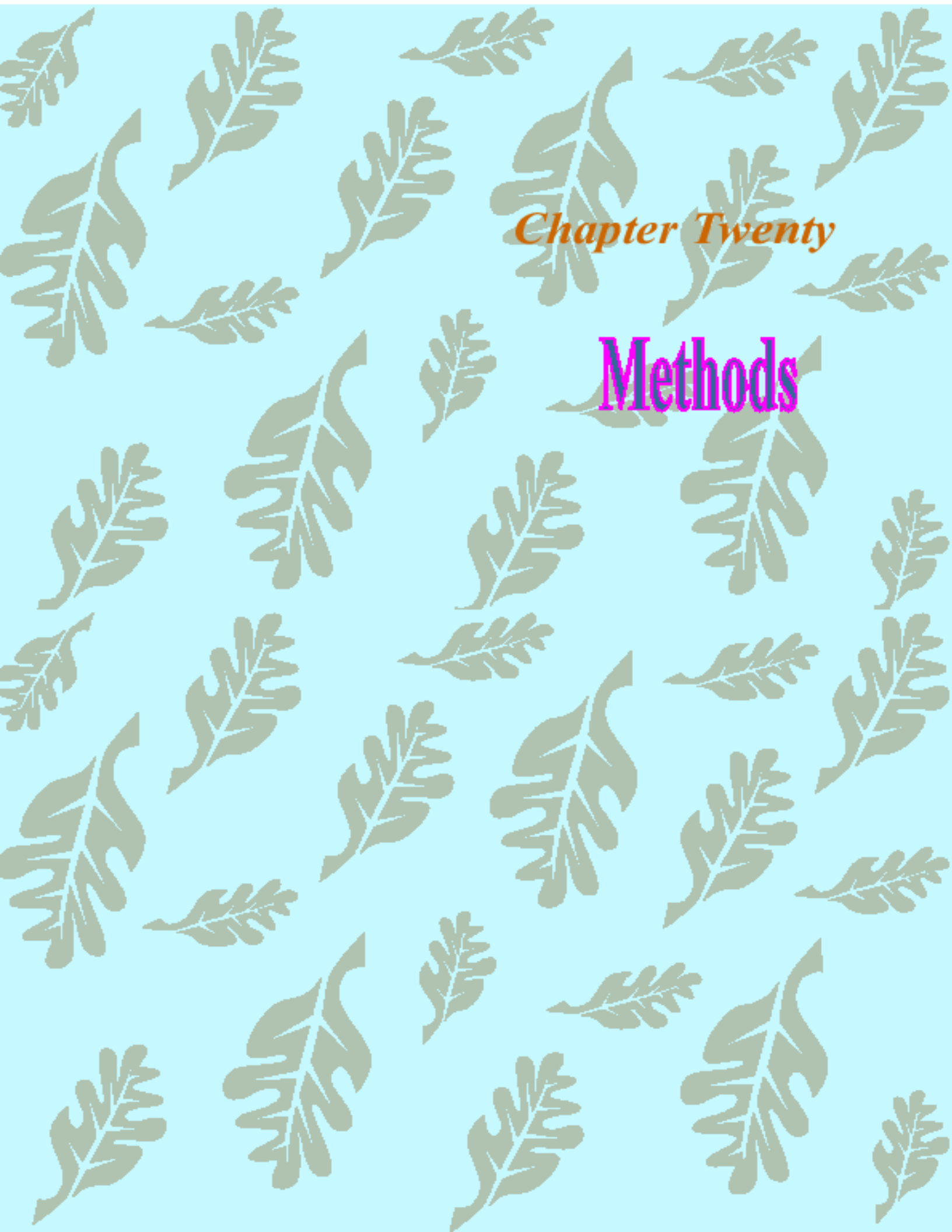
Aves

Chapter Seventeen

Mammals

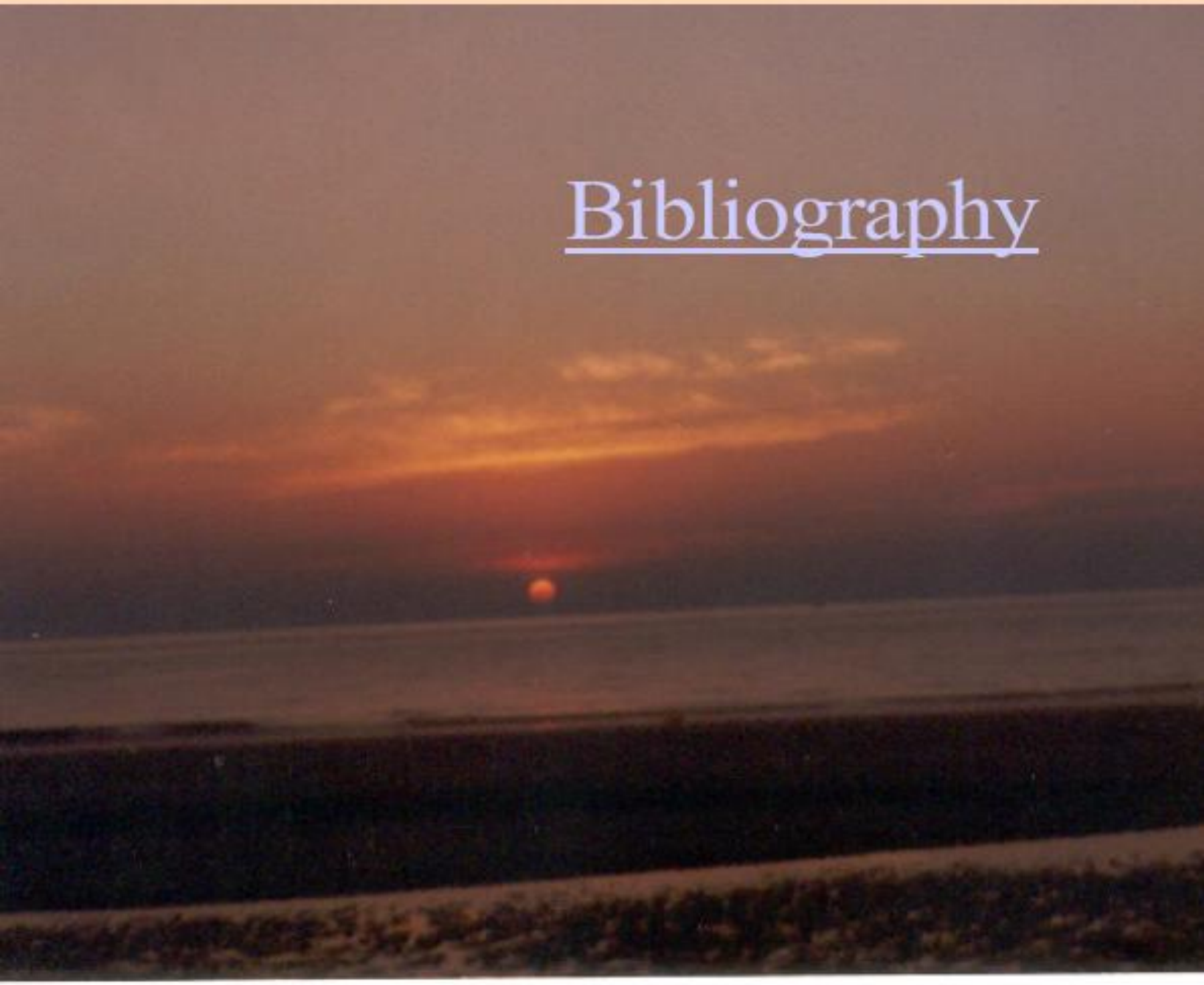
Chapter eighteen

Environmental issues


Chapter Twenty
Methods

Chapter Nineteen

Discussion



Bibliography