# CONSERVATION OF THANE CREEK AND ULHAS RIVER ESTUARY

## A DISSERTATION

*Submitted in partial fulfillment of the requirements for the award of the degree*

*of*

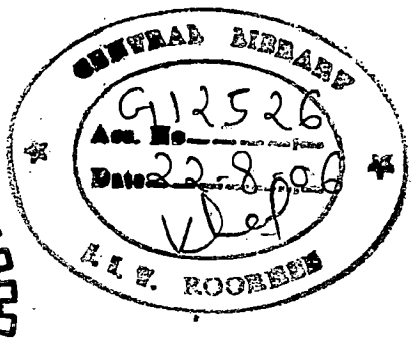
MASTER OF TECHNOLOGY

*in*

CONSERVATION OF RIVERS AND LAKES

*By*

**VINAY NIKAM**





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## CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in the dissertation entitled **"Conservation of Thane Creek and Ulhas River Estuary"** in partial fulfilment of the requirements for the award of the degree of Master of Technology in "Conservation of Rivers and Lakes" submitted in Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee is an authentic record of my own work carried out in the period between July 2005 to June 2006 under the guidance of **Shri Arun Kumar**, Chief Scientific Officer and Head of Department , Alternate Hydro Energy Center, **Dr D.K. Srivastava**, Professor, Department of Hydrology, Indian Institute of Technology, Roorkee and **Shri K. D. Lalla** , City Engineer ,Thane Municipal Corporation, Thane .

The matter contained herein has not been submitted by me for the award of any other degree or diploma elsewhere.

Dated Roorkee, the 30th June , 2006.

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This is to certify that the above statement made by the candidate is correct to the best of our knowledge.

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Dated 26th June , 2006

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# ABSTRACT

Thane creek and Ulhas River under Thane Municipal Area near Mumbai, Maharashtra are connected through a narrow and shallow channel. With the urbanization and industrial growth, Thane Creek and Ulhas river estuary has become receptable of waste from surrounding area. Water quality of both Thane creek and Ulhas estuary has deteriorated badly due to various anthropogenic discharges.

Various researchers have studied individual elements of Thane creek and Ulhas River Estuary at micro level, such studies are undoubtly essential to identify the causes of problem and to take adequate remedial measures. However each is a part of whole, a holistic approach for restoration and conservation of the creek and estuary is required.

Past and present studies have indicated an alarming situation that there is an immediate need to prepare a conservation plan. This necessitate a thorough understanding of every aspect and functioning of the system and calls for an integrated approach towards planning, utilization and management of resources to ensure sustainability in the development of Thane and Ulhas River Estuary.

In a present study various aspects of Thane creek and Ulhas river estuary viz: water quality and assessment of sediment quality, sources of pollution, ecological and hydrological aspects are studied. Different conservation measures such as sewerage system, solid waste management, dredging of the creek for improving flushing capacity, mangroves plantation, chanalisation of Thane creek, nalla-tapping works, and tidal gates are proposed. For sustainable development and management of creek and estuary, effective institutional arrangement, public awareness public and participation is required. Public awareness programs and Institutional structure is proposed for implementing different conservation measures.

Utilization of small hydro potential at sewage outfall is studied. Regular and continuous programs of monitoring water quality, tidal levels, meteorological data, bathymetric data and satellite mapping are proposed.

To create awareness among citizens public awareness programs are conducted during the study period. Present study helped in understanding the status of Thane creek and Ulhas river estuary and initiated a move towards its conservation in integrated way. Press reporting of the same has been there. An endeavour effort of participatory management is recommended to conserve both water bodies.

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# ABBREVIATIONS

| | |
|---|---|
| AHEC | Alternate Hydro Energy Centre |
| AMBI | ANZI's Marine Biotic Index |
| ASP | Activated Sludge Process |
| BOD | Bio chemical oxygen demand |
| BARC | Baba Atomic Research Center |
| CBO's | Community Based Organisation |
| CDP | City Development Plan |
| CWPRS | Central Water and Power Research Station |
| CRZ | Coastal Regulatory Zone |
| CETP | Combined effluent treatment plant |
| CIDCO | City and Industrial Development Corporation |
| CPCB | Central Pollution Control Board |
| COD | Chemical Oxygen Demand |
| CI | Cast Iron |
| Cu | Copper |
| Cd | Cadmium |
| Cr | Chromium |
| DDT | dichlorodiphenyltrichloroethane |
| DDE | dichlorodiphenyldichloroethyl-ene |
| DDD | dichlorodiphenyldichloroethane |
| DOD | Department of Ocean Development |
| DO | Dissolved Oxygen |
| DI | Ductile Iron |
| ESR | Environment Status Report |
| Fe | Iron |
| GIS | Geographical Information System |
| HCH | exachlorocyclohexane |
| HLWM | High-level water mark |

| | |
|---|---|
| Hg | Mercury |
| IITR | Indian Institute of Technology Roorkee |
| JNURM | Jawaharlal Nehru Urban Renewal Mission |
| KDMC | Kalyan Dombivali Municipal Corporation |
| LLWM | Lower level mark |
| MJP | Maharashtra Jeevan Pradhikaran |
| MWSSP | Maharashtra Water Supply and Sewerage Project |
| MMB | Maharashtra Maritime Board |
| MCGM | Municipal Corporation of Greater Mumbai |
| MBMC | Mira Bhayandar Municipal Corporation |
| MITCON | Maharashtra Industrial and Technical Consultancy Organisation Limited |
| MMRDA | Mumbai Metropolitan Regional Development Authority |
| MMR | Mumbai Metropolitan Region-Environment Improvement Society |
| MPCB | Maharashtra Pollution Control Board |
| MoEF | Ministry of Environment and Forest |
| MNES | Ministry of Non Conventional Energy Sources |
| MINARS | Monitoring of Indian National Aquatic Resources |
| MCZMA | Maharashtra Coastal Zone Management Authority |
| MRSAC | Maharashtra Remote Sensing Application Centre |
| Mn | Manganese |
| MLD | Million Litre per Day |
| n | Manning's coefficient |
| NRCA | National River Conservation Authority |
| NRCD | National River Conservation Directorate |
| NEERI | National Environmental and Engineering Research Institute |
| NIO | National Institute of Oceanography |
| NGO's | Non Government Organisation |
| NMMC | Navi Mumbai Municipal Corporation |
| PLI | Pollution Load Index |
| Pb | Lead |

| | |
|---|---|
| STP | Sewage Treatment Plant |
| STEM | Shahad Temghar Water Authority |
| TMC | Thane Municipal Corporation |
| TS | Transfer Station |
| TTC | Trans Thane Creek |
| TDS | Total Dissolved Solids |
| TSS | Total Suspended Solids |
| TPPF | Twin Pit Pour Flush toilet |
| UASB | Upflow Anaerobic Sludge Blanket |
| WHO | World Health Organisation |
| Zn | Zinc |

# CHAPTER 1
# INTRODUCTION

## 1.1 Preamble

India is blessed with water resources in the form of numerous rivers and streams. By virtue of its geographical position and varied terrain and climatic zones, it supports a rich diversity of inland and coastal wetlands. India accounts for 16% of the world's population in 2.42% of the earth's surface [1]. The water bodies and their resources have been an integral part of the social and cultural ethos of human societies. India has a long coastline of over 8000 km with associated continental shelf of 0.5 million sq. km. and an Exclusive Economic Zone of 2.02 million sq. km (Zingde 2002). Currently about 170 million people constituting 17% of India's total population in more than 3,800 coastal villages are scattered along the 7,500 km coastline. Mangroves, estuaries and backwaters occupy a spatial extent of 0.4, 3.9 and 3.5 million ha respectively [1].

Creeks and estuaries have been drained and transformed by anthropogenic activities like unplanned urban and agricultural development, industrial sites, road construction, impoundment, resource extraction, and dredge disposal causing substantial long-term economic and ecological loss. Thane creek and Ulhas river estuary is not a exception to anthropogenic activities.

Over 300 million people living in the coastal zone of India are considered to generate $1.11 \times 10^{10}$ cum. of sewage annually, a considerable fraction; particularly from coastal cities and towns where sewage collection network exists, enters the marine waters (Zingde 1999). There is a high concentration of large and medium industries within the narrow coastal belt of 25 km width than the rest of the country. These industries are estimated to generate 1.35 million cum per day of liquid effluent and about 34,500 Tons per day of solid waste (Zingde 2002).

Nearly 8% of industries in the country are located around Mumbai in four large industrial clusters namely, Trans Thane-Belapur belt, Kalyan-Ulhasnagar-Ambarnath belt, western bank of Thane Creek and around Patalganga and Amba Rivers. Evidently, Ulhas, Patalganga and Amba rivers as well as Thane Creek are the recipients of a variety of wastes (Zingde 1999).

Thane Creek [Long. $72^0$55'00''E to $73^0$00'E and Lat. $19^0$00' to $19^0$15' N] and Ulhas river estuary [Long. $72^0$45'00''E to $73^0$20'E and Lat. $18^0$45' to $19^0$00' N] are connected through a narrow and shallow channel. Thane creek is one of the largest marine body in an enclosed area in the country. It separates the Island city of Mumbai in the west from the main land in the east and Thane Belapur industrial belt at North East of Mumbai city. Pressure on land and demand for space resulted in a change on the basic character of the Island city resulting extension of the mainland and reclamation of the marine part. With the urbanization and industrial growth, Thane Creek and Ulhas river estuary has become receptable of waste from surrounding area as given in Table 1.1. Both water bodies are used as a mean of transport to both domestic and industrial waste to the sea. Wastewater treated or partly treated is discharged into both water bodies Thane creek and Ulhas estuary.

Table 1.1: Domestic and industrial waste contributors of Thane creek and Ulhas river estuary

| Thane Creek | Ulhas river estuary |
|---|---|
| • Municipal Corporation of Greater Mumbai (MCGM)<br>• Thane Municipal Corporation (TMC)<br>• Navi Mumbai Municipal Corporation (NMMC),<br>• Thane Belapur Industrial Association (TBIA),<br>• Maharashtra Industrial Development Corporation (MIDC) – Mumbai, Thane and Navi Mumbai<br>• City Industrial Development Corporation (CIDCO)<br>• Several large scale industries. | • Kalyan Dombivali Municipal Corporation (KDMC)<br>• TMC<br>• Mira Bhayandar Municipal Corporation (MBMC)<br>• Ulhasnagar Municipal Corporation<br>• Bhivandi Nijampur Corporation<br>• Vasai Corporation<br>• Dombivali phase I and II, Ambarnath, Badlapur, Chilkoli-Morivali, Saravali, Badlapur industrial estate<br>• Thane MIDC and several large and small industries from TMC, MBMC, |

Water quality of both Thane creek and Ulhas estuary has reached to an alarming stage due to various anthropogenic discharges. Mangrove and coral ecosystems have been degraded and continue to be under stress of man induces changes. Thane creek was highly bio productive, but fishing now becomes occasional activity in these two water bodies affecting the livelihood of the fisherman.

Various agencies like Baba Atomic Research Center (BARC), National Institute of Oceanography (NIO), National Environmental and Engineering Research Institute (NEERI), Mumbai Metropolitan Regional Development Authority (MMRDA), Maharashtra Pollution Control Board (MPCB), and Maharashtra

Industrial and Technical Consultancy Organisation Limited (MITCON) has investigated ecological parameters of the Thane creek in past few decades. NEERI reported that Thane creek has low assimilative capacity due to poor flushing capacity. Low current speed and shallow depth with multiple wastewater discharge, which has deteriorated water quality. Various researchers have studied individual elements of Thane creek and Ulhas River Estuary at micro level, such studies are undoubtly essential to identify the causes of problem and to take adequate remedial measures. However each is a part of whole, a holistic approach for restoration and conservation of the creek and estuary is required.

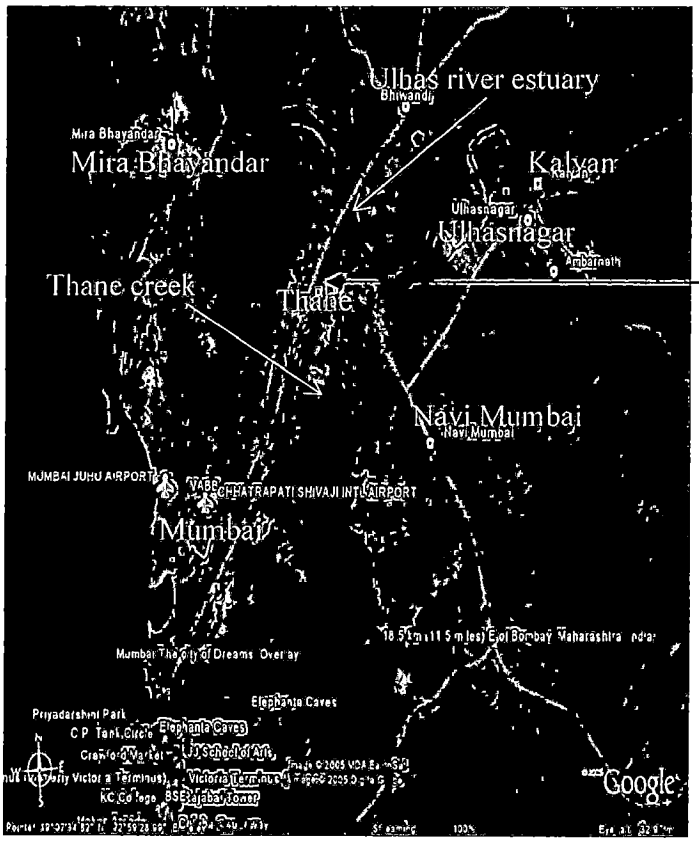
Survey conducted along with Enviro Vigil, an Non Government Organisation (NGO) during November, 2005 reflect that creek stretch in between Balkum to Vitawa has become a dead zone. Studies conducted in past has given an alarm that it is immediate need to prepare a conservation plan. This necessitate thorough understanding of every aspect of functioning of system and calls for an integrated approach towards planning, utilization and management of resources to ensure sustainability in the development of Thane and Ulhas River Estuary. An endeavour effort with participatory management is required to conserve both water bodies.

In a present study the creek and estuary are studied in totality but the mitigation measures are planned only for the Thane Municipal Corporation. Hence this chapter covers various aspects related to Thane City

**1.2 Historical Background of Thane City**

An ancient city, capital of the Shilahara kings, then owes much of its part history first to Portuguese and then the English. The first municipal council was formed in 1863, when population of city was close to 9000 people.

Thane City is the hub of Mumbai Metropolitan Region and is located 30 km North-East of Mumbai on the Western coast of India. Historically significant, the city of Thane forms an important urban agglomeration of Maharashtra State, India with accelerated industrial development and buzzing commercial activity.




Source: Google Earth


India map with Thane

### 1.3 Climate, Temperature, Rainfall, Wind speed and direction

#### 1.3.1 Climate

Thane has typical coastal climate, being located close to the coastal areas. The climate is moderate, with comparatively hot and humid summers and mild winters. Most of the rainfall is concentrated in the monsoon season from June to September, when the city receives typically 94 percent of the total rainfall of the year.

#### 1.3.2 Temperature

The maximum daytime temperatures in Thane are seen in the month of May and June, where the temperature routinely rises above 40°C. The variations in the day and night temperature are comparatively less, as befits a coastal area. The winter season, from December to February shows lower temperature compared to other months.

### 1.3.3 Rainfall

The city receives most of its rainfall from the South West Monsoon in the months of June to September. On an average over last ten years, the city received a rainfall has been approximately 2443 mm per year.

### 1.3.4 Wind speed and direction

The wind direction in the city is predominantly in West to North East direction. The mean wind velocity during the year 2003-04 was approximately 10.5m/s.

## 1.4 Demography Details

Over years, Thane has witnessed very high population growth rates, due to industrialization and resultant urbanization. One of the factors adding to the growth of Thane is its close proximity with Mumbai. Since independence, the city has witnessed remarkable immigration of people from all strata of the society and from all over the country. This has resulted changes in the demographic pattern.

### 1.4.1 Population

The population of the city, as revealed by the census data shows a continuous increase of population over last five decades. The highest growth rates in the city population have been witnessed in the decade between 1991 and 2001 as given in Table 1.2. The population of Thane is approximately 15 lakhs (2001 census: 1262551) and is expected to grow to 50 lakhs in the next 25 years. The average annual growth rate over the last seven decades is in tune of four percent. A ward- wise distribution indicates that the central region of the city, which is formed the original city of Thane, is most densely populated area of the city.

Table1.2: Population growth in last six decades

| Year | 1951 | 1961 | 1971 | 1981 | 1991 | 2001 |
|---|---|---|---|---|---|---|
| Population | 91054 | 136591 | 261615 | 474170 | 795833 | 1262551 |

### 1.4.2 Literacy Pattern

High quality, accessible education is the path to informed citizens ability of future generations to create and live a better life and is the foundation for a strong

democracy. Overall it is observed that in last few years, literacy rate has been increasing steadily, echoing the trend allover the country. The literacy rate in male population is more than in female as shown in Table 1.3. The literacy rates in urban portion of the city are more than the rural sections. Also, non-slum areas show much higher literacy rates compared to slum areas.

Table 1.3:Literacy rate in Thane as per 2001 census

| | Male | Female | Total |
|---|---|---|---|
| Literate | 5,61,086 | 4,22,109 | 9,76,195 |
| Non Literate | 1,14,061 | 1,65,295 | 2,89,356 |
| Total | 6,75,147 | 5,87,404 | 12,62,551 |

### 1.4.3 Sex Ratio

Population distribution in Thane is given in Table 1.4. The population show that almost 30 to 40 percent of city population resides in the slum areas. The sex ratio, that is number of female per 1000 males, is less in slum areas, as compared to the non-slum areas.

Table 1.4: Population distribution in Thane.

| | **Male** | **Female** | **Sex Ratio** |
|---|---|---|---|
| Total | 6,74,660 | 5,86,857 | 896 |
| Slum | 2,31,266 | 1,89,010 | 817 |
| Non Slum | 4,43,394 | 3,97,847 | 897 |

### 1.4.4 Land use pattern

The total area of Thane city is 147 sq kms. out of which land utilization of various sectors for developed and non developed area is shown in Figure 1.1 and 1.2, respectively.

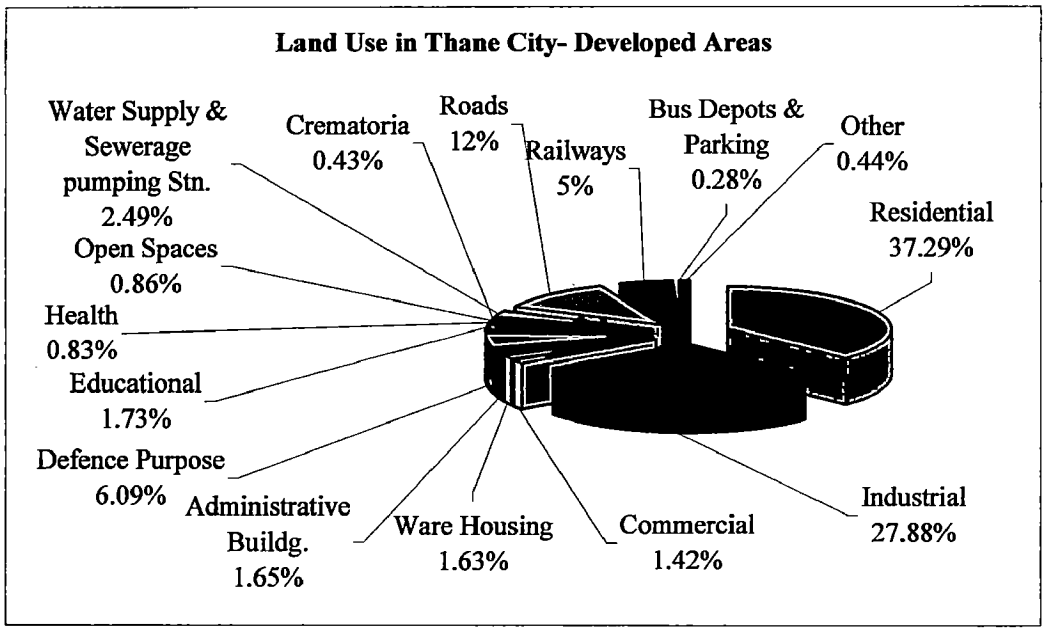



Figure 1.1: Land Use in Thane City- Developed Areas

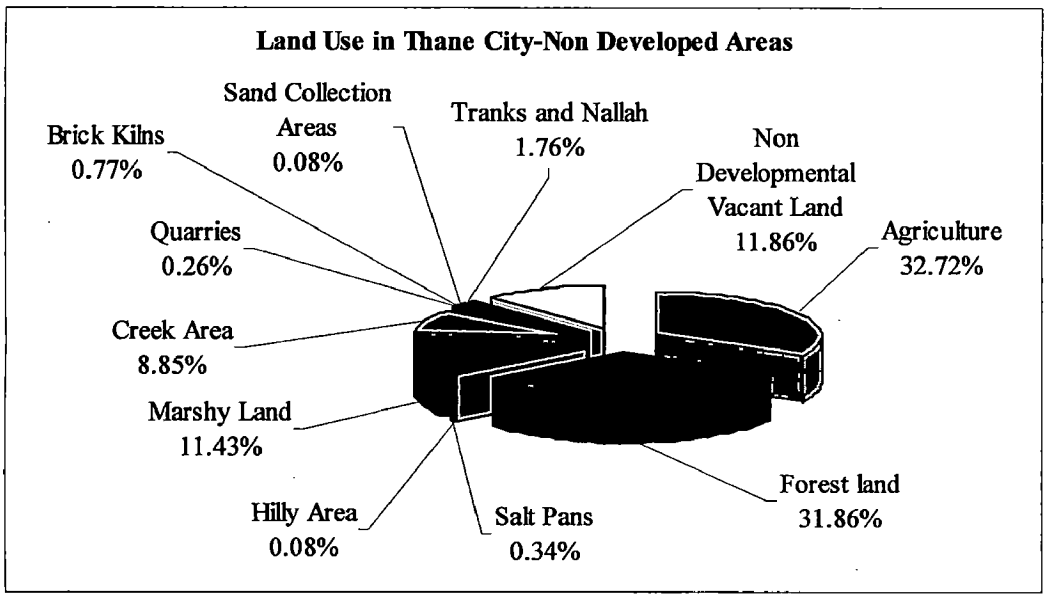



Figure 1.2: Land Use in Thane City-Non-Developed Areas

## 1.5 Thane Municipal Corporation

Thane Nagarpalika was established on 10th March, 1863 and since then it has carried out development works in various fields in the pre-freedom and post freedom era.

The Municipal Corporation of Thane came into existence on 1st October 1982, thus providing a new expanded and extended platform for development of urban infrastructure. Spread over an area of 128 square kilometers, the TMC has an annual budget of Rs.532 crores. The population of Thane is approximately 15 lakhs (2001 census: 1262551) and is expected to grow to 50 lakhs in the next 25 years.

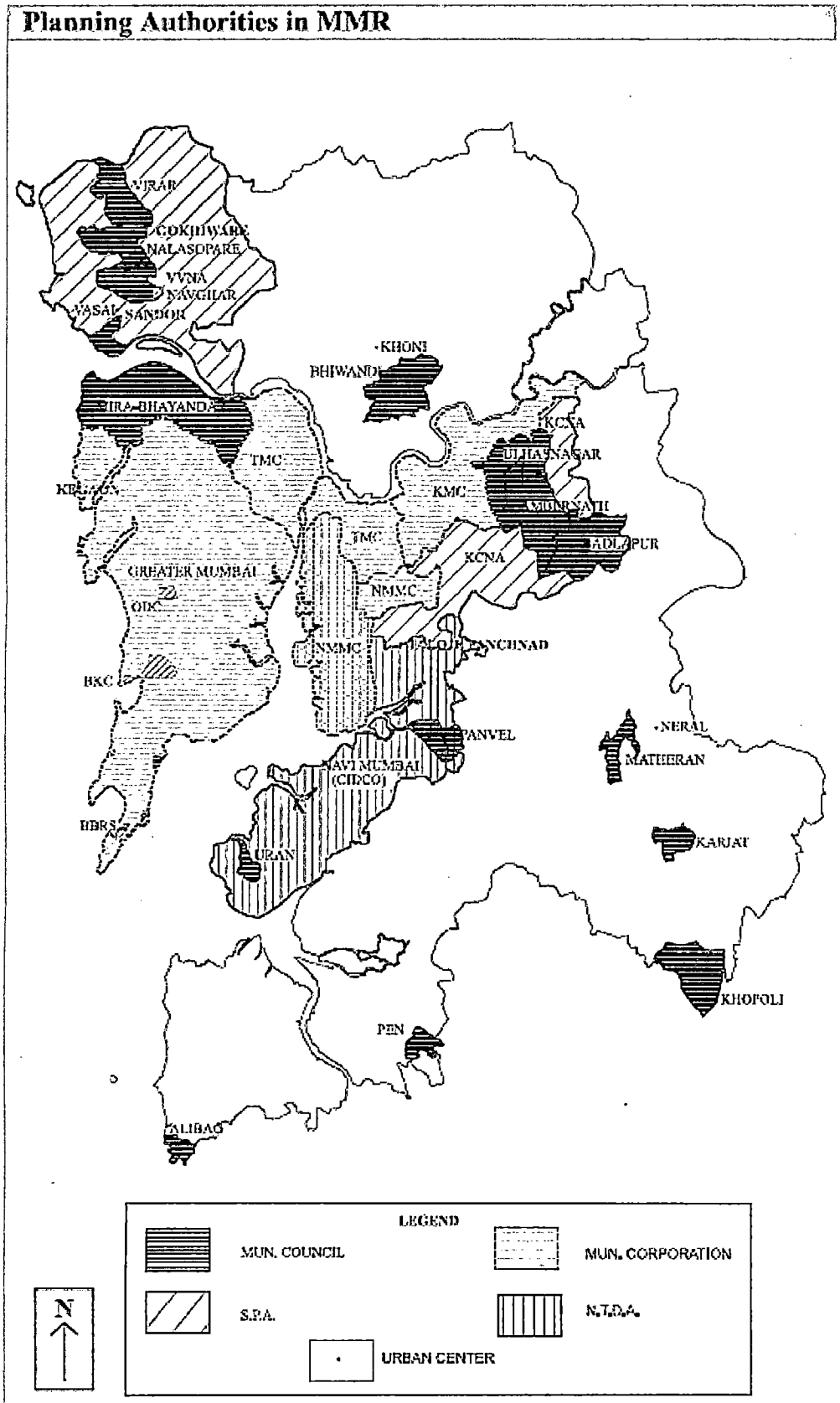
## 1.6 Issues Related To Thane Creek and Ulhas River Estuary

Thane Creek and Ulhas river estuary comes under various Municipal Corporation as show in Figure 1.3. Development in and around Mumbai is governs by Mumbai Metropolitan Development Authority (MMRDA). MMRDA has developed a land use plan (1996-2011) of the area around the Thane creek and Ulhas river estuary is shown in Figure 1.4.

The problems of both Thane creek and Ulhas river estuary faces today are complex – the cumulative effects of many activities over many years. Issues are identified based on the assessment of the work carried out by various agencies since 1981 and present study.

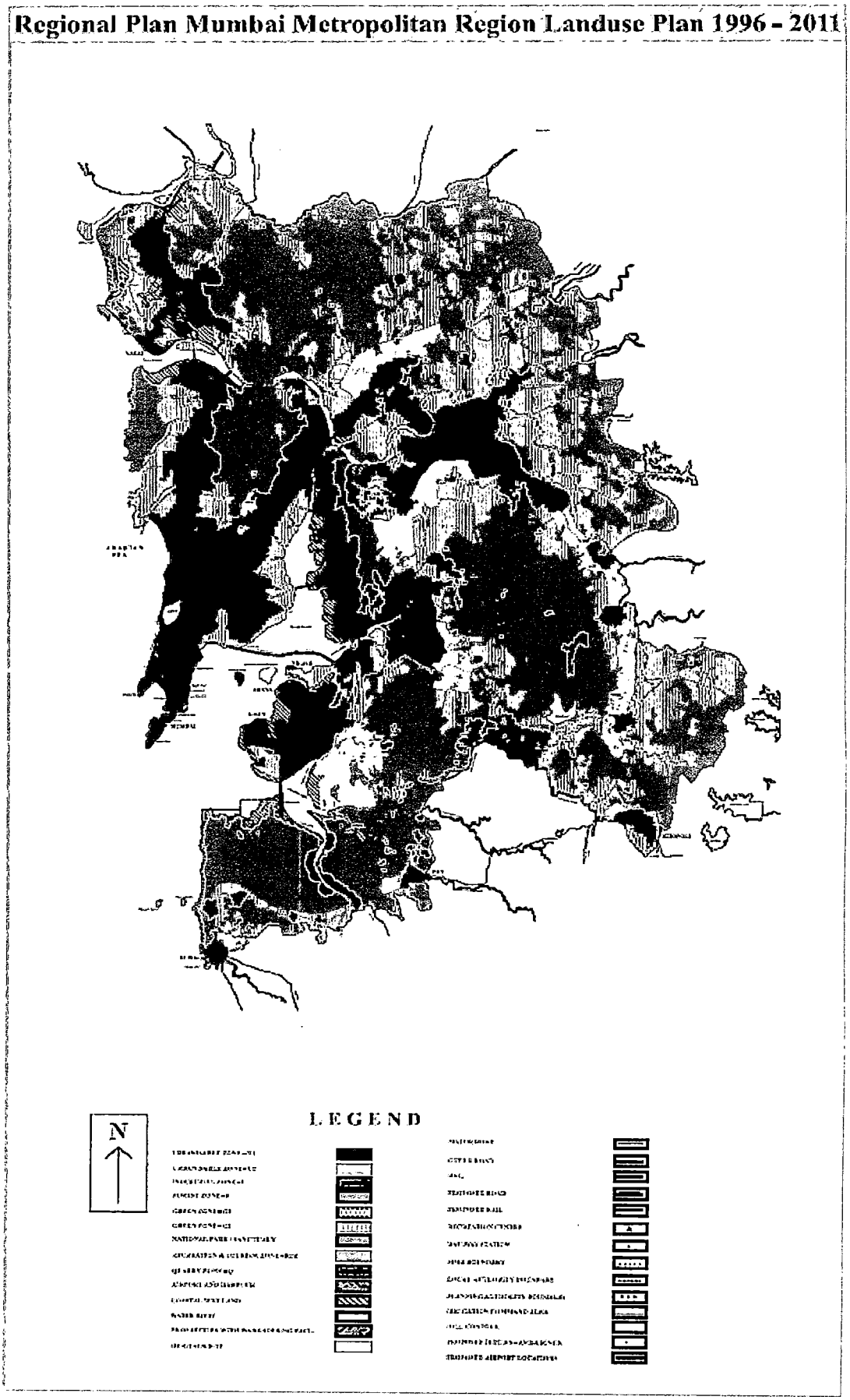
- Impacts of Human Activity and Growth
- Conventional and Toxic Pollutants
- Habitat Loss and Modification
- Flushing and Assimilating Capacity
- Institutional Constraint
- Public Awareness and Stewardship

The priority issues focus on the goals of the Creek conservation – goal such as preventing as well as reducing pollution and increasing wetland area rather than preventing further loss. They provide a foundation from which the decision-makers could examine related issues, discuss ideas, resolve differences and propose actions.




Source: MMRDA regional development plan

Figure 1.3 : Planning authorities of MMR




Source: MMRDA regional development plan

Figure 1.4: Mumbai Metropolitan Region Land Use Plan 1996-2001

### 1.6.1 Impacts of Human Activity and Growth

Human activity over past three decades has significantly affected natural systems. Individuals today are less aware of the impacts their activities have on the natural environment than their forebears, and are often less physically connected to the Thane creek and Ulhas river estuary. The pressures of human activity are evidenced in each of the other issues. Pollutant discharge into the both water bodies; land use practices cause runoff of contaminants and alter natural flood control processes; political boundaries do not recognise natural system such as watersheds; habitat is modified and destroyed. The biological integrity of the creek and estuary is compromised as a result.

Human population growth and activity will continue to occur. The impact of human activity over time and into the future is core consideration that needs constant attention. Significant concerns include:

- Loss of wetlands and impaired quality of fish.
- Pollutants accumulate in the ecosystem, impacting the food chain, water quality, and sediment.
- Biological integrity of both water bodies is disturbed.
- Diminished opportunities to enjoy and use the creek and estuary because of pollution from wastewater treatment, storm water, and other non-point sources.
- The paved streets and open land space around the buildings reduce the lands ability to absorb and filter rainwater, resulting contaminated runoff harm habitat and impair water quality.
- Development of floodplains can cause pollution and excessive runoff resulting property damage during concurrence of excessive rain and high tide.

The issue is how to manage human population growth. The effectiveness of land use planning will determine the extent to which sensitive areas and critical habitat can be sustained. Appropriate land use and development practices can reduce the stress placed on creek and estuary.

### 1.6.2 Conventional and Toxic Pollutants

Domestic wastewater partly treated or without treatment is getting discharged into the creek trough treatment plant outfalls and nallas. Presently domestic waste from the MCGM, TMC, NMMC, CIDCO is getting disposed in to Thane creek after primary treatment. In past 25 years various orgaisations and researcher studied

physico-chemical parameters and heavy metal of Thane Creek and Ulhas estuary. Dissolved oxygen (DO) of the Thane creek and Ulhas river estuary water is getting depleted since 1981. Water quality values have indicated that the inner portion of both water bodies is heavily polluted with the Biochemical oxygen demand (BOD) valued exceeding the standard values of 3 mg/l (SW II) in almost 100 percent samples collected from edge and center.

The depth profile of Hg and Ni studied by Jha (1999) clearly shows anthropogenic input in to Thane Creek coastal environment and observed positive evidence for the continued inputs of Hg and Ni a decade or two earlier at Airoli region. Zingde (1999) reported increase in Pb and Hg in the surfacial sediments of Ulhas estuary and Bioaccumulation of Fe, Zn and Pb in polychates is more in Thane creek as compared to Mahim and Versova creek.

### 1.6.3 Habitat Loss and Modification

Habitat is critical to sustaining fish. Depletion of mangroves along the Thane creek and degraded water quality directly affect species ability to reproductive successfully. The depletion of fish directly affects the economic, recreational and aesthetic uses of the creek and estuary. For example, a fisherman from the Thane area has to move towards the Vashi bride for fishing, due to non-availability of the fish in Thane area.

#### 1.6.3.1 Fishery

Goldin (2003) reported that in Thane creek monthly fish catch reveled 68 percent reduction in 1992-93 compared to 1981-82, whereas in 1999-2000 it has become an occasional activity in tune of 4 percent compared to 1981-82.

#### 1.6.3.2 Wetlands

Wetlands are one environmental indicator of habitat loss and modification. Wetlands provide important stopover, feeding and breeding habitat for fish and migratory shore birds. Stress on the land development has reduced the wetland area. Mangroves numbers are reduced as due to cutting for the fuel and developments long the coast-illegal encroachments, road construction, dumping of solid waste, dumping of sand, boat building activities, etc. thereby directly reducing the wetlands area. Varieties of birds are observed in the Vikroli area where mangrove forest is developed, but few varieties of birds are observed from Vitawa to Balkum area where mangroves are deteriorated and wetland area is reduced.

### 1.6.4 Solid Waste Disposal

The banks of Thane creek and Ulhas river estuary are used by the Municipal Corporations for the disposal of the solid waste. Kalyan Dombivali Municipal Corporation and Mira Bhayandar Municipal Corporation dispose their municipal solid waste along the Ulhas river estuary without any scientific measures. Till six month back TMC use to dispose some of its waste along the Thane creek. During the high tide solid waste is getting mixed with the water. Also ground water is getting deteriorated due to leachates.

### 1.6.5 Flushing and Assimilating Capacity

NEEEI studied the assimilating capacity of the Thane creek. They observed that it has very low assimilating capacity and wastewater disposed through the primary treatment units and nalla is not getting flushed totally. During the survey it is observed that the effective waterway below the various bridge is reduced. Creek bed level are increased due to various manmade activities along the banks viz: deposition of solid waste in past, disposal of debris for encroachment. It is also observed that the confluence of Thane creek and Ulhas river, the basin of the Thane creek is narrowed at the same time geometry is such that water from Thane creek is not getting disposed into Ulhas river effectively during low tides. Which also contribute in reducing overall flushing capacity.

### 1.6.6 Institutional Constraint

Various agencies and organisations have jurisdiction or exert influence over the management of Thane creek and Ulhas river estuary. The problems are complex, and decision-making process are complicated and time-consuming.

Following are the various constraints exists:

- Confusion regarding clear statutory authority and precise and implementable regulations.
- The decision- making cycles of most government process conflict with the longer timeframe needed to address many environmental issues. Problems requiring long-term solutions may be neglected in favour of those that appear easy to resolve or produce immediate results.
- Multiple issues compete for limited funding, and priorities are not always set. Jurisdiction are often unable to persue needed work because of insufficient

funding. Pressures on budgets at all government levels make a long term coordinated approach difficult.

- Diverse cultures with multiple perspective and needs.
- Lack of shared knowledge among agencies and across levels of governing bodies regarding other jurisdiction structures, responsibilities, schedules and contact points.
- Some interested parties may be underrepresented because of poor coordination and lack of common understanding about decision-making process.

### 1.6.7 Public Awareness and Stewardship

Citizens are integral part of a natural community and one need to develop and maintain a common concern for the well being of that community. This concern is expressed as a commitment to environmental stewardship. Lack of connection is compounded because it is very difficult to see the system as a whole. Interest groups tend to organize around single issue, interest, or place. There are few groups that promote the health of the creek and estuary. People often look to institution, not individuals for answers.

The problems we face today are multi-faced, the result of multiple actions that accumulate to degrade habitat and pollute water. At one time, point sources of pollution, such as major discharges from STP, manufacturing plants, etc. were considered the major contributor. Now we must address significant non-point sources, coming from numerous places and actions. This means that all of us need to access our activities and choices, understand their impacts and make adjustments.

## 1.7 Actions Proposed

MoEF has adopted a resolutions at the $X^{th}$ meeting of the National River Conservation Authority (NRCA) March 2001 –Prime Minister as a Chairperson and decided that coastal towns would get special attention because it has observes that sewage, solid waste, biomedical waste and the like are dumped into sea. Prioritisation of coastal towns for taking up such works may be done from the angle of mangroves, promotion of eco-tourism, cultural and religious importance of the place and the like (MoEF resolution no-10) NRCD(2001).

A holistic approach is required while planning the mitigation measures. Thane creek and Ulhas river estuary is to consider as whole while planning the mitigation measures. Various organisations are related to both water bodies: MCGM, TMC,

NMMC, KDMC, Ulhasnagar Municipal Corporation, MBMC, CIDCO, Maharashtra Maritime Board (MMB), State Government, Ministry of Environment and Forest (MoEF), Department of Ocean Development (DOD). The success of the conservation programe depends upon the will of the various agencies. Since each is a part of a whole, an integrated approach is required. TMC may become a lead partner in conservation. TMC has taken an initiative in conservation of Thane creek and Ulhas river estuary and come up with a plan in order to prevent ingress of pollutants from TMC limits.

Following are the various mitigation measures proposed for TMC and same could be adopted for entire portion of creek and estuary:

### 1.7.1 Sewerage Scheme

The salient feature of the TMC sewerage scheme is discussed in chapter 5 in detail. The sewage treatment plants are designed taking into consideration of the assimilative capacity of the Thane creek and Ulhas river estuary.

### 1.7.2 Solid Waste Management

Various provisions under the solid waste management are discussed in detail in Chapter 6. Proper measures are required to be taken to prevent the disposal of waste along the banks of water bodies. This is the area where proper public awareness is required and waste to be managed at community level.

### 1.7.3 Mangroves plantation

It is necessary that the mangrove should be properly protected and planted in consultation with experts. Mangrove forest should be developed at various locations. Godrej pattern could be adopted. While plantation, natural zoning of mangroves should be considered. Areas below the high tide level falling in Coastal Regulatory Zone (CRZ) I should be reserved for regeneration of mangroves. It is necessary to document the status of mangroves by acquiring satellite image of the coastal region. Mangrove plantation drive is already started by TMC, under which one lakhs mangroves are likely to be planted. Public Private Partnership option could be considered as one of the option for development of Mangroves forest.

### 1.7.4 Storm Water Study

Recently project has been initiated by NGO and TMC to find out the solutions to prevent 26$^{th}$ July disaster in future. It is proposed to take a help of Central Water and Power Research Station (CWPRS), Pune to study the effect of tides during the rains.

### 1.7.5 Satellite mapping and related studies

Satellite mapping of the entire Thane city covering Thane creek and Ulhas river estuary is proposed to be taken up for next five years to monitor city development, coastal water quality and mangrove-mapping .

### 1.7.6 Long term Monitoring Program

Five years Thane creek and Ulhas river estuary water quality monitoring program can be taken in association with NGO and Educational Institutes. Funded Conservation related research program could be carried out along with the Educational Institutes.

### 1.7.7 Dredging and Basin Canalisation

It is necessary to increase the flushing capacity of the creek, which can be done by dredging the basin in proper manner. The area under the bridge is required to be clean immediately to increase waterway.

### 1.7.8 Tide Gates

Tide gates for some of the nalla may be planned as a measure to prevent the ingress of tidal water during high tide

### 1.7.9 Tourism Development

Both Thane creek and Ulhas river estuary has a historical importance and rich with natural beauty. Many migratory birds visit Thane creek and hence if properly developed, it can become a birds paradise and gift to the bird watchers. Ulhas river estuary can be developed as a Kerala backwater with a dense mangrove forest on both sides. Eco-friendly coast conservation/developmental works in line with CRZ notification can be taken up along the Thane creek and Ulhas river estuary especially at Ghodbunder area The developmental work may carried out by Public Private Partnership basis. Boating facilities can be developed to generate the revenue for post implementation expenses.

### 1.7.10 Public Participation and Awareness

For successful implementation of conservation program it is necessary to involve public at various stages viz planning, implementation and post implementation stage. Awareness program acts as a catalyst, which trigger the sentiments of the citizens towards the creek and estuary. All stakeholders must have feeling of ownership. The basic ethos of TMC creek and estuary conservation program is **"Conservation Through Partnership".**

It is necessary to reserve separate funds for the creating awareness and public participation programs and capacity building through training program.

### 1.7.11 Institutional Development

Conservation program can be implemented at two levels viz-individual i.e Municipal Corporation level and other in totality. Success of the conservation program depends upon the willingness of all participating organizations. Management / expert Committee is required to be established to plan **"Common Minimum Program" and common Vision.** The actions should be **SMART**: Specific, Measurable, Achievable, Responsive and Trackable. The actions listed above by the TMC can be adopted as a common minimum program and TMC may become a lead partner.

At individual Municipal Corporation level, each organization should set up a Creek / estuary conservation Cell which is to be headed by City Engineer. Conservation Cell should comprises of Executive Engineer assisted by personnel from Public Works Department, Drainage Department, Garden Department, Encroachment Department, Town Planning Department and Pollution Control Department. It is necessary to establish a Pollution Control laboratory if any organization does not have their own laboratory.

# CHAPTER 2

# WATER QUALITY AND SOURCES OF POLLUTION

*If there is magic on this planet, and it is contained in water .... Its substance reaches everywhere; it touches the past and prepares the future; it moves under the poles and wanders thinly in the heights of air.*

- Loren Eiseley

Creek and Estuary are considered as a 'multiple use' environment. They are used as an easiest means of the disposal of the city waste. It is a fact the creek and estuary has varying capacities to handle degradable waste, but it depends on the size of system, flow pattern, its type and climatic zone. Manmade changes resulted in reduction in free connection with the open sea, which affects the natural waste assimilating capacity.

Thane creek and Ulhas river is a recipient of domestic and industrial waste from various Municipal Corporation and industrial belts /zones/ area through partially treatments units (Figure 2.1 and Figure 2.2) and without treatment from nallas (Figure 2.3 to Figure 2.8). Both creek and estuary banks are has been used as a simplest means of solid waste disposal without any treatment and measures (Figure 2.9 to Figure 2.12). Change in living pattern and 'use and throw' policy in addition to increase in complexity of pollutants affects the water quality of creek and estuary.

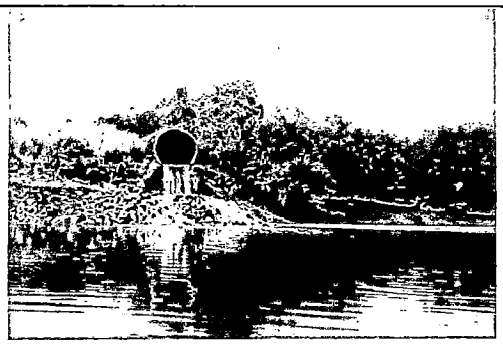


Figure 2.1:Treated waste water disposal from Kopari sewage treatment plant in Thane creek

Figure 2.2:Treated waste water disposal from CETP at Kalyan in Ulhas river estuary

Figure 2.3: Disposal of untreated waste water from Rabodi nalla in Thane creek

Figure 2.4: Disposal of untreated waste water from Ghatkopar nalla in Thane creek

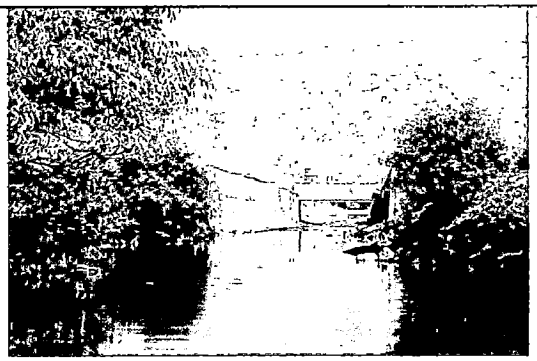


Figure 2.5: Disposal of untreated waste water from Koparkhairne nalla in Thane creek

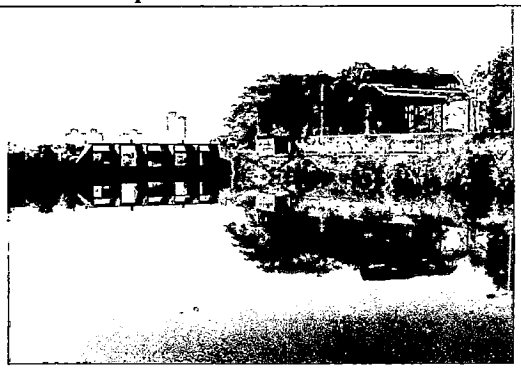


Figure 2.6: Disposal of untreated waste water from Balkum nalla in Ulhas river estuary

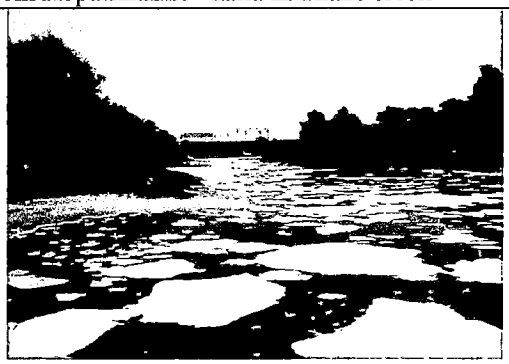


Figure 2.7: Disposal of untreated waste water from Dombivali nalla in Ulhas river estuary

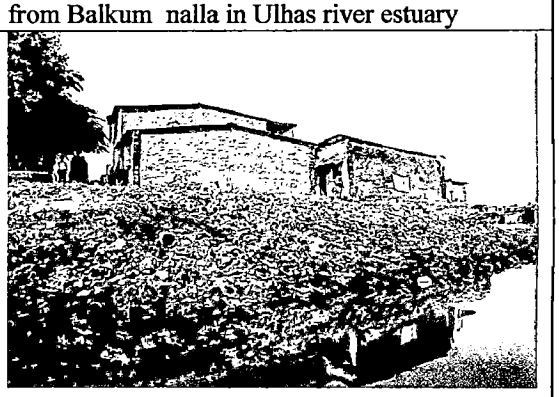


Figure 2.8: Disposal of untreated waste water from unauthorized slums in Thane creek

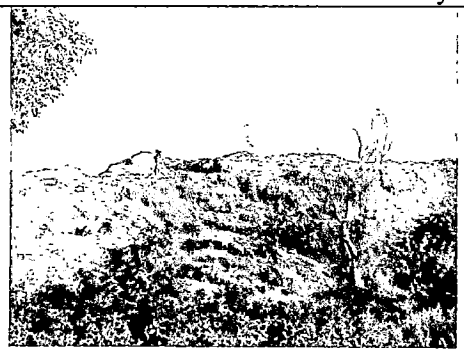


Figure 2.9: Disposal of solid waste at Kalyan along the banks of Ulhas river estuary

Figure 2.10: Disposal of solid waste at Mira along the banks of Ulhas river estuary

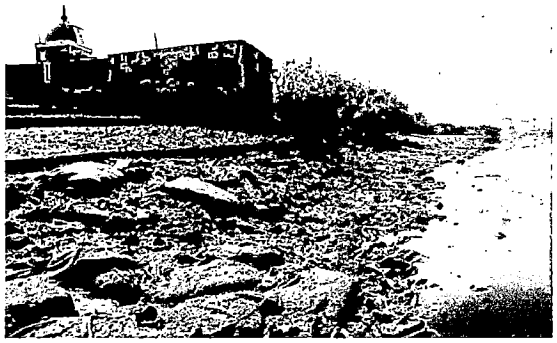


Figure 2.11: Disposal of food grain bags at Kopari ghat in Thane creek

Figure 2.12: Degraded Thane creek water quality at Vitawa

## 2.1 Studies done in past

Studies done in the recent past 25 years are summarised below:

### 2.1.1 Physico-Chemical parameters

In past 25 years various organisations and researcher studied physico-chemical parameters. Physico-chemical parameters of Thane creek and Ulhas river estuary are given in Table 2.1 and Table 2.2, respectively.

Table 2.1 Physico-chemical properties of Thane creek

| | 1981[1] | 1989[2] | | 91-92[3] Vitawa area | Sept 2001-Aug 02[4] | Nov 2001[4] |
|---|---|---|---|---|---|---|
| | | Pre monsoon | Post monsoon | | | |
| pH | | 7.25-8.56 | 6.5-7.8 | | 7.53-8.09 (7.73) | 7.69 |
| DO (ppm) | Surface-4.64 Bottom-4.89 | 1.98-4.56 | | 0.9-2.2 | 0.6838-5.0 (2.05) | 1.17 |
| COD (ppm) | | 110.5-236.4 | 125.9-269.5 | | | |
| $NO_2$-N (ppm) | | 0.001-0.0052 | 0.0058-0.016 | | 5.9-27.64 (16.17) | |
| $NO_3$-N( ppm) | | 0.0034-0.0136 | 0.0137-0.0156 | | 0.17-1.85 (0.95) | 1.67 |
| $PO_4$-N (ppm) | | 0.068-0.208 | 0.039-0.135 | | 0.044-0.126 (0.09) | 0.11 |
| Sulphate (g/l) | | 2.8 | | | | |
| Salinity (%) | 36.48 | 30.10 –37.42 | | | 3.493-34.73 (23.73) | 21.72 |
| Silicates (ppm) | | | | | 14.37-39.45 (21.63) | 17.57 |
| Light Penetration (cms) | | | | | 21.75-46.75 (34.63) | 39.79 |
| Suspended Solids (g/l) | | | | | 0.67-5.007 | |
| Organic Carbon (%) | | | | HLWM-24 LLWM-2.28 | 2.185-4.568 | |
| Total Nitrogen (%) | | | | 0.25-0.291 | 0.151-0.352 (0.247) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Total Phosphate (%) | | | | 0.079-0.107 | 0.132-2.142 (0.685) | |
| Clay (%) | | 51.28-67.11 | | | Silt & clay- 92 Low sand – 6.7 | |
| Organic matter (%) | | 2.57-4.73 | | 2.185-4.568 | | |
| pH | | 7.1-8.2 | | | | |
| N/P ratio | | | | 1.77-0.3 | | |
| C/P ratio | | | | 23.45 | | |

[1] Zingde 1981[+] [2] K C Sahu 1991[+] [3] Mishra 1994[+] [4] Athalye 2003[+]
[+] Samples collected at creek edge

Table 2.2 Physico-chemical properties of Ulhas river estuary

| | Autumn 1985-1986[1] | | | 1989[2] | | 1999 Bhayandar (Nov 95- Jan 96[3]) | | Nov 01[4] |
|---|---|---|---|---|---|---|---|---|
| | Balkum to Vasai | Kalyan to Balkum | Total | Pre monsoon | Post monsoon | W1 | W2 | |
| pH | 7.7 | 7.3 | 7.5 | 7.15-8.32 | 6.34-7.82 | 7.8 | 7.8 | 7.64 |
| DO ( ppm ) | 4.0 | 2.75 | 3.37 | 2.26-4.8 | | 1.5 | 2.5 | 2.21 |
| BOD( ppm ) | | | | | | | | |
| COD( ppm ) | | | | 98.2-211.8 | 129.6-228.0 | 510.0 | 850.0 | 53.13 |
| $NO_2$-N ( ppm ) | 0.0013 | 0.0030 | 0.00217 | 0.0005-0.0047 | 0.0021-0.0156 | | | |
| $NO_3$-N ( ppm ) | | | | 0.0025-0.0156 | 0.0096.-0.047 | | | 1.99 |
| $PO_4$-N( ppm ) | 0.05-1.1 (0.22) | 0.05 | 0.135 | 0.061-0.416 | 0.01-0.252 | | | |
| Sulphate (g/l ) | 2.6 | 2.35 | 2.475 | 0.50-2.90 | | | | |
| Salinity (%) | | | | 26.5-36.2 | | 27075 ppm | 39096 ppm | 11.44 |
| Silicates ( ppm ) | | | | | | | | 53.13 |
| Electrical Conductivity, mmhos/cm | | | | | | 45.0 | 41.5 | |
| TDS ( ppm ) | | | | | | 35000 | 27010 | |
| Chloride ( ppm ) | | | | | | 15000 | 21660 | |
| TSS ( ppm ) | | | | 12.6-350.0 | | 2000 | 3550 | 2450 g/l |
| Oil & grease ( ppm ) | | | | | | 38.0 | 48.0 | |
| MPN | | | | | | $1.5x\ 10^4$ | $1.5x\ 10^4$ | |
| Organic Matter, % | | | | 1.75-4.31 | | | | |
| Size (clay percent) | | | | 2.57-67.43 | | | | |
| pH | | | | 7.0-8.1 | | | | |

[1] S.K Sahoo 1987[+] [2] Sahu 1989[+] [3] Lokhande 1999[+] [4] Athalye 2003[+]
[+] Samples collected at estuary edge

Zingde (1981) reported DO level of 4.64ppm at surface and 4.89ppm at bottom of Thane creek and 36.48 percent salinity. Sahoo (1987) studied Ulhas river

estuary during autumn 1985 -1986 and DO level of 4.0 ppm, 1.3 μg/l of $NO_2$-N, 0.22 μg/l of $PO_4$-P are observed.

Sahu and Bhosale (1991) reported that the organic matter content in sediment varies from 2.57 to 4.73 percent in Thane creek and from 1.75 to 4.31 percent in the Ulhas River and is always high in the area around sewage discharges. Suspended solids (SS) range from 12.6 mg/l to350 mg/l in Thane creek and 9.87 mg/l to 538.8 mg/l in Ulhas river estuary. DO values ranges from 1.98 mg/l to 4.56 mg/l in Thane creek and 2.26 mg/l to 4.80 mg/l in the Ulhas river estuary. Salinity level in Thane creek ranges from 30.10 percent to 37.42 percent. The suspended solids are evidently finer (mean values 11.7 μm in Thane creek and 11.9 μm in Ulhas River). It is also reported that the seasonal variation in Ulhas sediments are disturbed due to dredging activities.

Mishra (1994) studied the sediments of Vitawa area. 24 percent organic carbon was observed in sediment at high-level water mark (HLWM) and 2.28 percent at lower level mark (LLWM). Total nitrogen and total phosphorus in sediment were higher at HLWM (average 0.291 percent and 0.107 percent, respectively) and at LLWM (average 0.25 percent and 0.079 percent, respectively), carbon to nitrogen ratio (C/N) at HLWM varies between 5.8 to 11.72, nitrogen to phosphorus ratio (N/P) varies from 1.77 to 6.3 and average carbon to phosphorus ratio (C/P) is 23.45.

Lokhande (1999) studied DO, pH, Coliform, Oil and grease, TDS, Chloride, Total hardness, COD, TSS, salinity of Vasai creek sediments in August 1995 – July1996. High values of COD (450 ppm to 1450 ppm) were reported at Bhayandar area of the creek.

Athalye (2003) reported that the DO values ranges from 0.67 ppm and 5.007 ppm (avg. 1.96 ppm) in Thane creek and 0.425 ppm to 2.715 ppm (avg. 1.89 ppm) in the Ulhas estuary. $NO_3$-N range from 0.17 ppm to 1.85 ppm (avg. 0.95 ppm) in Thane creek and 1.08 ppm to 2.57 ppm (avg. 1.67 ppm) in the Ulhas estuary. Salinity range from 3.493 to 34.73 percent (avg. 23.73 percent) in Thane creek and 0.796 to 27.341 percent (avg. 15.73 percent) in the Ulhas estuary.

In Thane creek the average salinity over the years has decreased from polyhaline (i.e., > 18ppm) to mesohaline (i.e, < 18 ppm). Logically dissolved oxygen should have improved, but on the contrary it showed decline indicating influence of pollutants. Suspended solids in Thane creek increased by 315 percent in 1999-2000 compared to those in 1981-82 Goldin (2003). The DO saturation values of Thane

creek as depicted in Figure 2.1 are reduced from 82 percent in 1981-82 to 25 percent in 1999-2000 Goldin (2003). Change in DO values of Ulhas river estuary is depicted in Figure 2.14.

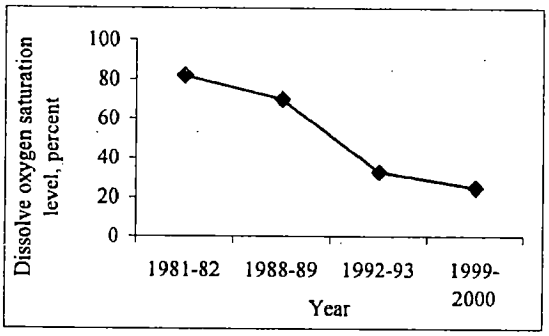



Figure 2.13 Yearwise DO saturation levels of Thane creek

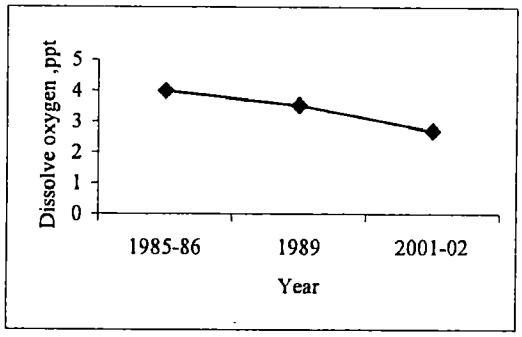



Figure 2.14 Change in DO values of Ulhas river estuary

### 2.1.2 Heavy Metals in Water and Sediments

Heavy metals in water samples and sediments of Ulhas river estuary are given in Table 2.3 and Table 2.4, respectively. Heavy metals in water samples and sediments of Thane creek are given in Table 2.5.

Table 2.3:Heavy Metals in Ulhas Estuary Water

| | Autumn( 1985-1986)[1] | | (Nov 95- Jan 96)[2] | | (Sept 01-Aug 02)[3] | Nov 2005[4] Kalyan to Vasai | |
|---|---|---|---|---|---|---|---|
| | Balkum to Vasai | Kalyan to Vasai | Bhayandar | | | | |
| Hg (µg/l) | | | 23.2 | 23.0 | | | |
| Cd (µg/l) | 1.5 | 1.46 | 15.3 | 15.0 | | | |
| Pb (µg/l ) | 20.8 | 11.2-55.0 (20.1) | 29.5 | 27.9 | | | |
| Zn (µg/l) | 49.2 | 32.0-110.0 (67.80) | 38.1 | 33.9 | 0.17 ppm | 0 -0.895 ppm | |
| Cu (µg/l) | 11.9 | 4.5-24.0 (10.5) | 18.1 | 18.5 | 0.767 ppm | 0 -0.221 ppm | |
| Fe (µg/l) | 35.8 | 37.21 | 53.2 | 50.4 | | | |
| Mn ( µg/l) | 4.1 | 6.52 | 30.0 | 30.2 | | | |
| Ni (µg/l) | 5.9 | 3.2-23.4 (7.9) | 21.9 | 20.1 | | | |
| Co (µg/l) | 1.4-22.6 (5.25) | 1.7-22.6(5.43) | | | | | |

1 S. K Sahu 1987[+] [2] Lokhande 1999[+] [3] Athalye 2003[+] [4] Present study[++]

[+] Samples collected at estuary edge [++] Samples collected at estuary center

Table 2.4: Heavy Metal in Ulhas River Estuary Sediments

| | 1981[1] (both water and sediment) | | | | Autumn (1985-1986)[2] | | 1989[3] | | | (Sept 01–Nov 02)[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | Aug 76 | June 77 | Apr 78 | July 79 | Balkum to Vasai | Total | Pre mon-soon | Post mon-soon | Aver-age | |
| | All values are in ppm | | | | | | | | | |
| Hg | <0.001 | 0.011 | 0.301 | 0.001 | | | 1.11 | 0.31 | 0.71 | |
| Cd | 1.32 | 1.32 | 1.51 | 1.97 | 2.5 | 2.2 | 4.8 | 2.0 | 3.4 | |
| Pb | 15.43 | 48.21 | 20.7 | 12.54 | 36.0 | 35.8 | 56.0 | 58.0 | 57.0 | |
| Zn | 232.0 | 193.8 | 500.5 | 88.0 | 128.0 | 156.9 | 130.0 | 157.0 | 144.0 | 247.84 |

| | 1981[1] (both water and sediment) | | | | Autumn (1985-1986)[2] | | 1989[3] | | | (Sept 01–Nov 02)[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | Aug 76 | June 77 | Apr 78 | July 79 | Balkum to Vasai | Total | Pre mon-soon | Post mon-soon | Aver-age | |
| | All values are in ppm | | | | | | | | | |
| Cu | 70.5 | 87.5 | 99.0 | 75.6 | 90.5 | 95.2 | 103.0 | 117.0 | 110.0 | 232.87 |
| Fe | | | | | 62243.0 | 64246.0 | 69085.0 | 69526.0 | 69305.0 | |
| Mn | | | | | 232.0 | 229.0 | 555.0 | 907.0 | 731.0 | |
| Ni | | | | | 91.5 | 92.1 | 92.0 | 103.0 | 98.0 | |
| Co | | | | | 41.8 | 43.08 | 47.0 | 39.0 | 43.0 | |
| Cr | 169.5 | 345.5 | 169.3 | 51.5 | | | 44.0 | 40.0 | 42.0 | |

[1] Mukherjee 1981+ [2] S. K Sahoo 1987+ [3] K C Sahu 1991+ [4] Athalye 2003+
+ Samples collected at estuary edge

Zingde (1981) observed mercury of 8.21 ppm (dry wt.) in sediments and 0.307µg/kg in water sample and reported standing stock of about 77 kg excess Mercury (Hg) in water of Thane Creek sediment contains about 14 Tons of Hg in excess of natural amounts by assuming background level to be 0.15ppm. Sahu and Mukherjee (1983) reported approximately 100kg of copper (Cu), 40000 kg of Zinc (Zn) and 7000 kg of Hg and 500 kg of Chromium (Cr) into Ulhas River system. Sahoo (1985) observed 5 to 10 µg/l of copper, 40 to 86 µg/l of Zn, 1 to 5µg/l of cadmium (Cd) and 15 to 50 of µg/l lead (Pb) in Ulhas river estuary.

Mahopatra (1987) investigated waste water released from 20 large and medium industries to the Thane Creek and reported low amount of cadmium and objectionable amount of Cu, Pb, Zn. Athalye (1989) observed 91 percent of Cu attached to solids does not get dissolved in marine water.

Bhosale and Sahu (1991) have reported a range of 0.045-0.372 µg/l for dissolved and 0.30 – 2.10 µg/l for particulate Hg in the Ulhas estuary. However considerable enrichment of Hg is evident in the estuary when compared with the values reported for the open shore coastal water off Bassien – Mumbai, Zingde (1981), Sahu and Bhosale (1991).

The enrichment factors are studied by Sahu and Bhosale (1991) higher for Thane Creek sediments than Ulhas River Sample indicating that Thane creek is more highly polluted. In Thane creek the total Hg concentration in the surface sediments varies from 0.17 to 8.21 ppm with definite enrichment in the inner creek. 90 percent of the Fe and Mn in both the Ulhas river and Thane creek are associated with the particulate fraction.

Table 2.5: Heavy Metals in Thane Creek Water and Sediments

| | Water | | | Sediment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1981[1] | (1994) 91-92[2] Vitawa area | Nov 05[3] | 1981[1] | (91-92)[2] Vitawa area | | 1989[4] | | | | | | Sept 02 – Nov 02[5] |
| | | | | | | | Balkum to Belapur | | | Balkum to Trombay | | | |
| | | | | | W1 | W2 | Pre monsoon | Post monsoon | Average | Pre monsoon | Post monsoon | Average | |
| Hg | 299.8 $ngl^{-1}$ | | | 8.21 ppm (dry wt.) | | | 0.38 | 0.34 | 0.36 | 1.04 | 0.29 | 0.66 | |
| Cd, (ppm) | | | | | 1.2-2 | 1.5 | 4.8 | 2.0 | 3.4 | 5.0 | 2.1 | 3.6 | |
| Pb (ppm) | | | | | 31.0* | 19.0* | 98.0 | 61.0 | 80.0 | 99.0 | 62.0 | 80.0 | |
| Zn (ppm) | | 0.404 | | | 169.0 | 115.0 | 167.0 | 170.0 | 168.5 | 167.0 | 175.0 | 171.0 | 227.51 |
| Cu (ppm) | | | | | 253.0 | 231.0 | 171.0 | 107.0 | 139.0 | 169.0 | 108.0 | 139.0 | |
| Fe (ppm) | | | | | | | 66741.0 | 67433.0 | 67087.0 | 66523.0 | 67713.0 | 67118.0 | |
| Mn (ppm) | | | | | | | 535.0 | 922.0 | 728.0 | 546.0 | 882.0 | 714.0 | |
| Ni (ppm) | | | | | | | 112.0 | 104.0 | 108.0 | 114.0 | 104.0 | 109.0 | 204.31 |
| Co (ppm) | | 1.12 | | | | | 55.0 | 38.0 | 46.0 | 54.0 | 37.0 | 46.0 | |
| Cr (ppm) | | | | | | | 51.0 | 36.0 | 44.0 | 51.0 | 37.0 | 44.0 | |
| Moisture content (%) | | 68.1 | | | | | | | | | | | |
| Qxidizable Matter, %) | | 4.2 | | | | | | | | | | | |

* During monsoon

[1] Zingde 1981[+]

[2] Mishra 1994[+]

[3] Present study[+]

[4] K C Sahu 1991[+]

[+] Samples collected at creek edge

Sahu and Bhosale (1991) Thane creek metals pollution load index (PLI) is 2.255 and Ulhas River PLI is 2.151, which illustrates that there is a higher level of pollution in Thane Creek

The depth profile of Hg and Nickel (Ni) studied by Jha (1999) clearly shows anthropogenic input in to Thane Creek coastal environment and observed positive evidence for the continued inputs of Hg and Ni in a decade or two earlier at Airoli region. The Hg contamination was found to be highly localized.

Zingde (1999) reported increase in Pb and Hg in the surfacial sediments of Ulhas estuary and bioaccumulation of Fe, Zn and Pb in polychates is more in Thane creek as compared to Mahim and Versova creek.

Jha (2002) studied recent net fluxes of different element viz: Fe, Cu, Zn, Pb, Cr and Mn in Thane creek. Low residence time for the Fe and Mn followed by Pb and Cu and high residence time for the Cr and Zn was obtained. The observed pattern of variation in the concentration of Pb, Zn, Cr, and Mn found greater than the sediments from non-polluted areas.

Jha (2003) studied depth profile of global fallout $^{137}$ Cs in sediment core samples collected at Thane creek and identified the effect of main atmosphere nuclear weapon tests carried in past. Depth profile of Hg (concentration upto 10 μg/g) and Pb (concentration upto 70μg/g) shows the anthropogenic input into the coastal environment around Thane Creek over the years.

Hg profile in cores from Arabian sea few kilometers from Ulhas River based on $^{120}$ Pb, the sediments at the bottom this core is inferred to have been deposited in the year 1949 roughly two years prior to the establishment of the first color-alkali plant and represents the background (0.06 – 0.10 μg/g), Ram (2003).

**2.1.3 Persistent organic pollutants**

DDT (dichlorodiphenyltrichloroethane), DDE (dichlorodiphenyldichloroethyl-ene), DDD (dichlorodiphenyldichloroethane) and four isomers of HCH (exachlorocyclohexane) have been detected by Pandit (2002) in the coastal sediments of Thane Creek. In surface sediment DDT residue ranged between 4.8 to 38.7 μg/g. While HCH residue range between 5.9 to 58.4 μg/g. DDT was detected in almost all the locations in the creek. Peak concentration was found to occur in the 1978 for DDT and HCH. Thane creek sediments are contaminated with organochlorine compound particularly with DDT.

### 2.1.4 Petroleum Hydrocarbon Residue (PHc)

Chauksey (2004) investigated the average concentration of PHc in water of Ulhas estuary varies in the range 3.3 to 21.3 µgl/l. The concentration of PHc in water of Thane creek varies over a wide range 7.8to 39.2µg/ l and varies 8.5 to 17 µg/ l from Balkum to Belapur. Also reported that the concentration of PHc in the sediment of the Ulhas estuary varies widely (2.0 – 40.8 ppm, dry wt.). The concentration of PHc in the Thane and Vashi area is 42.8 and 42.0 ppm, dry wt. respectively with a tidal excursion of about 9 km. Sedimentation rate increases from 0.2 cm/y near the Ulhas estuary, mouth to 25 km off shore. High concentration of PHc also occurs throughout the length in core. The sediment in this area is fairly undisturbed as revealed from the distribution of $^{210}Pb$ based on which the clay accumulation rate of 0.65 – 1.45 cm/y has been reported for the inner region of the Thane Creek.

### 2.2 Present Study

Survey was conducted along with NGO, Enviro Vigil during November, 2005 and January, 2006 to study the present status of Thane creek and Ulhas river estuary. An appeal was made to Bandodkar College and Dnyan Sadhana College to join the hands with TMC in carrying survey. Both college supported by deputing their volunteers for the survey.

In past most of the studies based on the water and sediments samples collected from the creek/ estuary edge. Hence it was decided to collect the samples from each nallas contributing to the creek and the center of the creek to understand the effect of the nalla. Total 120 water samples and 44 sediment samples were collected from Thane creek and Ulhas river estuary as shown in Figure 2.15, 2.16,2.17 and 2.18. Details of samples collected is as under:

| | Thane creek | Ulhas river estuary | Total |
|---|---|---|---|
| Water sample | | | |
| Nalla at the edge of creek | 35 | 21 | 46 |
| Center of creek | 34 | 30 | 64 |
| Total | 69 | 51 | 120 |
| Sediment sample | | | |
| Nalla at the edge of creek | 34 | 10 | 44 |

The study stations were visited by hiring a mechanical boat and canoe for creek/ estuary edge samples. Survey team members and sample collected are shown in Figure 2.19 and Figure 2.20, respectively . Samples were tested in TMC pollution control laboratory. Training was given to Bandodkar College and Dnyan Sadhana

College students for collecting samples and its analysis. Students voluntarily carried out different analysis of samples collected under the guidance of experts in the laboratory.

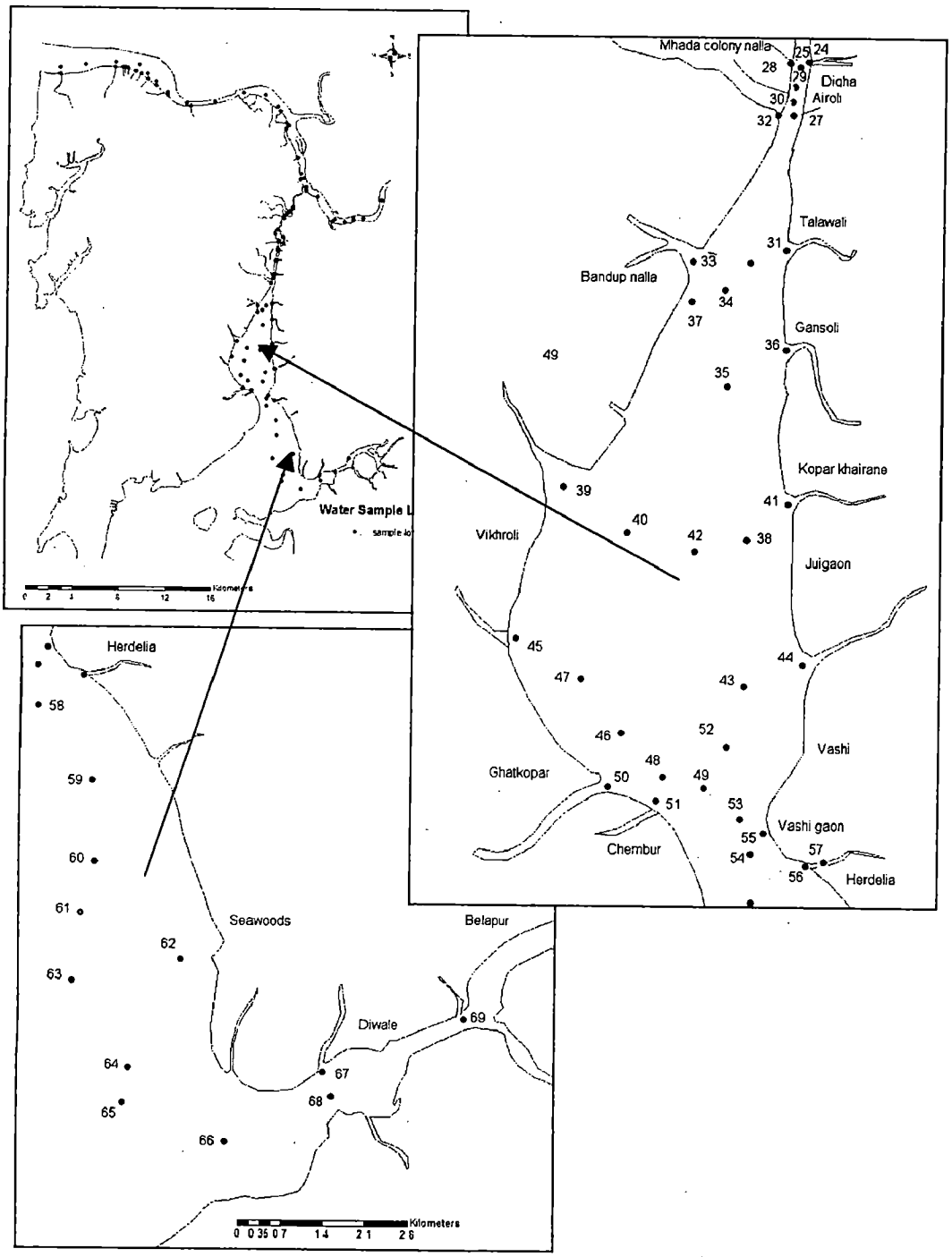
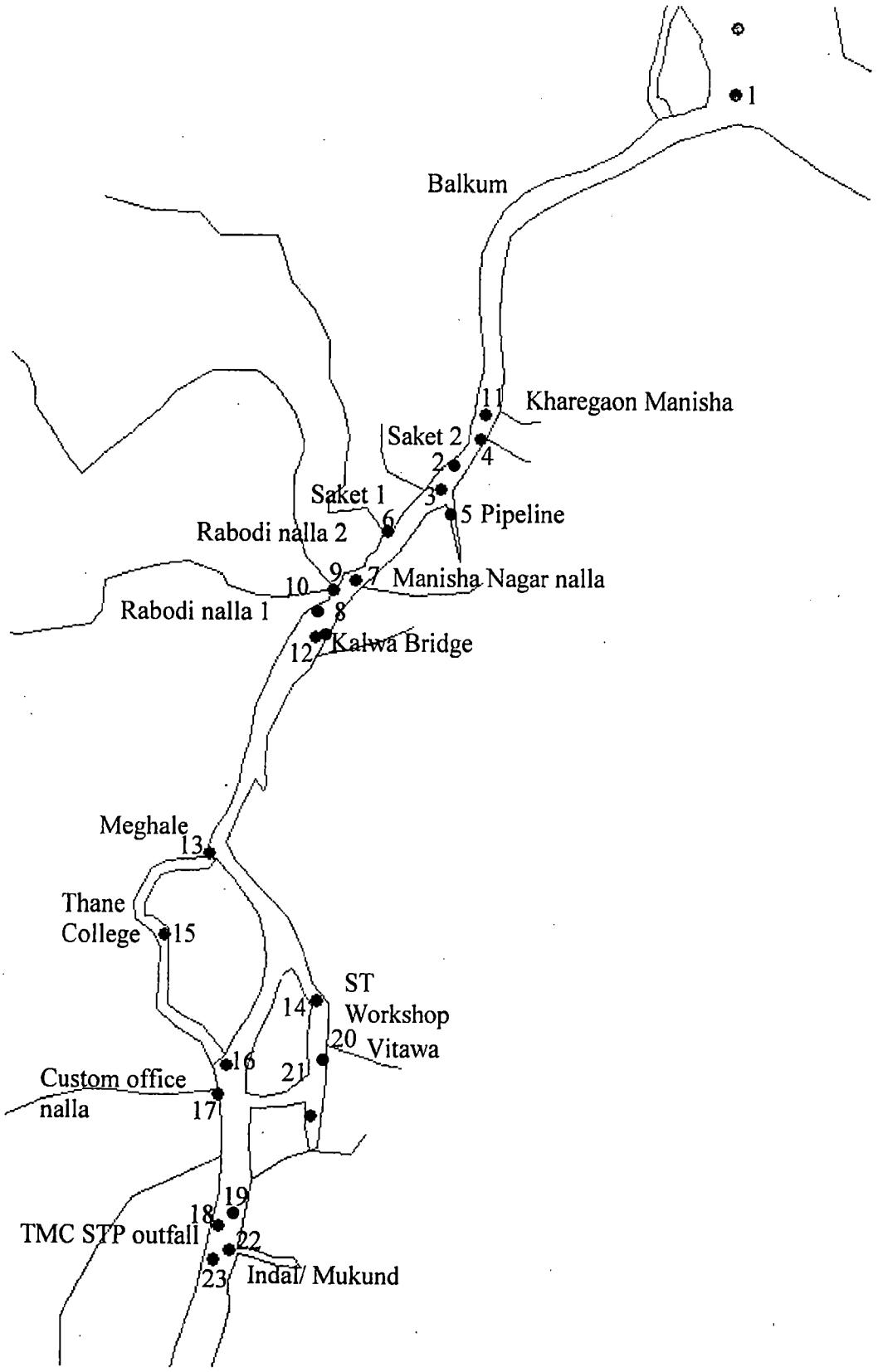



Figure 2.15: Water sample location-Airoli bridge to Belapur

Figure 2.16: Water sample location-Balkum to Airoli bridge



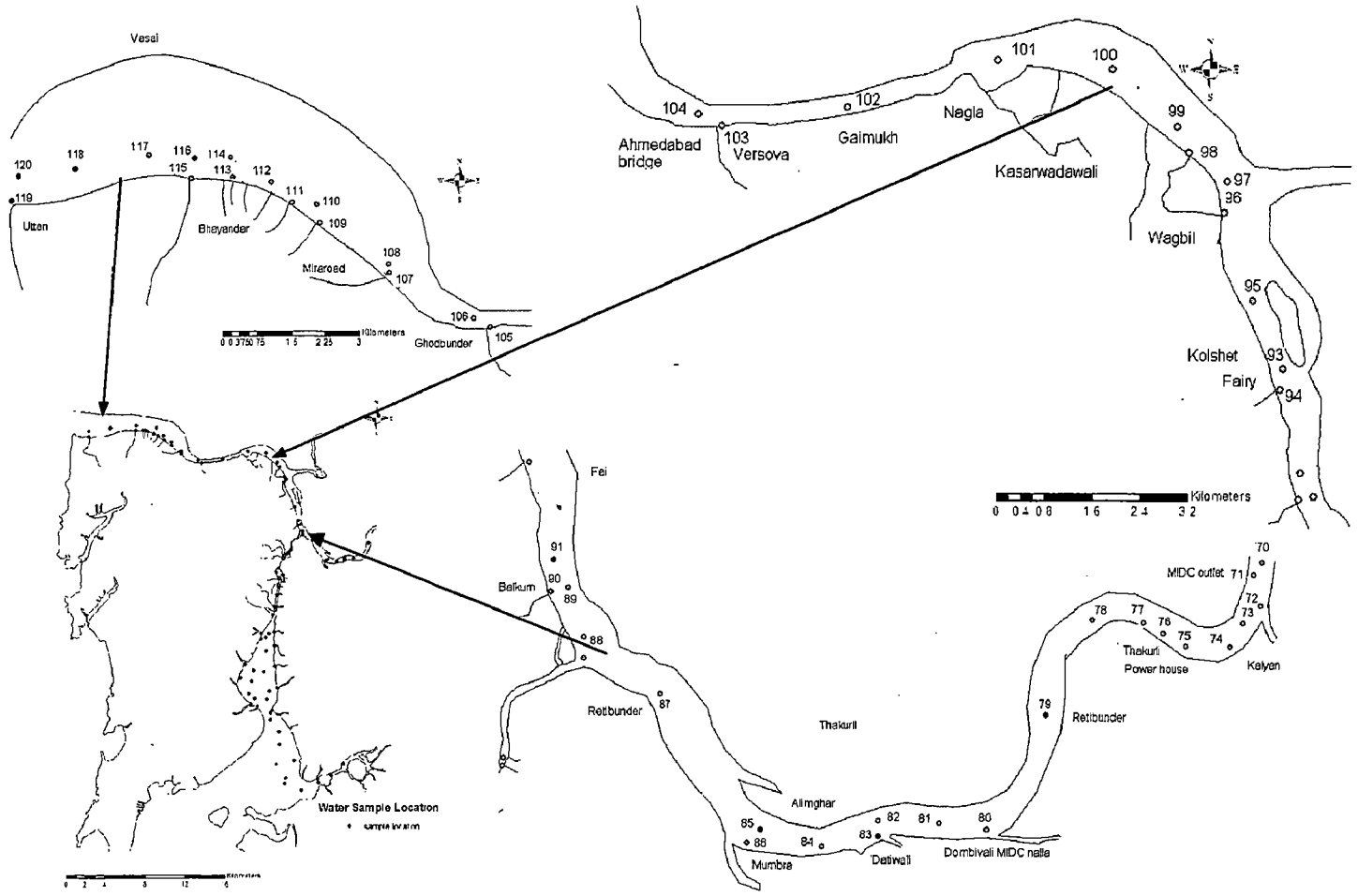



Figure 2.17: Water sample locations- Kalyan to Vasai

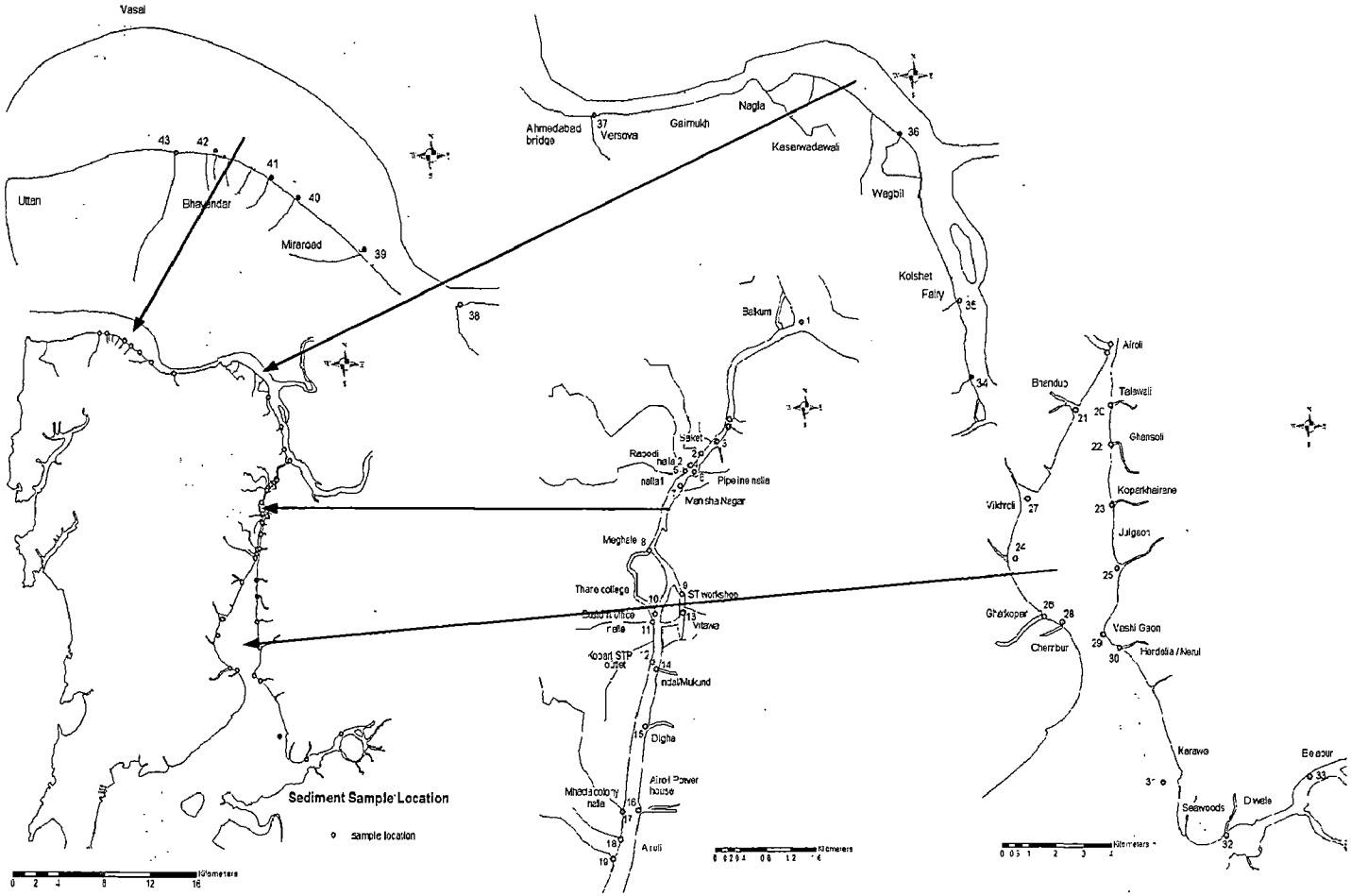



Figure 2.18: Sediment sample locations

Figure 2.19: Survey team

Figure 2.20:Samples collection

Geographic Information System (GIS) can be effectively used for assessing the spatial distribution of water and sediment quality. In this study ARC GIS 8.3 from ESRI is used to prepare input maps. The study area was digitized; water and sediment sampling locations were marked based on its Latitude and longitude. The various water quality parameters like DO, BOD, etc and parameters for sediments samples like organic content , nitrates , phosphates and heavy metals were added in attribute.

The special variation of quality parameter is done by Inverse Distance Weighted Method (IDW).

### 2.2.1 Physico-chemical properties of water samples

Physico-chemical properties of Thane creek and Ulhas river estuary are summarised in Table 2.6 and 2.7, respectively. Heavy Metals in Ulhas river estuary water sample is given in Table 2.3 and Annexure 1.

Table 2.6: Physico-chemical properties Thane creek and Ulhas river estuary water samples collected in Nov-2005

| | **Thane Creek** | | | | | | **Ulhas river estuary** | |
|---|---|---|---|---|---|---|---|---|
| | Balkum to Kalwa bridge | Kalwa bridge to Airoli bridge | Airoli bridge to Vashi bridge | Vashi Bridge to Belapur | Balkum to Vashi bridge | Balkum to Belapur | Balkum to Vasai | Kalyan to Balkum |
| pH | 7.1-7.9 (7.5) | 7.1-7.8 (7.5) | 7.1-7.4 (7.2) | 7.3-7.6 | 7.4 | 7.4 | 6.2-7.8 (7.0) | 7.4 – 8.0 (7.73) |
| DO (ppm) | (0-1.8) 0.9 | 0-3.6 (2.2) | 1-4.8 (3.1) | 3.2-6.0 (5.1) | 1.7 | 2.6 | 3.8-5.8 (5.1) | 3.4 – 4.6 ( 4.03 ) |
| BOD, (ppm) | (3.6-6.0) 4.8 | 3-5.4 (4.1) | 3-5.6 (4.1) | 4.8-7.0 (5.5) | 4.3 | 4.6 | 3-12 (5.1) | 7.34– 13.36 (9.61) |
| $NO_3$-N (ppm) | 0.4-0.8 (0.57) | 0.33-0.83 (0.5) | 0.19-0.53 (0.3) | 0.48-0.72 (0.7) | 0.45 | 0.51 | 0.162-0.901 (0.414) | |
| $PO_4$-N (ppm) | 0.213-0.483 (0.377) | 0.132-0.482 (0.2) | 0.041-0.862 (0.2) | 0.158-0.304 (0.2) | 0.274 | 0.261 | 0.025-0.126 (0.070) | |
| Chloride | 24822-79488 (50452) | 24822-81558 (45946) | 9574-31559 (15956) | 9749-37223 (21553) | 37451 | 33477 | 6217-23417 (12565) | 5318-8862 (6780) |
| Suspended Solids (ppm) | 20-50 (30.8) | 20-50 (30.0) | 10-40 (22.3) (g/l) | 10-40 (21.7) | 27.7 | 26.2 | | |

### 2.2.1.1 Dissolved oxygen (DO)

During the survey carried out in November 2005 poor water quality was observed in the inner portion of the creek upto Airoli bridge.Figure 2.22 and Figure 2.24 shows all samples collected from the middle of the creek from Vashi bridge to Balkum has DO values less than the prescribes standards of 4 mg/l (SW II) during low tide. Average DO values of the samples collected from the center of the creek between Balkum to Kalwa bridge, Kalwa bridge to Airoli bridge and Airoli bridge to Vashi bridge are 0.9 mg/l, 2.2 mg/l and 3.1 mg/l, respectively. This gives an alarm regarding the deteriorating condition of the creek in the inner portion. Samples collected from Vashi bridge to Belapur meets the standards as depicted in Figure 2.24 and, may be due to good flushing capacity. Figure 2.21 and Figure 2.24 shows water a sample collected from the Thane creek edge does not meet the standard.

DO values for Ulhas river is depicted in Figure 2.23 . Samples collected from the Kalyan area has DO less than the prescribes standards of 4 mg/l (SW II) during low tide. The samples collected from Dombivali to Vasai bassein marginally satisfy the standards. Samples collected along the edge of the estuary do not meet the standard.

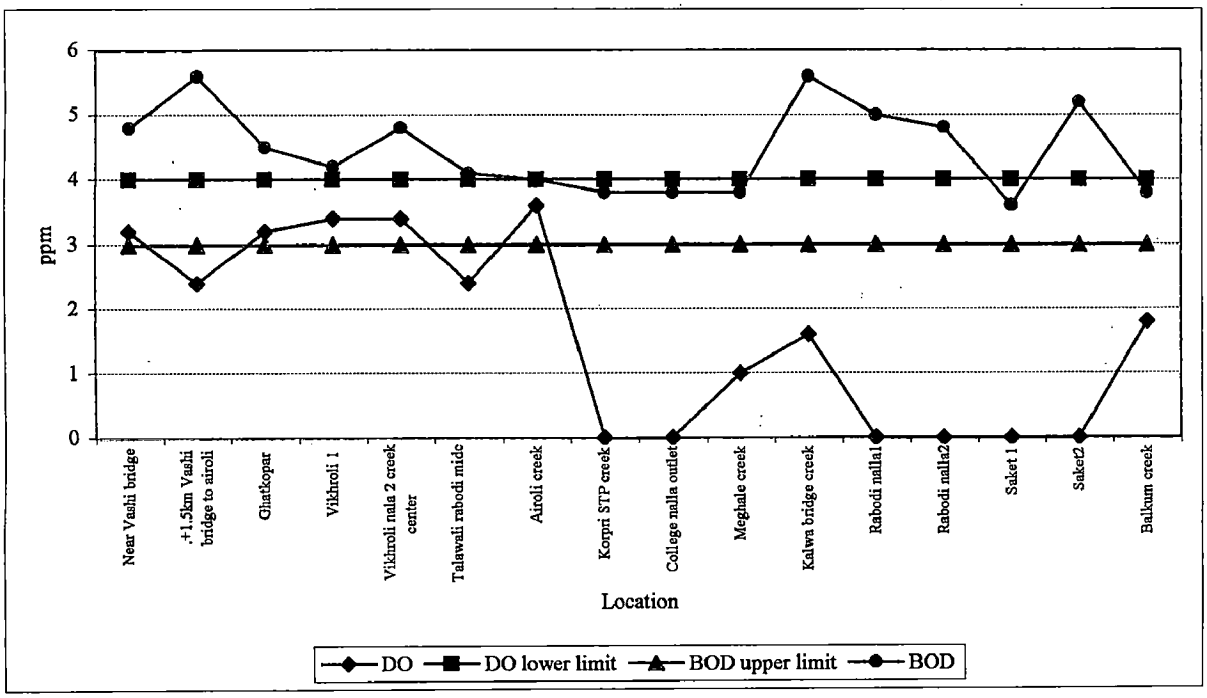



Figure2.21: DO and BOD levels at the Thane creek edge (Vashi to Balkum)

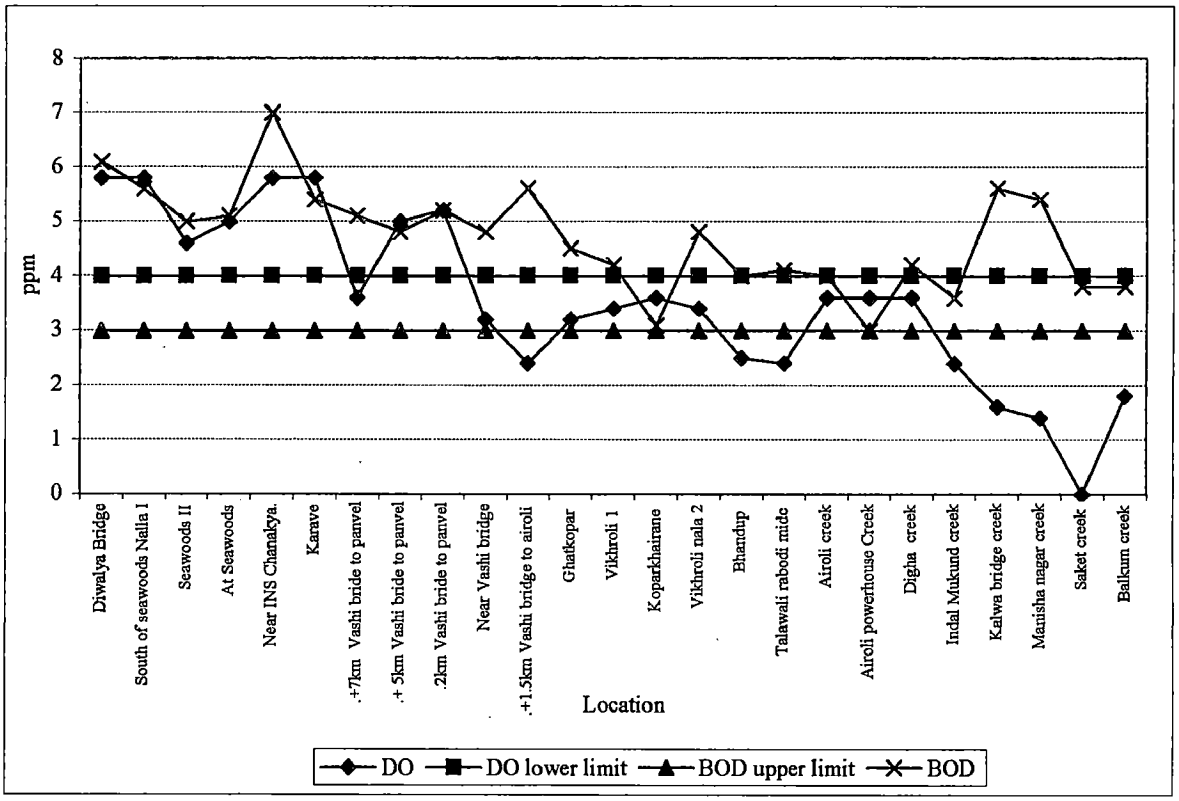



Figure 2.22: DO and BOD levels at Thane creek center

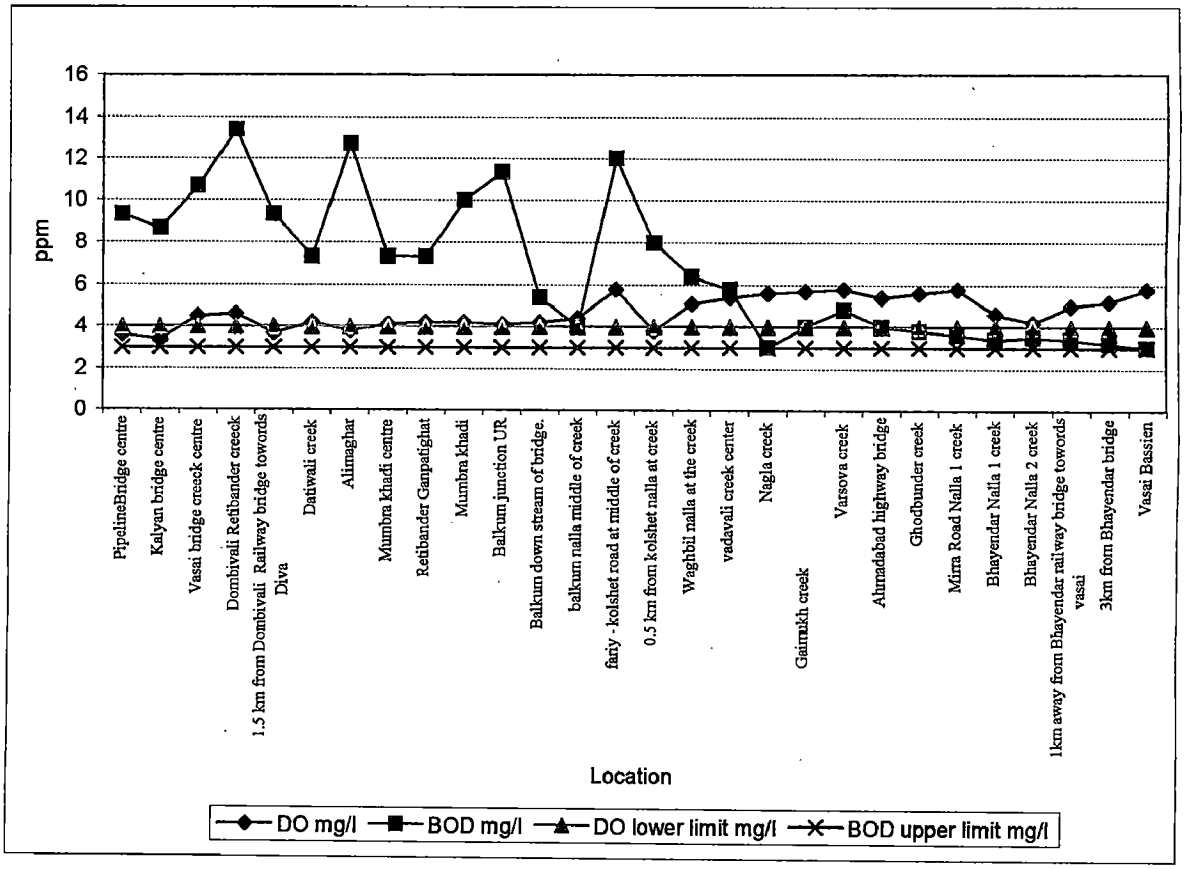



Figure 2.23. DO and BOD at the center of Ulhas river estuary

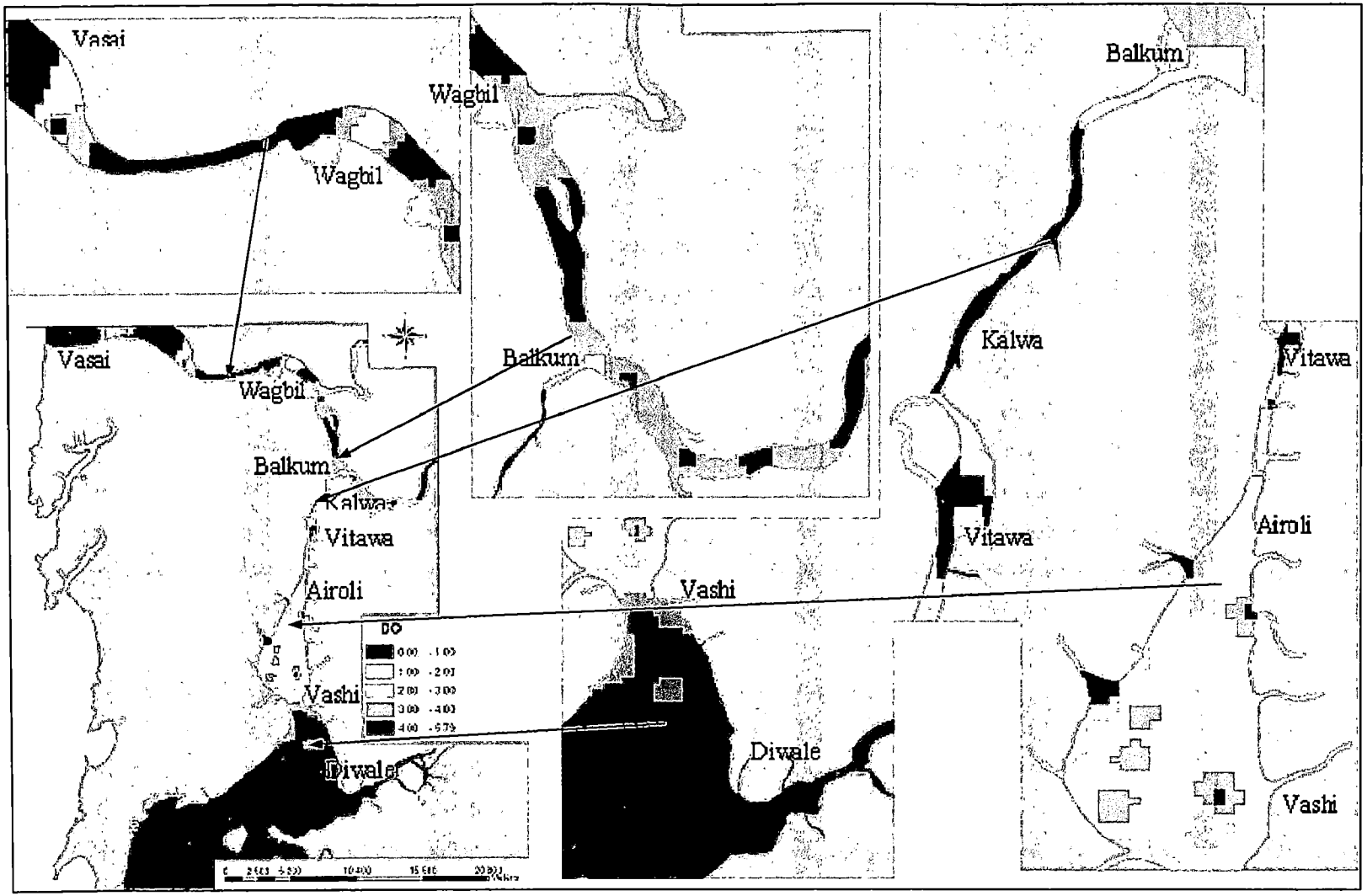



Figure 2.24: DO levels at various locations

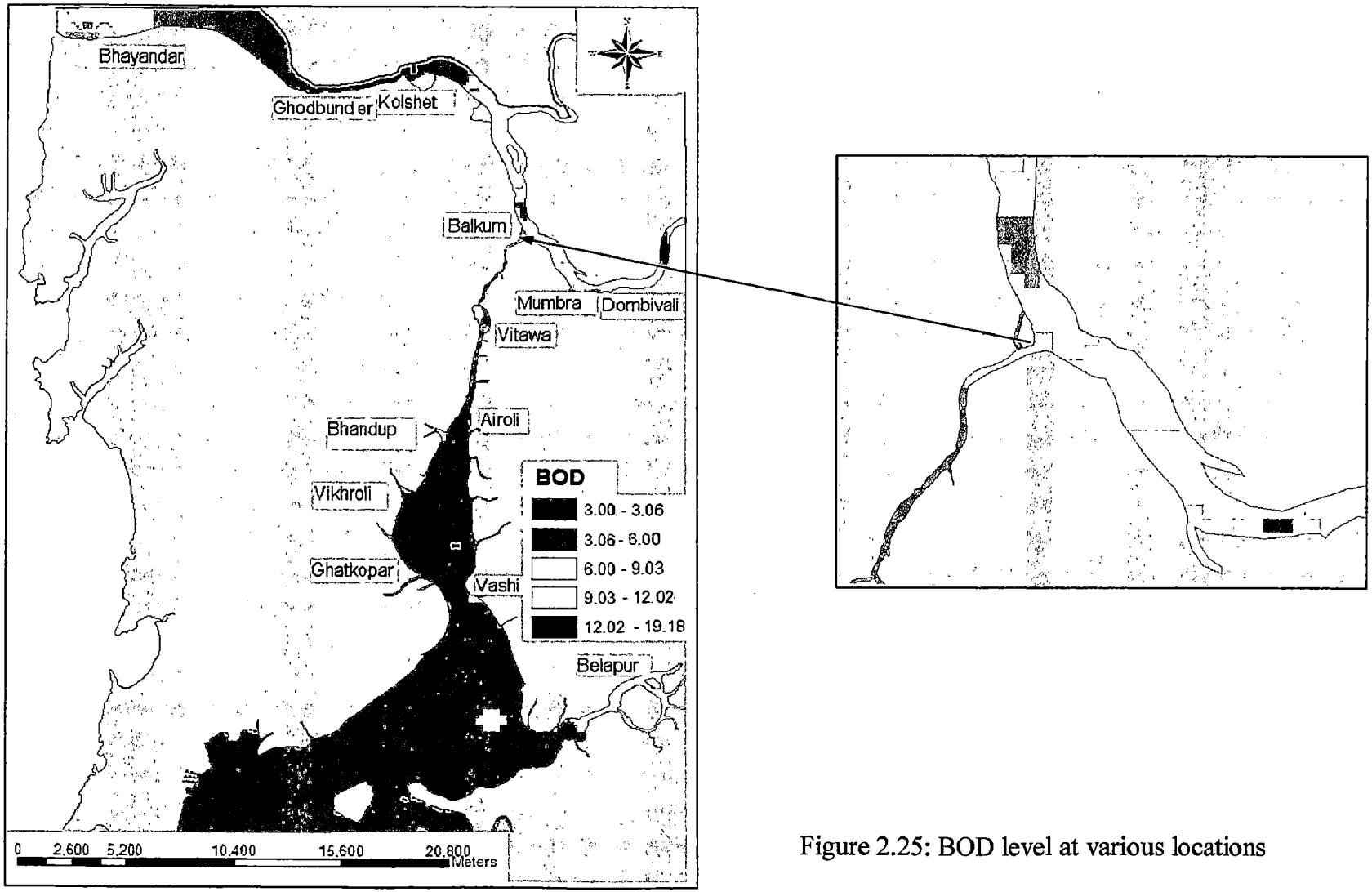



Figure 2.25: BOD level at various locations

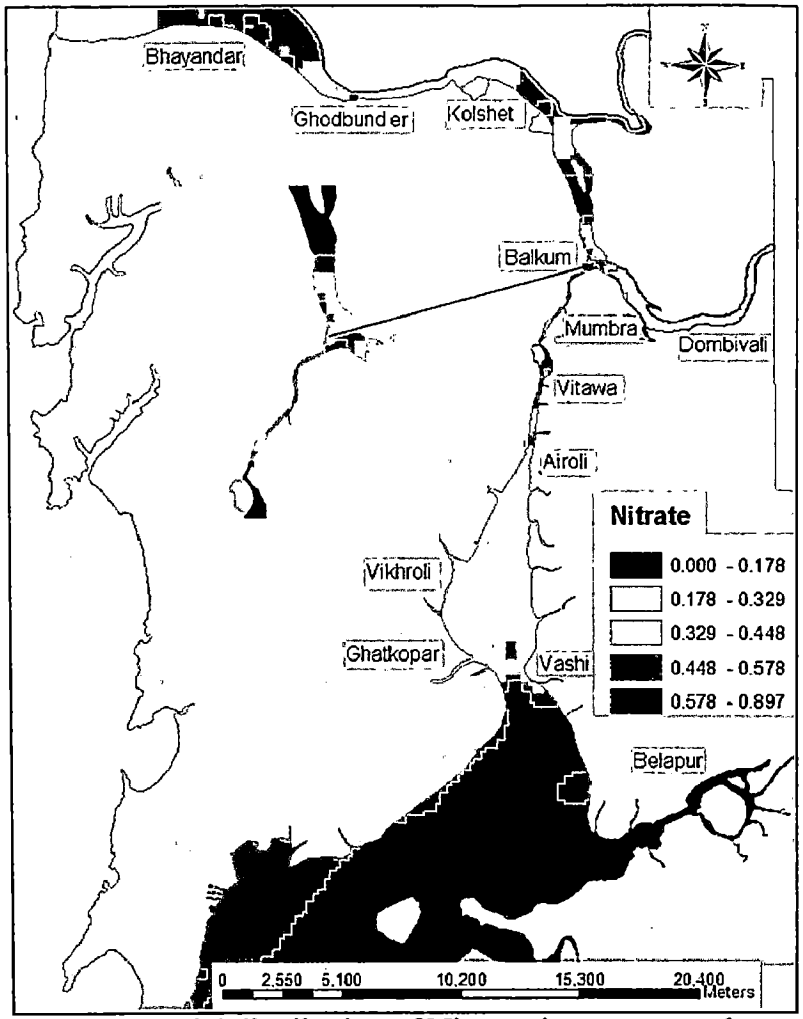



Figure 2.26: Spatial distribution of Nitrates in water sample

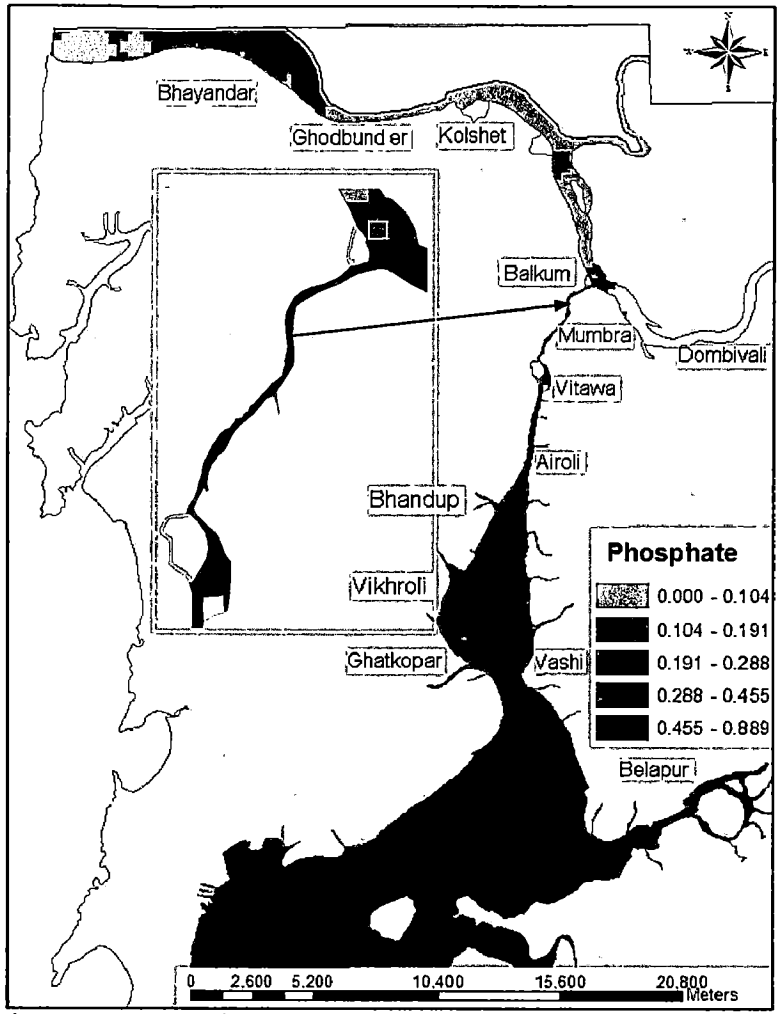



Figure 2.27: Spatial distribution of phosphates in water sample

### 2.2.1.2 Biochemical oxygen demand (BOD)

BOD is the indicator of biodegradable pollution. BOD values for Thane creek edge and center and Ulhas river estuary are depicted in Figure 2.21, 2.22 and 2.23 respectively. Spatial variation of BOD for Thane creek and Ulhas river estuary is depicted in Figure 2.25. BOD values indicate that inner portion of both water bodies is heavily polluted with the BOD values exceeding the standard of 3 mg/l (SW II) in almost 100 percent samples collected from edge and center.

### 2.2.1.3 Nitrates and Phosphates

Nitrates and phosphates levels in water samples collected at the center and edge of Thane creek are shown in Figure 2.28 and 2.29, respectively. Spatial variation of nitrates and phosphates for Thane creek and Ulhas river estuary are depicted in Figure 2.26 and Figure 2.27, respectively. Both nitrates and phosphates are higher at the edge than the center of creek. High nitrate levels are observed in water sample collected from 1.5 km from Vashi bridge, which may be due to the sewage outfall located at the center of creek. The values of both nitrates and phosphates has shown increasing trend from Ghatkopar to Balkum, where pollution is more due to ingress of domestic pollutants. Nitrates values are more from Diwale to Vashi as compared to Vashi to Balkum .

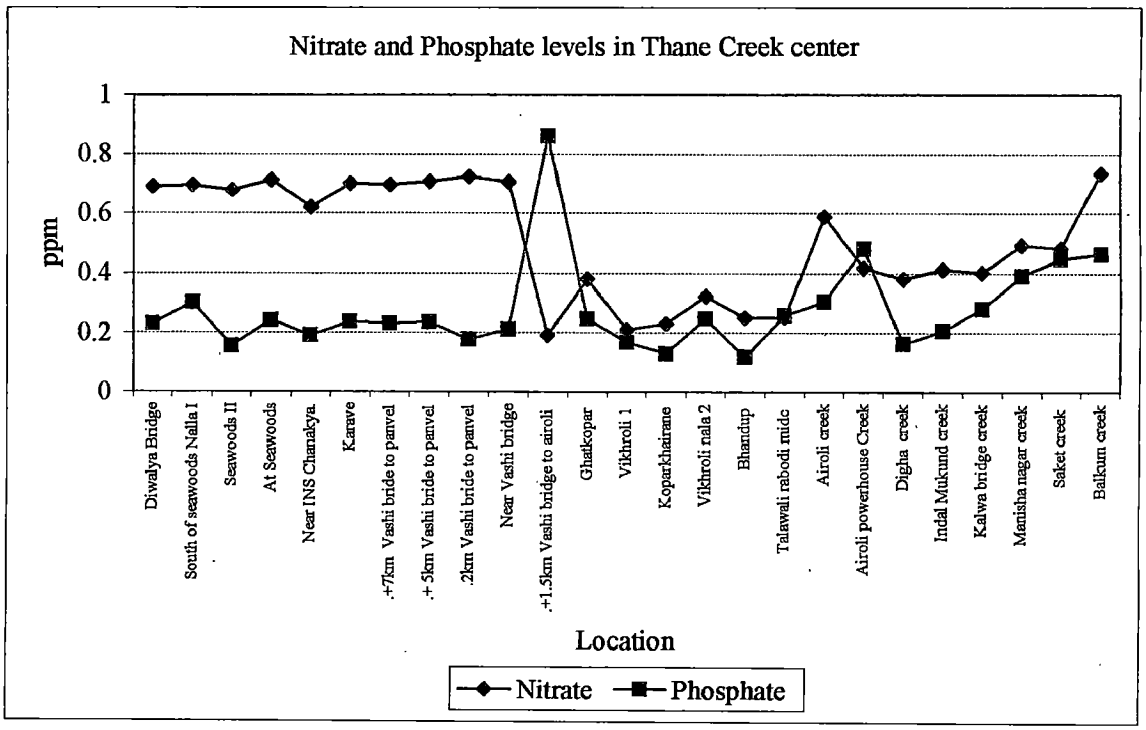



Figure2.28: Nitrates and Phosphates levels in water samples collected at the center of Thane creek

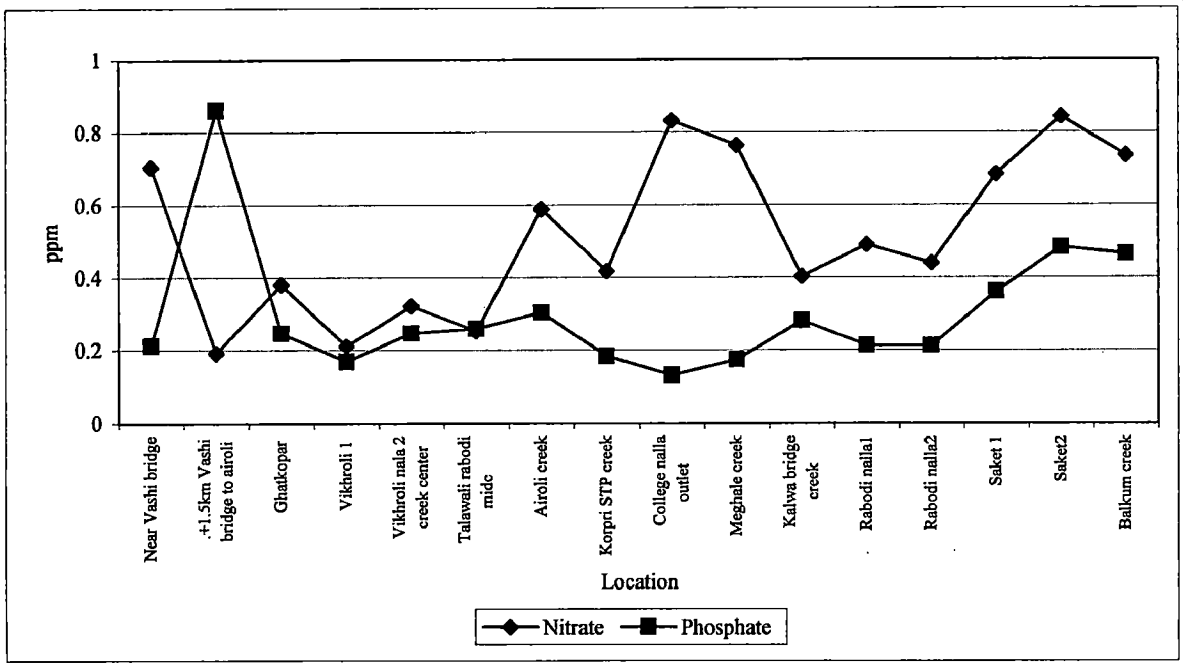



Figure 2.29. Nitrates and Phosphates levels in water samples collected at the Thane creek edge

### 2.2.2 Sediment Study

Sediments play an important role in immobilization of pollutants through their absorption by ion exchange. Sediment characteristics are considered sensitive indicators of sewage-derived pollution not only because sediments adsorb and retain pollutants, but also because of the important interaction between the sediments and the benthic invertebrates that inhabit them. Sediment studies indicate the quality of the overlaying water and are useful tool in assessment of environmental pollution. In present study 33 sediments samples from Thane creek and 10 Ulhas river estuary were collected.

The surface (10cm depth) samples were collected with the help of a scoop from different stations during low tide and further analysed for pH, organic content, nitrates, phosphates and heavy metals like zinc, chromium, cadmium and copper in TMC Pollution Control Cell laboratory.

Physico-chemical properties of sediments collected from Thane creek and Ulhas river estuary are given in Table 2.7 and Table 2.8, respectively.

Table 2.7: Physico-chemical analysis of Thane creek sediments

| Sample ID | Location | pH | Organic Content (%) | Nitrate (gm/Kg) | Phosphate (gm/Kg) | Zinc (Zn) (gm/Kg) | Chromium ($Cr^{+6}$) (gm/Kg) | Cadmium (Cd) (gm/Kg) | Copper (Cu) (gm/Kg) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Balkum Nalla | 7.9 | 20.45 | 0.079 | 0.029 | NA | NA | NA | NA |
| 2 | Saket Nalla | 8.2 | 20.47 | 0.053 | 0.035 | 0.54 | Traces | Traces | 0.07 |
| 3 | Opposite Saket | 7.9 | 18.12 | 0.063 | 0.031 | NA | NA | NA | NA |
| 4 | Rabodi Nalla 2 | 7.5 | 20.47 | 0.073 | 0.039 | 0.3 | Traces | 0.004 | 0.17 |
| 5 | Rabodi Nalla 1 | 8.7 | 19.65 | 0.068 | 0.34 | NA | NA | NA | NA |
| 6 | Nalla from backside pipeline | 8.2 | 19.03 | 0.054 | 0.03 | NA | NA | NA | NA |
| 7 | Manishanagar / Shastrinagar nalla | 8 | 18.13 | 0.042 | 0.039 | 0.59 | Traces | Traces | 0.05 |
| 8 | Meghale creek | 8.2 | 18.01 | 0.161 | 0.029 | 0.2 | 0.25 | Traces | 0.11 |
| 9 | Behind ST workshop | 7.8 | 18.19 | 0.105 | 0.009 | NA | NA | NA | NA |
| 10 | Thane college Nalla | 8.1 | 21.12 | 0.069 | 0.033 | NA | NA | NA | NA |
| 11 | Custom office nalla | 7.8 | 20.08 | 0.049 | 0.039 | 0.18 | Traces | Traces | 0.06 |
| 12 | Kopari STP outlet | 8.4 | 17.85 | 0.073 | 0.028 | 0.25 | Traces | Traces | 0.02 |
| 13 | Vitawa nalla | 8.1 | 18.29 | 0.182 | 0.028 | NA | NA | NA | NA |
| 14 | Indal Mukund nalla | 8 | 20.39 | 0.206 | 0.02 | 0.5 | 0.148 | 0.047 | 0.41 |
| 15 | Digha nalla | 8.1 | 15.30 | 0.121 | 0.03 | NA | NA | NA | NA |
| 16 | Airoli power house nalla | 8.2 | 15.20 | 0.118 | 0.021 | NA | NA | NA | NA |
| 17 | Mhada colony nalla | 8.2 | 22.94 | 0.0685 | 0.022 | 0.33 | 0.298 | 0.049 | 0.13 |
| 18 | Airoli nalla sector 17 | 8 | 19.43 | 0.113 | 0.02 | NA | NA | NA | NA |
| 19 | Airoli Nalla towards Vashi bridge | 7.8 | 15.11 | 0.153 | 0.051 | | | | |
| 20 | Talawali -Rabodi MIDC inlet | 7.6 | 15.62 | 0.085 | 0.06 | | | | |
| 21 | Bhandup Nalla | 7.6 | 16.27 | 0.17 | 0.022 | | | | |
| 22 | Ghansoli Nalla | 7.6 | 14.82 | 0.075 | 0.048 | | | | |
| 23 | Koparkhairne Nalla | 7.4 | 17.25 | 0.12 | 0.162 | | | | |
| 24 | Vikroli Nalla 1 | 7.6 | 16.81 | 0.19 | 0.021 | | | | |
| 25 | Juigaon Nalla | 7.6 | 18.25 | 0.08 | 0.089 | | | | |
| 26 | Ghatkopar nalla | 7.8 | 19.10 | 0.21 | 0.022 | | | | |
| 27 | Vikroli Nalla 2 | 7.4 | 16.32 | 0.172 | 0.031 | | | | |
| 28 | Chembur Nalla | 7.8 | 16.4 | 0.18 | 0.02 | | | | |
| 29 | Vashi Gaon nalla | 7.8 | 15.18 | 0.09 | 0.025 | | | | |
| 30 | Nerul Nalla downstream | 8.2 | 15.54 | 0.047 | 0.022 | 0.31 | 0.08 | 0.012 | 0.19 |
| 31 | Karawe | 8.1 | 11.54 | 0.06 | 0.018 | 0.28 | 0.19 | 0.041 | 0.21 |
| 32 | Seawoods Nalla | 8 | 16.04 | 0.098 | 0.024 | 0.39 | 0.21 | 0.018 | 0.1 |
| 33 | Near Uran Bridge | 8.2 | 11.26 | 0.046 | 0.019 | 0.41 | 0.234 | 0.05 | 0.08 |
| Minimum | | 7.4 | 11.26 | 0.042 | 0.009 | 0.18 | 0.08 | 0.004 | 0.02 |
| Maximum | | 8.7 | 22.94 | 0.21 | 0.34 | 0.59 | 0.298 | 0.05 | 0.41 |
| Average | | 7.9 | 17.5 | 0.1 | 0.0 | 0.4 | 0.2 | 0.032 | 0.133 |

Table 2.8 : Physico-chemical analysis of Ulhas river estuary sediments

| Sample ID | Location | pH | Organic Content (%) | Nitrate (gm/Kg) | Phosphate (gm/Kg) | Zinc (Zn) (gm/Kg) | Chromium ($Cr^{+6}$) (gm/Kg) | Cadmium (Cd) (gm/Kg) | Copper (Cu) (gm/Kg) |
|---|---|---|---|---|---|---|---|---|---|
| 34 | Airforce station Nalla | 8.1 | 14.08 | 0.078 | 0.038 | 0.047 | 0.41 | | 0.041 |
| 35 | Waghbi nalla 2 | 8 | 26.65 | 0.11 | 0.062 | 0.006 | 0.43 | | 0.043 |
| 36 | Kolshet nalla 1 | 7.9 | 26.65 | 0.183 | 0.048 | | | | |
| 37 | Versova nalla | 7.9 | 15.62 | 0.12 | 0.052 | | | | |
| 38 | Ghodbunder nalla | 8.2 | 16.18 | 0.11 | 0.04 | | | | |
| 39 | Miraroad nala1 | 7.9 | 17.10 | 0.098 | 0.038 | | | | |
| 40 | Miraroad nalla 2 | 8 | 16.20 | 0.12 | 0.052 | | | | |
| 41 | Miraroad nalla 3 | 8 | 18.56 | 0.098 | 0.061 | 0.003 | 0.2 | | 0.02 |
| 42 | Bhayandar nalla 1 | 7.7 | 17.89 | 0.12 | 0.0282 | | | | |
| 43 | Bhayandar nalla 2 | 7.7 | 17.89 | 0.153 | 0.031 | 0.016 | 0.14 | | 0.014 |
| Minimum | | 7.7 | 14.08 | 0.078 | 0.0282 | 0.003 | 0.14 | | 0.014 |
| Maximum | | 8.2 | 26.65 | 0.183 | 0.062 | 0.047 | 0.43 | | 0.043 |
| Average | | 7.9 | 18.7 | 0.1 | 0.045 | 0.018 | 0.295 | | 0.030 |

### 2.2.2.1 Organic Content

Organic content present in the sediments of Thane creek and Ulhas river estuary is show in Figure 2.30 and Figure 2.31, respectively. Spatial distribution of organic content present in the sediments of Thane creek and Ulhas river estuary is show in Figure 2.32 and Figure 2.33, respectively. The portion between Balkum to Airoli high organic content is observed as compared to rest of the part of Thane creek. This may be due to disposal of domestic sewage. In Ulhas river estuary high organic content are observed from Kolshet to Wagbil. High organic content was observed in sediment samples collected from Wagbil and Kolshet nalla at the edge of Ulhas river estuary.

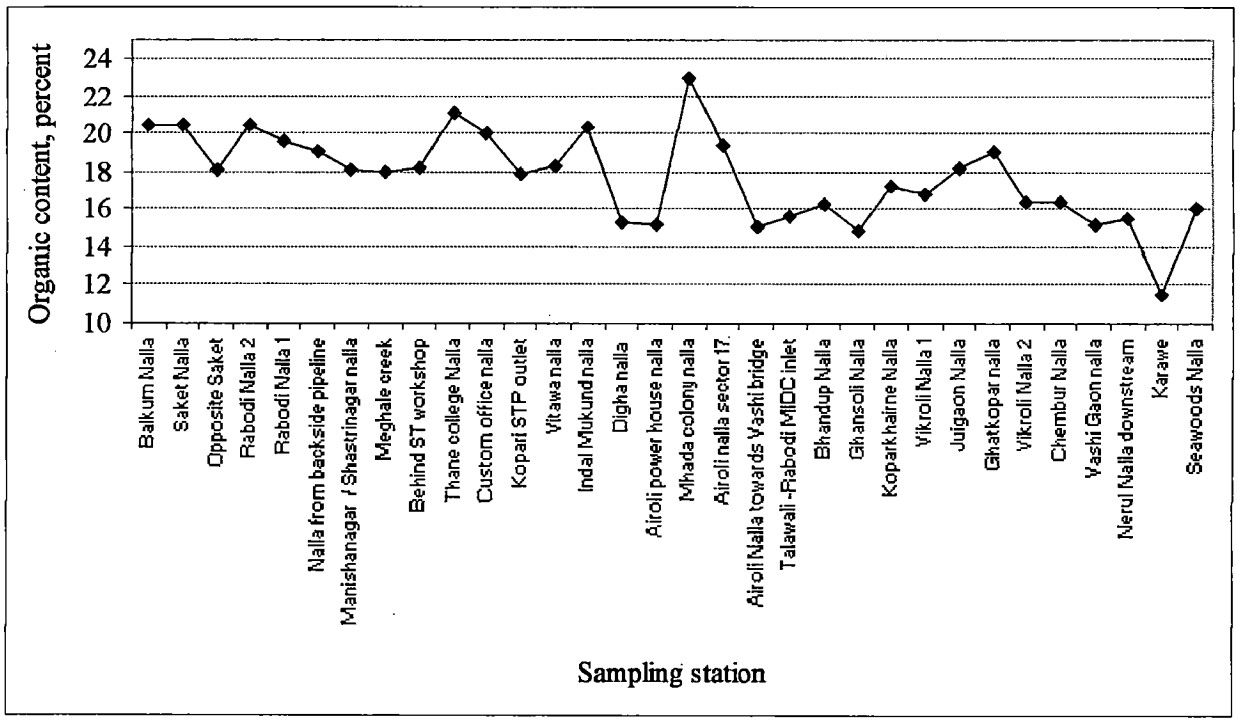



Figure 2.30: Organic content present in Sediments of Thane creek

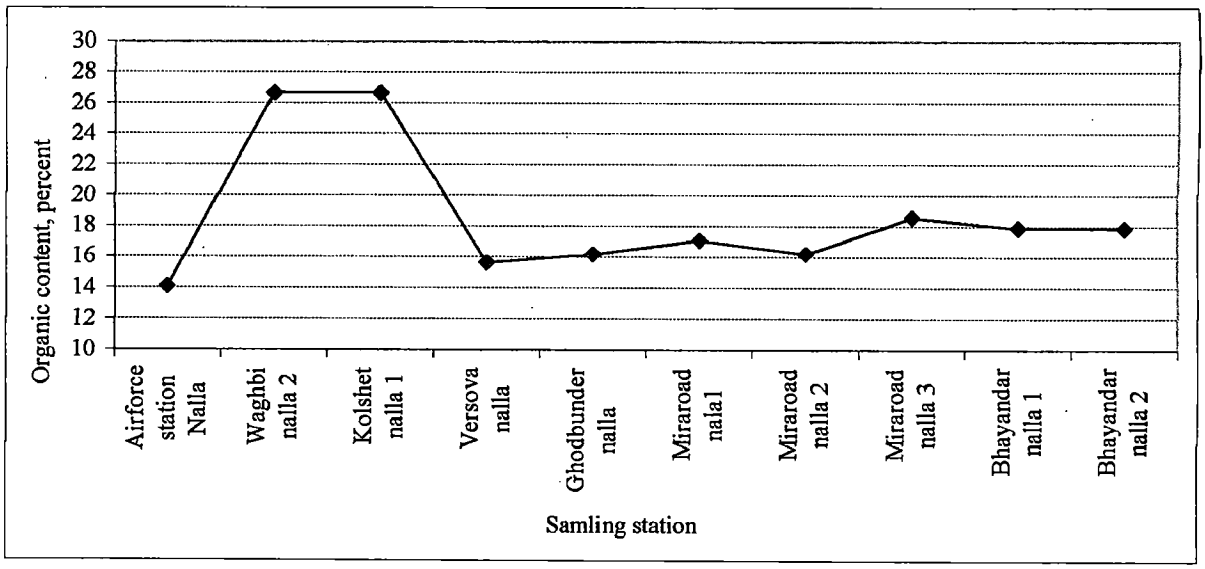



Figure 2.31: Organic content present in Sediments of Ulhas river estuary

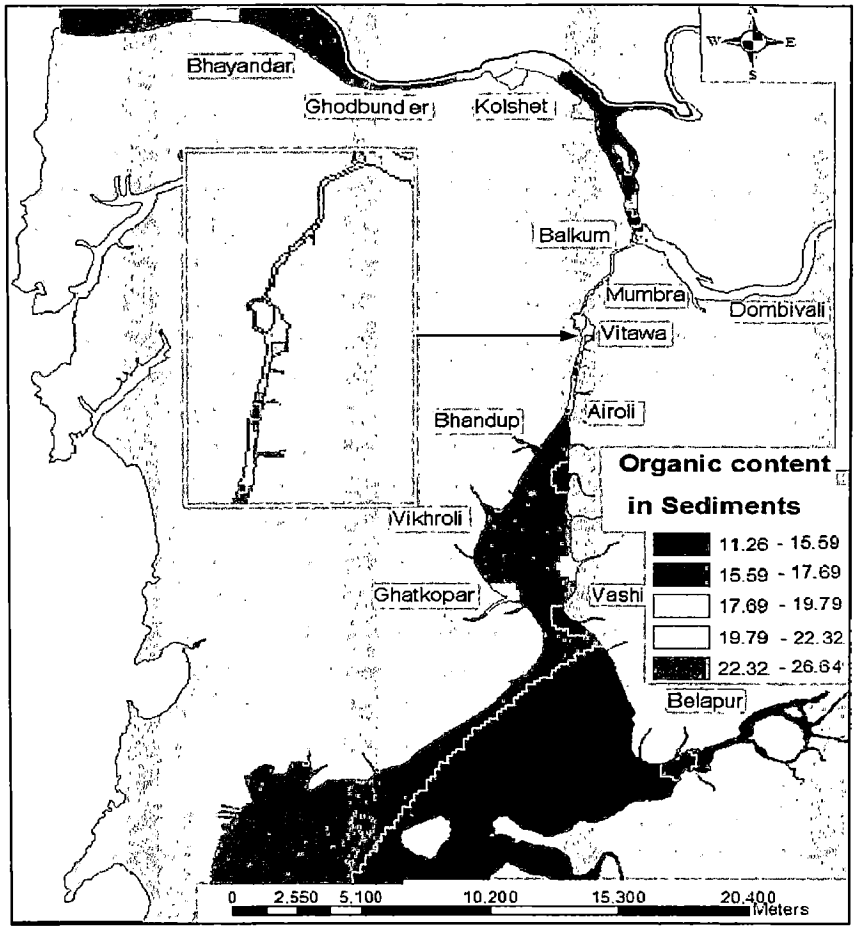



Figure 2.32: Spatial distribution of Organic content present in sediments

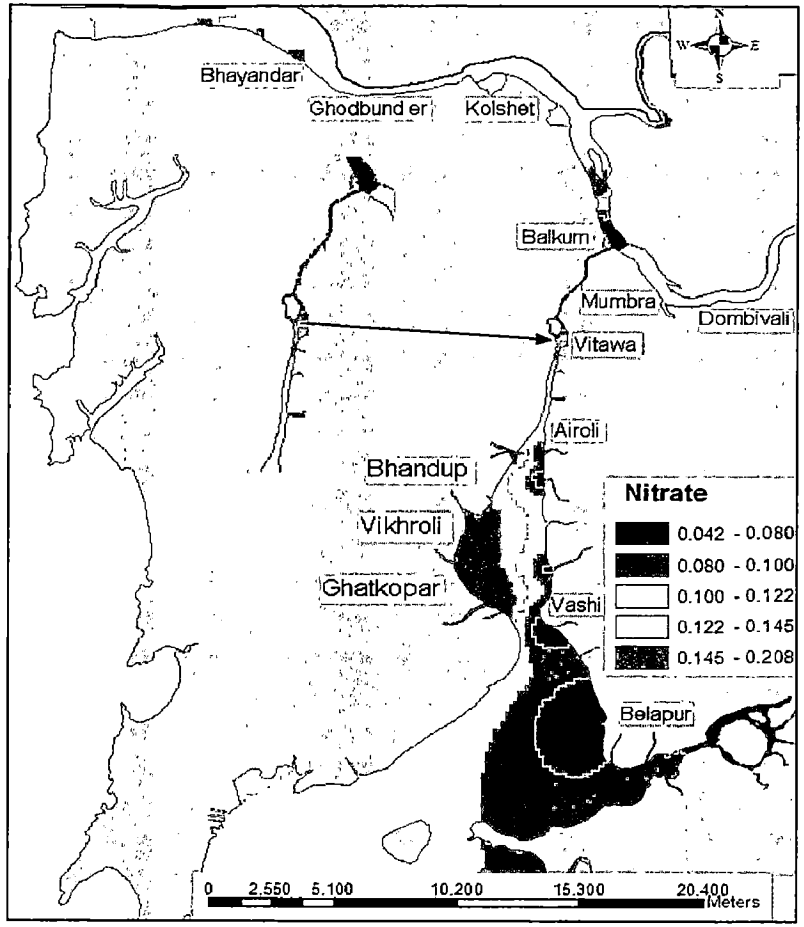



Figure 2.33: Spatial distribution of nitrates present in Sediments

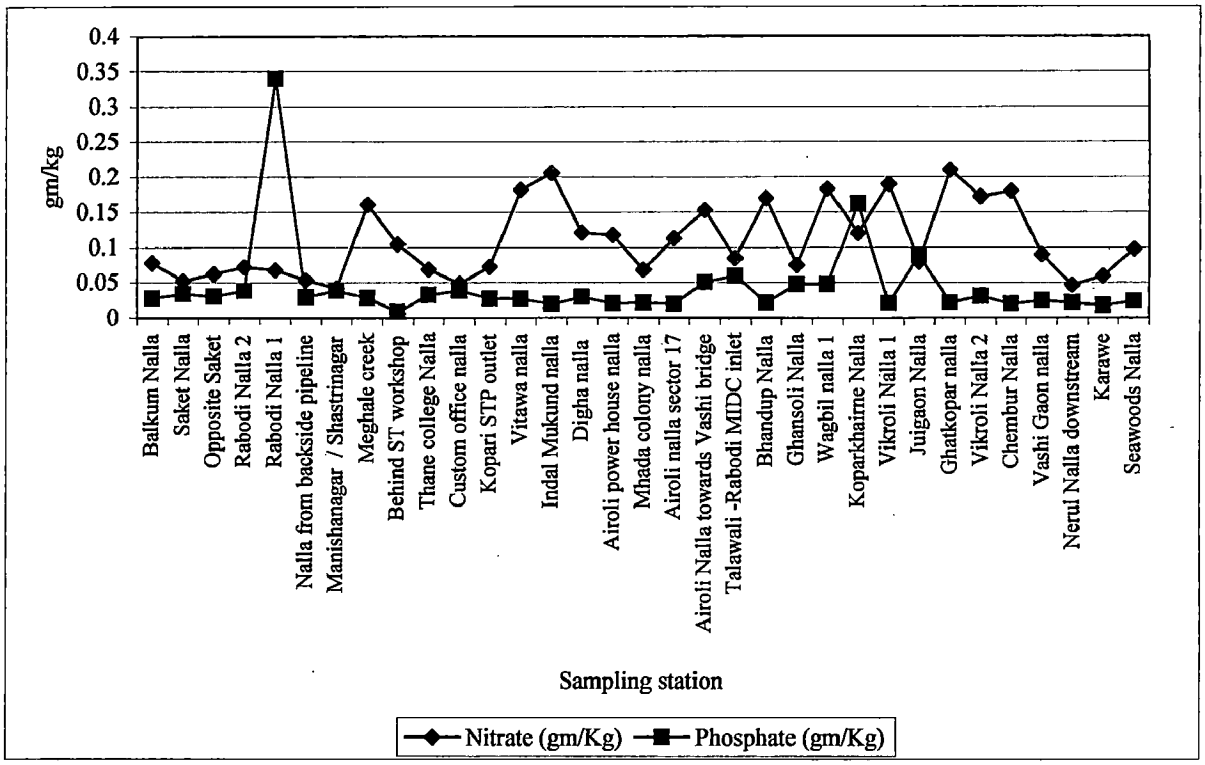



Figure 2.34: Nitrates and phosphates present in sediments of Thane creek

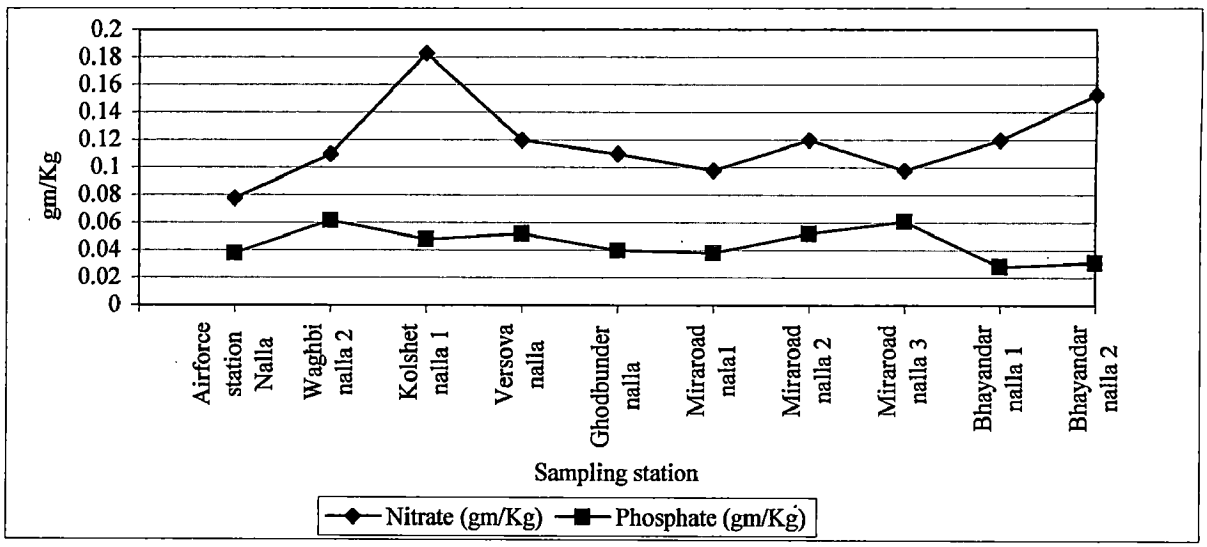



Figure 2.35: Nitrates and phosphates present in sediments of Ulhas river estuary

### 2.2.2.2 Nitrates and Phosphates

Nitrates and Phosphates present in sediments of Thane creek and Ulhas river estuary are shown in Figure 2.34 and Figure 2.35, respectively. Spatial distribution for nitrates and phosphates are shown in Figure 2.33 and 2.36, respectively. High nitrates values are observed from Bhandup to Ghatkopar for Thane creek and Bhayandar and Kolshet area for Ulhas river estuary , which are prone to the disposal of domestic waste .

High phosphates in sediments are observed at Ghatkopar , Vashi and area between Kalwa bridge to Balkum for Thane creek. High phosphate levels in sediment collected from Rabodi nalla creek edge was observed as compared to other samples collected from Thane creek.

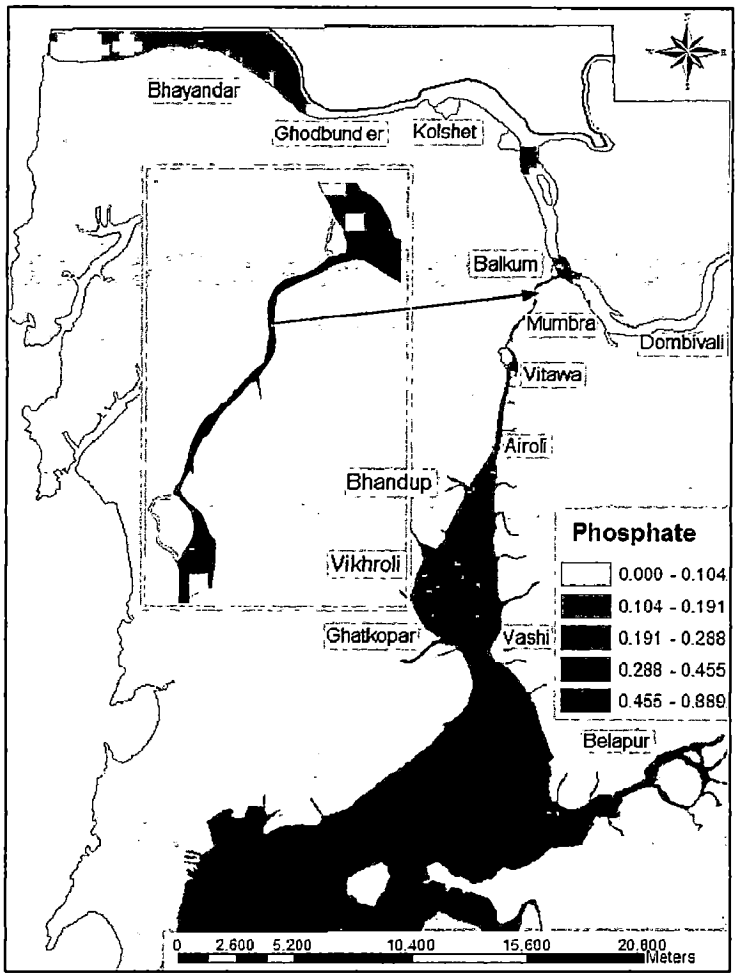



Figure 2.36: Spatial distribution of Phosphates present in sediments

### 2.2.2.3: Heavy Metals

Heavy metals viz: zinc, chromium , cadmium and copper content are traced in following location which gives an alarm that immediate conservation measures are needed

- Thane creek edge at: - Saket, Rabodi, Manishanagar, Meghale, Custom office nalla, Kopari STP outlet , Indal Mukund nalla, Mhada colony nalla , Nerul nalla, Karawe nalla, Seawoods nalla and near Uran bridge

Ulhas river estuary edge at: Airforce station nalla, Wagbil nalla, Miraroad nalla, Bhayandar nalla

Spatial distribution for Cadmium, Chromium, Zinc and Copper are depicted in Figure 2.37,2.38,2.39 and 2.40 , respectively. High Cadmium, Copper and Zinc are observed from Vikhroli towards Belapur as compared to the rest of Thane creek.

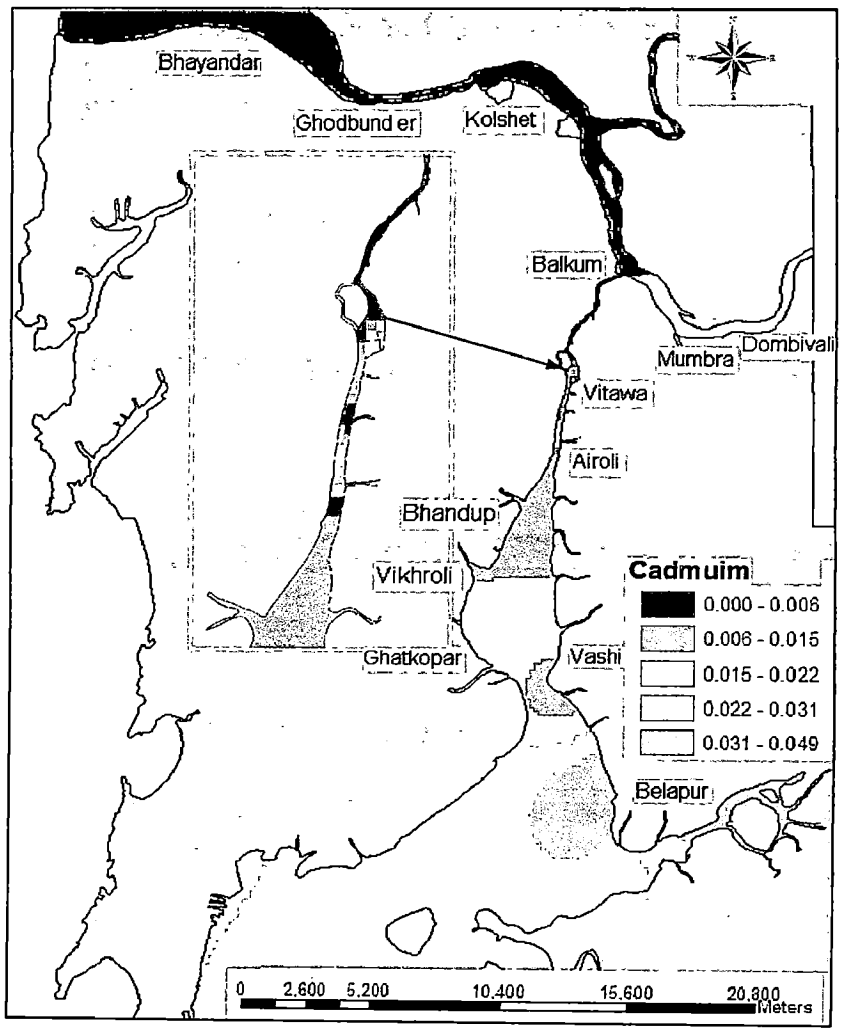



Figure 2.37: Spatial distribution of Cadmium present in sediments

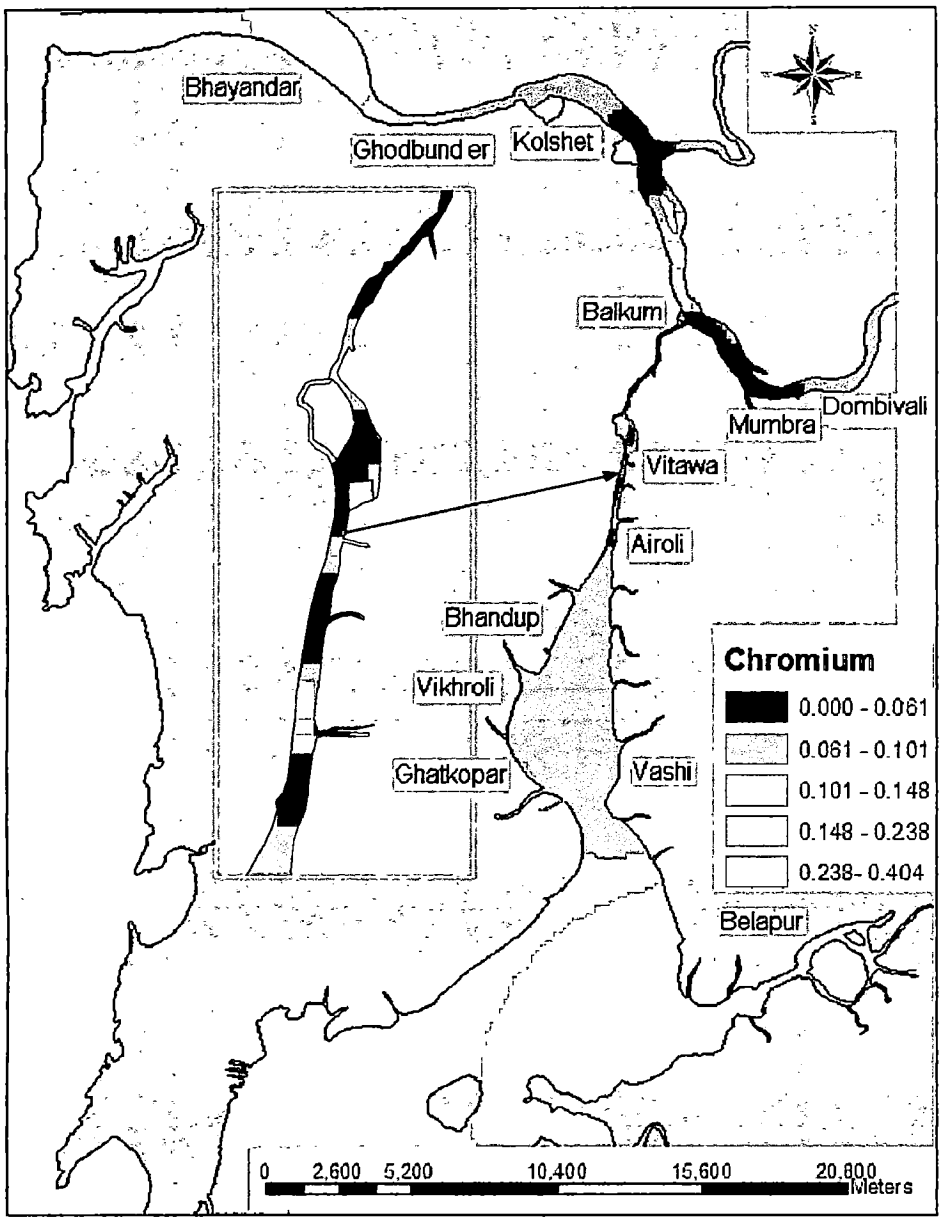



Figure 2.38: Spatial distribution of Chromium present in Sediments

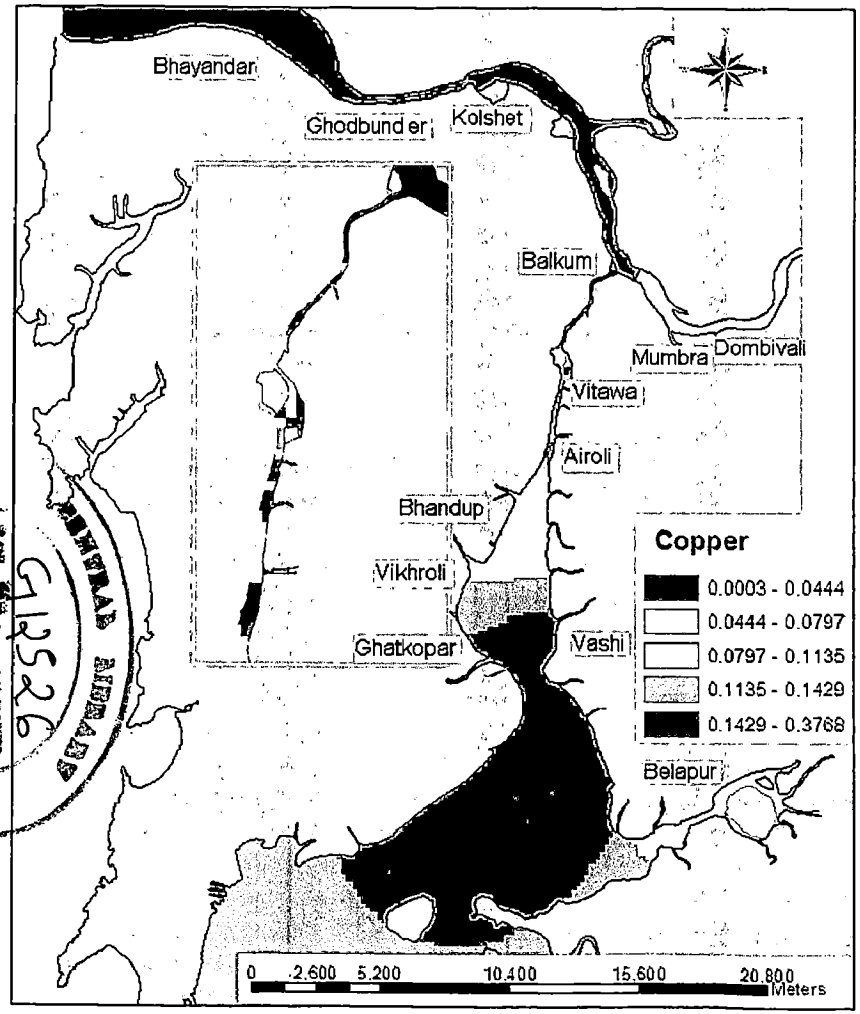



Figure 2.39: Spatial distribution of Copper present in sediments

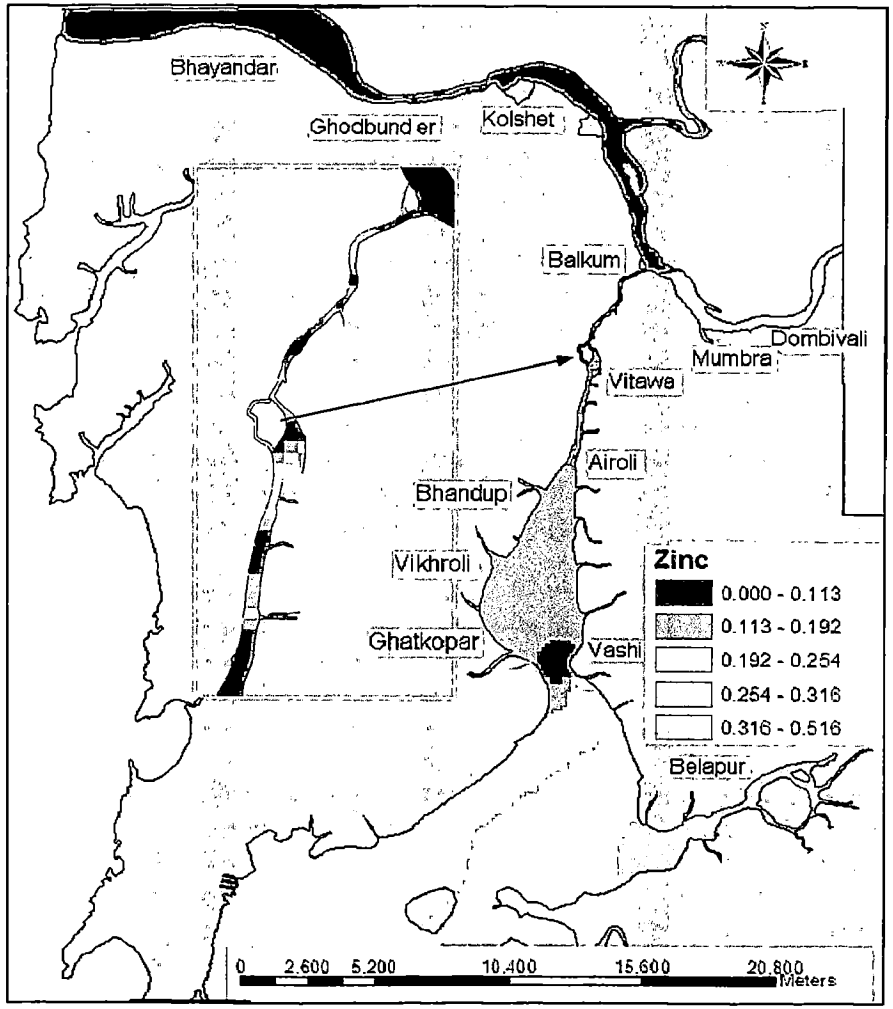



Figure 2.40: Spatial distribution of Zinc present in Sediments

## 2.3 Sources of pollution

Water pollution along the Thane creek and Ulhas river estuary is generated from various sectors as given below:

| Sector | Point Sources | Non-Point Sources |
|---|---|---|
| Domestic | o Sewered areas | o Unsewered areas<br>o Slums |
| Industrial | o Industrial effluent from large and medium industries. | o Small scale industries |
| Other sources | | o Runoff from catchment areas<br>o Tabelas (small dairy farms) |

Various anthropogenic sources of pollution are shown in Figure 2.41

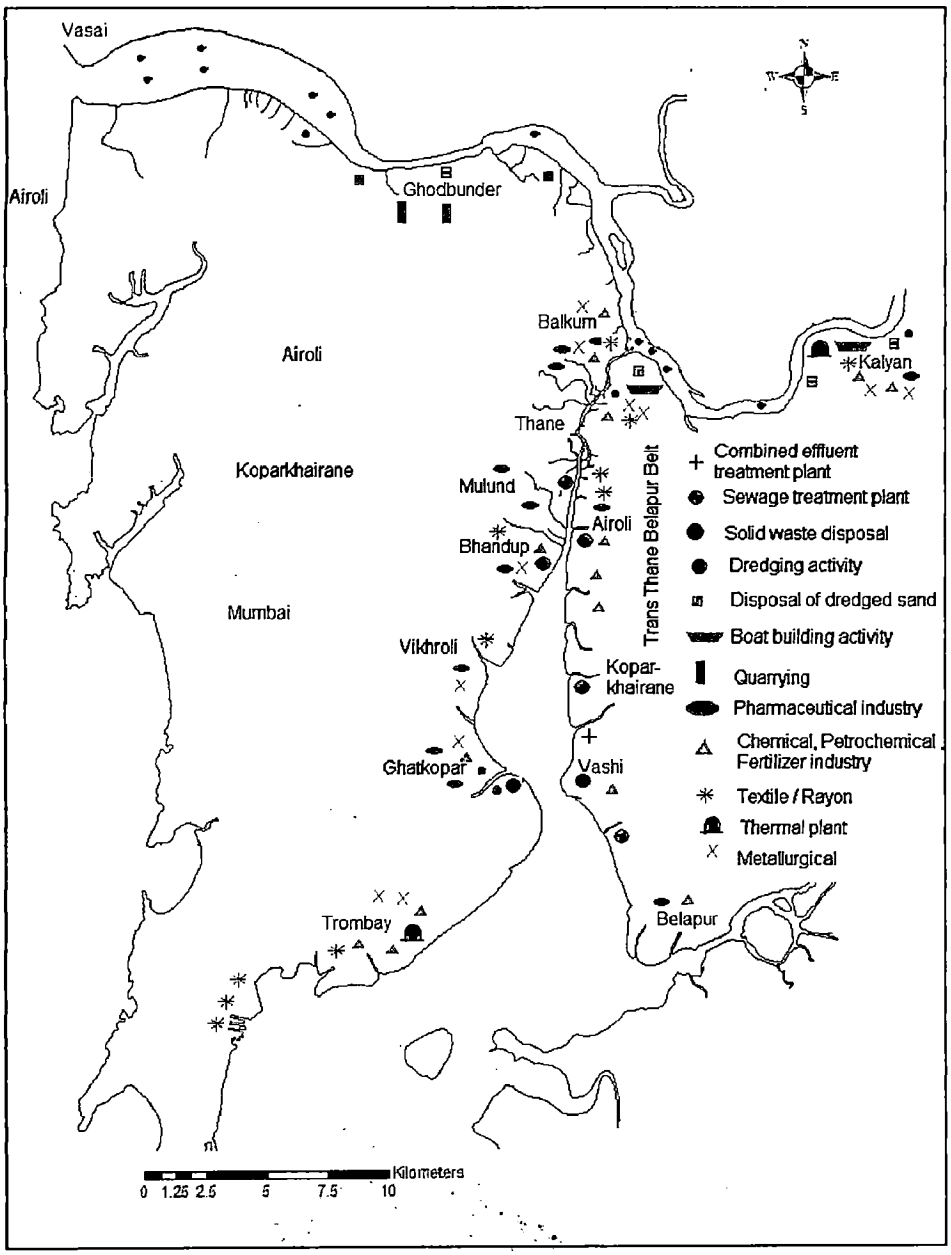



Figure 2.41 : Different sources of pollution

### 2.3.1 Waste Disposal Through Nalla

Large amount of untreated domestic waste is disposed in to Thane creek and Ulhas river estuary through nalla. Analysis of various nallas water samples in pre monsoon and post monsoon season is given in Table 2.9. It shows that majority of the nalla water sample DO is zero and all water samples BOD is more than 30 mg/lit.

Table 2.9: Analysis of nalla water sample in pre and post monsoon season in 2004

| Point | Season | PH | DO (ppm) | COD (ppm) | BOD (ppm) | Sulphate (ppm) | TSS (ppm) |
|---|---|---|---|---|---|---|---|
| Akashganga | Pre-Monsoon | 6.7 | Nil | 844 | 310 | 3.9 | 240 |
| | Post Monsoon | 6.9 | Nil | 240 | 84 | 2.1 | 110 |
| Saket | Pre-Monsoon | 7.2 | Nil | 187 | 70 | 1.3 | 110 |
| | Post Monsoon | 7.0 | 1.0 | 108 | 40 | 1.7 | 70 |
| Rabodi | Pre-Monsoon | 7.4 | Nil | 284 | 110 | 2.4 | 154 |
| | Post Monsoon | 7.6 | Nil | 220 | 74 | 2.7 | 94 |
| Balkum | Pre-Monsoon | 6.4 | Nil | 645 | 240 | 2.7 | 224 |
| | Post Monsoon | 7.1 | Nil | 212 | 80 | 2.8 | 82 |
| Castle Mill | Pre-Monsoon | 7.3 | Nil | 228 | 90 | 1.7 | 124 |
| | Post Monsoon | 7.4 | 0.7 | 117 | 45 | 1.5 | 55 |
| Kopari | Pre-Monsoon | 7.5 | 0.2 | 137 | 60 | 1.2 | 87 |
| | Post Monsoon | 7.2 | 1.1 | 97 | 40 | 1.4 | 60 |
| Kalwa Hospital | Pre-Monsoon | 8.3 | Nil | 179 | 70 | 2.1 | 90 |
| | Post Monsoon | 7.5 | 1.4 | 88 | 30 | 1.1 | 42 |
| Thane College | Pre-Monsoon | 7.9 | Nil | 185 | 65 | 2.3 | 78 |
| | Post Monsoon | 7.0 | 1.8 | 113 | 40 | 0.8 | 65 |
| Manisha Nagar | Pre-Monsoon | 7.4 | 0.5 | 124 | 50 | 1.5 | 64 |
| | Post Monsoon | 6.8 | 1.3 | 77 | 30 | 1.0 | 50 |
| Mumbra | Pre-Monsoon | 7.5 | Nil | 310 | 120 | 3.9 | 170 |
| | Post Monsoon | 7.2 | 1.0 | 184 | 70 | 2.7 | 118 |

Source: Thane Environmental status report –2005

### 2.3.2 Carcass Disposal

Illegal carcass disposal was observed in Rabodi area of Thane creek. There is no special arrangement for the carcass disposal in Thane city. Carcass is either disposed directly into creek or into nallas, which finally finds its way into creek.

### 2.3.3 Wastes from Tabelas

Tabelas (small dairy farms) are located at different locations along the nallas. Fodder waste and gobar from the Tabelas are directly disposed into nalla, which finally finds its way into Thane creek and Ulhas river estuary. Draining of cattle manure involves large quantity of water, which is derived from bore wells. This practice also makes an adverse impact on the ground water table in the respective zones. Maharashtra Pollution Control Board has issued a circular regarding the guidance for setting up tabelas, it is not yet implemented.

# CHAPTER 3
# ECOLOGICAL ASPECTS

*"Restoration ecology is experimental science, a science of love and altruism. In its attempts to reverse the processes of ecosystem degradation it runs exactly counter to the market system, to land speculation, to the whole cultural attitude of regarding the Earth as commodity rather than community. It is a soft-souled science."--- Stephanie Mills*

*Estuaries benefit from a diversity of producer types ' programmed' for virtually year around photosynthesis.* Estuaries are good example of a coupled system that achieves a good balance between physical and biotic components, and thereby a high rate of biological productivity. Estuaries often have all three types of producers, namely, microphytes, benthic microphytes and phytoplankton. Major life forms of autotrophs are often intermixed in an estuary and fill varying niches, maintaining a high gross production rate: phytoplankton; benthic microflora; and macroflora. Organisms have exploited many adaptations to cope with tidal cycles. For proper conservation it is necessary to study the all life forms of estuary and creek along with mangroves. Presently estuary and creek are suffering from 'tragedy of commons' (Hardin, 1968).

Water analysis illustrates the metabolic processes taking place in water and also indicates the pollution status of the ecosystem. The only drawback of physico-chemical study is that it indicates about the happenings at the time of collection and it does reflect the impact of pollutants on creek /estuary ecosystem. Hence biological criteria are considered important components of water quality standards programmes because they are direct measures of the condition of the biota (Dauer ,1993).

Studies of the benthic macrofaunal community are often used to indicate environmental health because benthic animals are relatively sedentary (cannot avoid deteriorating water/sediment quality conditions) and have relatively long life spans (indicate and integrate water/sediment quality conditions). Different species that exhibit different tolerances to stress and have an important role in cycling nutrients and other chemicals between the sediments and the water column (Dauer ,1993).

Weisber (1997) reported that exposure to hypoxia is typically greatest in near-bottom waters and anthropogenic contaminants often accumulate in sediments where benthos lives. Benthic organisms generally have limited mobility and cannot avoid these adverse conditions and this immobility is advantageous in environmental assessments

because, unlike most pelagic fauna, benthic assemblages reflect local environmental conditions.

### 3.1 Plankton

Phytoplankton acts as primary producers, trapping the solar energy. They make this energy available to the primary consumers, the zooplankton and also the consumers at other higher trophic levels such as fisheries, etc. The plankton mainly supports the pelagic food chain and fishery and also plays an indirect role in supporting the detritus food chain because many of them are short lived and their bodies settle down to form detritus (Athalye, 2003). Pollution due to anthroponic activities affects the plankton's health and hence it is important to study them.

Phytoplankton samples for the study carried out by Athalye were collected from intertidal region. The collected samples were fixed immediately using Lugol's iodine and brought to the laboratory.

Athalye (2003) studied intertidal macrobenthos flora and fishery of Ulhas river estuary and Thane creek in 2001-02. 37 types of plankton were observed in Ulhas river estuary and Thane creek belonging to following classes

- Bacillariophyceae 22 types
- Chlorophyceae 8 types
- Cyanophyceae 6 types
- Xanthophyceae 1 type

Month wise overall average density (no/l) of different phytoplankton species in Thane creek and Ulhas river estuary is given in Table 3.1 and 3.2 respectively.

The phytoplankton density in general was higher in Thane creek (average 25155726/l) as compared to Ulhas river estuary (average 22602107/l). The species number reduced from the riverine zone to the seaward zone. 12 genera from Thane creek and 20 from Ulhas river estuary show bloom conditions. Both the ecosystems have shown similar species diversity. Zone with moderate influence of marine water had the maximum diversity.

The maximum types in Ulhas river estuary were observed in November 2002 with further decreasing order as January 2002 > December 2002 > April 2002. In Thane creek the maximum species number was recorded in November 2002 followed by October 2002, and September 2002. The lowest species number in both ecosystems was observed in June i.e. onset of monsoon. Thus the monsoon fresh water influx, by lowering the salinity,

reduced the diversity. Maximum diversity was observed in November and late post monsoon period. Probably this period being of missing salinity that allowed growth of the freshwater as well as the marine water species; with growing salinity then some species got eliminated to reduce the number in summer (Athalye ,2003).

In both the ecosystems *Thalassiosira spp.* was the most successful phytoplankton. Dominant phytoplankton observed as under :

- Thane creek *Melosira spp. > Thalassiosira spp. > Navicula spp*
- Ulhas river estuary *Cyclotella spp.> Thalassiosira spp. > Asterionella spp.*

### 3.2 Zooplankton

Zooplankton act as indicators of water quality and pollution. Study of zooplankton is necessary as they for a vita link in pelagic food chain. Crustaceans, mollusks and fishes feed on zooplanktons. Fertility of the water mass is known by the abundance of zooplanktons.

Zooplankton samples for the study carried out by Athalye were collected during low tide. The net was held at 1m depth below the water surface and toed for 5 minutes. The volume of water filters was calculated considering the area of the mouth of the net and current speed. The samples collected were preserved in known volume of 10 percent formalin (made in filtered creek /estuarine water). Studying the 1 ml sub sample under trinocular microscope with built in illumination facility identified different types of zooplankton.

Monthwise overall average density (no/$m^3$) of different zooplankton species in Thane Creek and Ulhas river estuary studied by Athalye (2003) is given in Table 3.3 and 3.4, respectively. Total monthly zooplankton density ranges as under

- Thane creek 23no/ $m^3$ to 9350 no/$m^3$ (in April 2002) (average 1018 no / $m^3$)
- Ulhas river estuary 13 no/$m^3$ to 3055 no/$m^3$

Goldin (2001) reported average zooplankton density in range 902 no/$m^3$ to 492100 no/$m^3$ and overall average 27917 no/$m^3$ in Thane creek in his study during 1999-2000. As compared to this study the present averages are almost $1/27^{th}$ indicating significant reduction in zooplankton density as under in Thane creek as under :

| | |
|---|---|
| 1977 | 28nos/$m^3$ |
| 1982 | 268 nos/$m^3$ |
| 1990 | 4850 nos/$m^3$ |
| 1999-2000 | 27917 nos/$m^3$ |

As the nutrient levels in the water and sediments are quite high, they must not be limiting the phytoplankton growth. This lead to a conclusion that probably the reduction in plankton density (both phyto and zooplankton) has occurred due to some chemical pollution in the creek Athalye (2003).

In Ulhas river estuary increase in zooplankton density was observed as compared to the average 127no/$m^3$ observed by Mishra (2002) and decrease as compared to average 18969no/$m^3$ reported by Mustafa (1999). In Ulhas river estuary the zooplankton showed fluctuating trend when compared to past, suggesting organic pollution within limits, which has not crossed the tolerance limit of the ecosystem probably due to higher water mass and regular dredging activity. However, it is probable that the sand dredging activity is adversely affecting zooplankton density by making the water more turbid.

Total 10 groups and 26 types of zooplankton were recorded from Thane creek and Ulhas river estuary. Arthropods were the most dominant group in both. Anelids (especially Polychate) and mollusca were significantly higher in Thane creek owing probably to organic pollution.

In general zooplankton density in Ulhas river estuary and Thane creek was lower as compared to most Indian estuaries and creeks. During pre monsoon months (February to June) the zooplankton growth was maximum in both the ecosystem.

**3.3 Macrobenthos**

Benthic studies can indicate the magnitude as well as spatial and temporal distribution of pollution in the environment Hartley (1982). Macrobenthos make better pollution indicators than the small species Odum (1971).The study of marine communities helps in assessment of ecological and environment status. Benthic organisms are useful indicators of environmental status as they respond to anthroponic disturbances. Macrobenthos can be used to understand the dominance of certain ecological factors. Several anthropogenic activities promote the organic matter accumulation in bottom sediments. Muniz (2005) reported than the organic matter content in sediments is believes to play an important role on benthic communities, among other important characteristics influencing their trophic structure and biomass.

**3.3.1 Past studies**

The average Hg content of 0.73 ppm in Zooplankton of Thane creek was reported by Zingde(1981) and observed bioaccumulation in zooplankton and benthos.

Athalye (2003) compared 2001-2002 study data with the past data and following significant differences was recorded.

- The density in both the ecosystem has increased but the biomass shows decreased, suggesting increase in the organisms of small size
- The mud burrowing animal group polychates was once the dominant group in Thane creek that is being replaced by surface dwelling gastropods. This indicates that organic pollution in Thane creek has grown so much that the sediments are becoming anoxic due to which burrowing organisms are reducing and surface dwellers are increasing.
- The types of polychates and their distribution in Thane creek and Ulhas river estuary are changing due to increased organic pollution, chemical pollution and changed sediment texture. Polychates like L. *ounaryensis*, L. *indica*, *and Polydora tentaculata* are getting eliminated from Thane creek, whereas highly pollution tolerant *C. burmensis*, *Dendroneris spp.*, *L. ouanaryensis*, *Nephythys spp.*, *Sigambra bassi* are getting introduced in the estuary. These changes indicate that organic pollution in Ulhas river estuary is increasing and in Thane creek has crossed its limit.
- The gastropod population has declined in Ulhas river estuary and increased in Thane creek. However the gastropod type *Auricula elongata, Auricula spp.*, *Drupa spp.*, *Fairbankia bombayana*, *Littorina ventricos*, *Melanoides tuberculata*, *Dostia violaceae* (a organic pollution tolerant species), *Neretina spp.*, *Turbinicola nux*, which were recorded in the past, were not reported in 2002. *Cerethideospsilla spp.* seems to develop resistance to organic pollution.
- Bivalve population has declined in Ulhas river estuary and in Thane creek small sized bivalve types have increased. There is significant reduction in the density of edible bivalves *Cardium spp.* (blood clam) and *Katelysia spp.*
- Both ecosystems have shown dominance of pollution tolerant animal group but at locations that had proximity with major sewage reaches, their number dwindled indicating deterioration beyond their tolerance.
- The macrobenthos in general indicate growing pollution in Ulhas river estuary and pollution level crossing the tolerance limits in Thane creek.
- Metals are reported in plankton, macrobenthos –Gastropods, Bivalves, polychates and other macro benthos of Thane creek and Ulhas river estuary Table (3.5).

### 3.3.2 Benthic community health status

The analysis of changes in benthic communities, using various methods has become an important tool in assessment and monitoring of the biological effects of coastal pollution.

Diversity is a measure of the complexity of the community structure and is increased or decreased by physical, chemical and biological factors. High diversity is generally good, as it indicates a balanced, stable and responsive community. Low diversity occurs in an area where the community is dominated by few species, such as in a stressed area of high pollution, large and frequent disturbances or anoxic sediments.

Diversity indices provide a summary statistic of the diversity of a community. A community that has more species will have a greater diversity index than a community of similar evenness with fewer species. A community with greater evenness will also have a larger diversity index than a community of the same richness with lower evenness. Since diversity entails both richness and evenness, it is possible that one community is richer, whereas the other community is more even. Many diversity indices exist because information on richness and evenness can be combined in many different ways. Some indices are more influenced by evenness whereas others are more influenced by richness.

The benthic data of Thane creek and Ulhas river estuary given in Table 3.6 and 3.7, respectively are compared for various index. Various index for Thane creek and Ulhas river estuary are calculated and given in Table 3.8 and 3.9, respectively and depicted in Figure 3.1 and Figure 3.2.

#### 3.3.2.1 Shannon-Wiener Diversity Index

Many scientists in community ecology utilize a diversity index based on the Shannon Wiener diversity index, which was developed from the field of information theory. This, function describes the average degree of uncertainty of occurrence of a particular symbol at a certain point in a message, and consequently, the amount of information conveyed by each occurrence. As a diversity index for biotic communities, the function describes the average degree of uncertainty of predicting the species of a given individual picked at random from the community. This uncertainty increases both as the number of species increases, and as the individuals are distributed more and more equitably among species present (greater evenness).

The general formula for this index is:

$D_{SW}=\log N-[(1/N)\sum (ni (\log ni)]$

$D_{SW}$ Shannon-Wiener Diversity Index

N =total number of individuals of all species

ni = number of individuals in the i-th species

Index values ranges from 0.21 to 0.67 for Thane creek and 0.34 to 0.72 for Ulhas river estuary.

**3.3.2.2 Simpson's Diversity Index**

Simpson's diversity index (D) is a simple mathematical measure that characterizes species diversity in a community. Simpson's Index measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

$D=1-\lambda$

$= 1- [\sum ni (ni-1)/N(N-1)]$

D = diversity index

N =total number of individuals of all species

ni = number of individuals in the i-th species

Index values ranges from 0.24 to 0.76 for Thane creek and 0.36 to 0.74 for Ulhas river estuary.

**3.3.2.3 Pielou's evenness index**

$J= D_{SW} / \log S$

J = Pielou's evenness index

$D_{SW}$ = Shannon-Wiener Diversity Index

S =Number of species

Index values ranges from 0.04 to 0.20 for Thane creek and 0.09 to 0.25 for Ulhas river estuary.

**3.3.2.4 Gleson's Index**

D=S/LnN

D = Gleson's Index

S = Number of species

N = total number of individuals of all species

Index values ranges from 0.66 to 1.32 for Thane creek and 0.63 to 1.17 for Ulhas river estuary.

**3.3.2.5 Margalef's index**

Margalef's index calculates the number of species relative to the number of individuals in the sample, which reduces sample size bias.

$d = (S-1)/ \log N$

d = Margalef's index

S = Number of species

N = total number of individuals of all species

Margalef's Index values ranges from 1.29 to 2.70 for Thane creek and 1.21 to 2.36 for Ulhas river estuary.

Figure 3.1 and Figure 3.2 shows that Shannon-Wiener, Simpson's diversity and Pielou evenness index follow similar trends. Gleson's Index & Margalef's index shows similar trends. More index values represents greater evenness in sample. More index values represent community containing more species and vice versa. Lower index values are observed at Vitawa, Mulund / Bhandup and Talawali locations, where pollution load is high.

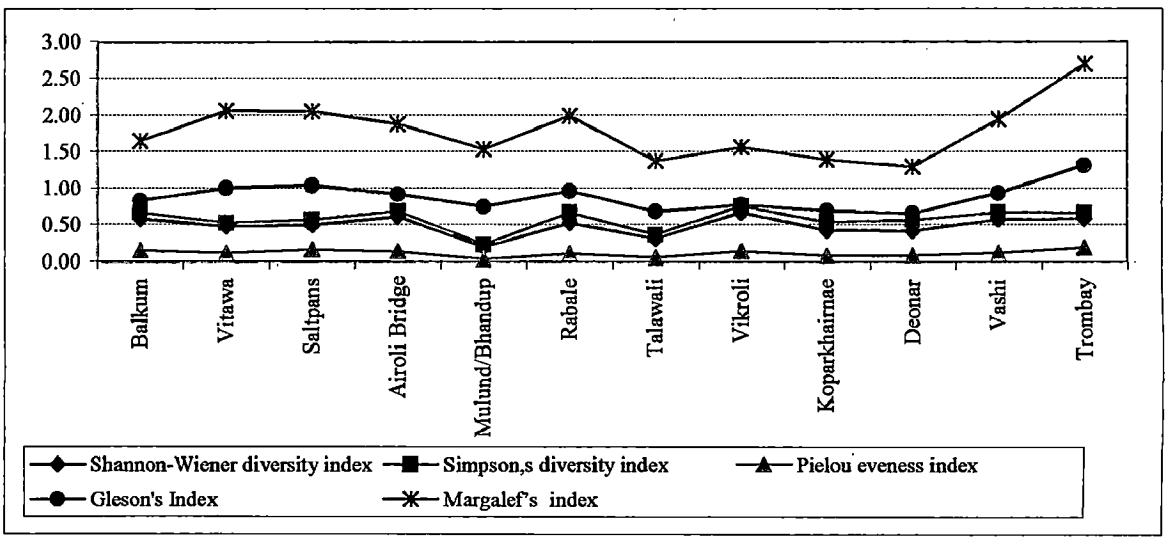



Figure 3.1 Shannon-Wiener, Simpson's diversity, Pielou evenness index, Gleson's Index & Margalef's index for Thane Creek

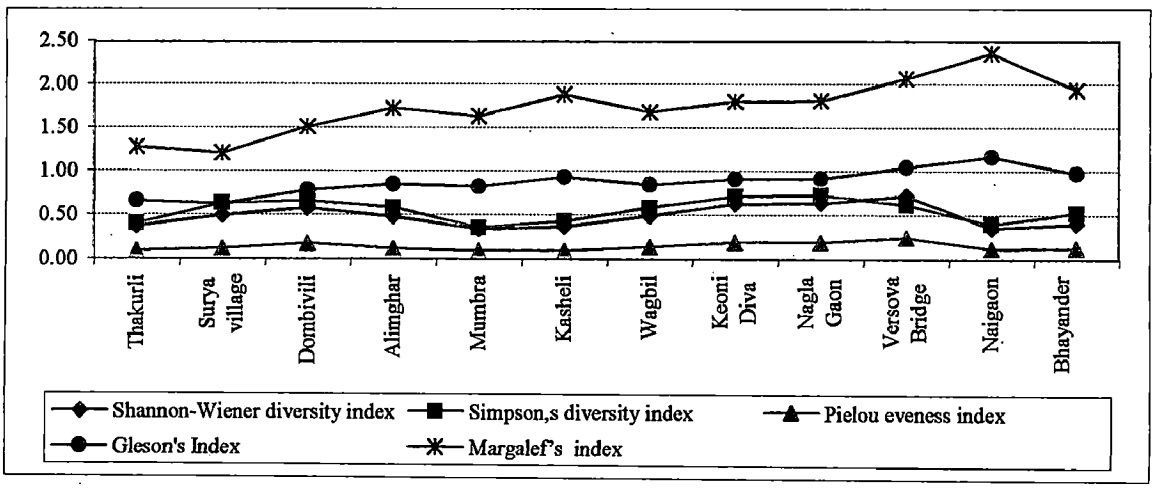



Figure 3. 2 Shannon-Wiener, Simpson's diversity, Pielou evenness index & Gleson's Index & Margalef's index for Ulhas River Estuary

### 3.3.2.6 Dominance of different macrobenthos

Dominance of different macrobenthos of Thane creek and Ulhas river estuary are shown in Figure 3.3 and Figure 3.4, respectively.

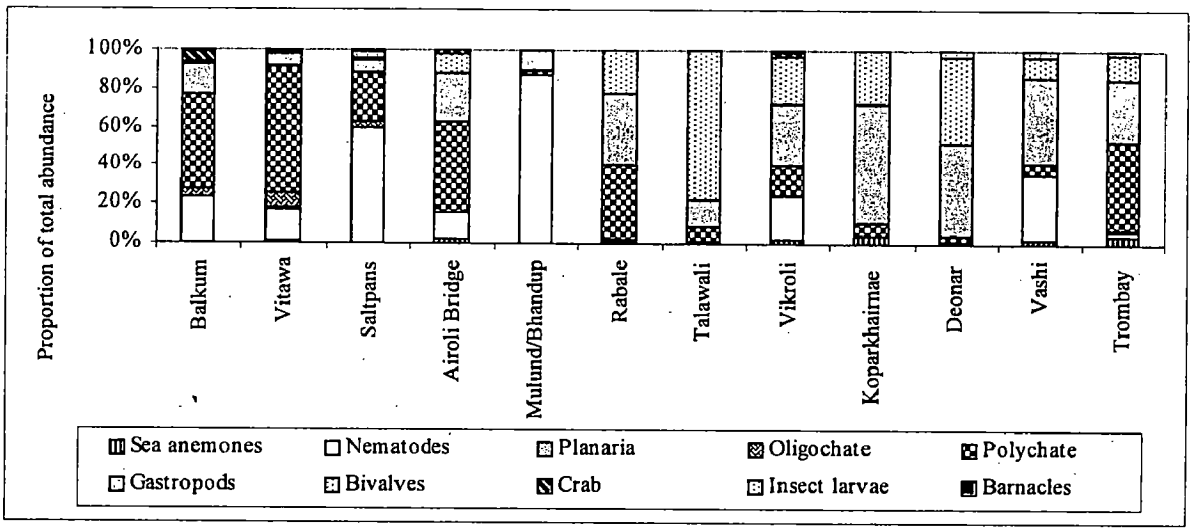



Fig. 3.3 Dominance of different macrobenthos species in Thane creek

Thane creek:

Nematodes are dominant at Mulund /Bhandup, Saltpans indicating that it is heavily polluted. Polychate are dominant at Balkum, Vitawa, Saltpans, Airoli bridge, Rabale, Trombay, indicates high organic pollution. Oligochate are the indicators of organic pollution, which are present at Balkum, Vitawa, and Saltpans. Bivalves are dominant at Talawali, which indicates less pollution, as they are sensitive to organic pollution.

Ulhas river estuary:

Polychate are dominant at Thakurli, Dombivali, Mumbra, Wagbil Versova bridge, and Naigaon which indicate the high organic pollution. Oligochate are the indicators of organic pollution, which are present at Thakurli, Surya village, Dombivali, Mumbra, Wagbil Versova bridge, and Naigaon.

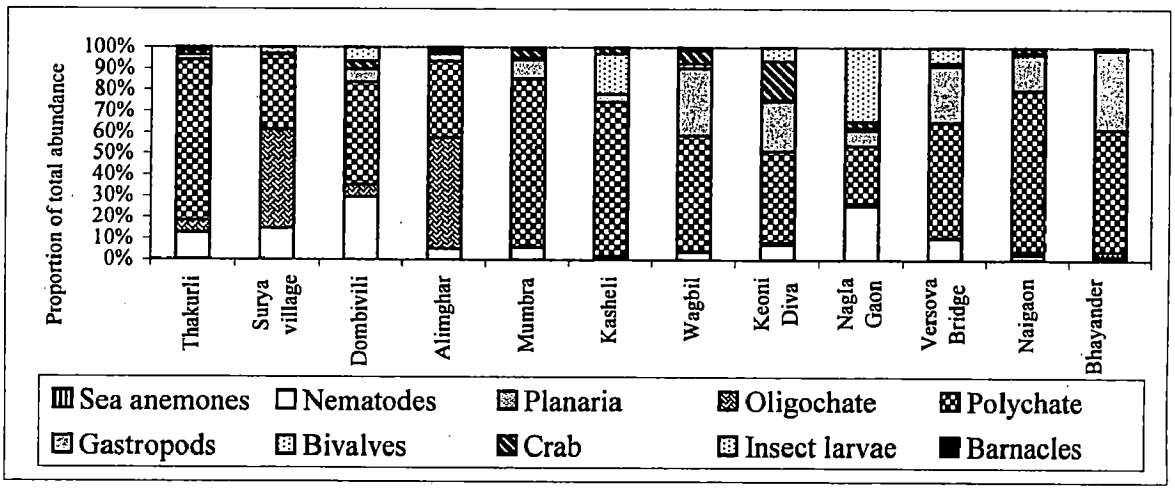



Figure 3.4 Dominance of different macrobenthos species in Ulhas river estuary

### 3.3.2.7 ANZI's Marine Biotic Index

Borja (2000) developed ANZI's Marine Biotic Index (AMBI) (a type saprobity index ) that assess the response of soft bottom communities to natural and man-induced changes to the environment, integrating long-term environmental conditions. For the development of the AMBI, the soft bottom macrofauna is divided into five groups according to their sensitivity to an increasing stress:

Group I(GI) : sensitive to pollution

Group II (GII) : indifferent to pollution

Group III (GIII) : tolerant to organic pollution

Group IV (GIV) : opportunistic of second order

Group V (GV) : opportunistic of first order

Biotic Coefficient= {(0x % GI) + (0x % GII)+ (0x % GIII)+ (0x % GIV)+ (0x % GV)}/100

Summary of the biotic coefficient and biotic index (Borja ,2000)

| Site pollution classification | Biotic coefficient | Biotic index | Dominating ecological group | Benthic community health |
|---|---|---|---|---|
| Unpolluted | 0.0<BC≤ 0.2 | 0 | I | Normal |
| Unpolluted | 0.2<BC≤ 1.2 | 1 | | Impoverished |
| Slightly polluted | 1.2<BC≤ 3.3 | 2 | III | Unbalanced |
| Meanly polluted | 3.3<BC≤ 4.3 | 3 | | Transitional to pollution |
| Meanly polluted | 4.5<BC≤ 5.0 | 4 | IV-V | Polluted |
| Heavily polluted | 5.0<BC≤ 5.5 | 5 | | Transitional to heavy pollution |
| Heavily polluted | 5.5<BC≤ 6.0 | 6 | V | Heavy polluted |
| Extremely polluted | Azonic | 7 | Azonic | Azonic |

Biotic community health status of Thane creek and Ulhas river estuary is given in Table 3.10 and Table 3.11, respectively and plotted in Figure 3.5 and Figure 3.6, respectively. It has shown similar trend as that of water quality. Balkum, Vitawa, Salt pans, Airoli bridge and Mulund/ Bhandup creek areas are heavily polluted due to ingress of untreated domestic waste and DO levels are very low. Benthic health status of Balkum and Airoli bridge is transitional to pollution. Balkum and Saltpan area, benthic health is polluted. Mulund /Bhandup area shows that it is transitional to heavy pollution. Rest portion of the creek the benthic community health status is unbalance.

For Ulhas river estuary Thakurli and Dombivali benthic community health is polluted. Surya village, Alimaghar, Mumbra, Kausa, Wagbil, Versova village, Versova bridge, Naigaon and Bhayandar portion of creek is transitional to pollution. Whereas at Nagla Gaon benthic community health is unbalanced.

Benthic community health status gives an alarm that immediate conservation measures are required for Thane creek and Ulhas river estuary to prevent its further degradation.

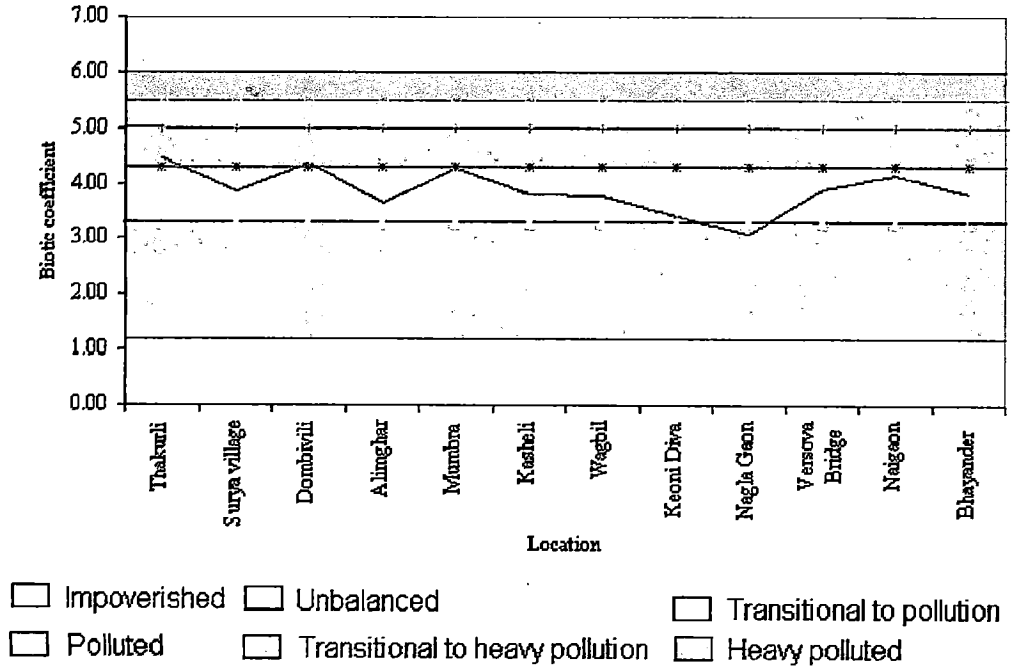



Figure 3.5. Benthic community health status of Ulhas river estuary

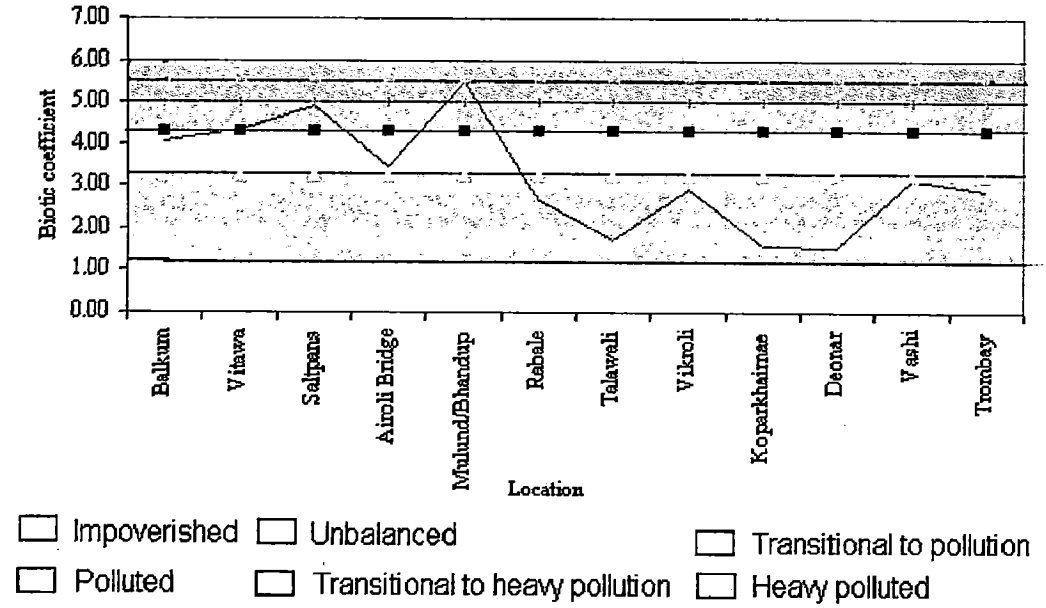



Figure 3.6. Benthic community health status of Thane creek

Effects on pollution on the benthic community is represented in better manner in by ANZI's Marine Biotic Index than other index studied as heath status can be classified into impoverished, unbalanced, transitional to pollution, polluted, transitional to heavy pollution and heavy polluted.

Limitation of ANZI's Marine Biotic Index is that it does not reflect the species diversity and evenness. Whereas Shannon-Wiener index, Simpson's diversity index, Pielou evenness index, Gleson's Index & Margalef's, represents species diversity and evenness. Hence for better understanding and planning the conservation measure it is advisable to study both diversity and saprobity index.

### 3.4 Fishery

Zone wise distribution of finfish fauna of Ulhas river estuary and Thane creek in given in Table 3.12 and depicted in Figure 3.7 and Figure 3.8, respectively. Total 61 types belonging to 23 families were recorded of which 47 types were recorded in Ulhas river estuary and 55 types in Thane creek (Athalye,2003).The difference in number could mainly due to brackish water condition in Ulhas river estuary as compared to dominance of sea water in Thane creek.

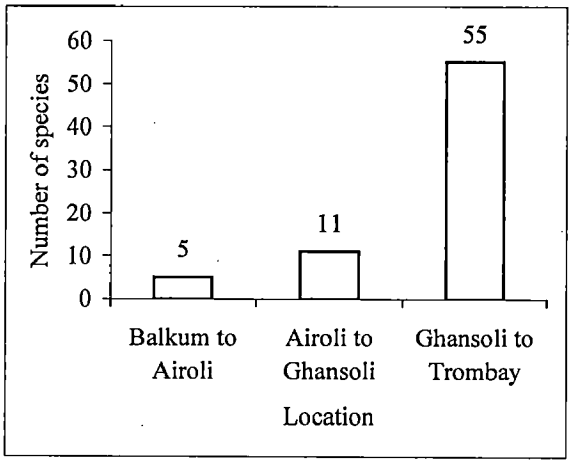



Figure 3.7 Fish diversity in Thane creek

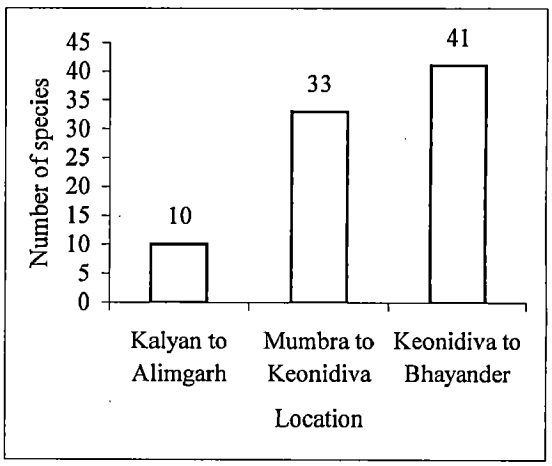



Figure 3.8 Fish diversity in Ulhas river estuary

Goldin (2003) reported that in Thane creek monthly fish catch reveled 68 percent reduction in 1992-93 compared to 1981-82, whereas in 1999-2000 it has become an occasional activity in tune of 4 percent compared to 1981-82 as shown in Figure 3.9.

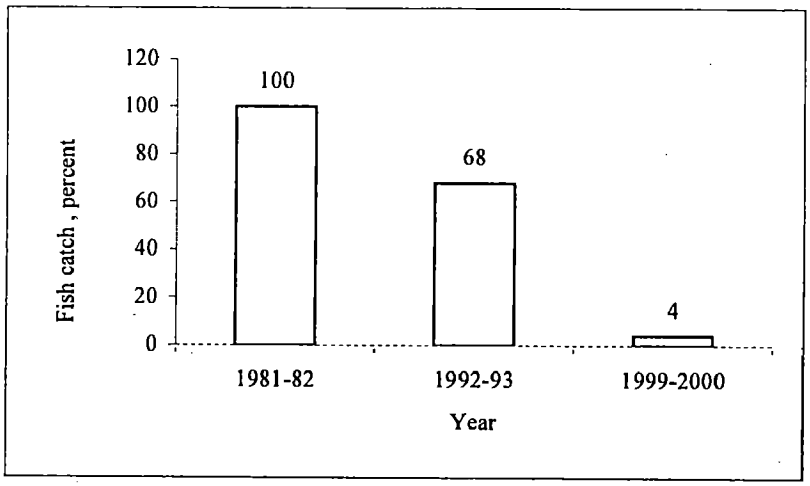



Figure 3.9 Fish catch in Thane creek as compared to 1981-82

Athalye (2003) has compared 2001-02 data with past and following observations are made :

- Fishery organism like fishes *Trypauchen vagina*, mudskippers and mollusks *Paphia spp.*, *Meretrix spp.*, *Carduim spp.* and prawns were abundant in Thane creek about 20 years back. The mudskipper and prawns now are not obtained almost throughout the Thane creek.
- The sediment composition of Thane creek has changed significantly in past decade the substratum hard and less sinking which was favorable for prawns, mudskippers, etc. Presently the siltation in the Thane creek has got enhanced due to heavy sewage load, solid waste dumping and construction activities. This has made the sediment clayey-silt, i.e. more silt less clay. Such sediments are very much sinking type and unfavorable for prawns, mudskippers and bivalves. Hence probably the organisms have got eliminated from the creek.
- Kalyan to Alimghar stretch of Ulhas river estuary showed growing organic pollution and siltation hence from this zone also mudskippers are getting displaced.
- Balkum to Ghansoli portion of Thane creek showed heavy pollution by plastic bags, which clogged the nets, making the fishing operation almost impossible.
- Heavy metals are observed in various fish species Table (3.13).

**4.5 Mangroves**

The Shorter Oxford Dictionary describe the word "mangrove" as obscurely connected with the Portuguese word "mangue" and the Spanish word "mangle" and the English word "grove" and it dates its origin as 1613. Marta Vannucci in her book "*The Mangrove and Us*" points out that the word is neither Portuguese nor Spanish and, after an exhaustive search, she concludes that the word "mangue" derives from the national

language of Senegal. She comments that it was probably adopted by the Portuguese, and later modified by the Spanish, as a result of their exploration of the coast of West Africa. [2]

### 4.5.1 Importance of Mangroves

Mangroves are salt tolerant plant species found in the inter-tidal regions along the creeks and estuaries near the coast, on the river mouth. Mangroves are flood buffers and can be called as *'Lakshmanresha'*. It is natural barrier beyond which there should not be human interference. Mangroves stabilize coastal landmass against sea erosion. They also help to stabilise climate by moderating temperature, humidity, wind and even waves. Mangroves are specially adapted to withstand salinity, wave action, and can grow in poor soils.

Dense mangrove forests growing along the coasts of tropical and sub-tropical countries can help reduce the devastating impact of tsunamis and coastal storms by absorbing some of the waves energy. When the tsunami struck India's southern state of Tamil Nadu on 26$^{th}$ December 2004, areas in Pichavaram and Muthupet with dense mangroves suffered fewer human casualties and less damage to property as compared to areas without mangroves [3] .

Mangroves play a key role in biological diversity by supporting nursery and breeding ground of several marine life forms, such as species of prawns, crabs, fishes and mollusca [4]. Mangroves produce much more of organic matter than is consumed by heterotrophs, and an important fraction of this gets exported into coastal waters by freshwater addiction and tidal action. This productivity and physical safety afforded by mangroves also attracts a large number of larvae and juveniles, especially those of shrimps. Because of these reasons, mangrove swamps have come to be widely acknowledged as playing a significant role in enhancing coastal marine fisheries in the tropical region. Mangroves sustain the ecological security of the coastal areas as well as livelihood security of the thousand of fisherman and other who leave in these areas. [5]

### 4.5.2 Threats

Indian has approximately 700,000 ha of area covered by mangroves along the estuaries and major deltas. [6] Anthropological pressures have disturbed the mangrove ecosystem (Figure 3.10 and Figure 3.11). Growing industrial areas along the coastlines and discharge of domestic and industrial sewage are polluting these areas has reduced its area. In Thane creek, people cleared the mangroves and raised the level of creek and preceded construction of buildings, solid waste dumping.

Samant (2002) reported that in Thane creek surrounding Digha and Mankhurd (Vikroli and Ghatkopar) 103.2 ha and 343.18 ha, respectively area of land reclaimed after 1990. Goldin (2003) reported that the increase in human pressure has significant destroyed the mangroves of Thane city. In 1981-82 mangroves occupied an area of about 25 ha which reduced to 15 ha in 1992-93 and to 9 ha in 1999-2000 Figure (3.12).

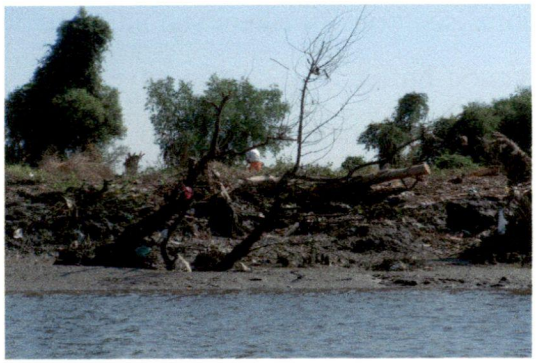


Figure 3.10: Cutting of mangroves

Figure 3.11: Mangroves getting affected by plastic carry bags, etc.

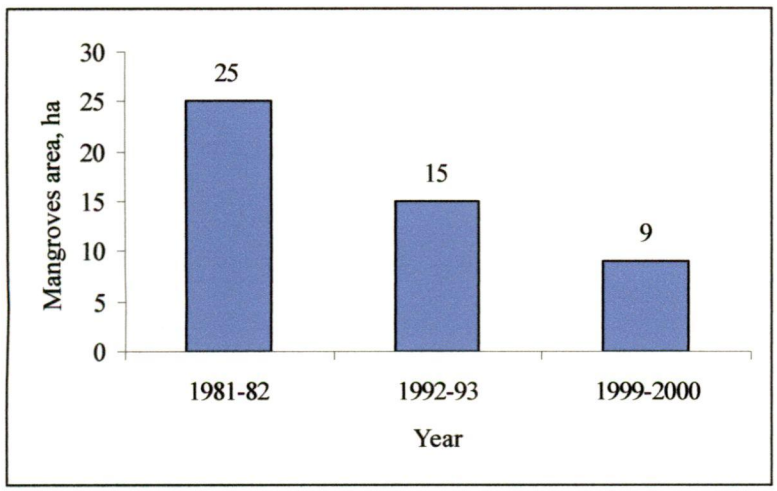



Figure 3.12: Decrease in mangrove area of Thane creek

The summary of the study on mangroves conducted by B.N Bandodkar college of Science, Thane for Thane creek and Ulhas river estuary is given in Table 3.14 and 3.15, respectively.

Unfortunately, for a long time, man has been indiscriminately exploiting the valuable resources found in these areas and recently the cumulative pressure on this wetland ecosystem has increased tremendously. Unless preventive and remedial action is implemented in all seriousness, the damage to the environment and to MAN will be irreversible (Odum , 1996).

### 4.5.3 Measures proposed

Protection, restoration and management of the mangroves are a Herculean task. It is not expected that the Government alone undertake the mangrove plantation of entire creek and estuary banks, the area being vast. It is therefore essential that industries, non-government organisations, scientists, educationalists, policy makers should come forward and work in co-ordination to preserve the natural buffer zone. Mangrove forest can be developed at various locations with the aid of government and industries. It is also a corporate social responsibility to conserve the natural ecosystem. Mangrove forest developed by Godrej is a supreme example and it could be adopted for other part of Thane creek and Ulhas river estuary.

Mangrove plantation drive is already started by TMC, under which one lakhs mangroves are likely to be planted. Public Private Partnership option may be considered as one of the option for development of Mangroves forest.

While plantation, natural zoning of mangroves should be considered. Areas below the high tide level falling in Coastal Regulatory Zone (CRZ) I should be reserved for regeneration of mangroves. It is necessary to document the status of mangroves by acquiring satellite image of the coastal region.

Following remedial measures are recommended for mangrove conservation and management:

- Development of mangroves forest
- Promote local communities to cultivate the fast growing mangrove species like *Avicennia* in degraded areas.
- Public awareness about the importance and conservation of mangroves.
- Involvement of citizens and particularly fisherman in planning and implementation of management action plans.
- Massive planting programmes to strengthen the creek and estuary banks.
- Plantation of mangroves on the mudflats that are formed newly by siltation.
- Identification of cyclone-prone areas and strengthen with mangrove planting.

### 4.5.4 Plantation methodology

Before starting actual planting it is essential to make a tentative plan of the operation and important to know available area, species to be planted and position of zonation pattern. [7]

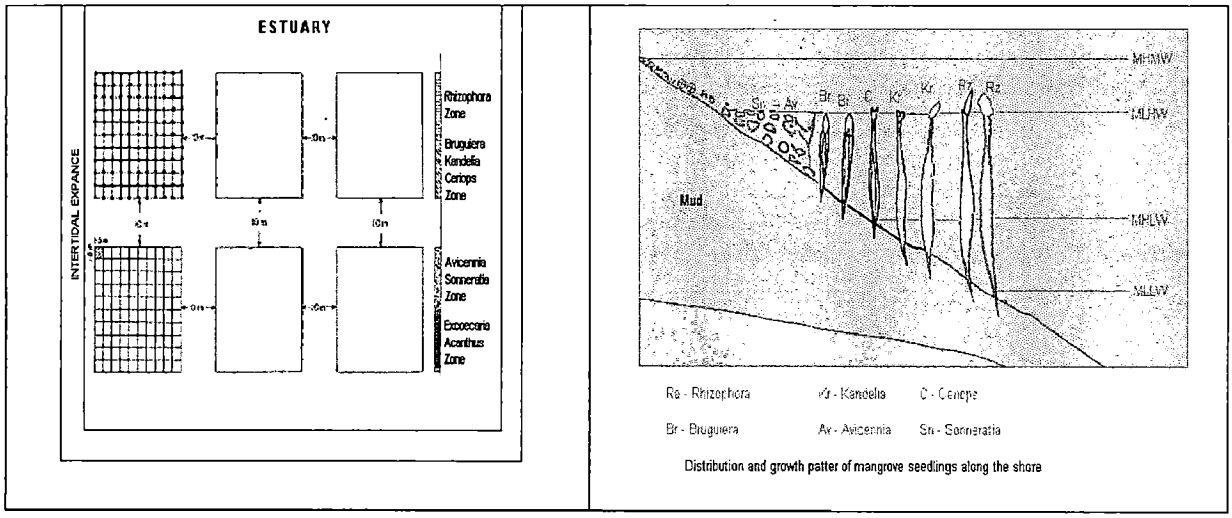



Figure 3.13 Plantation pattern of mangroves [6]

Mangrove plot size depends on availability of the area. Distance of about 10 m should be provided between two plots Figure (3.13). In case of fringing mangroves, where intertidal expanse is narrow, plot may be parallel to the shoreline. In larger areas plot may be either rectangular or square with a gap in between two plots. Plantation of seedlings may be undertaken according to the length of the propagules. Rhizophora mucronata or Rhizophora apiculata whose seedlings are the longest should always be planted towards the waterfront, these can be followed by Kandelia, Ceriops, Bruguiera, Avicennia, Lumnitzera etc. Species with smallest seeds like Sonneratia will come to the landward side of the intertidal expanse, followed by species of grasses and sedges [6].

Direct planting method has to be used in open areas. The selected propagules or seedlings are transported to the site and planted. Care has to be taken that the pointed end of Rhizophora, Ceriops, Bruguiera and Kandelia seedlings should always be penetrated into the mud and the other blunt end, which is a shoot portion, should always be 6 - 8 inches above the sol level. Avicennia fruits are to be pressed gently into soil surface. Spacing between the plans range from 1.3m to 1.5m.

Table 3.1: Monthwise overall average density (no/l) of different phytoplankton species in Thane creek (Athalye,2003)

| | Sept,01 | Oct,01 | Nov,01 | Dec,01 | Jan,02 | Feb,02 | March,02 | Apr,02 | May,02 | June,02 | Jul,02 | Aug,02 | Sept,02 | Oct,02 | Nov,02 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bacillariophyceae** | | | | | | | | | | | | | | | | |
| *Cyclotella* | 0 | 817448 | 817365 | 0 | 817448 | 1634764 | 613107 | 0 | 408682 | 0 | 1024355 | 1405925 | 715567 | 817561 | 408765 | 632064 |
| *Gomphonema* | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 27246 |
| *leptocylindrus* | 204341 | 1021707 | 1021789 | 1430390 | 408765 | 0 | 408682 | 408682 | 408682 | 0 | 0 | 0 | 613603 | 204341 | 204341 | 422355 |
| *Melosira* | 8889390 | 7458834 | 1839072 | 2043828 | 817448 | 1634847 | 817696 | 4E+07 | 7254907 | 5313042 | 2452180 | 40836405 | 2452097 | 2452097 | 2656438 | 8449046 |
| *Navicula* | 204341 | 2043497 | 4700018 | 8582671 | 1634814 | 2247788 | 1328260 | 6028320 | 1430390 | 204341 | 1123919 | 204341 | 1430390 | 1430390 | 1737026 | 2288701 |
| *Pleurosigma* | 204341 | 613107 | 1226131 | 1021707 | 613107 | 0 | 0 | 0 | 0 | 0 | 408765 | 2110308 | 511143 | 0 | 408682 | 474486 |
| *Navicula closterium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Thalassiosira* | 204341 | 1021872 | 817448 | 613107 | 1226131 | 6232769 | 2860780 | 9.2E+07 | 2045980 | 7364865 | 1123919 | 2043480 | 143072 | 1430472 | 817365 | 8106700 |
| *Amphora* | 0 | 613107 | 408765 | 408765 | 306553 | 613057 | 204341 | 0 | 613024 | 204341 | 204341 | 0 | 817365 | 613024 | 408682 | 361025 |
| *Biddulphia* | 204341 | 0 | 204341 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 817365 | 613024 | 204341 | 163473 |
| *Nitzschia* | 613107 | 613107 | 1634814 | 2043497 | 1124167 | 1021707 | 1226048 | 2758741 | 204341 | 0 | 1021872 | 255447 | 718050 | 919826 | 1021872 | 1011773.1 |
| *Pinnularia* | 0 | 0 | 0 | 0 | 0 | 817465 | 0 | 0 | 0 | 0 | 255488 | 0 | 0 | 204341 | 204341 | 98776 |
| *Thalassionema* | 0 | 0 | 0 | 0 | 0 | 3269628 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 217975 |
| *Rhizosolenia* | 0 | 0 | 0 | 0 | 715236 | 0 | 0 | 408682 | 204341 | 204341 | 0 | 1226114 | 919826 | 408682 | 408682 | 299727 |
| *Synedra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13623 |
| *Coscinodiscus* | 0 | 0 | 0 | 0 | 204341 | 408765 | 306553 | 0 | 204341 | 0 | 204341 | 204341 | 511143 | 204341 | 0 | 149878 |
| *Surirella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 13623 |
| *Cymbela* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 306801 | 0 | 34076 |
| **Chrophyceae** | | | | | | | | | | | | | | | | |
| *Skeletonema* | 0 | 0 | 0 | 0 | 204341 | 0 | 204341 | 0 | 408682 | 0 | 204341 | 0 | 0 | 0 | 306801 | 88567 |
| *Asterionella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 13623 |
| *Triceratium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gyrisigma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 408765 | 0 | 204341 | 0 | 204341 | 0 | 0 | 54497 |
| *Trtraedron* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ankisstrodesmus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13623 |
| *Crucigenia* | 0 | 204341 | 411248 | 0 | 204341 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 204341 | 306801 | 204341 | 115984 |
| *Scenedesmus* | 204341 | 204341 | 204341 | 0 | 0 | 0 | 0 | 0 | 408765 | 0 | 0 | 0 | 0 | 306801 | 306801 | 109026 |
| *Volvox* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gonuim* | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 27246 |
| *Koliella spiculiformis* | 0 | 0 | 0 | 0 | 0 | 2656521 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 177101 |
| *Golenkenia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6743598 | 0 | 0 | 613024 | 490442 |
| **Cyaophyceae** | | | | | | | | | | | | | | | | |
| *Nostoc* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gleocapsa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anabaena* | 408682 | 204341 | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 68114 |
| *Oscillatoria* | 408765 | 408765 | 1226048 | 613024 | 613024 | 0 | 613024 | 408682 | 408682 | 2452180 | 613024 | 613024 | 204341 | 613024 | 613603 | 653948 |
| *Spirulina* | 0 | 204341 | 408682 | 613107 | 0 | 0 | | 0 | 0 | 204341 | 0 | 0 | 0 | 306801 | 408682 | 143064 |
| *Lyngbya* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5108784 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 340586 |
| **Xanthophyceae** | | | | | | | | | | | | | | | | |
| *Tribonema* | 204341 | 204341 | 408682 | 408682 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 95359 |
| Total | 11750336 | 15633154 | 15328753 | 18187464 | 8889721 | 20945999 | 8787178 | 1.5E+08 | 14409589 | 15947454 | 9045233 | 56051671 | 11958981 | 11342646 | 11342481 | 25155726 |
| Species no. | 11 | 14 | 14 | 12 | 13 | 12 | 11 | 10 | 13 | 7 | 13 | 12 | 16 | 17 | 19 | 31 |

**Indicate pollution indicator species**

Table 3.2: Monthwise overall average density (no/l) of different phytoplankton species in Ulhas river estuary (Athalye,2003)

| | Sept,01 | Oct,01 | Nov,01 | Dec,01 | Jan,02 | Feb,02 | March,02 | Apr,02 | May,02 | June,02 | Jul,02 | Aug,02 | Sept,02 | Oct,02 | Nov,02 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bacillariophyceae** | | | | | | | | | | | | | | | | |
| *Cyclotella* | 23116073 | 9702204 | 10855173 | 10826620 | 3454851 | 715228 | 1021789 | 204341 | 1021789 | 613040 | 817531 | 2350046 | 1533264 | 919908 | 817365 | 4531281.47 |
| *Gomphonema* | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13623 |
| *leptocylindrus* | 0 | 204341 | 613107 | 817531 | 613107 | 0 | 406200 | 1498503 | 817448 | 204341 | 817448 | 0 | 613107 | 511143 | 0 | 474419 |
| *Melosira* | 7148060 | 3250593 | 2043828 | 1430390 | 408765 | 953593 | 613024 | 0 | 613107 | 204341 | 1157934 | 204341 | 715484 | 1021707 | 613107 | 1358552 |
| *Navicula* | 613107 | 2228803 | 1021872 | 817448 | 1021872 | 1975325 | 613107 | 613024 | 613024 | 0 | 1771041 | 408682 | 1124250 | 715484 | 613107 | 943343 |
| *Pleurosigma* | 0 | 408682 | 613107 | 613107 | 1226462 | 7501292 | 2860945 | 204341 | 204341 | 0 | 204341 | 0 | 204341 | 0 | 408682 | 963310 |
| *Navicula closterium* | 408765 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40874 |
| *Thalassiosira* | 3474052 | 3474052 | 204341 | 408765 | 204341 | 2452200 | 4087077 | 10427719 | 1635228 | 11307472 | 1024355 | 510864 | 1737274 | 2349967 | 1021789 | 2954634 |
| *Amphora* | 817531 | 613107 | 613107 | 613107 | 204341 | 0 | 204341 | 0 | 0 | 0 | 204341 | 0 | 408682 | 306801 | 204341 | 279314 |
| *Biddulphia* | 411248 | 1024272 | 411248 | 204341 | 204341 | 0 | 0 | 1021723 | 1226462 | 1634748 | 1637297 | 0 | 613024 | 1430472 | 511143 | 688688 |
| *Nitzschia* | 408765 | 1226048 | 817448 | 1430555 | 204341 | 6130491 | 1021707 | 6488126 | 613107 | 0 | 204341 | 204341 | 715567 | 1532850 | 1124250 | 1474796 |
| *Pinnularia* | 0 | 0 | 0 | 0 | 204341 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27246 |
| *Thalassionema* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizosolenia* | 0 | 0 | 0 | 0 | 0 | 204341 | 204341 | 0 | 1022121 | 0 | 204341 | 0 | 408682 | 204341 | 511143 | 183954 |
| *Synedra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coscinodiscus* | 0 | 0 | 0 | 0 | 817531 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 408682 | 0 | 408765 | 122621 |
| *Surirella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1634731 | 0 | 0 | 0 | 408699 | 0 | 204341 | 306801 | 170305 |
| *Cymbela* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 204341 | 0 | 0 | 204341 | 40868 |
| **Chrophyceae** | | | | | | | | | | | | | | | | |
| *Skeletonema* | 0 | 0 | 0 | 0 | 408682 | 12720937 | 0 | 0 | 613107 | 0 | 0 | 0 | 613603 | 817365 | 408682 | 1038825 |
| *Asterionella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36374679 | 0 | 0 | 613024 | 0 | 204341 | 0 | 408682 | 2506715 |
| *Triceratium* | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 1021707 | 0 | 0 | 0 | 81737 |
| *Gyrisigma* | 0 | 0 | 0 | 0 | 0 | 204341 | 408682 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 306801 | 74945 |
| *Trtraedron* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 27245 |
| *Ankisstrodesmus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crucigenia* | 613107 | 204341 | 408682 | 204341 | 613107 | 8721092 | 2433889 | 204341 | 204341 | 204341 | 204341 | 0 | 204341 | 613107 | 204341 | 1002514 |
| *Scenedesmus* | 204341 | 0 | 204341 | 204341 | 204341 | 0 | 0 | 0 | 0 | 0 | 817448 | 204341 | 511143 | 204341 | 0 | 170309 |
| *Volvox* | 8377998 | 817365 | 1226131 | 613107 | 0 | 0 | 0 | 0 | 204341 | 0 | 204341 | 0 | 0 | 0 | 0 | 762886 |
| *Gonuim* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Koliella spiculiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Golenkenia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 408682 | 0 | 204341 | 0 | 40868 |
| **Cyaophyceae** | | | | | | | | | | | | | | | | |
| *Nostoc* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 27246 |
| *Gleocapsa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204341 | 0 | 204341 | 0 | 0 | 0 | 0 | 0 | 27246 |
| *Anabaena* | 204341 | 204341 | 613107 | 613107 | 2861028 | 7501292 | 204341 | 0 | 0 | 0 | 0 | 0 | 306801 | 408682 | 204341 | 874759 |
| *Oscillatoria* | 408765 | 817365 | 1021789 | 817531 | 204341 | 204341 | 408682 | 613024 | 613024 | 0 | 204341 | 1123931 | 408682 | 408682 | 306801 | 504093 |
| *Spirulina* | 204341 | 204341 | 204341 | 204341 | 408765 | 0 | 0 | 408682 | 204341 | 0 | 0 | 0 | 0 | 0 | 204341 | 136233 |
| *Lyngbya* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Xanthophyceae** | | | | | | | | | | | | | | | | |
| *Tribonema* | 2452262 | 1635154 | 2043414 | 1839072 | 204341 | 7501292 | 204341 | 0 | | | | | | | 0 | 1058658 |
| Total | 48862756 | 26219348 | 22915042 | 21862051 | 13673248 | 56785759 | 15101155 | 60510606 | 9605781 | 1437262 | 10290813 | 7049981 | 10731277 | 12057883 | 8993164 | 22602107 |
| Species no. | 15 | 16 | 16 | 17 | 19 | 14 | 16 | 17 | 14 | 7 | 16 | 11 | 17 | 17 | 20 | 31 |

**Indicate pollution indicator species**

Table 3.3 : Monthwise overall average density (no/$m^3$) of different zooplankton species in Thane Creek (Athalye,2003)

| | Sept,01 | Oct,01 | Nov,01 | Dec,01 | Jan,02 | Feb,02 | March,02 | Apr,02 | May,02 | June,02 | Jul,02 | Aug,02 | Sept,02 | Oct,02 | Nov,02 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Protozoa** | | | | | | | | | | | | | | | | |
| Noctiluca | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.667 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.244 |
| Foraminifera | 8.333 | 7.667 | 8.333 | 18.33 | 7.333 | 0 | 23 | 10.67 | 30.33 | 4.333 | 0 | 0 | 7.667 | 11.67 | 1 | 9.244 |
| Tintinids | 0 | 0 | 0 | 0 | 0.667 | 0 | 0.333 | 84.33 | 0 | 0 | 0 | 0 | 41.67 | 0 | 8.667 | 9.044 |
| Ctenophore | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.000 |
| Coelenterates | 6.333 | 7.333 | 11 | 7.333 | 6.667 | 0 | 4.333 | 6.667 | 0 | 0 | 0.333 | 0 | 0 | 3.667 | 0 | 3.578 |
| Rotifer | 8.667 | 2.333 | 1.333 | 0.667 | 2 | 0 | 0.667 | 0 | 0 | 0 | 184.3 | 728.7 | 115.7 | 29.67 | 9.333 | 72.225 |
| Nematode | 0.333 | 5 | 3.667 | 3.667 | 4.667 | 4.333 | 7.333 | 0 | 9.333 | 0 | 5 | 0 | 6.667 | 3.333 | 0.667 | 3.600 |
| **Annelida** | | | | | | | | | | | | | | | | |
| Oligochate | 0 | 0 | 0 | 0 | 0 | 0.333 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.022 |
| Polychate | 0 | 6 | 16.67 | 34.33 | 96 | 336.7 | 424.3 | 536 | 251.3 | 265.7 | 77.67 | 11 | 100.7 | 78 | 55.33 | 152.647 |
| **Mollusca** | | | | | | | | | | | | | | | | |
| Gastropods | 12 | 10.67 | 14.33 | 11.33 | 40.67 | 98.33 | 148.3 | 301.7 | 171.3 | 393 | 296 | 84 | 60.33 | 38 | 29.33 | 113.953 |
| Bivalves | 4 | 2 | 3.667 | 3 | 20 | 49.67 | 16.33 | 46.67 | 71 | 168.3 | 102.3 | 42.67 | 36.67 | 16.67 | 6.667 | 39.308 |
| **Arthropoda** | | | | | | | | | | | | | | | | |
| Ostracods | 14 | 0 | 1.333 | 0 | 0.333 | 0 | 0.333 | 0 | 0.333 | 0 | 0 | 0 | 0.667 | 0 | 0.333 | 1.155 |
| Cypris | 0 | 0 | 0 | 0 | 0 | 5.667 | 0 | 55.33 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 4.733 |
| Cladocera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.333 | 0.333 | 0 | 0.044 |
| Nauplius | 57 | 15.33 | 29.33 | 54.33 | 74 | 20 | 131.7 | 614.7 | 303.7 | 41.67 | 22 | 18.67 | 16.67 | 23 | 18.33 | 96.029 |
| Zoes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36.67 | 4 | 0 | 6 | 2.667 | 0 | 3.289 |
| Cyclopoid copepods | 108 | 14.33 | 13 | 9.667 | 64 | 70.33 | 108.7 | 63.33 | 63.67 | 0 | 15.33 | 3 | 30.67 | 20 | 26.67 | 40.713 |
| Calanoid copepods | 2.667 | 0.667 | 3 | 10.67 | 4.667 | 37.67 | 855 | 3792 | 191 | 44.33 | 52.33 | 3.333 | 48 | 136.7 | 75.67 | 350.514 |
| Harpactcoid copepods | 0 | 0 | 0 | 0 | 8.333 | 2.333 | 15.33 | 0 | 7.667 | 0 | 0 | 0 | 5 | 0 | 8.667 | 3.155 |
| Acetes | 0 | 0.667 | 4.333 | 0.667 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0.667 | 5 | 1.333 | 1.111 |
| Acetes Larvae | 0 | 0 | 0.667 | 13 | 7.667 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 2.822 |
| Prawn Juvenile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.000 |
| Mite | 0 | 0.667 | 0 | 0 | 0 | 0 | 0 | 0 | 0.333 | 0 | 0 | 0 | 0.667 | 0 | 0 | 0.111 |
| Other arthopod | 0 | 0 | 0 | 0 | 2.333 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.156 |
| eggs | 299.3 | 218.7 | 85.33 | 86.67 | 71.67 | 135.7 | 202.3 | 100.7 | 127.3 | 0 | 125.7 | 21.33 | 69.67 | 77.33 | 26.67 | 109.891 |
| Fish Larvae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.333 | 0 | 0.333 | 0 | 0.044 |
| Total | 520.7 | 291.3 | 196.0 | 253.7 | 411.0 | 761 | 1941.0 | 5615 | 1249 | 964.0 | 885.0 | 912.7 | 547.7 | 446.3 | 268.7 | 1017.556 |
| Species no. | 11 | 13 | 14 | 13 | 16 | 11 | 15 | 12 | 14 | 8 | 11 | 8 | 17 | 15 | 14 | 24 |

Table 3.4 : Monthwise overall average density (no/$m^3$) of different zooplankton species in Ulhas river estuary (Athalye,2003)

| | Sept,01 | Oct,01 | Nov,01 | Dec,01 | Jan,02 | Feb,02 | March,02 | Apr,02 | May,02 | June,02 | Jul,02 | Aug,02 | Sept,02 | Oct,02 | Nov,02 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Protozoa** | | | | | | | | | | | | | | | | |
| Noctiluca | 0 | 0 | 0 | 0 | 0.333 | 0 | 4 | 177 | 9.333 | 0 | 0 | 0 | 0 | 2.667 | 50 | 16.22 |
| Foraminifera | 0 | 0 | 0.667 | 0.667 | 0 | 0 | 0.667 | 0 | 0.667 | 2.333 | 0 | 0 | 0 | 0 | 0 | 0.33 |
| Tintinids | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.333 | 0 | 0 | 0.667 | 0 | 1.667 | 0 | 2.667 | 0.42 |
| Ctenophore | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.20 |
| Coelenterates | 1.333 | 5 | 7.333 | 6.667 | 0 | 6 | 3 | 0 | 0 | 0 | 1.667 | 0 | 0.667 | 0 | 0.667 | 2.16 |
| Rotifer | 1.333 | 0.667 | 1.333 | 1.333 | 43.33 | 75.67 | 299.3 | 888 | 430.3 | 6.667 | 21.67 | 8 | 19 | 30 | 24.67 | 123.42 |
| Nematode | 0 | 0.667 | 0 | 0.667 | 0 | 0 | 2.333 | 0 | 0 | 0 | 0 | 0 | 1 | 0.667 | 0 | 0.36 |
| **Annelida** | | | | | | | | | | | | | | | | |
| Oligochate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1.333 | 0 | 0.333 | 0.333 | 0 | 0.20 |
| Polychate | 0 | 2 | 0.667 | 0 | 9.667 | 8.667 | 16.67 | 0 | 0.667 | 2.333 | 1.333 | 4.667 | 0.667 | 0.667 | 0.667 | 3.24 |
| **Mollusca** | | | | | | | | | | | | | | | | |
| Gastropods | 0 | 0 | 2 | 0 | 2.667 | 0.667 | 1.333 | 22.67 | 1.333 | 26.67 | 2.333 | 58 | 11.67 | 8 | 5 | 9.49 |
| Bivalves | 1 | 0.667 | 2 | 1.333 | 8.667 | 14.67 | 5.667 | 0 | 2 | 2.333 | 2 | 0 | 0.667 | 3.667 | 0 | 2.98 |
| **Arthropoda** | | | | | | | | | | | | | | | | |
| Ostracods | 1 | 0 | 0.667 | 0.667 | 0 | 19 | 0.667 | 0 | 0.667 | 0 | 0.667 | 0 | 2.667 | 0 | 1 | 1.80 |
| Cypris | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.333 | 0.333 | 9 | 0 | 2.667 | 0.667 | 0 | 0 | 0.87 |
| Cladocera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.333 | 1.667 | 0.667 | 1 | 0.31 |
| Nauplius | 28 | 38 | 49 | 39.67 | 91.67 | 55.33 | 45.33 | 38.67 | 3 | 188.7 | 74.67 | 110 | 20.33 | 13.33 | 27.67 | 54.89 |
| Zoes | 0 | 0 | 0 | 0 | 0 | 4 | 0.667 | 0 | 32.33 | 0 | 2.333 | 0 | 1.667 | 1.667 | 1 | 2.91 |
| Cyclopoid copepods | 19 | 136.3 | 78.33 | 121.3 | 0 | 749 | 329.3 | 4 | 50.67 | 137.7 | 91.67 | 8.667 | 38.67 | 60.33 | 43.33 | 124.55 |
| Calanoid copepods | 180.3 | 198.3 | 52.33 | 57.67 | 159 | 5.333 | 203.3 | 127.3 | 220 | 261 | 193 | 25 | 37 | 63 | 67.67 | 123.35 |
| Harpactcoid copepods | 0 | 0 | 0 | 0 | 0 | 3.667 | 1.667 | 0 | 0.667 | 0 | 0 | 0 | 1.667 | 2.333 | 0.667 | 0.71 |
| Acetes | 0.667 | 1.333 | 1.333 | 3 | 0 | 0 | 0 | 0 | 7.667 | 0 | 0 | 0 | | 4 | 6 | 1.71 |
| Acetes Larvae | 0.667 | 0 | 0.667 | 0.667 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.13 |
| Prawn Juvenile | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 |
| Mite | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.333 | 0 | 0.02 |
| Other arthopod | 0 | 0 | 0 | 0 | 0 | 1 | 0.667 | 0 | 0 | 0 | 0.667 | 0 | 0 | 0.667 | 0.333 | 0.22 |
| eggs | 48.67 | 36 | 28.33 | 25.67 | 44 | 300 | 0 | 44.67 | 7.667 | 6.667 | 7.667 | 31.67 | 66 | 29.33 | 21.67 | 46.53 |
| Fish Larvae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.333 | 0.333 | 0 | 0.333 | 0.07 |
| Total | 283 | 419 | 224.657 | 259.3 | 359.3 | 1246 | 915.6 | 1303 | 768.3 | 643.4 | 401.7 | 250.3 | 206.3 | 221.7 | 254.3 | 517.05 |
| Species no. | 11 | 10 | 13 | 12 | 8 | 14 | 16 | 9 | 16 | 10 | 14 | 10 | 18 | 17 | 17 | 26 |

Table 3.5: Metals in Plankton, macrobenthos –Gastropods , Bivalves , Polychates, and other macrobenthos of Thane creek and Ulhas river estuary (Athalye,2003)

| | Thane creek | | Ulhas river estuary | | Thane creek | | Ulhas river estuary | |
|---|---|---|---|---|---|---|---|---|
| | Copper , ppm | Zinc , ppm | Zinc , ppm | Copper , ppm | Copper , ppm | Zinc , ppm | Zinc , ppm | Copper , ppm |
| | 2001-02 | | | | 1987 | | | |
| Plankton | | | | | | | | |
| Zooplankton | 105.98 | 205.95 | 205.95 | 68.162 | | | | |
| Phytoplankton | 609.98 | 1162.45 | 1162.45 | 766.647 | | | | |
| Macrobenthos | | | | | | | | |
| Gastropods | | | | | 0.026 to 0.034 | | 0.425 to 0.454 | |
| Shell metals | 74.46 | 214.92 | 311.54 | 146.81 | | | | |
| Biomass metals | 150.64 | 209.72 | 531.25 | 286.37 | | | | |
| Bivalves | | | | | 0.048 to 0.068 | | 0.526 to 0.620 | |
| Shell metals | 14.91 | 31.30 | 1379.06 | 40.17 | | | | |
| Biomass metals | 81.21 | 141.4 | 399.95 | 124.98 | | | | |
| Polychates | | | | | 0.053 | 0.296 | 0.062 | 0.358 |
| N.gangetica | 277.253 | 304.495 | 206.617 | 351.647 | | | | |
| Ceratonereis | 845.980 | 463.95 | 2716.617 | 466.647 | | | | |
| L.indica | 6176.647 | 316.617 | 3187.45 | 364.98 | | | | |
| Other macrobentos | | | | | | | | |
| Nemetods | 999.98 | 4749.95 | 2549.95 | 1449.98 | | | | |
| Oligochates | 4562.48 | 1749.95 | 1066.617 | 1233.313 | | | | |
| L. gangetica | 159.657 | 348.337 | 1130.213 | 769.717 | | | | |
| Larvae | 579.98 | 4159.95 | 799.950 | 883.313 | | | | |
| Sea anemone | 104.819 | 591.885 | | | | | | |

Table 3.6 Monthwise overall average density (no/$m^2$) of different macrobenthos species in Thane Creek (Athalye,2003)

| | Balkum Balkum | Vitawa | Saltpans | Airoli Bridge | Mulund/ Bhandup | Rabale | Talawali | Vikroli | Koparkhairnae | Deonar | Vashi | Trombay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sea anemones | 0 | 43 | 0 | 392 | 353 | 340 | 1428 | 693 | 4779 | 220 | 745 | 36 |
| Nematodes | 1003 | 1245 | 488 | 2348 | 142477 | 419 | 247 | 6872 | 0 | 0 | 14195 | 27 |
| Planaria | 0 | 16 | 0 | 39 | 0 | 29 | 0 | 0 | 3 | 13 | 1 | 4 |
| Oligochate | 184 | 597 | 29 | 93 | 32 | 4 | 0 | 1 | 168 | 3 | 4 | 4 |
| Polychate | 2125 | 4817 | 209 | 8241 | 4165 | 12309 | 8977 | 4841 | 6212 | 1656 | 2653 | 421 |
| Gastropods | 693 | 443 | 57 | 4567 | 17113 | 11964 | 17145 | 9727 | 65584 | 21048 | 18572 | 303 |
| Bivalves | 25 | 115 | 0 | 1535 | 123 | 7215 | 97508 | 7629 | 28959 | 19499 | 4431 | 115 |
| Crab | 265 | 52 | 5 | 423 | 45 | 115 | 57 | 611 | 13 | 0 | 12 | 0 |
| Insect larvae | 27 | 23 | 27 | 27 | 23 | 7 | 7 | 240 | 168 | 1280 | 1297 | 15 |
| Barnacles | 0 | 0 | 8 | 0 | 7 | 27 | 27 | 0 | 0 | 0 | 11 | 4 |
| Total (N) | 4322 | 7351 | 823 | 17665 | 164338 | 32429 | 125396 | 30614 | 105886 | 43719 | 41921 | 929 |
| Number of species (S) | 7 | 9 | 7 | 9 | 9 | 10 | 8 | 8 | 8 | 7 | 10 | 9 |
| N/S | 617 | 817 | 118 | 1963 | 18260 | 3243 | 15675 | 3827 | 13236 | 6246 | 4192 | 103 |

Table 3.7: Monthwise overall average density (no/m2) of different macrobenthos species in Ulhas River Estuary (Athalye,2003)

| | Thakurli | Surya village | Dombivali | Alimghar | Mumbra | Kasheli | Wagbil | Keoni Diva | Nagla Gaon | Versova Bridge | Naigaon | Bhayandar |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sea anemones | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 13 |
| Nematodes | 1012 | 1971 | 597 | 571 | 271 | 73 | 131 | 151 | 524 | 80 | 20 | 0 |
| Planaria | 0 | 0 | 0 | 3 | 0 | 3 | 8 | 0 | 0 | 0 | 0 | 13 |
| Oligochate | 439 | 6171 | 109 | 6011 | 13 | 0 | 0 | 24 | 27 | 5 | 13 | 24 |
| Polychate | 5988 | 4681 | 975 | 4139 | 3760 | 3744 | 2051 | 903 | 560 | 428 | 696 | 716 |
| Gastropods | 176 | 52 | 127 | 373 | 436 | 213 | 1196 | 500 | 153 | 212 | 157 | 464 |
| Bivalves | 0 | 0 | 0 | 97 | 28 | 964 | 72 | 13 | 21 | 4 | 8 | 3 |
| Crab | 172 | 21 | 76 | 177 | 192 | 143 | 227 | 388 | 63 | 7 | 19 | 11 |
| Insect larvae | 120 | 413 | 128 | 81 | 48 | 7 | 55 | 131 | 717 | 56 | 3 | 0 |
| Barnacles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (N) | 7907 | 13309 | 2012 | 11452 | 4748 | 5148 | 3740 | 2110 | 2065 | 792 | 921 | 1244 |
| Number of species (S) | 6 | 6 | 6 | 8 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 7 |
| N/S | 1318 | 2218 | 335 | 1432 | 678 | 644 | 534 | 301 | 295 | 113 | 115 | 178 |

Table 3.8: Shannon-Wiener , Simpson's diversity ,Pielou evenness index ,Gleson's Index & Margalef's index for Thane Creek

| | Balkum | Vitawa | Saltpans | Airoli Bridge | Mulund /Bhandup | Rabale | Talawali | Vikroli | Kopar-khairne | Deonar | Vashi | Trombay | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shannon-Wiewer diversity index | 0.58 | 0.48 | 0.50 | 0.61 | 0.21 | 0.53 | 0.32 | 0.67 | 0.43 | 0.42 | 0.58 | 0.59 | 0.21 | 0.67 |
| Simpson,s diversity index | 0.67 | 0.53 | 0.58 | 0.69 | 0.24 | 0.67 | 0.37 | 0.76 | 0.54 | 0.57 | 0.67 | 0.67 | 0.24 | 0.76 |
| Pielou eveness index | 0.16 | 0.12 | 0.17 | 0.14 | 0.04 | 0.12 | 0.06 | 0.15 | 0.08 | 0.09 | 0.12 | 0.20 | 0.04 | 0.20 |
| Gleson's Index | 0.84 | 1.01 | 1.04 | 0.92 | 0.75 | 0.96 | 0.68 | 0.77 | 0.69 | 0.66 | 0.94 | 1.32 | 0.66 | 1.32 |
| Margalef's index | 1.65 | 2.07 | 2.06 | 1.88 | 1.53 | 2.00 | 1.37 | 1.56 | 1.39 | 1.29 | 1.95 | 2.70 | 1.29 | 2.70 |

Table 3.9: Shannon-Wiener , Simpson's diversity ,Pielou eveness index & Gleson's Index & Margalef's index for Ulhas River Estuary

| | Thakurli | Surya village | Dombi-vali | Alimghar | Mumbra | Kasheli | Wagbil | Keoni Diva | Nagla Gaon | Versova Bridge | Naigaon | Bhaya-nder | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shannon-Wiewer diversity index | 0.38 | 0.50 | 0.58 | 0.48 | 0.34 | 0.37 | 0.49 | 0.63 | 0.64 | 0.72 | 0.36 | 0.41 | 0.34 | 0.72 |
| Simpson,s diversity index | 0.41 | 0.64 | 0.67 | 0.59 | 0.36 | 0.43 | 0.59 | 0.72 | 0.74 | 0.62 | 0.40 | 0.53 | 0.36 | 0.74 |
| Pielou evenness index | 0.10 | 0.12 | 0.18 | 0.12 | 0.09 | 0.10 | 0.14 | 0.19 | 0.19 | 0.25 | 0.12 | 0.13 | 0.09 | 0.25 |
| Gleson's Index | 0.67 | 0.63 | 0.79 | 0.86 | 0.83 | 0.94 | 0.85 | 0.91 | 0.92 | 1.05 | 1.17 | 0.98 | 0.63 | 1.17 |
| Margalef's index | 1.28 | 1.21 | 1.51 | 1.72 | 1.63 | 1.89 | 1.68 | 1.80 | 1.81 | 2.07 | 2.36 | 1.94 | 1.21 | 2.36 |

Table 3.10: Benthic community health status of Thane creek

| | Groups | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Balkum | Vitawa | Saltpans | Airoli Bridge | Mulund/Bhandup | Rabale | Talawali | Vikroli | Koparkhairnae | Deonar | Vashi | Trombay |
| Sea anemones | I | I | I | I | I | I | I | I | I | I | I | I |
| Nematodes | V | V | V | V | V | V | V | V | V | V | V | V |
| Planaria | I | I | I | I | I | I | I | I | I | I | I | I |
| Oligochate | III | III | III | III | III | III | III | III | III | III | III | III |
| Polychate | IV | IV | IV | IV | IV | IV | IV | IV | IV | IV | IV | IV |
| Gastropods | II | II | II | II | II | II | II | II | II | II | II | II |
| Bivalves | II | II | II | II | II | II | II | II | II | II | II | II |
| Crab | II | II | II | II | II | II | II | II | II | II | II | II |
| Insect larvae | I | I | I | I | I | I | I | I | I | I | I | I |
| Barnacles | I | I | I | I | I | I | I | I | I | I | I | I |
| Biotic Coefficient | 4.07 | 4.33 | 4.92 | 3.47 | 5.47 | 2.68 | 1.71 | 2.94 | 1.61 | 1.56 | 3.14 | 2.90 |
| Biotic index | 3 | 4 | 4 | 3 | 5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Dominant Ecological Group | IV-V | IV-V | IV-V | II -IV | V | II & IV | II | II & V | II | II | II & V | II & IV |
| Benthic community health | Transitional to pollution | Polluted | Polluted | Transitional to pollution | Transitional to heavy pollution | Unbalanced | Unbalanced | Unbalanced | Unbalanced | Unbalanced | Unbalanced | Unbalanced |

Group I : Species sensitive to pollution
Group II :Species indifferent to enrichment
Group III : Species tolerant to excess organic matter enrichment and indicators of pollutant
Group IV : Species to pronounce situations
Group V: Species available in highly organic polluted area
Benthic community health status of Ulhas river estuary

Thakurli, Dombivali – waste from city and industrial area
Mumbra : waste discharge through nalla from Mumbra

Biotic Coefficient= {(0x % GI) + (0x % GII)+ (0x % GIII)+ (0x % GIV)+ (0x % GV)}/100

Table 3.11: Benthic community health status of Ulhas River estuary

| | Percent Dominance | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thakurli | Surya village | Dombivali | Alimghar | Mumbra | Kasheli | Wagbil | Keoni Diva | Nagla Gaon | Versova Bridge | Naigaon | Bhayandar |
| Sea anemones | | | | | | I | | | | | | I |
| Nematodes | V | V | V | V | V | V | V | V | V | V | V | |
| Planaria | | | | I | | I | I | | | | | I |
| Oligochate | III | III | III | III | III | | | III | III | III | III | III |
| Polychate | IV | IV | IV | IV | IV | IV | IV | IV | IV | IV | IV | IV |
| Gastropods | II | II | II | II | II | II | II | II | II | II | II | II |
| Bivalves | | | | II | II | II | II | II | II | II | II | II |
| Crab | I | II | II | II | II | II | II | II | II | II | II | II |
| Insect larvae | I | I | I | I | I | I | I | I | I | I | I | I |
| Barnacles | | | | | | | | | | | | |
| Biotic Coefficient | 4.44 | 3.88 | 4.37 | 3.63 | 4.26 | 3.80 | 3.76 | 3.39 | 3.07 | 3.88 | 4.13 | 3.78 |
| Biotic index | 4 | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| Dominant Ecological Group | IV-V | III -IV | IV-V | III -IV | IV-V | III -IV | III -IV | II -IV | II | III -IV | III -IV | III -IV |
| Benthic community health | Polluted | Transitional to pollution | Polluted | Transitional to pollution | Polluted | Transitional to pollution | Transitional to pollution | Transitional to pollution | Unbalanced | Transitional to pollution | Transitional to pollution | Transitional to pollution |

Group I : Species sensitive to pollution
Group II :Species indifferent to enrichment
Group III : Species tolerant to excess organic matter enrichment and indicators of pollutant
Group IV : Species to pronounce situations
Group V: Species available in highly organic polluted area
Benthic community health status of Ulhas river estuary

Thakurli, Dombivali – waste from city and industrial area
Mumbra : waste discharge through nalla from Mumbra

Biotic Coefficient= {(0x % GI) + (0x % GII)+ (0x % GIII)+ (0x % GIV)+ (0x % GV)}/100

Table 3.12: Fin fish fauna in the Ulhas river estuary and Thane creek

| | Fin fish fauna | | Ulhas river estuary | | | Thane creek | | |
|---|---|---|---|---|---|---|---|---|
| No. | Species | Family | Kalyan to Alimgarh | Mumbra to Keonidiva | Keonidiva to Bhayander | Balkum to Airoli | Airoli to Ghansoli | Ghansoli to Trombay |
| 1 | Boleopthalmus dussumieri | Gobiidae | + | + | ++++ | - | - | + |
| 2 | Boleopthalmus boddaerti | | - | + | +++ | - | - | + |
| 3 | Gobious tennuis | | - | + | + | - | - | - |
| 4 | Gobious giuris | | - | +++ | + | - | - | ++ |
| 5 | Gobuis ocelatus | | - | - | ++ | - | - | + |
| 6 | Tripauchen vagina | | - | ++ | +++ | - | - | - |
| 7 | Eleotris amboinensis | *Trachinidae* | - | - | - | - | - | + |
| 8 | Sillago sihama | *Clupeidae* | - | + | ++ | - | - | +++ |
| 9 | Kawala coval | | - | + | +++ | - | - | +++ |
| 10 | Trichiurus savala | | - | ++ | +++ | - | - | ++ |
| 11 | Clupea sp. | | - | ++ | ++++ | - | - | ++ |
| 12 | Pellona feligera | | - | ++ | +++ | - | + | ++ |
| 13 | Pellona elongata | | - | ++ | ++ | - | - | ++ |
| 14 | Coilia Dussumieri | | - | + | +++ | - | - | +++ |
| 15 | Chaetosus chacunda | | - | - | +++ | - | ++ | ++ |
| 16 | Chaetosus nasus | | - | + | ++ | + | + | +++ |
| 17 | Engraulis sp. | | - | ++ | +++ | - | - | + |
| 18 | Megalops maculates | *Chromidae* | ++ | + | + | - | - | ++ |
| 19 | Etroplus maculates | *Sparidae* | - | + | ++ | - | - | - |
| 20 | Chrysophrys datnia | *Cyprinodontidae* | - | ++ | ++ | - | - | ++ |
| 21 | Haplochilus lineatus | | - | ++ | ++ | - | - | + |
| 22 | Mugil spigleri | *Mugilidae* | + | - | +++ | + | - | ++ |
| 23 | Muugil Dussumieri | | - | ++ | - | + | - | ++ |
| 24 | Batrachus grunniens | *Batrachidae* | - | +++ | + | - | - | + |
| 25 | Lates calcarifer | *Percidae* | + | + | + | - | + | ++ |
| 26 | Therapon theraps | | - | + | +++ | - | + | +++ |
| 27 | Therapon jarbua | | + | - | +++ | - | + | +++ |
| 28 | Teuthis cramin | | - | ++ | - | - | - | + |
| 29 | Oreochromis mossambicus | *Cichlidae* | ++ | +++ | ++ | - | + | + |
| 30 | Mystus gulio | | ++ | + | ++ | ++ | +++ | ++ |
| 31 | Mystus sp. | *Siluridae* | + | + | ++ | - | - | - |
| 32 | Arius thalassinus | | + | - | +++ | - | - | ++ |
| 33 | Plotossus arab | | - | - | - | - | - | - |
| 34 | Osteogeniosus militaris | | - | + | - | - | - | + |
| 35 | Barbus pinnauratus | *Cyprinidae* | - | ++ | - | - | - | ++ |
| 36 | Acaena Dussunieri | *Scieaidae* | - | - | ++++ | + | + | +++ |
| 37 | Scaena glaucus | | + | + | - | - | + | +++ |
| 38 | Otolithoides brunneus | | - | - | ++ | - | + | ++ |
| 39 | Umbrina russellii | | - | + | - | - | - | ++ |
| 40 | Tetrodon Fulvitilis | *Gymnodontes* | - | + | ++ | - | - | + |

| | Fin fish fauna | | Ulhas river estuary | | | Thane creek | | |
|---|---|---|---|---|---|---|---|---|
| No. | Species | Family | Kalyan to Alimgarh | Mumbra to Keonidiva | Keonidiva to Bhayander | Balkum to Airoli | Airoli to Ghansoli | Ghansoli to Trombay |
| 41 | Trtrodon oblongus | | - | - | ++ | - | - | + |
| 42 | Trtrodon stellatus | | - | - | - | - | - | + |
| 43 | Tetrodon lunaris | | - | - | - | - | - | + |
| 44 | Polynemus tetradactylus | *Polynemidae* | - | - | + | - | - | +++ |
| 45 | Cynoglosus elongatus | *Pleuronectidae* | - | - | ++ | - | - | ++ |
| 46 | Cynoglosus lingua | | - | + | + | - | - | ++ |
| 47 | Congromuraena anago | *Muraenidae* | - | - | ++ | - | - | + |
| 48 | Harpodon nehereus | *Scopelidae* | - | - | ++ | - | - | + |
| 49 | Sctophagus argus | *Squamipinnes* | - | - | +++ | - | - | + |
| 50 | Trichanthus brevirostris | *Sclerodermi* | - | - | + | - | - | + |
| 51 | Trichanthus strigilifer | *Carangiidae* | - | - | - | - | - | + |
| 52 | Caranx sp. | | - | - | - | - | - | +++ |
| 53 | Equula rueonius | | - | ++ | ++ | - | - | ++ |
| 54 | Equula splendens | | - | - | - | - | - | ++ |
| 55 | Equula insidiatrx | | - | - | - | - | - | + |
| 56 | Equula Dussumieri | *Scombridae* | | | | | - | + |
| 57 | Rastrelliger kanagurta | | | | | | - | ++ |
| 58 | Cybium guttatum | | | | | | - | + |
| 59 | Echeneis neuerates | *Stromatidae* | | | | | - | + |
| 60 | Stromateus argenteus | | | | | | - | + |
| 61 | Stromateus sinensis | | | | | | - | + |
| | Total no. of spp. | | | | | | 11 | 55 |

Table 3.13:Heavy metals in fishery type of Th ary

| | Thane creek | | uary | |
|---|---|---|---|---|
| | Copper, ppm | Zinc ,p | | Zinc ,ppm |
| Tilipia Ulhas | 4.98 | 56.9 | | 74.95 |
| Mugil | 9.98 | 38.95 | | 32.95 |
| Mystus sp. | 4.48 | 43.95 | | 39.95 |
| Boleopthalmus | - | - | 6.23 | 28.075 |
| Lates calcarifer | 4.48 | 27.45 | - | - |

What is the allowable limit?

Table 3.14 : Thane Creek Mangrove Status

| Zone | Length , km | Salinity, ppm | Width, m | Area , $km^2$ | | Damage causing factor |
|---|---|---|---|---|---|---|
| Balkum to Airoli | 6 | 0.46 to 34.8<br>Avg- 19.3 | 50.0 | 0.30 | Dominance –*A. marina var acustissima*<br>12 spp of associate mangroves and 4 spp of non mangrove halophytes<br>*Avicennia marina ; Sonneretia apetala* : other<br>40:40:20 | Cutting for fuel and aquaculture pond.<br>Dumping of solid waste. |
| Airoli to Ghansoli | 10 | 1.9 to 38.0<br>Avg. 23.51 | 100 | 1.0 | Dominance- *A. marina*<br>Mangrove plantation by Godrej- *Bruguiera cylindrical, ceriops tagal ,Rhizophora mucronata , Aegiceras corniculatum.*<br>Mangrove associate- *Exoecoeceria agallocha* | Reclamation for salt pans,<br>Cutting for fuel and aquaculture pond.<br>Dumping of solid waste. |
| Ghansoli to Trombay | 10 to 12 | 5.2 to 38.0<br>Avg . 27.42 | 75.0 | 0.90 | Dominance- *A. marina along paches of S. apetala.*<br>Dominant associate- *Acantus ilicifolius*<br>*A marina : Sapetala* : Others<br>60:25:15 | Cutting for fuel and aquaculture pond.<br>Solid waste dumping at certain places. |

Table 3.15: Ulhas River Estuary Mangrove Status

| Zone | Length , km | Salinity, ppm | Width, m | Area , $km^2$ | | Damage causing factor |
|---|---|---|---|---|---|---|
| Kalyan to Alimghar | 15 | 0.25 to 27.68<br>Avg – 8.68 | 20 | 0.30 | *A. marina* absent<br>*Avicennia officinalis* and *Sonneretia apetala* – 1 : 1.<br>Mangrove associate- *Acanthus ilicifolus*<br>*A. officinalis : Sonneretia apetala : Acanthus ilicifolus:* others – 35:35:20:10<br>Terrestrial trees – *Pondamia pinnata, Tamarindus indicus*<br>Grass- *Cypercus* spp | Cutting of paddy fields, Road construction,<br>Dumping of solid waste and sand landing at some places |
| Mumbra to Keonidiva | 10 | 0.64 to 33.04<br>Avg. 14.34 | 50 | 0.50 | Dominance- *Avicennia officinalis*<br>Front mangrove - *Bruguiera gymnortiza*<br>*Avicennia: Sonneratia:* Other – 50:25:25<br>*A. officinalis : Sonneretia apetala : Exocecaria agallocha:Salvadora persica::Acanthus illicifolis* – 50:25:5:8:12 | Reclamation of land by paddy fields,<br>Road construction,<br>Dumping of solid waste and<br>Sand landing at some places |
| Keonidiva to Bhayandar | 15 | 0.93 to 36.0<br>Avg. 22.8 | 50 | 0.75 | Dominance- *A. marina*<br>New species- *Bruguiera caryophylloides cylindrical, Rhizophora apiculata, Rhizophora mucronata*<br>*A marina : Sonneretia apetala* – 50:50 | Sand landing at Retibander,<br>Cutting for fuel,<br>Road and house construction. |

# CHAPTER 4

# HYDROLOGICAL ASPECTS

Hydrological aspects of Thane creek and Ulhas river estuary in respect of conservation is studied to understand the present condition and plan the rehabilitation mitigation measures. It also helped in planning of future studies to be carried as a part of regular conservation monitoring program.

## 4.1 Past Studies

NEERI studied the assimilating capacity of the Thane creek. NEERI carried out depth integrated hydrodynamic and water quality computations to stimulate the DO, BOD and Feacal Coliform (FC) concentrations after their release in the modeling reach which covers a region extending up to 19 kms from Thane-Kalwa road bridge in the north to Trombay downstream of Vashi bridge.

The model results show that the pollutants move in Thane creek along the west coast. During a tidal cycle at low tides, the eastern coast of the creek becomes dry and discharges in the eastern coast of the creek during this period gets absorbed/adsorbed on the bed of the creek and undergoes to a small extent aquifer treatment/wetland treatment. With the flooding, re-dissolution of the pollutants takes place. The currents are always moving longitudinally with no lateral movement in the creek. During spring tide, the discharge at Bhandup reaches up to Ghatkopar discharge point and reverses with the tide reaching Kopari at the flooding tide. During neap tide, the discharges at Bhandup reach, about 4 km south during ebbing tide and reverse with the tide reaching a little above Airoli bridge during flooding tide. As a result, complete flushing of the creek does not take place with seawater from the harbor side (Gupta 2004).

NEERI observed that Thane creek has very low assimilating capacity due to poor flushing, low current speed and shallow depth (NEERI,2002). Limited flushing capacity has deteriorated water quality.

Following measures are recommended by NEERI:

1. All present discharges should be given secondary treatment before discharge, i.e., BOD<20 mg/l, DO>2mg/l, and FC lower than 1 x $10^5$ cts / 100 ml.

2. Industrial effluent should have BOD<30 mg/l, DO>2mg/l, and FC lower than $1.0 \times 10^5$ cts / 100 ml.
3. Discharges into the Thane creek to be reduced.
4. Discharges into the inner part of the creek to be avoided. Preferably discharges to be located in center of the outer portion of the creek.

Sharma (1994) observed the clay accumulation rate of 0.65-1.46 cm /year for the inner region of the Thane creek.

Jha (2003) studied depth profile of global fallout $^{137}$ Cs in sediment core samples collected at Thane creek and a high sediment rate was observed (upto 1cm/ yr). Depth profile of Hg (concentration upto 10 µg / g) and Pb (concentration upto 70 µg / g) show the anthropogenic input into the coastal environment around Thane Creek over the years.

Sediment rate increases from 0.2 cm/ year near estuary mouth to 2.9 cm / year at 25 km off shore. High outflow through the Ulhas estuary to the sea during monsoon that transport much of the annual suspended load generates strong currents and high turbulence in the mouth area that probably do not favour the dispersion of fine particles associated with estuary plume, in the vicinity (Chouksey 2004).

Ram (2003) reported that the estuarine flushing time varies between 73 and 211 tidal cycles during the dry season, suggesting the possibility of a built up of contaminants in the inner Ulhas river estuary.

Thane creek is under the influence of semidurinal tides with mean spring tidal range of 4.9-5.0m throughout Thane creek, while the spring tidal range of 4.5 m in the mouth of Ulhas estuary decreases to 2.8 m at 55 km inland. The annual mean rainfall of 2600-2800mm that the catchment receives during June – September (monsoon period) leads to high runoff through the Ulhas River and its tributaries to Arabian Sea (Chouksey 2004).

**4.2 Present Study**

Bathymetric data of Thane creek from Balkum to Salt pan is obtained from Hydrographer, Maharashtra Maritime Board (MMB). Contours and longitudinal section are plotted from the bathymetric data and it has been depicted in Figure 4.1a, 4.1 b and Figure 4.2, respectively. The cross section of Thane creek at various chainage is show in Figure 4.3(a) to Figure 4.3(k). Contour graph and longitudinal section shows that the from Ch. 0 to Ch. 300 and from Ch. 4400 onwards there is free flow during low tide. In portion between Ch. 300 and Ch. 4400 there is variation with

peaks at various locations. The bed stratum in the area between Ch. 4000 and Ch. 4400 is rocky, and in other areas bed level is elevated due to siltation. The width of the creek is getting reduced due to encroachment by unauthorized slum, dumping of solid waste in past, disposal of construction debris, which leads to increase in bed levels. In past both banks used to be nourished with mangroves, which served as a effective protection from erosion. But due to various manmade activities, mangrove area is reduced thereby increasing banks erosion , increase in bed level and further reduction in basin capacity.

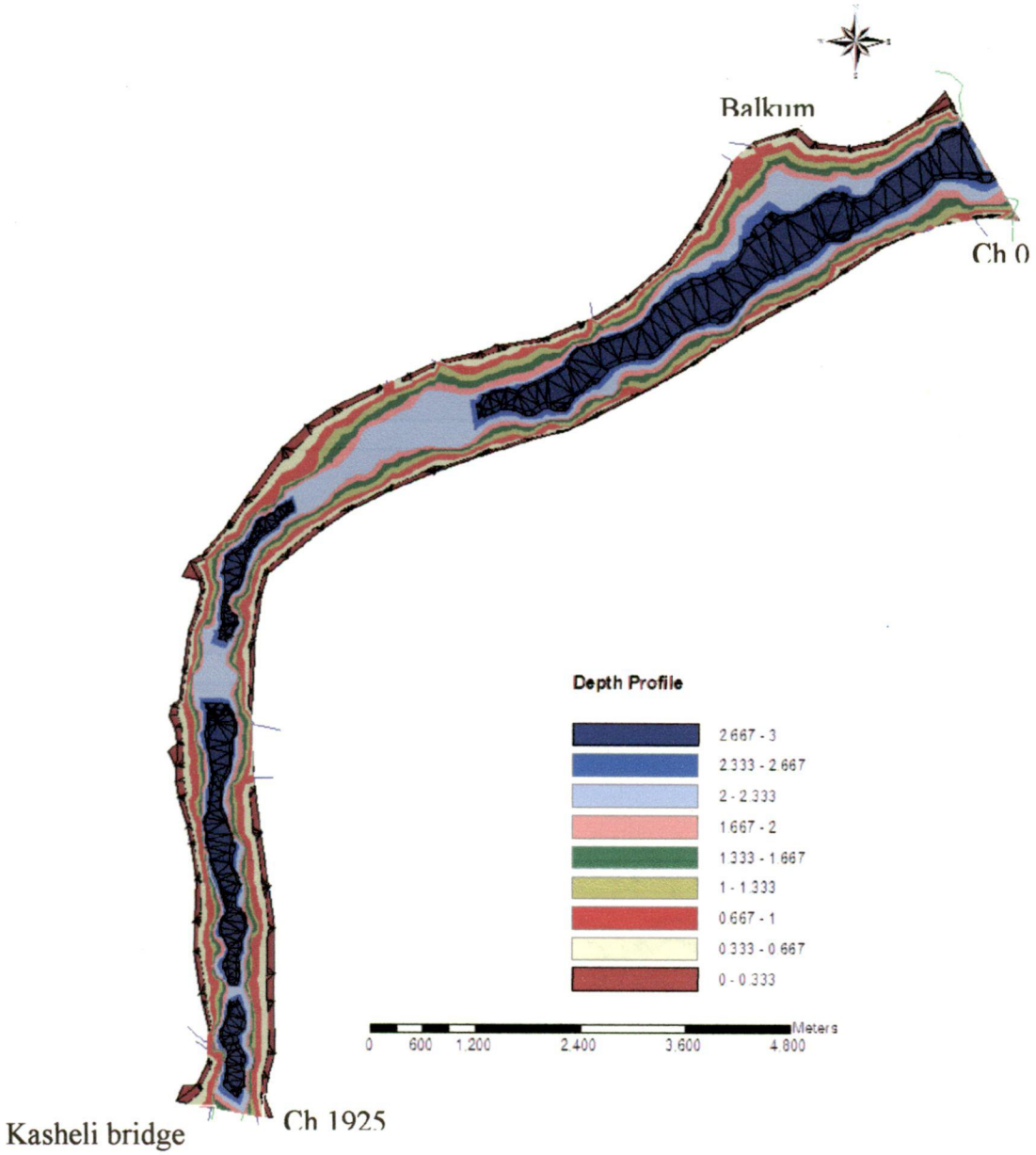



Figure 4.1a: Contour profile of Thane creek –Balkum to Kasheli bridge

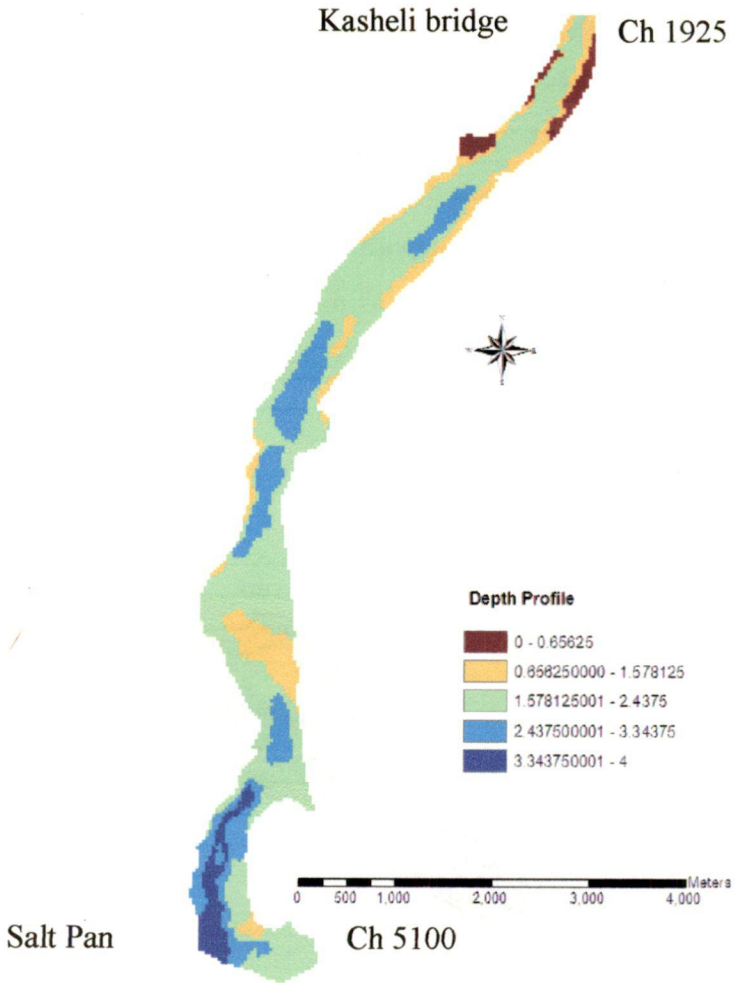



Figure 4.1b: Contour profile of Thane creek – Kasheli bridge to Salt pan

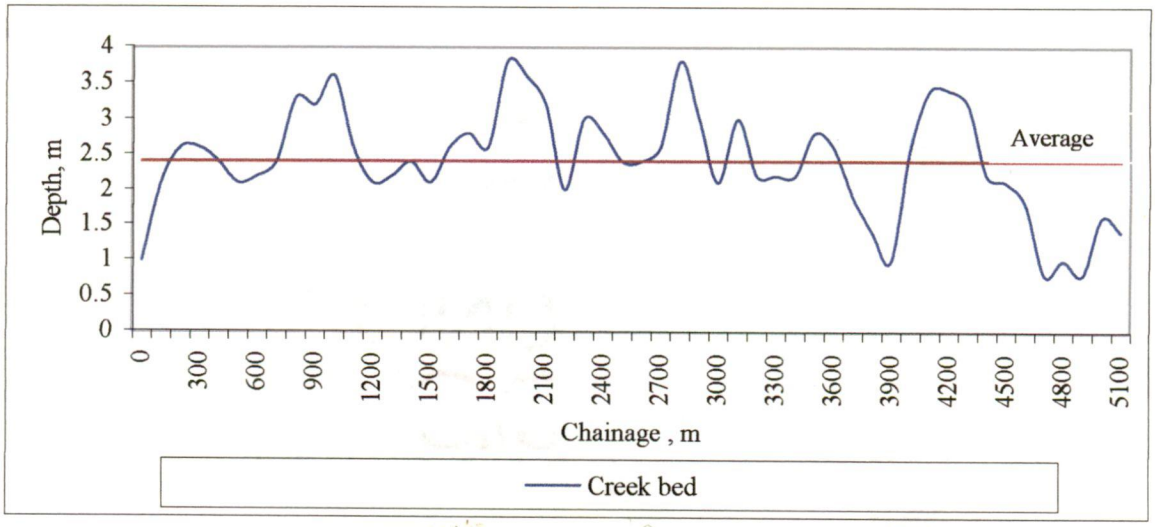



Figure 4.2: Longitudinal section of Thane creek ( Ch. 0 to Ch 5100m )

| | | | |
|---|---|---|---|
| Ch. 0 | Balkum | Ch. 1325 | Balkum Ghat |
| Ch. 1925 | U/s of Kasheli bridge | Ch. 1975 | D/s of Kasheli bridge |
| Ch. 3400 | U/s of Kalwa bridge | Ch. 3425 | D/s of Kalwa bridge |
| Ch. 4275 | U/s of railway bridge | Ch. 5125 | Salt Bunder |
| Ch. 4300 | D/s of railway bridge | | |

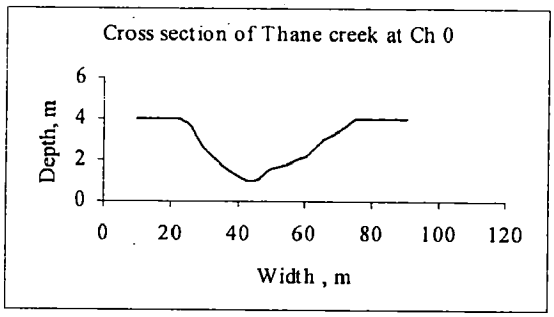



Figure 4.3(a): Cross section of Thane creek at Ch 0

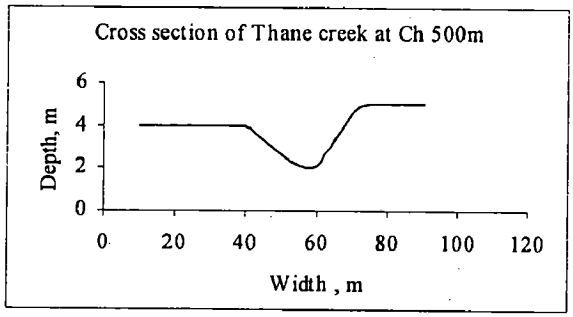



Figure 4.3(b): Cross section of Thane creek at Ch 500m

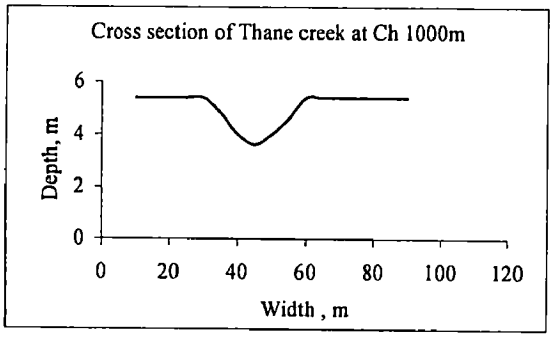



Figure 4.3(c ): Cross section of Thane creek at Ch 1000m

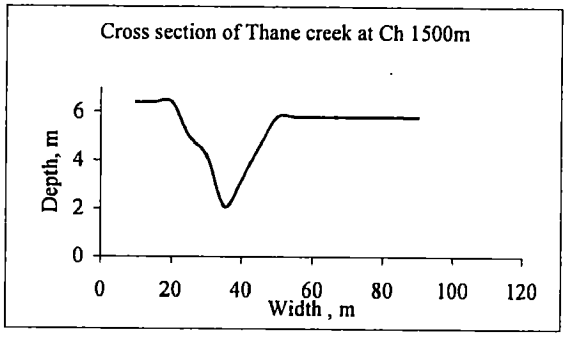



Figure 4.3(d): Cross section of Thane creek at Ch 1500m

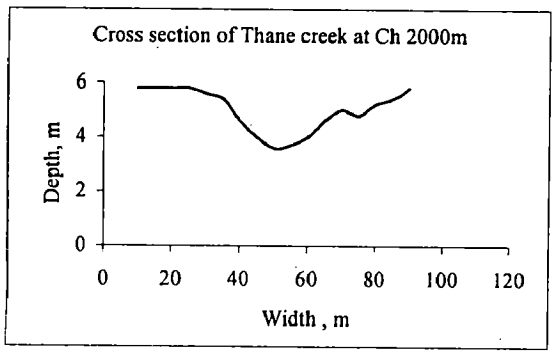



Figure 4.3(e): Cross section of Thane creek at Ch 2000m

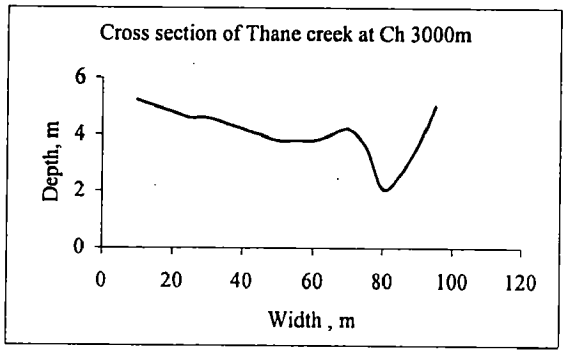



Figure 4.3(f): Cross section of Thane creek at Ch 2500m

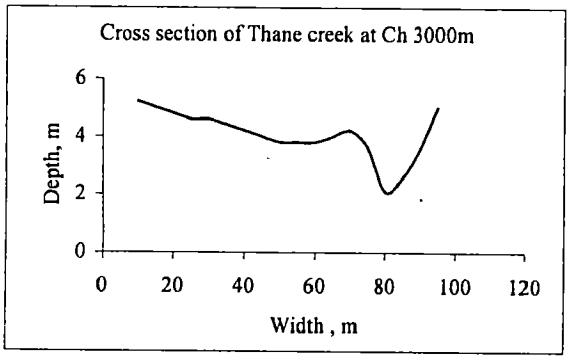



Figure 4.3(g): Cross section of Thane creek at Ch 3000m

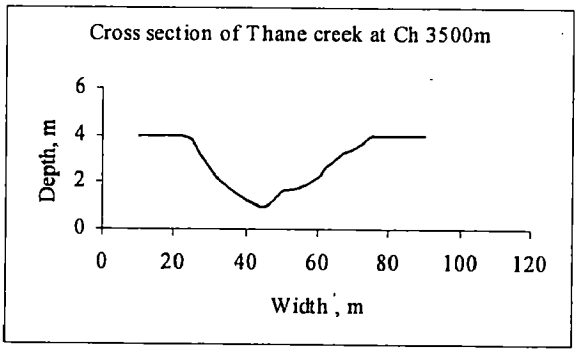



Figure 4.3(h): Cross section of Thane creek at Ch 3500m

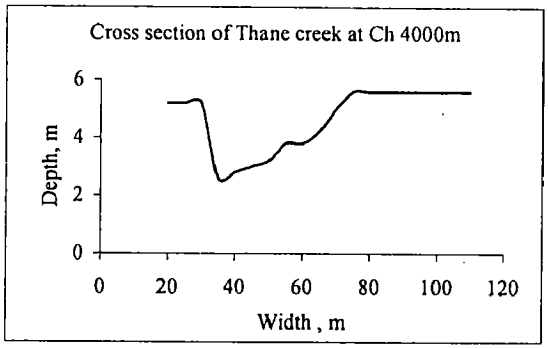



Figure 4.3(i): Cross section of Thane creek at Ch 4000m

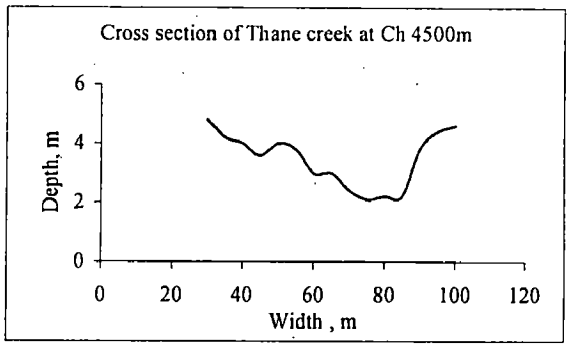



Figure 4.3(j): Cross section of Thane creek at Ch 4500m

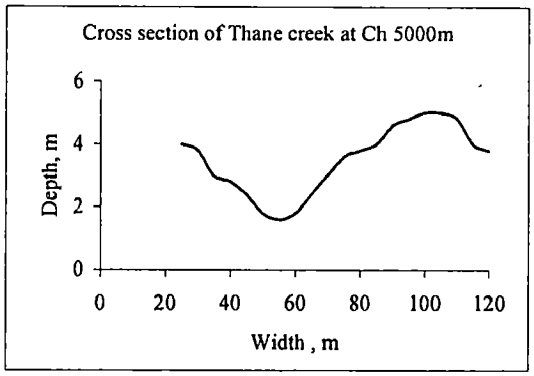



Figure 4.3(k): Cross section of Thane creek at Ch 5000m

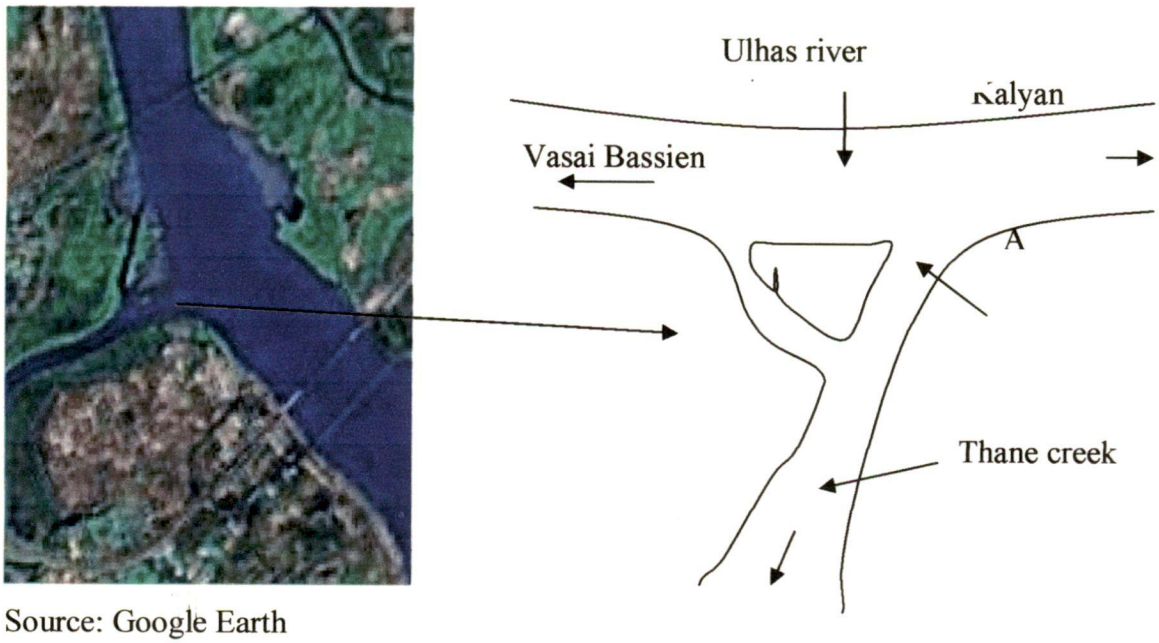
The geometry of the confluence of Thane creek and Ulhas river is show in Figure 4.4. During the high tide water flow from Vasai bassein to Kalyan and vice versa during low tide. It is commonly known and sited in literature that Ulhas river estuary water enters into a Thane creek during monsoon. Patel (1985) reported that the Ulhas river water flows in to Thane creek only in high flood during monsoon months. Hardly any reference was available is past regarding the flow effect of Ulhas river estuary on Thane creek, hence it was decided to observe the tidal water movement for a complete day at the confluence.

The flow pattern during high tide and low tide for both water bodies are shown in Figure 4.5a, 4.5b and Figure 4.6a, 4.6b, respectively. It is observed that the flow pattern is quite complex. During high tide water from the Ulhas estuary and Trombay meets about 300 m from Kasheli bridge towards estuary (Figure 4.5a). Velocity of the tidal flow is also measured at Balkum ghat. It is observed that the water from the Trombay comes with a high velocity that dominates and pushes back the water that comes from the Ulhas estuary (Figure 4.5b). The tidal water carries waste from the city towards the estuary during high tides. At the confluence due to shape and high tidal current in estuary the water from Thane creek does not get assimilate into it. Due to this, waste gets accumulated at the confluence and gets rotated. During low

tide, estuary water enters into a Thane creek (Figure 4.6a) and it flows upto Kalwa bridge and returns back in to estuary (Figure 4.6b).

Tidal velocities during low tide and high tide at Balkum ghat, Thane creek and Kharegaon crematoria, Ulhas river estuary (Figure 4.7) are measured and tidal flow is calculated which, is shown in Figure 4.8 and Figure 4.9, respectively. The maximum velocity during high tide at Balkum ghat recorded is 0.842m/s. This may be because of reduced section of the creek. During low tide maximum velocity of 0.345 m/s is recorded. Maximum daytime high tide velocity at center of the creek at Kharegaon crematoria is 0.337m/s.

It is observed that shape of the Thane creek at Kharegaon (Figure 4.10) is such that, it obstructs the free tidal movement. High tidal water from Ulhas river is not entering into Thane creek freely and during low tide water does not move into Ulhas river. In order to improve the flow characteristics the portion "A" as show in Figure 4.9 has to be properly studied and chanalisation is required. It is also necessary to protect the banks after dredging / chanalisation of the banks to prevent erosion.




Source: Google Earth

Figure 4.4: Geometry of the confluence of Thane creek and Ulhas river estuary

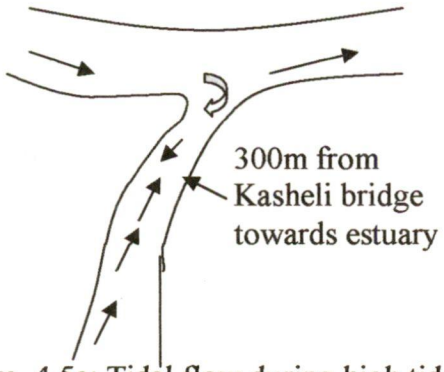



Figure 4.5a: Tidal flow during high tide

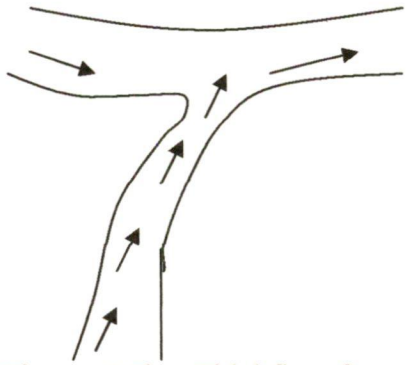


Figure 4.5b : Tidal flow from Vashi to Balkum during high tide

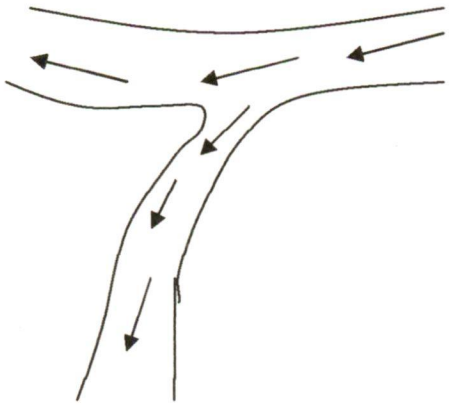


Figure 4.6 a: Tidal flow during low tide

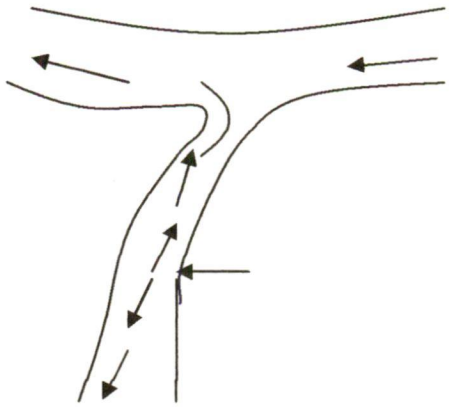


Figure 4.6 a: Tidal flow from Thane creek to estuary during low tide

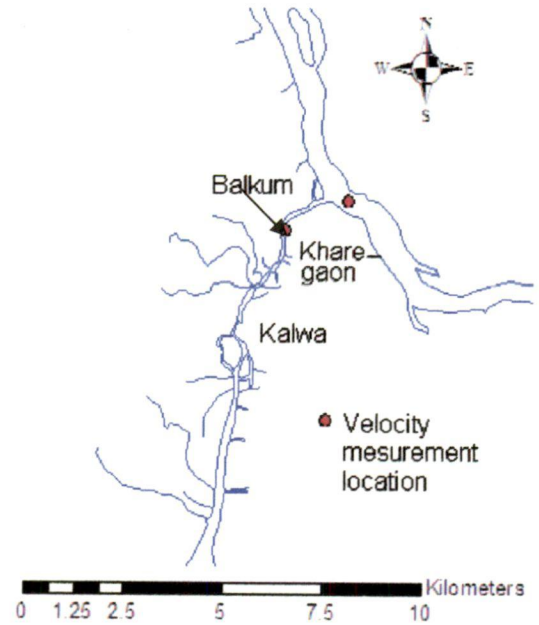



Figure 4.7: Locations where velocity is measured

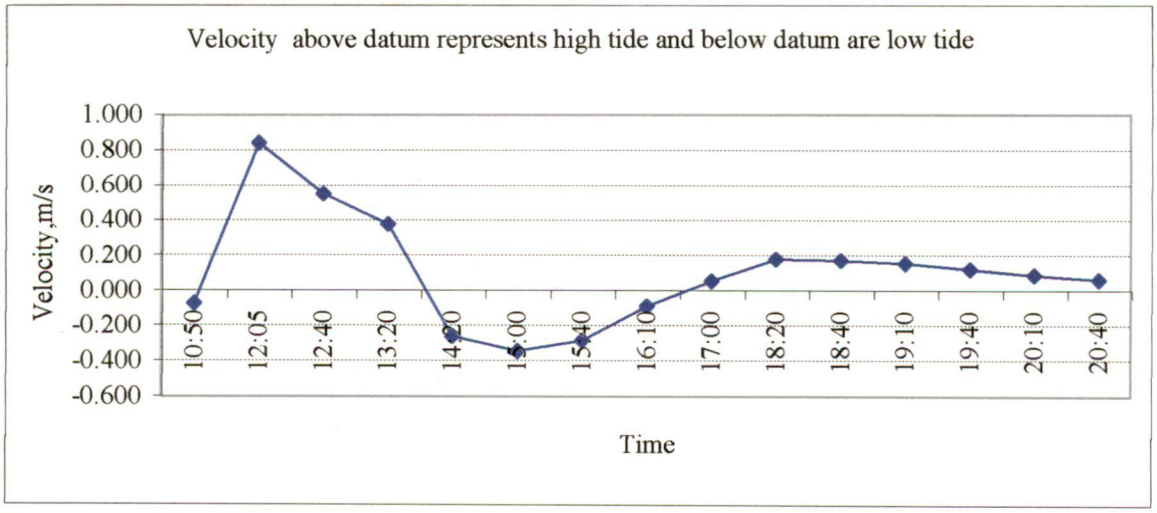



Figure 4.8: Velocity at the center of Thane creek near Balkum Ghat

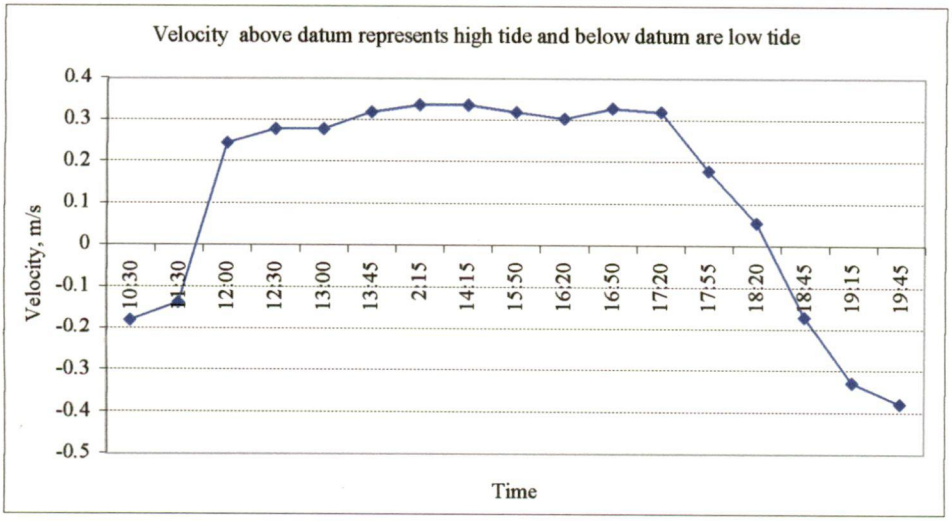



Figure 4.9: Velocity at the Ulhas river center near Kharegaon crematoria


Source: Google Earth

Figure 4.10: Sharp curve at Kharegaon

In total there are seven bridges in the 5.1 km portion of the Thane creek from Balkum to Vitawa. It is observed that the effective waterway below the various bridges is reduced (Figure 4.11 to Figure 4.18). Blockage of waterway between the piers of the bridge reduces the free flow and volume of tidal water, thereby reduces the flushing capacity of the creek.

Figure 4.11: Blocked water way below 100 MLD Saket bridge

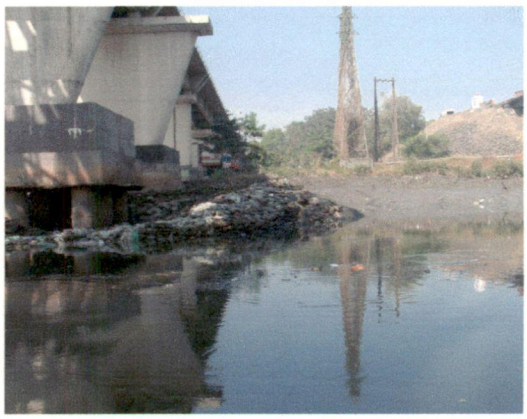


Figure 4.12: Blocked water way below 100 MLD Saket bridge

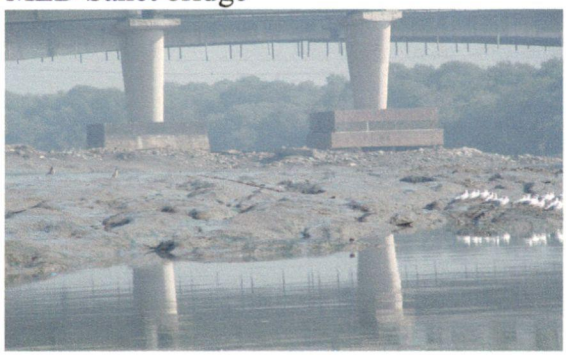


Figure 4.13: Mud flats near Saket bridge

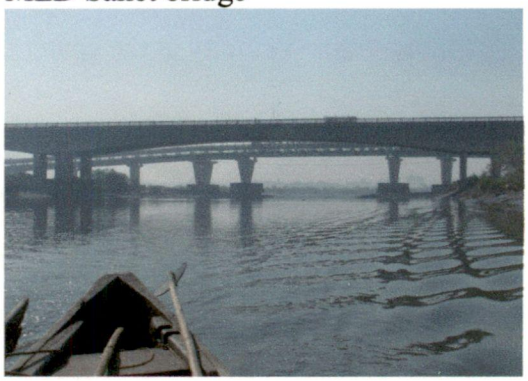


Figure 4.14: Shorter span Saket bridge behind longer span highway bridge

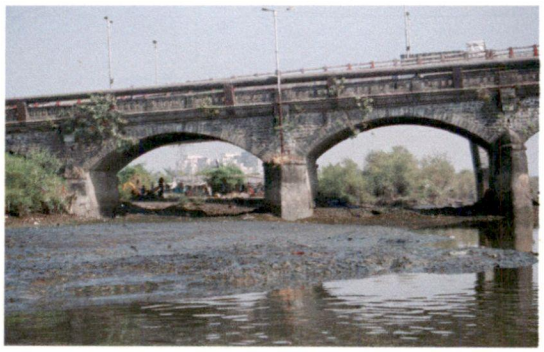


Figure 4.16: Kalwa bridge with encroachment on side bank

Figure 4.15: Mudflats near Kalwa bridge

Figure 4.17: Vitawa railway bridge

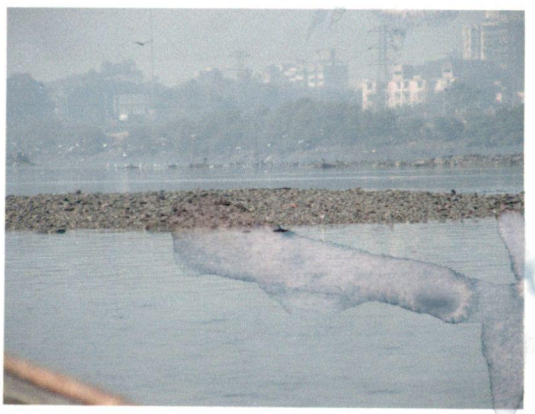


Figure 4.18: Exposed bed during low tide

Overall reduction in creek basin capacity effecting effective flushing may also be considered as one of the causes of flooding in the Thane City. After discussions with the local fishermen visiting the Thane creek regularly from last 20 years it is understood that silt deposition is in the tune of 4m to 6m. It is also understood from fishermen that Vitawa area was least affected during the 26th July, 2005 disaster area upstream of Vitawa is flooded. This may be because creek from Vitawa towards Airoli has more flushing capacity as compared to Kalwa to Balkum. This is also clear from the longitudinal section.

### 4.3 Future Study

#### 4.3.1 Bathymetric data

Bathymetric data obtained from MMB is of year 1999. It is essential to carry out the bathymetric survey for understanding the present condition of the creek and estuary. It will give the idea about the siltation taken place in the last 7 years. Also it will become a data for modeling of Thane creek and Ulhas river estuary.

#### 4.3.2 Storm water study and preparation of management plan

Hariyali, NGO along with Thane Municipal Corporation has undertaken the study with the support of Mumbai Metropolitan Region Environment Society, Maharashtra on the flooding of the Thane city and preparation of the Environment Management plan with respect to floods. The scope of the study is to find the reasons for the flooding in Thane city on 26th July 2005 and study possible solutions to prevent disaster in future due to floods

The expert committee is headed by Shri Patankar, retired Chief Engineer, Mumbai Municipal Corporation. Committee has discussed the issue with Central Water and Power Research Station (CWPRS), who are ready to take assignment of developing mathematical model (computer model) of Thane creek and Ulhas river estuary. It is proposed to study various options viz:

- Training of Nallah.
- Filling ponds.
- Removal of silt.
- Embankments.
- Tunneling.

### 4.4 Measures Proposed to Improve Flushing Capacity

From the analysis of the bathymetric data, velocities collected, field survey and various factors resulting the deterioration of the creek, the following remedial measures are proposed.

### 4.4.1Dredging

It is necessary to increase the flushing capacity of the creek, which can be done by dredging the basin in proper manner. The area under the bridge is required to be cleaned immediately to increase its waterway.

Various dredging option are studied and depicted in Figure 4.18. All Dredging options are designed for the width of 90.0 m. The change in velocity for due to proposed dredging for varying length of 3700m and 4400m and 90 m width is calculated by using Manning's formula is shown in Figure 4.19. Value of 'n' for calculating velocity is taken as 0.25. Change in tidal volumes during low tide and high tide is shown in Figure 4.20 and Figure 4.21, respectively and in Table 4.1. It shows that by dredging, low tide volumes for all the options can be increased by 2.53 million litres to 4.74 million litres as against 0.01 million litres. High tide volume can be increased by 199 percent to 222 percent for ch.0 to ch.4400 m and 189 percent to 209 percent for ch. 0 to ch.5100 m. Increase in volume carrying capacity of the creek will reduce the possibility of flood accumulation in Thane city during high tide. The estimated excavation quantities are given in Table 4.2. The excavation quantities for option 1, II, III and IV are 9.13, 2.48, 2.50 and 14.59 cum. respectively.

Out of various options option IV may be considered as the best suitable option.The estimated cost for dredging option IV comes to be Rs. 27.0 crores (Rs 21.9 crores for dredging Ch 0 to Ch 5100 m and Rs 5.1 crore for other part of the creek with TMC limit ) (dredging rate is takes as Rs 150 per cum (PWD 2005). TMC is executing Integrated Nalla Development Program (INDP) under which all nallas are designed for carrying storm water from city area into Thane creek, but it will not serve the purpose unless, volume of the Thane creek is increased. The estimated cost of the INDP project is Rs 150 crores. Thane Municipal Corporation suffers heavy damage about Rs. 171.71 crores (Road damage-Rs. 35.07 crores, Building damage-Rs. 0.225 crore, Pumping stations – Rs 29.60 crore, other – Rs 106.81 crore) due to 26$^{th}$ July, 2005 flood (GoM, 2005). By spending Rs. 27.0 crores on dredging creek basin will be a value addition to INDP and also minimise the possibility of heavy loss due to floods in future. Dredging will also help in inland water transport from Vashi to Thane.

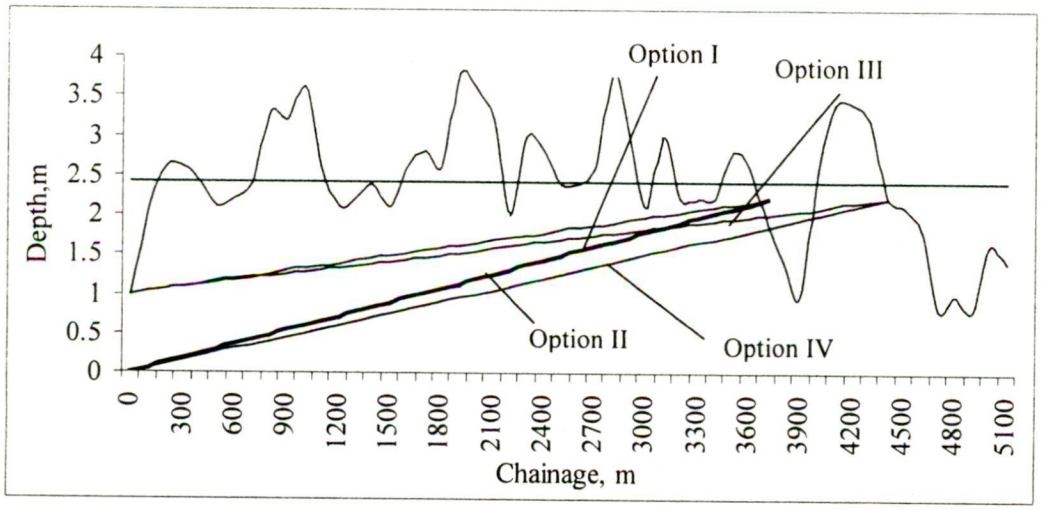



Figure 4.18: Various dredging options in Thane creek

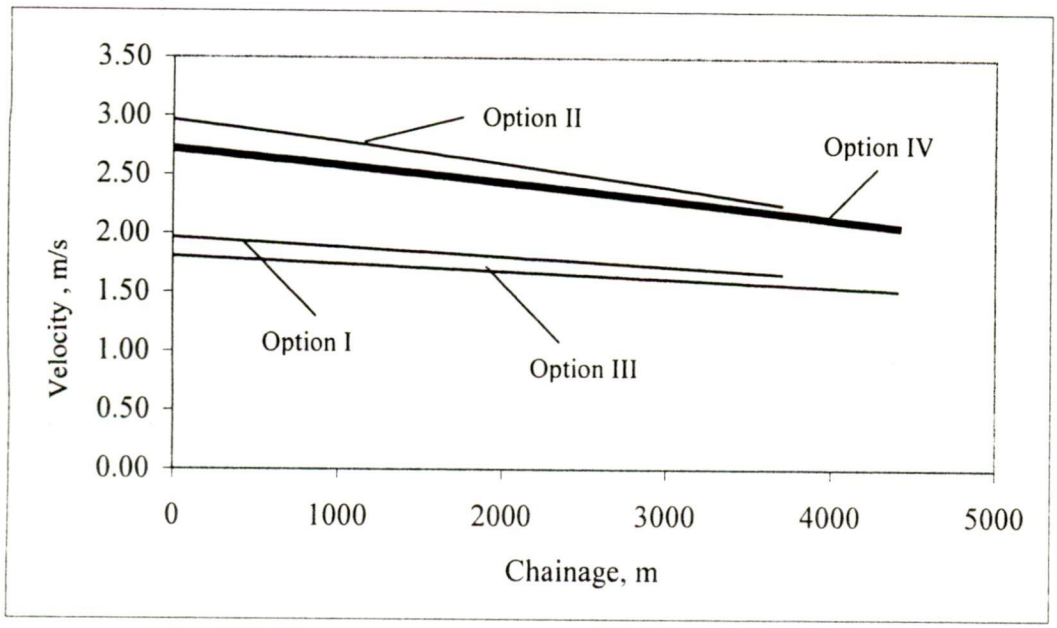



Figure 4.19: Velocity profile for various dredging options in Thane creek

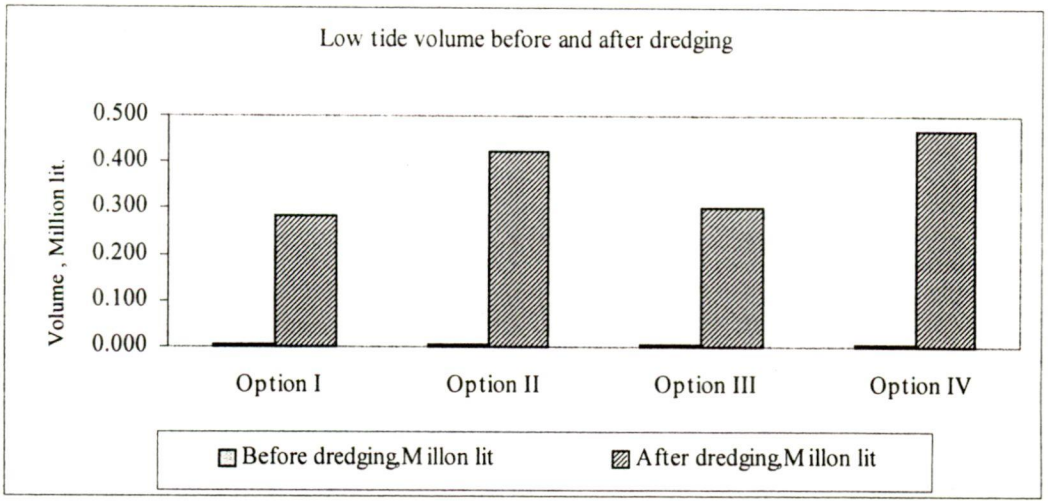



Figure 4.20: Low tide volume before and after dredging in Thane creek

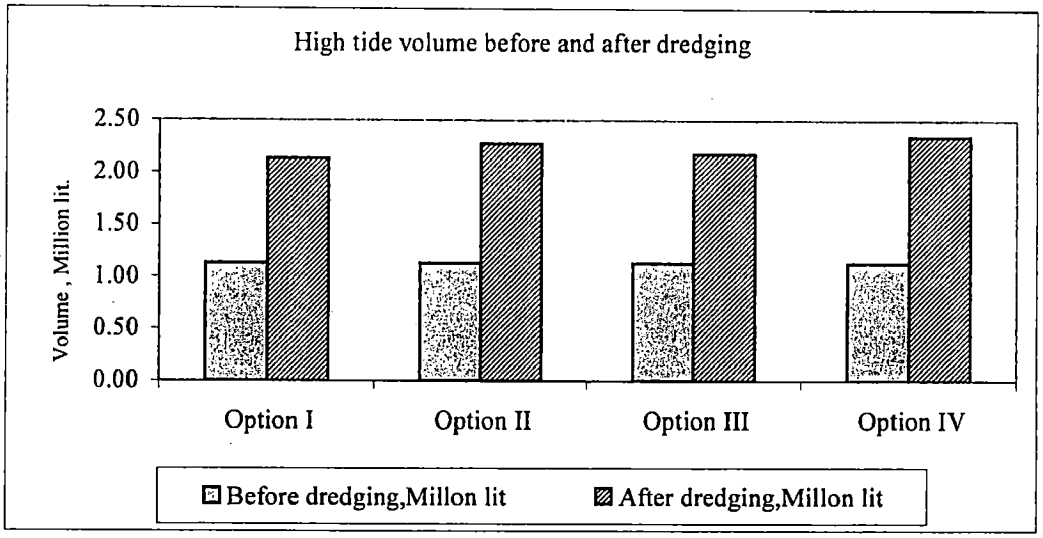



Figure 4.21: High tide volume before and after dredging in Thane creek

Table 4.1: Tidal flow quantities before and after dredging for various options in Thane creek

| | | Ch 0-4400 | | | | Ch 0- 5100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Option I | Option II | Option III | Option IV | Option I | Option II | Option III | Option IV |
| Low Tide | Before dredging, Million lit | 0.001 | 0.001 | 0.001 | 0.001 | 0.003 | 0.003 | 0.003 | 0.003 |
| | After dredging, Million lit | 0.25 | 0.42 | 0.28 | 0.48 | 0.28 | 0.42 | 0.30 | 0.47 |
| High Tide | Before dredging, Million lit | 1.08 | 1.08 | 1.08 | 1.08 | 1.13 | 1.13 | 1.13 | 1.13 |
| | After dredging, Million lit | 2.16 | 2.32 | 2.21 | 2.41 | 2.14 | 2.28 | 2.18 | 2.35 |
| % Increase | | | | | | | | | |
| Low Tide | After dredging | 22768 | 37736 | 24816 | 42541 | 10468 | 15729 | 11187 | 17418 |
| High Tide | After dredging | 199 | 215 | 204 | 222 | 189 | 201 | 193 | 208 |

Table 4.2: Estimated dredging quantities for various options.

| | Option I | Option II | Option III | Option IV |
|---|---|---|---|---|
| Estimated quantity, Lakh cum | 9.13 | 12.48 | 12.5 | 14.59 |

### 4.4.2 Chanalisation

It is necessary to chanalise the creek at various locations especially at Kharegaon area.

### 4.4.3 Tide gates

Tide gates for some of the nallas may be planned as a measure to prevent the ingress of tidal water during high tide.

# CHAPTER 5
# SEWERAGE AND SEWAGE TREATMENT

## 5.1 Introduction

Disposal of partially and untreated wastewater in creek has resulted in deterioration of water quality, aquatic flora and fauna over years. The analysis of creek and estuary water sample results shows that BOD is exceeding the standards, indicating the impact of addition of untreated domestic effluent.

Partly treated domestic wastewater from Mumbai, Navi-Mumbai and Thane, city enters into the Thane creek. The untreated domestic wastewater from cities like Kalyan-Dombivali, Ulhasnagar, Ambarnath, Bhiwandi, Thane etc. reach Ulhas River Estuary. Treated effluent from industrial areas in Dombivali, Sarvali (Bhiwandi), Thane, Ulhasnagar, Ambernath etc. is also disposed into Ulhas river estuary. The percent sewerage coverage of various Municipal Corporations disposing wastewater in Thane creek and Ulhas river estuary is depicted in Figure 5.1

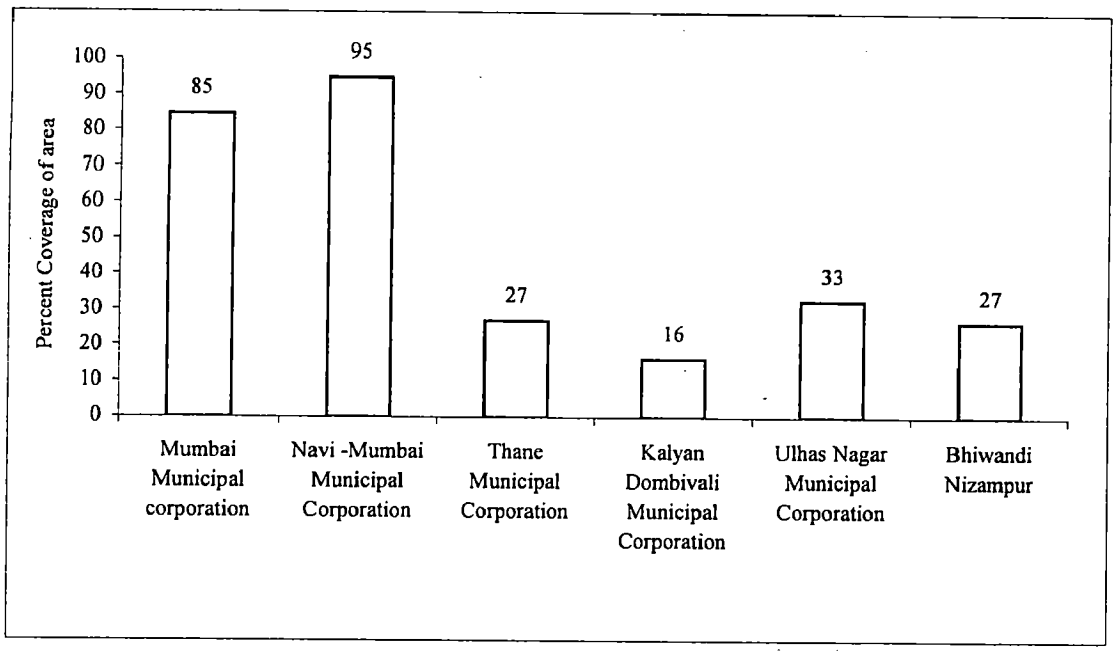



Figure 5.1 : Percent sewerage connection of various Municipal Corporation

In Mumbai 3050 MLD effluent generated and 2700 MLD is treated out of which 318 MLD primary treated effluent is disposed into Thane creek. Considering the quality of sewage effluent generation it seems that the STP's provided by MCGM are inadequate and under capacity utilized (Mumbai-ESR). At present 60 percent of

Mumbai city population live in slums. Coastal area, creeks, river quality is deteriorated mainly because of non-availability of sanitation & proper drainage & collection system. The city authority has to provide drainage systems covering such area, which are developed in an unorganized manner (Mumbai-ESR).

Total sewage effluent generated in Navi Mumbai Municipal Corporation area is 190 MLD and same is collected through underground sewerage system provided in most of the areas (Navi Mumbai-ESR).

Combined effluent treatment plant (CETP) at Trans Thane creek (TTC) was established on November 1997 and is designed to treat 12 MLD of effluent. This CETP is upgraded to enhance the total capacity up to 27 MLD. Treated and partially treated effluent is collected through underground sewer network and brought to CETP. After secondary treatment effluent is discharged into the Thane Creek through a sewer line of length 3.5 kms. by gravity through submerged outfall (Navi Mumbai-ESR). CETP user pattern is as follows

- Small-scale user members 425
- Medium / large scale user members 55
- Non user associate members 1905

Treated effluent from various industrial estate viz Dombivali phase I and II, ALMA, Ambarnath, Badlapur, Chilkoli-Morivali, Saravali, Badlapur amounting 28.25 MLD enter to Ulhas river estuary with a total BOD load of 9100 kg /day (Kalyan ESR)

Thane city generates more than 200 MLD of sewage. Only thirty percent of the sewage is collected and primary treated while the remaining finds its way into creek through nalla.

National Environmental and Engineering Institute (NEERI) conducted a study on "Determination of Assimilating Capacity of Thane creek". Considering the low assimilating capacity and deteriorated water quality beyond standards, NEERI recommended that comprehensive treatment efforts are needed to safeguard creek water quality. It is further recommended that level of treatment should be chosen so treated effluent should satisfy following limit for domestic wastewater NERRI (2003).

- BOD< 20 mg/l
- DO > 2 mg/l
- FC <1 x $10^5$ cts / 100 ml

## 5.2 Existing TMC Water Supply Facilities

### 5.2.1 Water supply sources

Water supply available to TMC at present is as follows :

| | |
|---|---|
| STEM | 127 MLD |
| MIDC | 75 MLD |
| MCGM | 60 MLD |
| TMC own supply | 100 MLD |
| Total | 362 MLD |

### 5.2.2 Distribution

99 % of Thane city population is connected through house connections and balance fraction being served through public stand posts (approx. 150 stand posts). Various details of distribution system is given in Table 5.1

Table 5.1: Salient features of TMC water supply distribution system

| | | |
|---|---|---|
| a. | Principal zones | Central, Northern and Eastern zone |
| b. | Water districts served by individual service reservoirs | 44 |
| c. | Service reservoirs | • Old scheme: 3 nos. in central and 6 nos in north zone.<br>• Phase I distribution project -14 in eastern zone and 5 nos. in central zone.<br>• Phase II distribution project - 10 in north zone and 5 in east zone. |
| d. | Distribution network | • Material - cast iron and ductile iron pipes<br>• Diameters - 100 mm to 800 mm<br>• Total length - 600 km |
| e. | Connection sizes | Domestic - diameter 120 mm to 150 mm<br>Non-domestic - diameter 150 mm |

In year 2002, TMC initiated a project for augmentation of the water supply distribution system. Upon completion of water supply project , water will be distributed to various wards of the city through a number of service reservoirs and a pipe network of about 600 km length.

## 5.3 Existing Sewerage Scheme

Maharashtra Jeevan Pradhikaran (MJP) developed the existing sewerage system in two stages. These two stages together cover an area of 17sq.km. and a population of 8,49,301 in old Thane town. The extended areas beyond the old town

have not been sewered so far. The old scheme was commissioned in year 1977 in the area east of the Express Highway in the old town. In the second stage area to the west of the Express Highway was covered under Maharashtra Water Supply and Sewerage Project (MWSSP), a part of the World Bank assisted project and commissioned in year 2001. Existing sewerage system in the Thane is shown in Figure5.2. The summary of existing sewerage facility is give in Table 5.2.

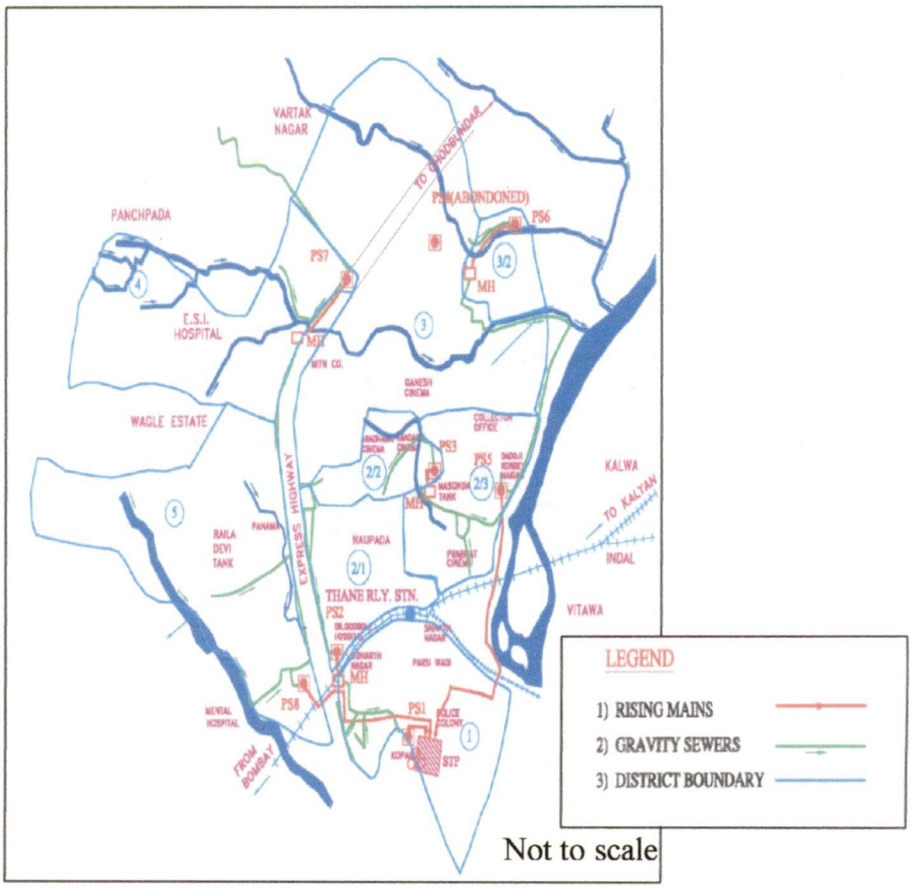



Figure 5.2 Map showing the existing sewerage system in Thane

Table 5.2:Existing sewerage facilities

| Component | Old Scheme | Stage II | Total |
|---|---|---|---|
| Area, km $^2$ | 9 | 8 | 17 (13 %) |
| Population, nos | 2,87,735 | 5,61,566 | 8,49,301 |
| Sewers, km | 48.5 | 20.7 | 69.2 |
| Manholes, nos | 1424 | 750 | 2174 |
| Pumping Stations, nos | 5 | 3 | 8 |
| STP, MLD | 18 | 36 | 54 |

### 5.3.1 Old scheme (stage I scheme)

The old scheme covered the old municipal limit, which includes Kolbad, Panchpakhadi, Khopat, Uthalsar, Charai, Vishnunagar, Naupada, Brahman Society, Bhaskarcolony and Kopari. The total area of the above said catchment is around 9 sq.

km. The main components of this scheme are as under:

(a) Sewers

48.50 km long sewers with 1,424 manholes

(b) Pumping Stations

Five in No.

(i) SPS No.1 in the premises of Kopari STP;

(ii) SPS No.2 near Kopari Bridge;

(iii) SPS No.3 near Masunda Tank;

(iv) SPS No.4 near Castle Mill; and,

(v) SPS No.5 near Dadoji Konddev Stadium.

(c)Sewage treatment plant

One of 18 MLD capacity at Kopari, which consists of pretreatment works, primary settling tank and digester.

(d) Disposal of the effluent

Clarifier into the creek.

**5.3.2 Stage II Scheme**

The works were commenced in 1982 and completed in 2001. The scheme covers an area of 8 sq.km. and a design population of 561,566. The main components of this scheme are as under:

(a) Three sewerage districts (3/2,4 and 5)

(b) 20.70 km long sewers and 750 manholes for collection system

(c) Sewage pumping stations (3 nos)

(i) Station No.6 near Shrirang Housing Society:

(ii) Station No.7 on bank of nalla near Cadbury Factory; and.

(iii) Station No.8 behind Dnyan Sadhana College.

(d) Pumping mains (3 nos)

(i) 430 mm CI pipeline, 810m long, from SPS 6:

(ii) 700 mm CI pipeline. 670 m long, from SPS 7: and.

(iii) 800 mm PSC pipeline, 1500 m long, from SPS 8.

(e) Pumping Station No.7 to collect sewage from the area to the west of Express Highway in Drainage District No. 4 and to pump through a 700 mm CI pumping main of 670 m length.

(f) STP at Kopari augmented from 18 MLD to 54 MLD by providing a new treatment

plant of 36 MLD, with the following units:

(i) Two screens (one mechanically operated and other manual);

(ii) Detritus tank;

(iii) Parshall flume for flow measurement;

(iv) Two clarifiers;

(v) Chlorine contact tank;

(vi) 1800 mm diameter and 840 m long outfall sewer upto creek;

(vii) Sludge thickener;

(viii) Sludge digester; and,

(ix) Centrifuges.

### 5.3.3 Status of existing sewerage system

The existing sewer network is overloaded and blocked at many places, resulting in overflowing manholes and flooding. TMC receives about 30 complaints daily of overflowing of a manholes. Many manholes are broken. Infiltration of sewage takes place through defective pipes, joints and manholes. Civil Structure of the pumping stations needs repairs. The pump installations require major repairs or replacement.

Sewage treatment plants suffer in their performance due to the following reason:

(i) The plants are overloaded and not achieving the desired discharge standards.

(ii) Screens and grit removal units need retrofitting.

(iii) Skimmer arrangement and sludge removal arrangement are not working properly. Sludge is removed manually once or twice in a year.

(iv) Chlorination arrangement is not in working condition.

(v) Sludge thickener and digesters are in a state of disrepair and need replacement. With the sludge removal only once or twice in a year, digesters are not in operative condition.

(vi) Sludge de-watering system is not working.

(vii) Civil structures need repairs for their continued use.

(viii) Mechanical and electrical components need to be replaced.

### 5.3.4 Operation and maintenance of existing sewerage system

The sewerage treatment plant at Kopari is being operated and maintained by TMC through its own staff. TMC has outsourced the operation and maintenance of the sewerage system on annual service contracts. Labour contractors do desilting and maintenance of the sewer lines and jetting machines are provided by the Corporation.

The pumping stations are operated and maintained by contractors and minor repairs and the contractors arrange consumables. Major repairs and spares required for replacement are also arranged by the contractor, but are paid by TMC at agreed rates, provided in the contract.

### 5.4 Proposed Sewerage System

TMC proposes to develop an Underground Sewerage Network and Treatment Project, designed to meet the sewerage needs of the project area up to year 2036 and to conserve Thane creek and Ulhas river estuary. Project components are: laying of sewer lines, installation of pumping stations, upgradation of existing STP and construction of new decentralised STP's, and low cost sanitation system.

Hills on the west and along the western boundary of Mumbra Kausa area, coupled with Thane creek passing through the eastern boundary of old Thane town and Ulhas river flowing along the northern and north-eastern boundary of the city, provide a peculiar topography which is suitable for the development of a sewerage system in a comparatively decentralized and phased manner. The detailed engineering is under preparation by MWH, consultant, considering topography and accordingly designs are being developed with four Sewage Treatment Plants sited at different locations.

#### 5.4.1 Design criteria for sewerage scheme

##### 5.4.1.1 Population forecast

The population of TMC area is increased from 91,054 in year 1951 to 12,62,551 in year 2001. The Corporation has been registering a high growth rate consistently in last five decades as depicted in Figure 5.3.

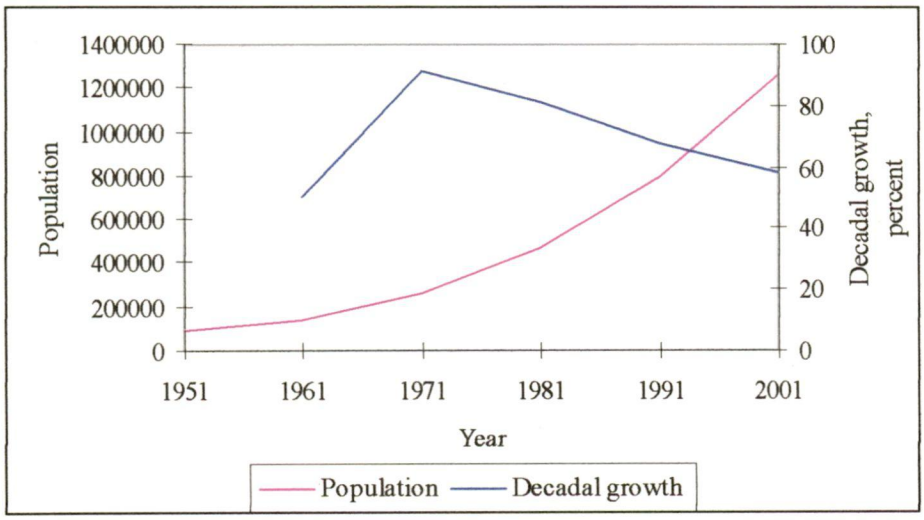



Figure 5.3: Population growth in last five decades

Projected population as projected in the Detailed engineering report prepared by MWH is given in Table 5.3

Table 5.3: Population projection

| Year | Population | Decadal Growth rate (percent ) |
|---|---|---|
| 2011 | 19,07,734 | 51.22 |
| 2016 | 22,53,105 | |
| 2021 | 26,11,365 | 36.88 |
| 2026 | 29,82,516 | |
| 2031 | 33,66,556 | 28.92 |
| 2036 | 37,63,486 | |
| 2041 | 41,73,305 | 23.96 |

Source: TMC Detailed Sewerage Project Report

**5.4.1.2 Per capita sewage flow**

Water supply of 150 lpcd at the consumer end and sewage flow of 120 lpcd, assuming that 80 percent of the water supplied to the consumers will return as sewage has been assumed for designing the scheme. Additional infiltration is assumed at 10 percent i.e: 12 lpcd. Therefore the rate of sewage flow works out to 132 lpcd.

**5.4.1.3 Design parameter**

Design parameter is given in Table 5.4

Table 5.4: Design parameters

| | | | |
|---|---|---|---|
| A | Design Year | | |
| | i. | Ultimate design horizon | 2036 |
| | ii. | Intermediate design year | 2021 |
| B | Sewer sizes and slopes | | |
| | i. | Design horizon | 30 years |
| | ii. | Minimum size | |
| | | Interceptor sewers | 500 mm |
| | | Secondary sewers | 300 mm |
| | iii. | Velocities | Minimum velocity of 0.6m /sec for peak flow in design year |
| | iv. | Depth of flow | To utilize 80 percent of the full bore of the sewer at peak flow in design year |
| | v. | Minimum cover | 1.50m |
| | vi. | Maximum depth of sewer | 10m below ground level |
| C | Peak factor | | 3 to 2 |
| D | Pipe material | | |
| | i. | Sewers | RCC NP3/ NP4 class pipes |
| | ii. | Pumping stations | CI and DI pipes |
| E | Sewage pumping stations | | |

| | | | |
|---|---|---|---|
| | i. | Types | Dry well and wet well for horizontal centrifugal pumps.<br>Wet well and value chamber for submersible pumps |
| | ii. | Civil structure | Design year 2036 flows |
| | | Mechanical and electrical items | Design year 2021 flows |
| | | Force mains | Design year 2021 flows |
| | | Capacity of wet well | |
| | | Horizontal pumps | 5 minutes at peak flow |
| | | Submersible pumps | 3.75 minutes at peak flow |
| F | Sewage treatment plants | | |
| | i. | Location | Based on topography , usage of existing system, proximity to disposal point , availability and accessibility of site , availability of other utilities and capitalized cost |
| | ii. | Sewage characteristics | |
| | | COD (ppm) | 708 |
| | | BOD (ppm) | 237 |
| | | Suspended solids (ppm) | 538 |
| | iii. | Adopted for design | |
| | | COD (ppm) | 550 |
| | | BOD (ppm) | 250 |
| | | Suspended solids (ppm) | 550 |
| | iv. | Effluent standards (MPCB) standards for disposal in Thane creek | |
| | | pH | 5.5-9 |
| | | BOD (ppm) | 100 |
| | | Suspended solids (ppm) | 100 |
| | | COD (ppm) | 250 |

Source:TMC Detailed Sewerage Project Report

### 5.4.2 Sewerage Project features

#### 5.4.2.1 Sewers

Total sewer length under the proposed project is 350 km. Minimum 300 mm diameter for secondary sewers is adopted as to avoid frequent blockages. Sewers are designed for year 2036.

#### 5.4.2.2 Pumping Stations

Demolition and reconstruction of old pumping stations No.2, 3 and 6 and Rehabilitation of pumping stations No.1, 5, 7 and 8. Pumping mains have been sized for a 30 years design period, considering the life of the pipe material and constraints of laying pipeline along narrow roads. Various pumping stations are shown in Figure 5.4.

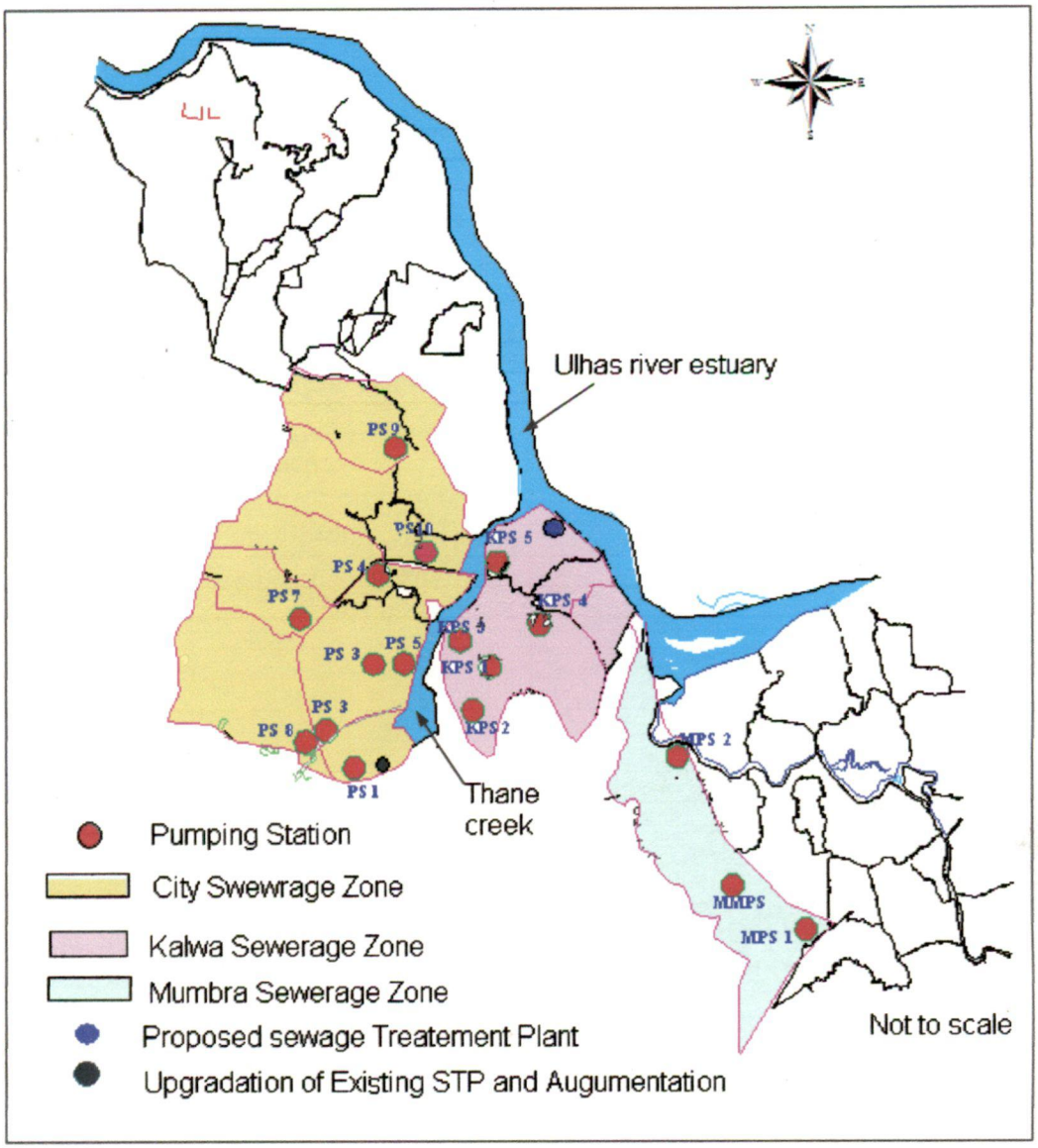



Figure 5.4: Locations of various pumping station and STP

Twenty-five pumping stations are proposed as under

| | |
|---|---|
| City area | 3 |
| Ghodbunder (South) | 3 |
| Ghodbunder (North) | 4 |
| Kalwa | 8 |
| Mumbra | 3 |

**5.4.2.3 Sewage treatment plants**

Sewage treatment plants are designed for year 2021with a sewage flow of 120 lpcd. Three treatment technology options were studied and the comparison of various technology options is given in Table 5.5. Out of three different options UASB followed by chemical treatment is accepted by TMC as proposed by the consultant.

Four sewage treatments plant of total capacity 294 MLD are proposed including upgradation of existing sewage treatment plant at Kopari and augmentation of its capacity from 54 MLD (existing) to 129 MLD.

| | |
|---|---|
| i.) Up gradation of existing STP at Kopari and augmentation of its capacity from 54 MLD(existing) to 129 MLD | 129 MLD |
| ii.) New STP at Kharegaon | 100 MLD |
| iii.) New STP for Mumbra – Kausa area | 25 MLD |
| iv.) New STP for northern part along Ghodbunder road | 40 MLD |
| Total | 294 MLD |

Table 5.5 Comparison of various technology options

| Sr. | Units | Option 1 | Option 2 | Option 3 |
|---|---|---|---|---|
| | | **Activated Sludge Process** | **Activated Sludge Process + UASB** | **UASB followed by Chemical Treatment** |
| A | **General** | | | |
| 1 | Ease of Operation | Very skilled | Very skilled | Skilled |
| 2 | Possibility of Biogas Production? | Yes | Yes | Yes |
| 3 | Possibility of Sludge Production? | Yes | Yes | Yes |
| 4 | Treated Sewage Characteristics:<br>BOD (mg/l)<br>TSS (mg/l) | <br><30<br><50 | <br><30<br><50 | <br><100<br><100 |
| 5 | Likely problem areas<br>Odor<br>Seasonal variability<br>Ground water pollution<br>Mosquito nuisance potential | <br>Moderate<br>Minimum<br>Minimum<br>Moderate | <br>Moderate<br>Minimum<br>Minimum<br>Moderate | <br>Localized<br>Minimum<br>Moderate<br>Minimal |
| 6 | Sludge handling problem | High | High | Moderate |
| B | **Land requirement** | | | |
| | Land available | 8 ha | 8 ha | 8 ha |
| | Land required | 8 ha | 8 ha | 7.5 ha |
| D | **Cost Analysis** | | | |
| 1 | Capital Cost , Rs lakhs | | | |
| | Civil | 2382.22 | 2418.5 | 2372.83 |
| | Mechanical | 776.82 | 688.4 | 442.35 |
| | Electrical & Instrumentation | 242.52 | 185.89 | 69.73 |
| | **Total** | **3401.56** | **3292.79** | **2884.91** |
| 2 | O & M Cost / year, Rs lakhs | **447.20** | **282.60** | **134.60** |
| 3* | Capitalised cost, Rs lakhs | **6,804.80** | **5,443.50** | **3,909.40** |
| | **If Chlorination system is to be provided then Capital and 0 & M cost will be as follows** | | | |
| | **Capital cost, Rs lakhs** | | | |
| | Civil | 6 1.71 | 61,71 | 61.71 |
| | Mechanical | 59.77 | 59,77 | 59.77 |

Source: TMC Detail Sewerage Project Report

### 5.5 Sewage Treatment

Decentralised wastewater treatment system based on UASB technology id proposed at existing Kopari treatment unit, Kharegaon and Mumbra.

#### 5.5.1 Nalla tapping works

Even after implementation of sewerage project in Thane city possibility of disposal of wastewater from slum and small industries along the nallas, which will finds it way into Thane creek and Ulhas river estuary. This will affect the objective of preventing untreated wastewater disposal into creek and Ulhas river estuary. Hence it is proposed to trap a nalla at location nearer to pumping station. Nalla water can be diverted and further treated in STP. The design submitted by consultant need to be revised for nalla tapping works. During the monsoon wastewater from the nallas could be allowed to flow into creek.

#### 5.5.2 Constructed wetland

Plantation of mangroves is proposed along the banks of the creek and estuary which will have an added benefit in terms of wastewater treatment by natural process.

#### 5.5.3 Ecosanitation

Sewerage system needs high volume of water for the transportation of feaces and other residues to the wastewater treatment plant. It means we are diluting the solids into liquid and further converting it into solid, i.e., sludge. Pathogenic organisms, organic load as well as nutrients can be removed to a large extent by biological treatment plants. About 30 to 15 percent organic charges are however released even after UASB and ASP treatment respectively into the water bodies. This demands sustainable alternatives, hence concept of Ecosanitation is proposed for organised residential and commercial complex . Water is scare in India and for metro cities it is not advisable to use 10 to 15 litres potable water for one time flushing. The toilets should be designed in such a manner that it demands less water for flushing.

Ecological sanitation is based on the idea that urine, faeces and water are recourses in an ecological loop. It is an approach that seeks to protect the human health, prevents pollution of the environment, reduces the use of water in sanitation systems and recycles nutrients to help to reduce the need for artificial fertilizer in agriculture. This recycling of nutrients helps to secure food security. Ecological sanitation is flexible, centralized can be combined with decentralized, waterborne with dry sanitation and high tech with low tech solutions. By considering a much

larger range of options optimal economic solutions can be developed for each particular situation [8].

#### 5.5.3.1 Excreta-Based Biogas & Biofertilizer Technology for residential and commercial complex

Excreta-Based Biogas & Biofertilizer Technology can be adopted by coming up new residential/commercial complex in Thane, which will reduce the load on TMC STP's. Rebate in taxes may be given to those implement this technology.

Dr. Pathak of Sulabh International has promoted on a massive scale, the idea of obtaining biogas from human excreta. Excreta contain 66% methane, a burnable gas that can be used for cooking and electricity generation [8]. It has the added advantage of being a source of renewable energy. Biogas so produced is used for lighting, cooking, etc and the effluent is a rich fertilizer. Biogas plant could be coupled with Sulabh effluent plant that lowers down BOD of sewage from 200 mg/l to 10 mg/l [9]. The effluent is made colorless, odorless and pathogen-free, fit for discharge into any water body, promoting a better and healthier environment.

#### 5.5.3.2 Waterless Toilet

Waterless toilet is a sanitation system that does not require any water to function. Not only does it save on water use, but also it is entirely isolated from the surrounding environment and cannot contaminate underground water resources. The system utilises a natural biological process to break down human waste into a dehydrated odourless compost-like material.

The schematic diagram of ecosan waterless toilet is shown in Figure 5.6. The human excrement falls down a vertical chute (2) and into one end of a specially designed helical screw conveyor (3). Every time the toilet lid (1) is lifted, a mechanism rotates the conveyor. With each rotation the human excrement slowly moves along, taking approximately twenty-five days before falling into a reusable collection bag (4). It takes six months for the bag to fill with dry and odourless waste [8]

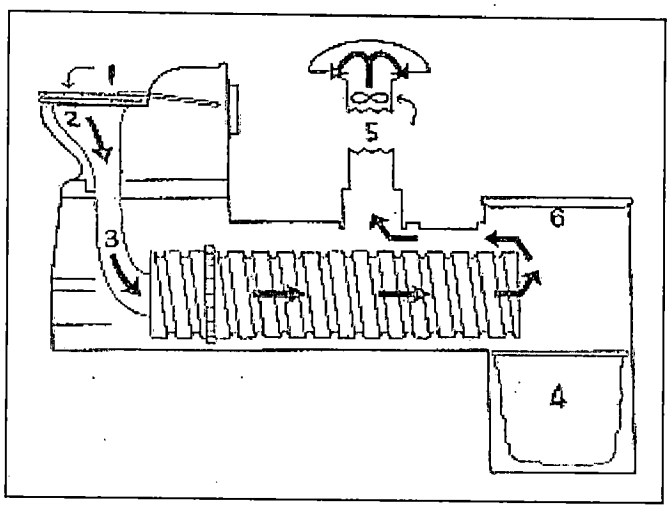


Figure 5.5: Schematic diagram of ecosan waterless toilet [8]

Through the uniquely designed ventilation pipe (5), adequate airflow is provided for the dehydration / evaporation, deodorising process. Human excrement consists of roughly 95% moisture. As the solids dry in the conveyer the urine and moisture is vented into the atmosphere. The solid waste then dries into a compost-like material, roughly 5 - 10% of its original mass, which can be used as compost.

# CHAPTER 6

# MUNICIPAL SOLID WASTE MANAGEMENT

Increase in population, commercial and industrial development results in increase in waste generation in the city. Solid waste disposal is one of the major problem in various cities faced by city municipal corporations. Solid Waste Management Status of various Municipal Corporation in Thane and around areas is given in Table: 6.1. There is an inadequacy of the collection and segregation of solid waste as well as transportation facility. The disposal sites have been fully utilized and exhausted. The municipal solid waste generated from cities is disposed improperly along the creeks, which results in additions of leachates/ runoffs in creek. The leachates generated from the dumping ground are not collected properly and untreated leachates directly finding its way into Thane creek and Ulhas river estuary. There is an urgent need to select new disposal sites and adopt scientific method for disposal of municipal solid waste .

Table 6.1: Summary of Solid Waste Management of Various Municipal Corporation related to Thane creek and Ulhas river estuary

| | Mumbai | Navi Mumbai | Thane | Bhivandi | Mira-Bhayandar | Ulhas Nagar |
|---|---|---|---|---|---|---|
| Total quantity collected (MT/day) | 7025 | 310 | 600 | 300 | 260 | 236 |
| Area of dumping ground/ landfill site | 150.7 | 110 | 19 | 20 | 31.46 | 68 |
| Cost of SWM services in Rs per capita per year | 256.38 | 151 | 255.39 | | | 277 |
| Cost of SWM services in (Rs/ MT) | 1154 | 753 | 2017.3 | | | 921 |
| Total cost of SWM (Rs lakhs ) | 31618 | 1100 | 3411.4 | 1550 | 412.34 | 1312 |
| Establishment in (Rs lakhs ) | 24106 | 950 | 2768.4 | 1400.3 | 291.27 | 956 |
| Tools, equipment ( Rs lakhs ) | 400.02 | 40 | 19.87 | 50 | 45.62 | 70 |
| O & M (Rs lakhs ) | 2194.76 | 150 | 249.78 | 56 | 13.39 | 233.6 |
| Hiring charges for contractors' vehicle & machinery ( Rs lakhs ) | 4355.18 | 17.63 | 4.94 | 30 | 62.05 | 53 |
| Other misc. expenses (Rs lakhs ) | 562.04 | | 1.15 | 20 | | |

Source: National solid waste Association of India [10]

## 6.1 Existing Status of Solid Waste Management Practices in Thane

Disposal of solid waste poses the serious problem in TMC. The Municipal Solid Waste (Management and handling) Rules 2000 (vide Ministry of Environment and Forest, Government of India notification S.O. 908(E) dt. 25$^{th}$ September 2000)

(MoEF 2000) makes it mandatory for the Municipal Corporation to setup effective collection, treatment and disposal infrastructure for managing the solid waste.

### 6.1.1 Generation pattern of Solid Waste

The solid waste is generated in the city from various commercial, domestic and industrial activities. Some of the normal sources of the solid waste in the city are:

- Household garbage.
- Vegetable waste from the markets.
- Building and construction debris.
- Solid waste generated from Commercial activities.
- Solid waste generated in the effluent treatment plants

The solid waste generation in the city is increasing with population growth of the city. 518 Tons of solid waste is generated per day Thane city. Samiti and ward wise waste generation is given in Table: 6.2.

Table 6.2: Samiti and ward wise waste generation

| Samiti | Ward No. | Population | Length of Road, km | Number of Households | Community Points | Generation , MT |
|---|---|---|---|---|---|---|
| Kalwa | 4 | 34950 | 8.02 | 7160 | 5 | 12.23 |
| | 10 | 40578 | 11.77 | 10018 | 3 | 14.2 |
| | 11 | 40644 | 19.25 | 11331 | 3 | 14.22 |
| Kopari | 12 | 39803 | 7.59 | 7504 | 7 | 13.93 |
| | 13 | 37694 | 4.89 | 6243 | 6 | 13.19 |
| | 14 | 33732 | 9.64 | 6728 | 6 | 11.8 |
| Manpada | 1 | 38715 | 12.17 | 12616 | 8 | 13.554 |
| | 2 | 36816 | 11.76 | 7796 | 4 | 12.88 |
| | 3 | 34291 | 16.54 | 8079 | 6 | 12 |
| | 24 | 37566 | 13.37 | 3366 | 6 | 13.14 |
| Mumbra | 5 | 34556 | 2.32 | 11356 | 6 | 12.09 |
| | 6 | 38975 | 0 | | | |
| | 7 | 34953 | 5.7 | 19072 | 6 | 12.23 |
| | 8 | 40074 | 8.51 | 12569 | 9 | 14.25 |
| | 9 | 34863 | 2.09 | 7563 | 8 | 12.2 |
| Naupada | 28 | 33933 | 7.97 | 6452 | 9 | 12 |
| | 29 | 34498 | 4.87 | 6078 | 9 | 12.07 |
| | 35 | 33895 | 5.27 | 5994 | 9 | 11.86 |
| | 36 | 35721 | 9.3 | 5050 | 9 | 12.5 |
| | 37 | 51925 | 7.1 | 8297 | 12 | 18.17 |
| Railadevi | 15 | 34585 | 5.94 | 10103 | 9 | 12.1 |
| | 16 | 39604 | 2.68 | 10382 | 10 | 13.86 |
| | 17 | 36755 | 1.92 | 6826 | 10 | 12.86 |
| | 18 | 38239 | 5.29 | 5467 | 10 | 13.38 |
| | 30 | 35257 | 10.61 | 14003 | 9 | 12.33 |
| Uthalsar | 25 | 37417 | 7.85 | 9707 | 10 | 13.09 |
| | 26 | 36943 | 8.44 | 8471 | 10 | 12.93 |
| | 27 | 40977 | 5.76 | 6869 | 14 | 14.34 |
| | 34 | 33771 | 4.07 | 9484 | 9 | 11.81 |

| Samiti | Ward No. | Population | Length of Road, km | Number of Households | Community Points | Generation , MT |
|---|---|---|---|---|---|---|
| | 38 | 52403 | 9.73 | 11543 | 12 | 18.34 |
| Vartak Nagar | 22 | 36859 | 5.25 | 10450 | 9 | 12.9 |
| | 23 | 39727 | 15.25 | 20713 | 10 | 13.9 |
| | 32 | 36868 | 8.03 | 9745 | 9 | 12.9 |
| | 33 | 39477 | 4.87 | 6076 | 10 | 13.81 |
| Wagle | 19 | 39953 | 4.41 | 9316 | 11 | 13.98 |
| | 20 | 38545 | 5.31 | 15270 | 11 | 13.94 |
| | 21 | 39552 | 3.6 | 9891 | 11 | 13.84 |
| | 31 | 36423 | 17.01 | 10529 | 9 | 12.74 |
| **Total** | | **1441537** | **294.2** | **348117** | **314** | **491.56** |

### 6.1.2 Characteristics of the Waste

Prabhag (Ward) samitiwise waste category breakup is given in Table 6.3. Composition of solid waste generated from residential and commercial area is depicted in Figure 6.1 and Figure 6.2, respectively. The physico- chemical characteristic of the solid waste generated in the city is given in Table 6.4.

Table 6.3: Prabhag Samitiwise waste category breakup.

| Name of Prabhag Samiti | No. of Wards | Quantity of Waste , MT | | | | | |
|---|---|---|---|---|---|---|---|
| | | Bio-degradable | Recyclable | Non recyclable | Green Waste | Total Quantity | Distance from disposal site |
| Kalwa | 3 | 25.405 | 5.669 | 5.669 | 2.834 | 39.577 | 14.6 |
| Kopari | 3 | 24.319 | 5.837 | 5.837 | 2.913 | 38.906 | 20.9 |
| Manpada | 4 | 32.23 | 7.735 | 7.735 | 3.868 | 51.568 | Owla- 24.3 |
| Mumbra | 5 | 32.117 | 7.707 | 7.707 | 3.857 | 51.388 | 9.1 |
| Naupada | 5 | 41.524 | 9.974 | 9.974 | 4.986 | 66.458 | 20.9 |
| Railadevi | 5 | 40.329 | 9.679 | 9.679 | 4.843 | 64.53 | CP Talao TS -20.1 |
| Uthalsar | 5 | 44.016 | 10.563 | 10.563 | 5.281 | 70.423 | Balkum-16.5 |
| Vartak | 4 | 33.442 | 8.026 | 8.026 | 4.016 | 53.51 | CP Talao TS -20.1 |
| Wagle | 4 | 33.78 | 8.107 | 8.107 | 4.056 | 54.05 | CP Talao TS -20.1 |
| Total | 38 | 307.162 | 73.297 | 73.297 | 36.654 | 490.41 | |

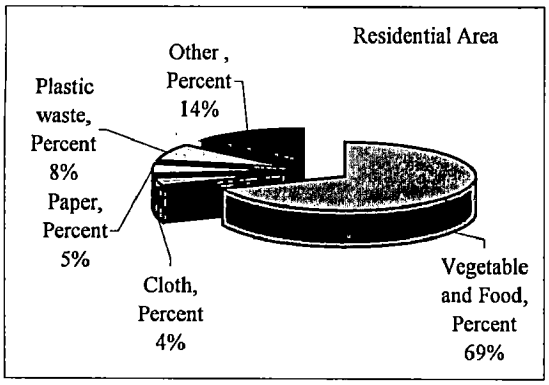



Figure 6.1 Composition of solid waste generated from residential area

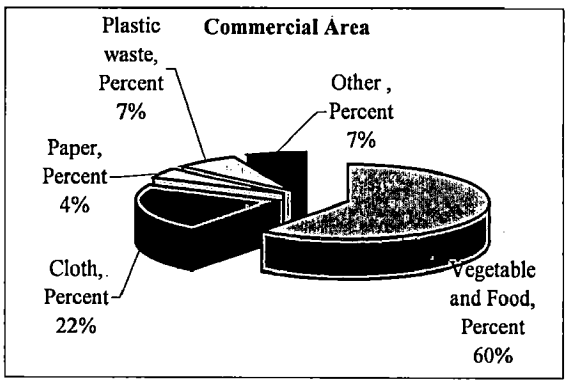



Figure 6.2 Composition of solid waste generated from commercial area

Table 6.4 : Physico chemical characteristics of solid waste in Thane City

| Parameter | Range in percent by weight |
|---|---|
| Total Soluble Solids (%) | 1.0-1.7 |
| Loss on Ignition (%) | 36.0-63.0 |
| Total Organic Carbon (%) | 15.0-37.0 |
| Total Phosphorus (%) | 0.04-0.07 |
| Total Potassium (%) | 0-0.3 |
| Total Kjeldal Nitrogen (%) | 0.3-0.4 |
| Arsenic (mg/100g) | Traces |
| Cadmium (mg/100g) | 3.0-3.6 |
| Copper (mg/100g) | 5.0-6.0 |
| Chromium (mg/100g) | 4.0-5.0 |
| Iron (mg/100g) | 150.0-200.0 |
| Lead (mg/100g) | 0.3-34.0 |
| Mercury (mg/100g) | Traces |
| Nickel (mg/100g) | Traces |
| Zinc (mg/100g) | 40.0-48.0 |

Source: TMC (2004)

### 6.1.3 Storage of Solid Waste

Solid waste from the household is transfered to the community bin by the residents. TMC has provided primary collection bins of 4.5 cum capacity at 160 locations and of 1 cum capacity at 220 locations in the city.

Solid waste generated by industries is stored in their premises. It is the responsibility of industries to dispose the solid waste generated by them.

Bio-medical waste generated in the hospitals and dispensaries are stored in separate bins and further transferred to centralized Bio-medical treatment unit set up at by TMC in joint venture with Enviro-Vigil an NGO.

Shivaji market generates a solid waste about 20 Ton per day and is collected directly in Maharaja machine (elevated collection arrangement) so that littering of waste is avoided as shown in Figure 6.3.

Waste generated from tabelas are stored in tabelas (where domestic animals like cows live) and disposed directly into nalla, which finally finds its way into Thane creek and Ulhas river estuary.

Ash collected from the crematoria is collected in bins and disposed into creek weekly. Small slaughterhouse owners store their waste into bins and dispose into community bins or nearby nallas as per their convenience.

### 6.1.4 Street Sweeping

The cleaning of the street / road of the entire city roads length of about 1400 given below.

| Road Width (m) | Length of Road (m) | No. of Municipal workers |
|---|---|---|
| 15 to 30 | 112 | 687 |
| | 168 | 840 |
| Sub Total | 280 | 1527 |
| 1.5 to 3.0 | 1120 | 560 |
| Total | 1400 | 2087 |

Out of 2087 workers 1400 are on Municipal Corporation pay roll whereas 687 are on contract basis. Streets are cleaned daily and wastes are stored in community bins, which is further transfered to disposal sites.

### 6.1.5 Transfer Transport, Processing and Disposal of Solid Waste

#### 6.1.5.1 Transfer and transport

Collection and transportation of waste is one of the important and critical activities. Any slip in these activities can result a lot of nuisance and public health hazard. Steps taken by TMC for collection of waste are as under: -

- Municipal Corporation has organized door-to-door collection by Ghantagadi (mobile collection van) (Figure 6.4) and community bins.
- From Slums- collection from house to house started by using 49 three-wheeler Tempos. In each Tempo the buckets of 100 lit. with the lids are kept for collection of wet and dry waste separately.
- Municipal Corporation collects hotels segregated garbage directly from the hotels at night between 11 pm to 2 am daily.
- For Slaughterhouse waste 4.5 cum collection bins are placed and lifted daily.
- For treating Bio-medical waste, facility has been set up in partnership with NGO.
- Debris/ Demolition waste is collected separately.
- Door to door collection by ladies organization covering 2500 families.

190 MT of waste collected is directly transported to the dumping site while 310 MT of waste is transported to dumping site through transfer site Figure 6.5 and Figure 6.6).

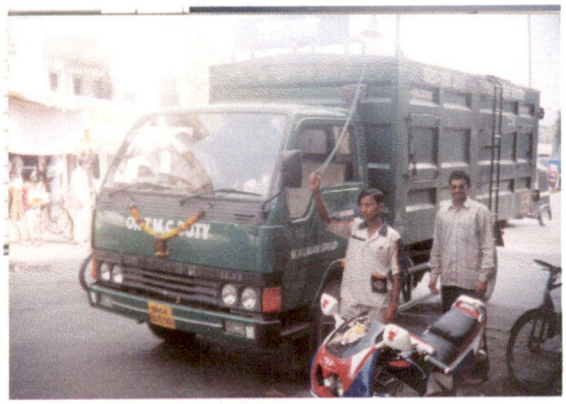


Figure 6.3 : Ghantagadi

Figure 6.4 : Maharaja machine

Figure 6.5: Transfer station ramp

Figure 6.6 : Waste is being transfered from dumper placer to transfer vehicle

### 6.1.5.2 Treatment and disposal of waste

Twenty five percent of the total waste generated is segregated at source. Waste is segregated through Ghantagadi. 15 percent to 20 percent of waste is segregated through rag pickers from dumping ground.

Keeping in mind the saturation limit of the existing dumping ground, a 6 MW capacity Waste to Energy Project with Municipal solid waste as a source of power has been proposed. For the decentralised solid waste treatment; the Corporation has undertaken the erection of 10 Bio-Methanisation Plants out of which 5 Plants (Each 25 MT capacity) are on Built operate and Transfer (BOT) basis and 5 Plants (Each 5 MT capacity) are through private participation with the association of Corporation. Out of these plants, one plant of 20 MT capacity has been commissioned at Kalwa hospital premises . The Power generated by these plants will be utilized to run the plants themselves along with Public Canteens and Hospital Kitchens.

For the safe disposal of Bio-Medical Waste, as per the norms laid down by Hazardous Waste (Management and Handling) Rule, steps have been taken for setting

up of incinerators for treating infectious medical waste. This project is being run on partnership basis with local NGO's.

The Municipal Solid Waste Rules issued by the Central Pollution Control Board make safe and proper handling and disposal mandatory. Till now total sanitary treatment and disposal is not achieved and looks still a dream. Even today open dumping areas have significant quantities of solid wastes dumped. Most of the solid waste is dumped randomly and secured landfill practices are not being followed. This presents a grave concern to the population of the city. Uncontrolled, illegal dumping of solid waste, especially construction debris continues to overburden the Corporation. Illegal dumping of solid waste in and around the creek area has created severe nuisance and also affected the ecological balance of the creek. This further creates obstacles in the normal flow of the creek water .

Inspite of administration making lot of efforts and expenditure in improving solid waste management system, the satisfactory results are not achieved. The system can be made effective by a positive participation by the public. Public awareness, effective community participation, transparent and clean administration, introduction of citizen charters and accountability at all levels can only bridge the gap.

### 6.1.6 Institutional Arrangement for Solid Waste Management

Solid Waste Management in the Thane Municipal Corporation is the responsibility of the solid waste department. The organization of the solid waste department is given in Table 6.5.

Table 6.5 : Number of employees catering to solid waste management in Thane city.

| **Details** | **Manpower** |
|---|---|
| Medical officer | 1 |
| Health Officer | 1 |
| Chief Sanitary Inspector | 1 |
| Additional Chief Sanitary Inspector | 1 |
| Deputy Chief Sanitary Inspector | 20 |
| Sanitary Inspector | 27 |
| Head Mukadam | 1 |
| Mukadams | 54 |
| Sanitary Worker Departmentally | 2483 |

| Details | Manpower |
|---|---|
| Permanent | 2337 |
| Daily Basis | 114 |
| Fixed Payment | 32 |
| Contract Basis | |
| For Cleaning | 115 |
| For Lifting Waste | 108 |
| JCB Operator | 2 |
| Driver | 127 |
| Departmental | 65 |
| Contract Basis | 28 |
| Clerk | 7 |

### 6.2 Citizens Perception About Present Solid Waste Management Practices

A total of 259 households were interviewed out of which non-slum respondents are 157 and slum dwellers are 102, Nikam (2005) .The analysis of the data suggests that people give third priority to solid waste management related problems after sanitation and air pollution

Disposal methods adopted by the citizens for inorganic waste are depicted in Figure (6.7). Analysis shows that 56.4 percent households dispose off inorganic waste through scrap dealers (Kabadiwala). 15.1 percent households dispose it partially through kabadiwala and partially along with the organic waste.15.1 percent households throw inorganic waste along with organic waste. 3.1 percent people segregate their inorganic and organic waste. 10.3 percent households dispose inorganic waste by giving it to the people who provide domestic help.

The analysis of responses to the questionnaire related with the transfer of waste from household to the nearest disposal/collection point shows that 43 percent household transfer their waste from house to curbside container Figure (6.8). Door to door collection is 20 percent. Waste collected partially through door to door and partially through ghantagadi (small mobile collection van) is 15 percent. Waste collected through ghantagadi is 15 percent whereas waste collected through ghantagadi and curbside containers is 7 percent.

Majority, i.e., 43 percent household preferred door-to-door waste collection method for future Figure (6.9). 26 percent household prefer curbside container for disposal of waste. 12 percent household prefer partially door to door and partially ghantagadi. Preference for ghantagadi as mode of transfer of waste for further disposal is 19 percent.

Main Solid Waste Management related problems are infrequent collection, location of container and foul odor Figure (6.10). The problem of infrequent collection and problems of people associated with solid waste management at Corporation level, i.e., sanitary inspectors, sanitary mukadam and sanitary workers are interconnected. The analysis of the responses to the questionnaire suggests that sanitary inspectors, sanitary mukadam and sanitary workers have problem pertaining to shortage of vehicles, disposal of collected waste with inadequate existing dumping ground capacity, non availability and/or maintenance of tools and equipments and interference by interested groups like corporators etc. In addition to this the sanitary workers feel that there is no appreciation for their work. Improper sanitation arrangement and open-air defecation by children on roads near curbside container creates unhygienic conditions around container which makes it difficult for people to come near to the disposal container for disposals of waste in to container and it finally finds its place on open roads.

Majority of citizens complain to the corporators regarding problems related with solid waste management Figure (6.11). They find it is easy to approach corporators rather than corporation officials. Hence, it is necessary that corporator should also be aware of solid waste management system of the city. They should understand the facts and limitation of the present system and not interfere with the day to day working of the officials and workers.

Two third of the citizens feel the need for an awareness program Figure (6.12). Majority of the respondents are interested to know about how to manage different kinds of waste. They also want to know about where to complain for waste collection related problems like collection schedule, etc.

The collected data suggests that citizens are ready to pay for effective solid waste management services. Use of plastic carry bags is common to both consumers and shopkeepers. After analysis of questionnaire filled by sanitary inspectors and sanitary mukadam, it can be concluded that they have to work beyond working hours,

but do not get financial returns or appreciation for extra work. Seventy five percent sanitary inspectors and sanitary mukadam and eighty two percent sanitary workers feel the need of training programs to increase their work productivity and effectiveness.

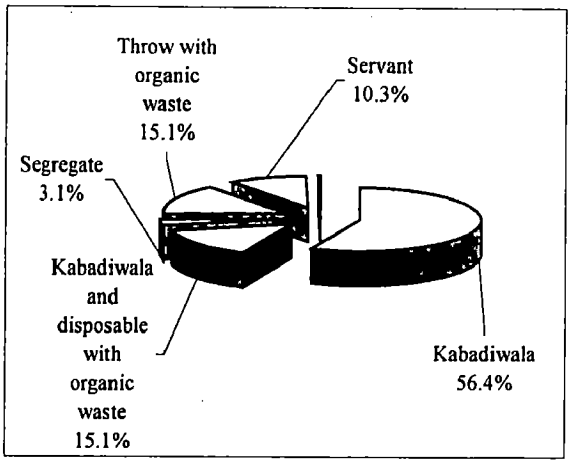



Figure 6.7. Disposal of inorganic waste from households.

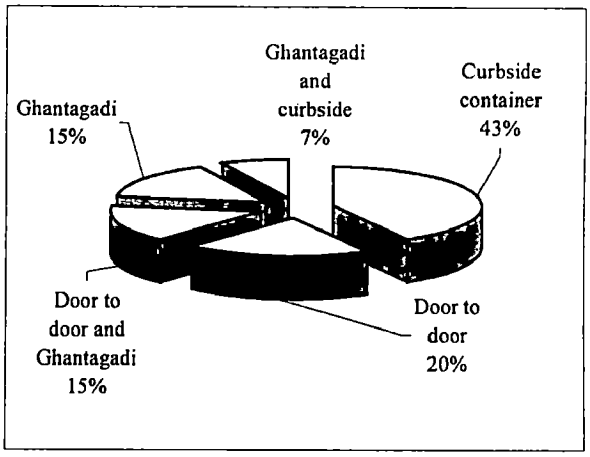



Figure 6.8. Present waste collection method from house for further disposal.

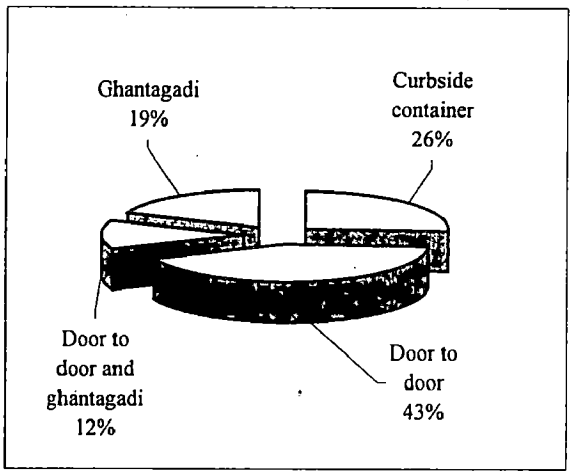



Figure 6.9. Preferred waste collected method from households for further disposal.

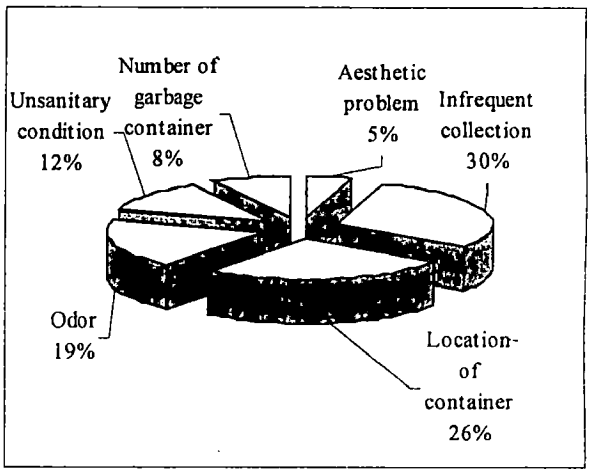



Figure 6.10. Solid Waste Management related problem.

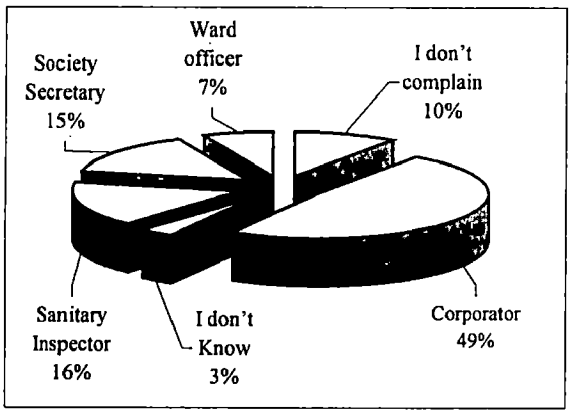



Figure 6.11. Whom to complain about irregularity in collection services

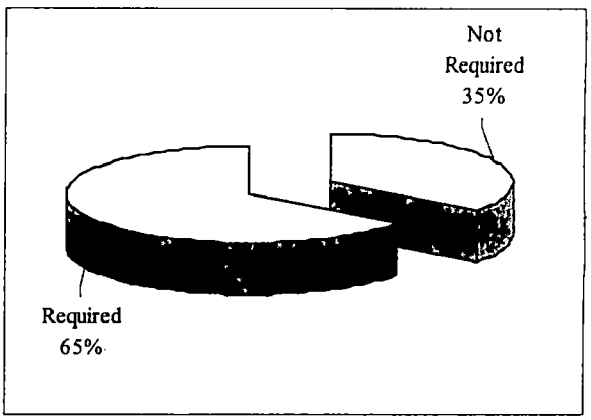



Figure 6.12. Need of awareness program

## 6.3 Proposed Solid Waste Management System

***Vision:*** *To achieve environmentally sustainable waste management practice to conserve Thane creek and Ulhas river estuary*

The improvement of SWM services in Thane requires significant improvement as an integral part of the conservation of Thane creek and Ulhas river estuary. Therefore it is urgent requirement to improve the present SWM system. The action taken by TMC should be coupled with continuous awareness programme. Emphasis could be on development of landfill site in addition to making operations more efficient, preparing proper routing and scheduling of waste collection and transportation. Initiative towards delivery of better service and establishing the institutional, operational and financial foundations for further improvement is needed.

### 6.3.1 Projected Waste Generation

Projected waste generation is calculated for various years for different category of waste based on the waste characteristics. Samitiwise total waste generation is given in Table 6.6 and yearwise per day total waste generation is depicted in Figure 6.13. Samitiwise biodegradable, recyclable, nonrecyclable and green waste (vegetable waste) is given in Table 6.7,6.8,6.9 and 6.10, respectively. Yearwise per day biodegradable, recyclable, green waste, debris and silt generation is shown in Figure 6.14. Yearwise per day metal, glass, paper and plastic in waste generated is shown in Figure 6.15.

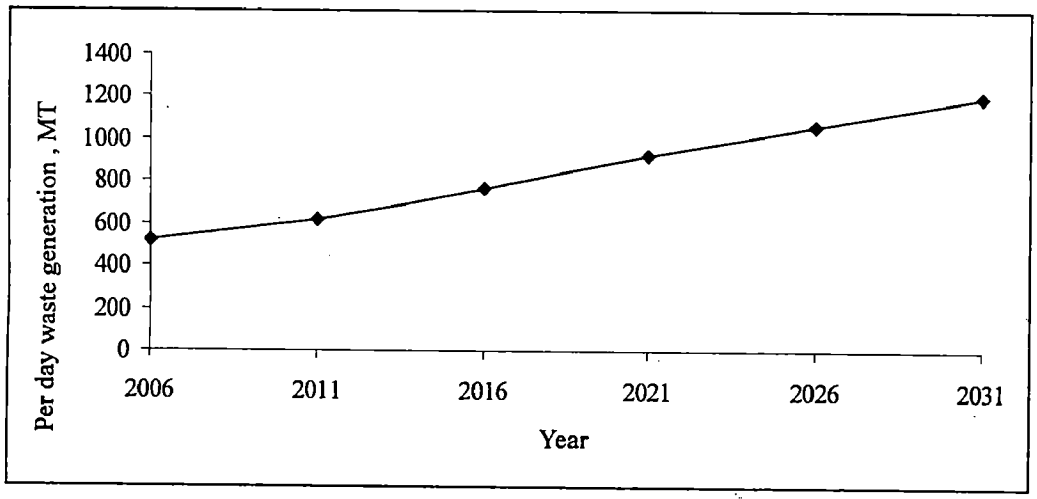



Figure 6.13: Yearwise total waste generation per day

Table 6.6: Samitiwise total waste generation

| Samiti | Total waste generation, MT | | | | | |
|---|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 | 2031 |
| Kalwa | 64.87 | 79.69 | 103.14 | 126.59 | 150.36 | 174.13 |
| Kopari | 24.6 | 26.00 | 27.52 | 29.05 | 30.78 | 32.52 |
| Manpada | 76.44 | 106.04 | 161.44 | 216.85 | 265.37 | 313.89 |
| Mumbra | 83.54 | 106.11 | 148.43 | 190.76 | 227.03 | 263.30 |
| Naupada | 43.07 | 49.82 | 57.78 | 65.74 | 73.06 | 80.37 |
| Railadevi | 50.61 | 54.57 | 59.04 | 63.52 | 68.17 | 72.81 |
| Uthalsar | 57.52 | 62.86 | 68.99 | 75.11 | 81.38 | 87.65 |
| Vartak Nagar | 60.99 | 67.83 | 75.77 | 83.72 | 91.34 | 98.97 |
| Wagle | 57.25 | 59.59 | 62.05 | 64.52 | 67.27 | 70.03 |
| Total | 518.89 | 612.5 | 764.17 | 915.85 | 1054.76 | 1193.67 |

Table 6.7: Samitiwise Biodegradable waste generation

| Samiti | Biodegradable waster generation, MT | | | | | |
|---|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 | 2031 |
| Kalwa | 40.54 | 49.81 | 64.46 | 79.11 | 93.97 | 108.82 |
| Kopari | 15.37 | 16.24 | 17.20 | 18.15 | 19.24 | 20.32 |
| Manpada | 47.77 | 66.26 | 100.89 | 135.51 | 165.84 | 196.16 |
| Mumbra | 52.85 | 67.12 | 93.90 | 120.67 | 143.62 | 166.56 |
| Naupada | 26.85 | 31.06 | 36.03 | 40.99 | 45.55 | 50.11 |
| Railadevi | 31.63 | 34.11 | 36.90 | 39.70 | 42.60 | 45.51 |
| Uthalsar | 35.91 | 39.24 | 43.07 | 46.89 | 50.80 | 54.72 |
| Vartak Nagar | 38.12 | 42.39 | 47.36 | 52.32 | 57.09 | 61.86 |
| Wagle | 35.49 | 36.93 | 38.46 | 39.99 | 41.70 | 43.41 |
| | | | | | | |
| Total | 324.51 | 383.17 | 478.25 | 573.34 | 660.40 | 747.46 |

Table 6.8:Samitiwise recyclable waste generations

| Samiti | Recyclable waste generation, MT | | | | | |
|---|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 | 2031 |
| Kalwa | 12.343 | 15.164 | 19.626 | 24.087 | 28.610 | 33.133 |
| Kopari | 5.072 | 5.361 | 5.676 | 5.991 | 6.348 | 6.706 |
| Manpada | 12.016 | 16.668 | 25.377 | 34.086 | 41.714 | 49.341 |
| Mumbra | 15.926 | 20.229 | 28.298 | 36.367 | 43.282 | 50.196 |
| Naupada | 6.831 | 7.902 | 9.164 | 10.427 | 11.587 | 12.747 |
| Railadevi | 7.822 | 8.435 | 9.126 | 9.818 | 10.536 | 11.255 |
| Uthalsar | 4.762 | 5.204 | 5.711 | 6.218 | 6.737 | 7.256 |
| Vartak Nagar | 6.462 | 7.186 | 8.028 | 8.869 | 9.677 | 10.486 |
| Wagle | 8.097 | 8.426 | 8.775 | 9.123 | 9.513 | 9.903 |
| Total | 79.329 | 94.575 | 119.781 | 144.987 | 168.005 | 191.022 |

Table 6.9: Samitiwise nonrecyclable waste generation

| Samiti | Non recyclable generation ,MT | | | | | |
|---|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 | 2031 |
| Kalwa | 12.343 | 15.164 | 19.626 | 24.087 | 28.610 | 33.133 |
| Kopari | 5.072 | 5.361 | 5.676 | 5.991 | 6.348 | 6.706 |
| Manpada | 12.016 | 16.668 | 25.377 | 34.086 | 41.714 | 49.341 |
| Mumbra | 15.926 | 20.229 | 28.298 | 36.367 | 43.282 | 50.196 |
| Naupada | 6.831 | 7.902 | 9.164 | 10.427 | 11.587 | 12.747 |
| Railadevi | 7.822 | 8.435 | 9.126 | 9.818 | 10.536 | 11.255 |
| Uthalsar | 4.762 | 5.204 | 5.711 | 6.218 | 6.737 | 7.256 |
| Vartak Nagar | 6.462 | 7.186 | 8.028 | 8.869 | 9.677 | 10.486 |
| Wagle | 8.097 | 8.426 | 8.775 | 9.123 | 9.513 | 9.903 |
| Total | 79.329 | 94.575 | 119.781 | 144.987 | 168.005 | 191.022 |

Table 6.10 Samitiwise Green waste generation

| Samiti | Green Waste Generation ,MT | | | | | |
|---|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 | 2031 |
| Kalwa | 6.172 | 7.583 | 9.814 | 12.045 | 14.307 | 16.569 |
| Kopari | 2.538 | 2.683 | 2.840 | 2.998 | 3.177 | 3.355 |
| Manpada | 6.011 | 8.339 | 12.696 | 17.054 | 20.870 | 24.686 |
| Mumbra | 7.969 | 10.122 | 14.159 | 18.197 | 21.657 | 25.116 |
| Naupada | 3.415 | 3.950 | 4.582 | 5.213 | 5.793 | 6.373 |
| Railadevi | 3.910 | 4.217 | 4.562 | 4.908 | 5.267 | 5.626 |
| Uthalsar | 2.376 | 2.597 | 2.850 | 3.103 | 3.362 | 3.621 |
| Vartak Nagar | 3.230 | 3.592 | 4.013 | 4.434 | 4.838 | 5.242 |
| Wagle | 4.052 | 4.217 | 4.391 | 4.566 | 4.761 | 4.956 |
| Total | 39.674 | 47.300 | 59.908 | 72.517 | 84.031 | 95.544 |

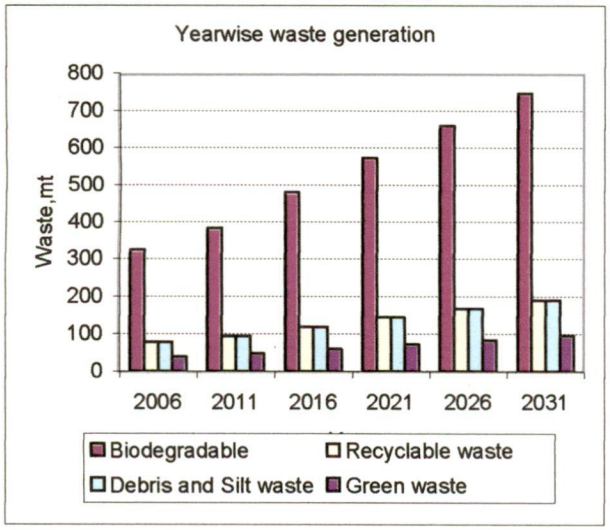



Figure 6.14: Yearwise biodegradable, recyclable, debris , silt and green waste

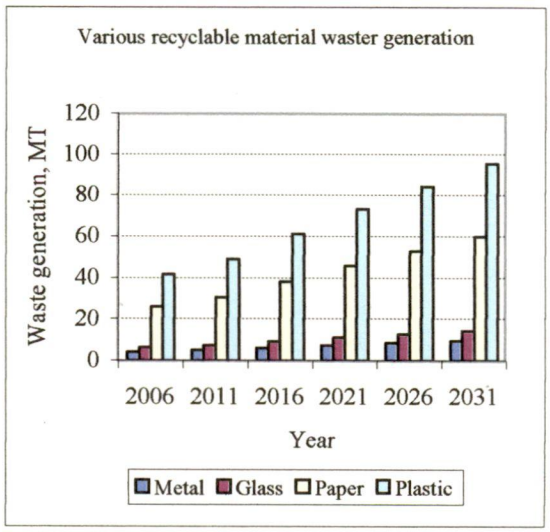



Figure 6.15: Yearwise metal, glass, plastic and paper in waste generated

### 6.3.2 Primary and Secondary collections systems

Activities proposed towards improvement of collection systems include:

- Private societies, complexes and multistoried buildings should be encouraged for waste collection by engaging private sweepers with one container for biodegradable and one for non-biodegradable.
- The sanitary workers / sweepers shall be provided with implements like long broom, showels, hand gloves, gum boots, face masks , soaps , etc.
- Provision of litterbins
- Adequate solid waste handling training to Rag pickers to ensure safe handling of waste
- Public awareness campaigns for effective source segregation and proper management of solid waste.
- Separate collection of green waste from vegetable markets, biodegradable waste from hotels and gobar from tabelas and transported to Bio-metanisation units.

Bins and container are calculated for future and details given in Table 6.12.

Table 6.12 : Proposed bins and containers

| Samiti | Proposed Community Points | Proposed HPDE Lid Type Wheeled Bins 660 liters | Proposed MS Lid Type Skip Container 4500 liters |
|---|---|---|---|
| Kalwa | 6 | 21 | 24 |
| Kopari | 4 | 10 | 8 |
| Manpada | 12 | 38 | 31 |
| Mumbra | 15 | 42 | 30 |
| Naupada | 24 | 42 | 12 |
| Railadevi | 24 | 42 | 13 |
| Uthalsar | 28 | 56 | 14 |
| Vartak Nagar | 19 | 38 | 18 |
| Wagle | 21 | 40 | 15 |
| Total | 153 | 329 | 165 |
| **Avaialble** | 153 | 0 | 165 |
| **To be provided** | | 329 | 0 |

### 6.3.3 Transfer and Transportation of Waste

Discouragement of manual loading and unloading and promoting direct lifting through hydraulic system .A schedule should be developed including appropriate routing plan and timings for improving waste transport system.

- Transportation of waste during night time in congested areas.

- It is economical to set up transfer station since the disposal site is more than 10 km away from the each samiti area as given in Table: 6.4. Five transfer station (TS) have been proposed at various areas viz: Kalwa, Kopari, Owla, Balkum and Kolshet as shown in Figure 6.16. The exact location of the will depend upon the availability of the suitable land.
- The vehicle management to be improved to make existing service more efficient. The target would be for each collection vehicle to make two trips per shift.
- Door to door collection of waste by Ghantagadi.

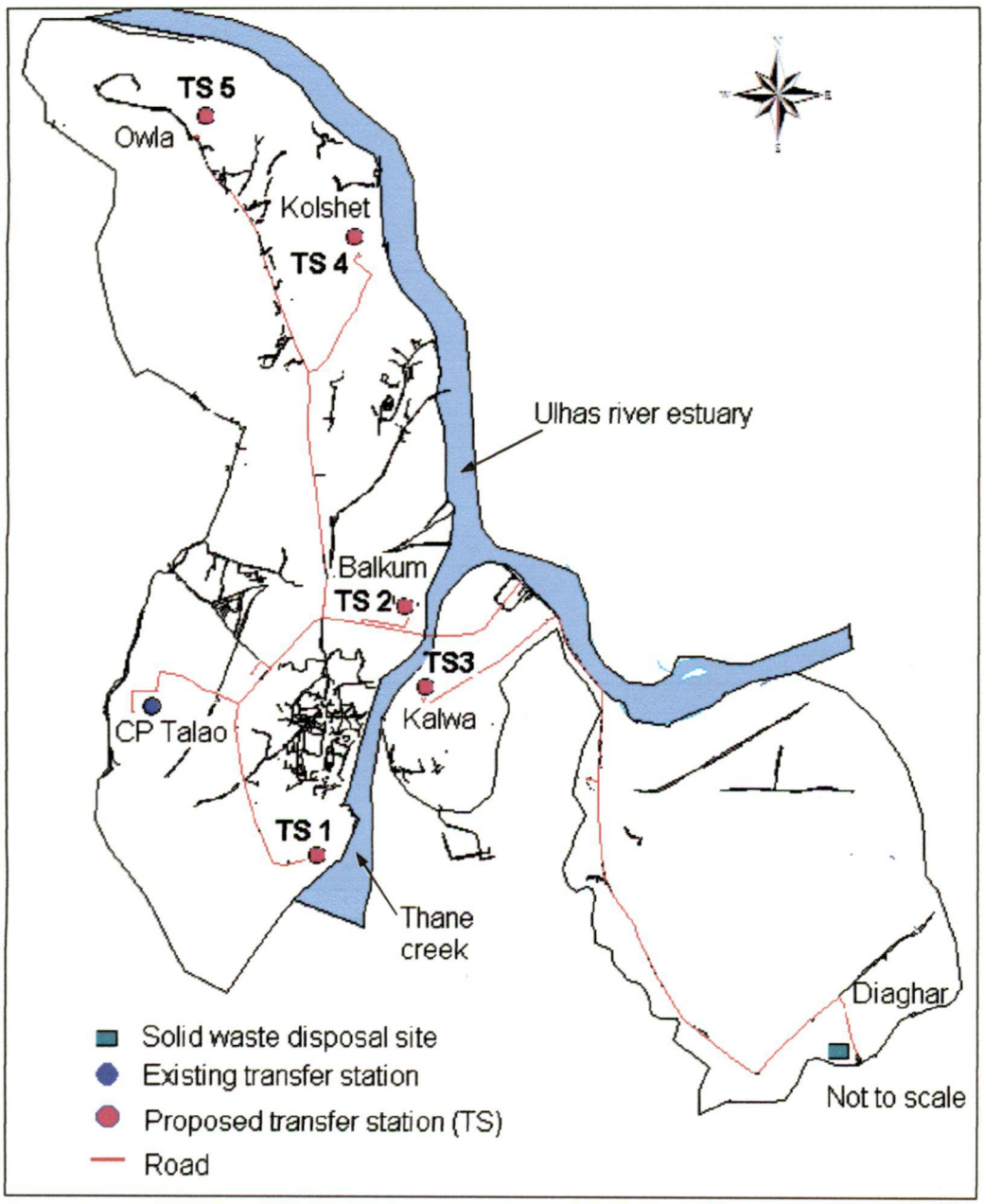



Figure 6.16: Proposed transfer station and dumping site

### 6.3.4 Process and Treatment

From the summary Table 1 of various Municipal Corporation it is observed that the Establishment cost of the NMMC comes out to be Rs 650 per ton, which is lowest of other Municipal Corporation. This may be because NMMC has contracted various services such as sweeping of the roads through 2000 contract sweepers. TMC has also adopted contract system partly for street cleaning. It is essential that waste to be segregated initially at the source, transfer station and only non-recyclable waste to transport to the final disposal site for judicious utilization of the available limited disposal site area. This needs to adopt the waste conversion methods like composting, compact biogas system & Waste to energy conversion of Biodegradable waste, Recovery of recyclable waste like plastic, paper, glass, metals, etc. Green waste from the vegetable markets and gobar from the tables can be taken care by Bio-methanisation plants and thereby methane gas generating.

| Waste Type | Technology |
|---|---|
| Biodegradable waste | Waste to Energy by composting plant at Diaghar and compact biogas system at community level. |
| Green waste | Five Bio- methanisation units |
| Recyclable waste | Plastic recycling unit. |
| Non recyclable | Disposal Site |

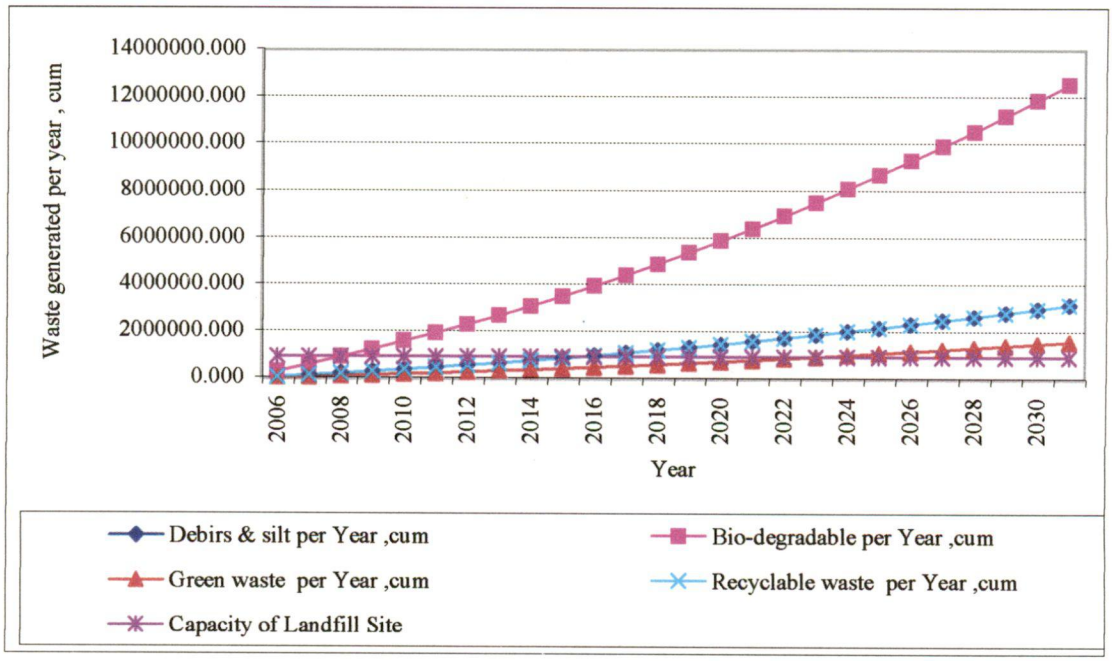



Figure 6.17:Waste generation per year and landfill site capacity

### 6.3.4.1 Compact Biogas System

Biogas systems are those that take organic material (feedstock) into an air-tight tank, where bacteria break down the material and release biogas – a mixture of mainly methane with some carbon dioxide. The biogas can be burned as a fuel, for cooking or other purposes, and the solid residue can be used as organic compost.

Most of the domestic solid waste comprises of biodegradable component. It is proposed to set up a compact bio gas system at the community levels like organized residential complex , hotels ,etc. If biodegradable waste is treated at the waste generation source, then it will reduce the TMC burden of transport and treatment of biodegradable solid waste.

The current practice of using low calorie inputs like cattle dung, municipal solid waste, or sewerage, makes methane generation in conventional biogas plants highly inefficient. Dr Anand Karve had developed a compact biogas system that uses starchy or sugary feedstock. 2 kg of such feedstock produces about 500 g of methane, and the reaction is completed with 24 hours. The conventional biogas systems, using cattle dung, sewerage, etc. use about 40 kg feedstock to produce the same quantity of methane, and require about 40 days to complete the reaction [11].

The various components of compact biogas system is shown in Figure 6.18 and Figure 6.19 . The compact plants are made from cut-down high-density polythene (HDPE) water tanks, which are adapted using a heat gun and standard HDPE piping. The standard plant uses two tanks, with volumes of typically 0.75 sqm. and 1 sqm. It needs a space about 2 sqm. and 2.5 m high. The plant is filled with a starter mix, either cattle dung mixed with water and waste flour or else effluent from an existing biogas plant mixed with starch. The feeding of the plant is built up over a few weeks until it provides a steady supply of gas, typically 250 gms of gas per day from 1 kg (dry matter) of feed [11]. The smaller tank is the gas holder and is inverted over the larger one which holds the mixture of decomposing feedstock and water (slurry).

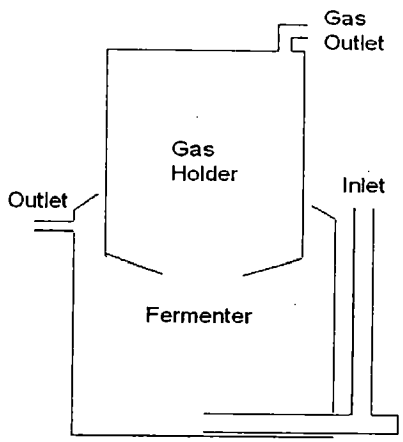



Figure 6.18: Various component of compact biogas unit [11]

Figure 6.19: Compact biogas unit [11]

An inlet is provided for adding feedstock, and an overflow for removing the digested residue. This contains a much smaller amount of solid matter than the residue from a manure-based plant. A pipe takes the biogas to the kitchen, where it is used with a biogas stove.

### 6.3.5 Disposal

TMC has taken a possession of 46 acres of land at Diaghar for disposal of solid waste. Non-biodegradable and rejects from the paletization plant only tobe disposed off in to a disposal site. From the Figure 6.17 it is clear that the proposed 46 acres of disposal site will be available for disposal of only non-recyclable waste up to year 2021.

### 6.3.6 Recommendations

Sample survey of the population helped in understanding the public perception about present solid waste management of the city and accordingly various suggestions for developing an efficient solid waste management system are given below:

1. Locality wise Citizen Monitoring Committee for solid waste collection system should be formulated comprising of public representatives from different political parties, senior citizens, educational institutes for technical support, National Cadet Corps students and non-government organisations as volunteers. The officials of the Municipal Corporation associated with solid waste management of a particular area should also find representation in the committee.

2. Corporators should not interfere with the day to day working of sanitary inspector, sanitary mukadam, and sanitary worker and disturb their working schedule. They should complain only to health officer or senior sanitary inspector, who in turn should instruct the staff working under them.
3. A time schedule be fixed for lodging of complaints. Contact person address and phone number should be made available to all stakeholders. These can be notified and properly displayed at various locations.
4. Awareness program for different group such as corporator, citizens, sanitary inspector, sanitary mukadam, sanitary worker, school children should be designed. Special provision should be made in annual budget for awareness programs.
5. Motivation program for sanitary workers is necessary for creating a better work culture. For this various training programmes should be organized for different categories of workers.
6. It is observed that sanitary inspectors and sanitary mukadam remain under continuous stress due to work pressure and interference from corporators. For this stress management program can be conducted in which Yoga expert may conduct the meditation and Yoga classes. All level of officials and workers dealing with solid waste management can attend them. This will create a feeling that Corporation is interested in welfare of all employee involved in solid waste management system and create a team spirit amongst them.
7. Locality / area wise ragpicker can identified and their associations can be formed. Identity card may be issued to such ragpickers. Such ragpickers can collect the waste from door to door and segregate the waste. Plastic and reusable can be processed and further sold out .The earning can be shared among the ragpickers. Ragpickers should not be allowed to collect the plastics from the curbside containers. Authorised ragpickers are to be allowed to collect the reusables only from transfer station or dumping site.
8. Majority of the people are interested in door-to-door collection of solid waste generated by them. Private player may be considered for door-to-door collection, on payment for service basis.
9. Before introducing privatization and modernization system, sufficient awareness programs should be conducted for citizens, workers and Labour Union representatives, so that they are not reluctant to change. Sanitary worker should be

assured that due to introduction of privatization and modernization their livelihood will not be affected but will go a long way in improving their working conditions.

10. To avoid pasting of posters on the footpath side on compound wall, environment related painting could be made on compound wall by school children, with the help of sponsors. This will supplement awareness generation programs
11. Considering the trend of use of plastic carry bags by the consumer and shopkeepers, awareness program should be conducted to encourage use of biodegradable paper bags. Use of plastic shopping bags may be banned.
12. Local cable operators and cinema halls can help in creating awareness. It could be made mandatory that at least three poster/ slides about good practices are displayed before a show in each cinema hall.
13. Provisions for composting of biodegradable waste could be made mandatory while approving a new complex / locality and tax rebate could be given for the existing complexes who provide facilities for composting of waste generated by them.
14. For Municipal crematoria grounds, new improved facilities (like Mokshda) of burning of corpse, which requires less firewood could be constructed.
15. Public are ready to pay for effective solid waste management services. Cess may be charged on the same basis as drainage tax is charged. It could be included in property tax and based on the retable value, which differ from area to area and ultimately principle of affordability will follow. Adequate funds can be reserved for the tools and equipments, transport facilities, curbside containers, medical facilities and safety measures like gumboots and gloves, etc.

**6.3.7 Cost Estimates**

Detail cost estimates is given in Chapter 15. The present TMC per ton expenses on solid waste management establishment is high as compared to the other Municipal corporation, which could be reduced by adopting contract system. The contract system is to be taken in stage wise. Revenues can be increased buy levying proper cess for which people support is required. If an individual household can afford Rs 250 to Rs 300 per month for cable network, why not some amount be share for better solid waste management practices for betterment our own heath conditions. Paying little will reduce the chances of unhealthy conditions and improve the city environmental conditions and it will help in maintaining our precious water bodies.

### 6.3.8 Proposed Institutional arrangement

It is proposed that the Additional Chief Sanitary Inspector could be incharge of the disposal site and transfer station. Deputy Chief Sanitary inspector, one for transfer station and another for disposal site should assist additional Chief Sanitary Inspector. Locality wise NGO's and CBO's could create an awareness program. The proposed institutional set up is depicted in Figure 6.20.

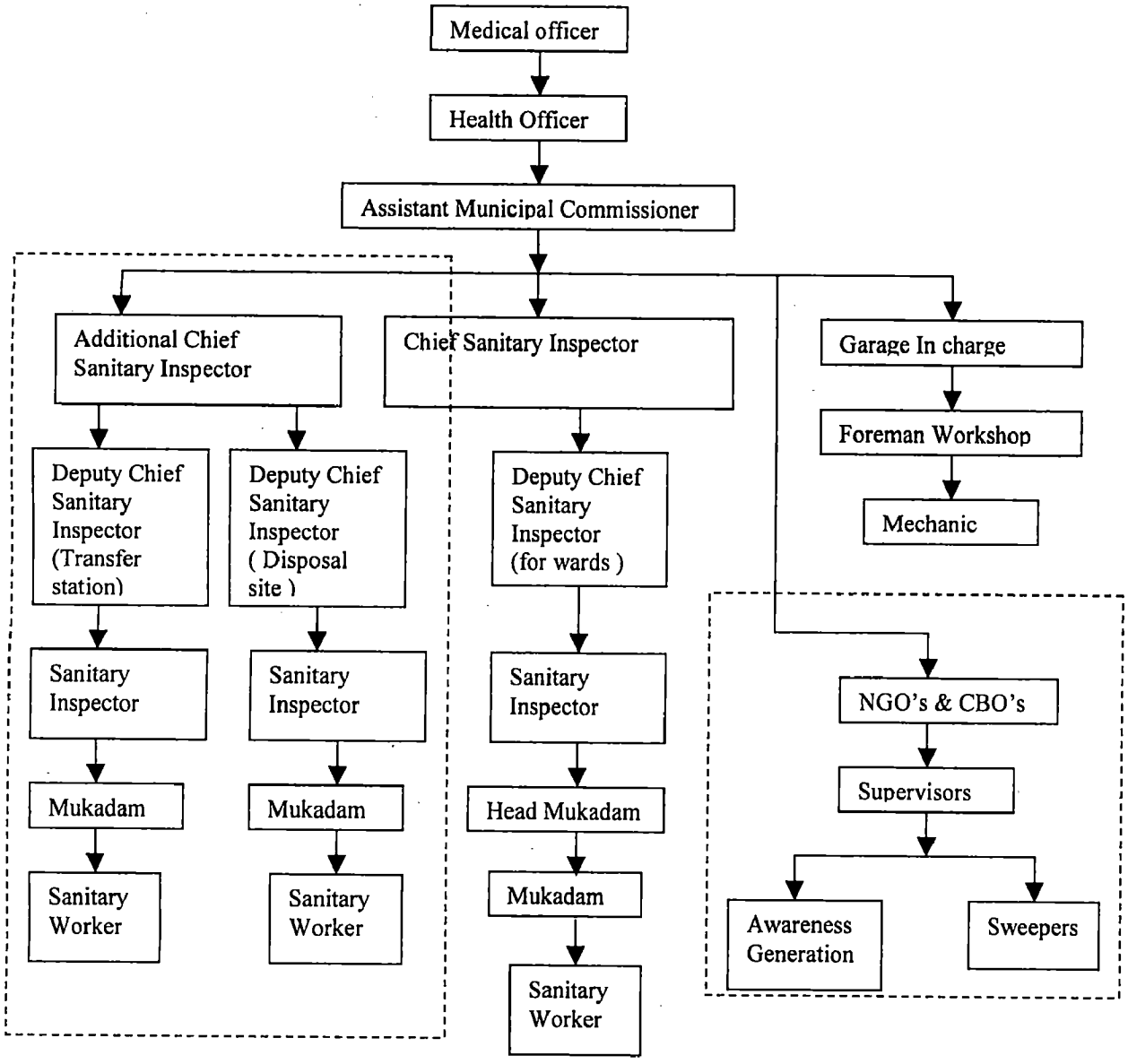


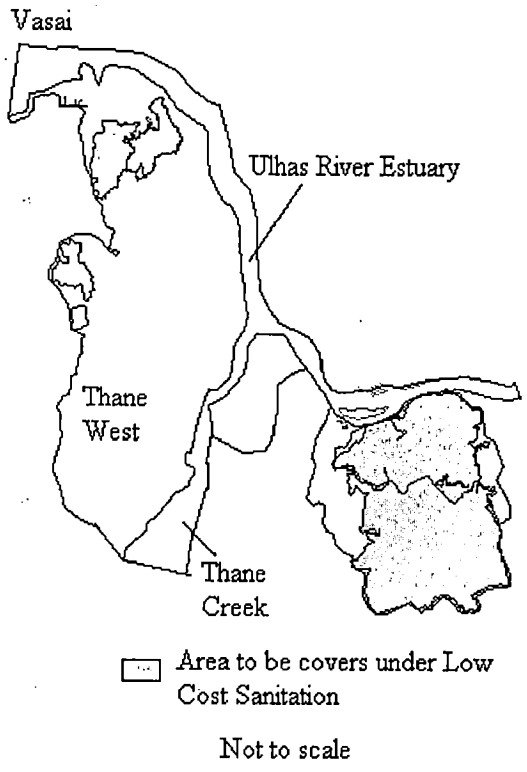

Figure 6.20: Proposed Institutional structure for solid waste management

# CHAPTER 7
# LOW COST SANITATION

The 24 villages on the boundary on the north and east of the city are proposed to be covered by low cost sanitation works since they are at remote places, sparsely developed and could not be conveniently connected to the sewerage system being developed.

The project includes the construction of community latrines in 24 villages. The area to be covered s depicted in Figure 7.1. The reconnaissance survey done at the time of the preparation of the feasibility study of Thane sewerage scheme showed that approximately 1471 household latrines and 80 community latrines (with 603 seats) existed in these villages (TMC DPR 2005) . The design proposal includes the construction of community latrines, each with 2 to 5 seats. A total of 5340 latrines, with septic tanks and soak pits, are proposed to be constructed in two phases to cover the projected population of year 2021. Phase I will cover the gaothan (village) areas, which are already developed, while Phase II will take care of future growth.

Figure 7.1: Area to be covered under Low Cost Sanitation Scheme



TMC has identified a total of 221 slums, with an estimated number of 90,930 households and a population size of 4,57,465 (TMC DPR 2005). Approximately 34 of these slums are to be rehabilitate as part of the Slum Redevelopment Schemes under implementation by TMC. Existing sewer network already covers about 11 slums. A few slums are temporarily in nature, or have very narrow passage or no prospect of development of household latrines. In the remaining 130 slums, while a few households may have individual latrines, most households largely depend on public cover services to these slums. In order to effectively cover the households in these slums, it is essential;

- to improve internal sewer network in these slums and integrate it with the city sewer network being developed in the new project.
- to undertake a program of promoting households latrines, group latrines and public latrines in these slums.

TMC has proposed toilets with septic tanks and soak pits, but it is necessary to adopt sustainable technologies like twin pit pour flush toilet and Excreta-based Biogas & Biofertilizer Technology.

### 7.1 Individual Toilet Twin Pit Pour Flush Toilet (TPPF)

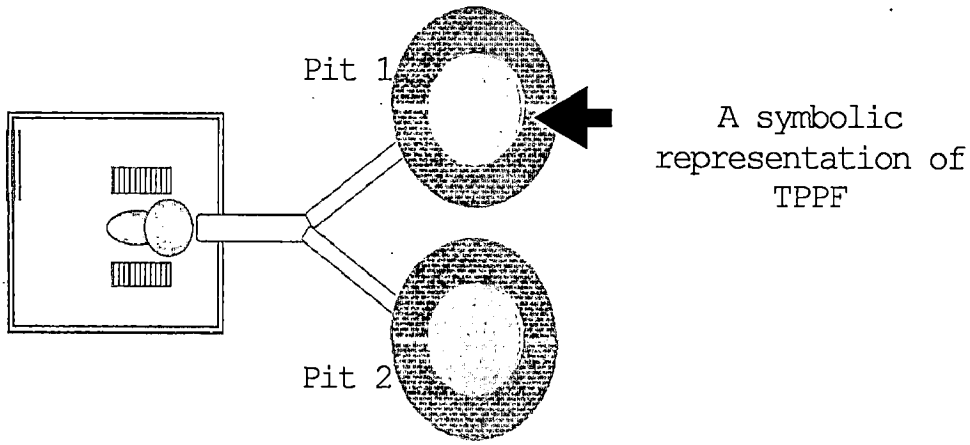
Sulabh has designed TPPF toilet which meets the following World Health Organisation (WHO ) conditions for sanitary latrine[8]:

- The surface soil should not be contaminated.
- There should be no contamination of ground water that may enter springs or wells.
- There should be no contamination of surface water.
- Excreta should not be accessible to flies or animals.
- No handling of fresh excreta; or, when this is indispensable, it should be kept to a strict minimum.
- Freedom from odours or unsightly conditions.
- The method used should be simple and inexpensive in construction and operation.

TPPF consists of a squatting plate or a pan with a steep bottom slope of 25 to 28 degree gradient and side slopes and a gas-trap with a 20-mm water-seal [8]. It alternately deposits waste into two pits as shown in Figure 7.2. Each pit is about one and a half meters deep and lined with a lattice of bricks. A family of five for up to four years can use the first pit. When the first pit is full, the family can switch to the second pit, which

also can be used for about four years. Over that period, the waste in the first pit is gradually and naturally converted into a rich material that can be removed and used as dry, powdery fertilizer. First pit can be emptied and used again after the second pit is full. Thus the two pits are used alternatively and continuously. Airtight covers cover both pits.

Figure 7.2: A symbolic representation of TPPF [8]




About 1.5 to 2 liters of water are sufficient to flush the excreta into the leach pits through pipes or covered drains as compared to 14 liters required by a regular toilet. The water-seal checks the escape of foul gases and microbes into the atmosphere from the leach pits. The gas formed by the decomposing waste is absorbed into the surrounding soil, eliminating any foul smell.

Experiments conducted in India have established that bacteria from the pits travel not more than three meters vertically, and extend less than one meter downward. The design of the system and the pits can be modified as needed to protect water sources and underground soil.

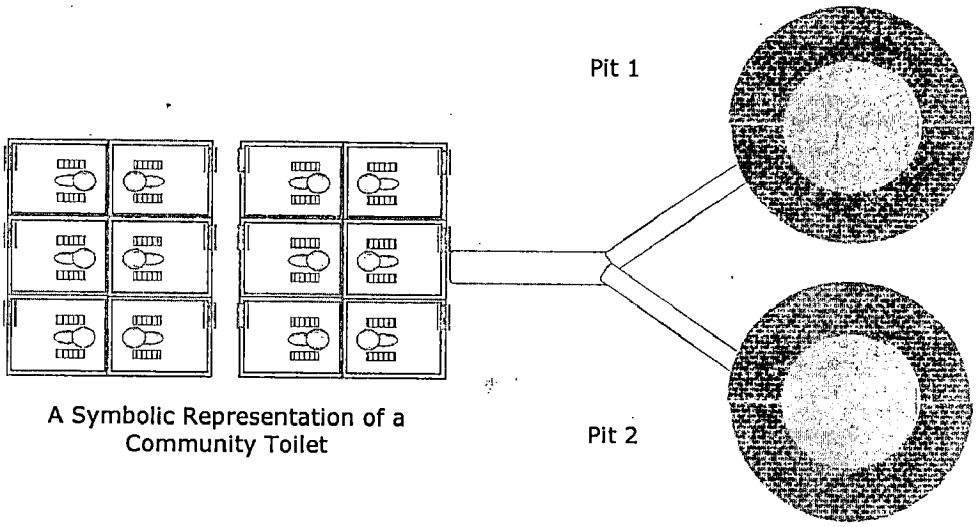
### 7.2 Community Toilet

#### 7.2.1 Twin Pit Pour Flush Toilet (TPPF)

Those households, which either can afford an individual TPPF or has no space for it, need a community toilet. Such a facility is also needed for commuters, pavement dwellers and other floating population mainly in urban settlements. Sulabh technology is providing community toilet complexes (known as Sulabh Shauchalaya Complex) with bathing, laundry and urinal facilities on the pay-&-use basis in urban areas and places

where people congregate. The schematic representation of community toilet is shown in Figure 7.3.

Figure 7.3: Symbolic representation of a community toilet [8]

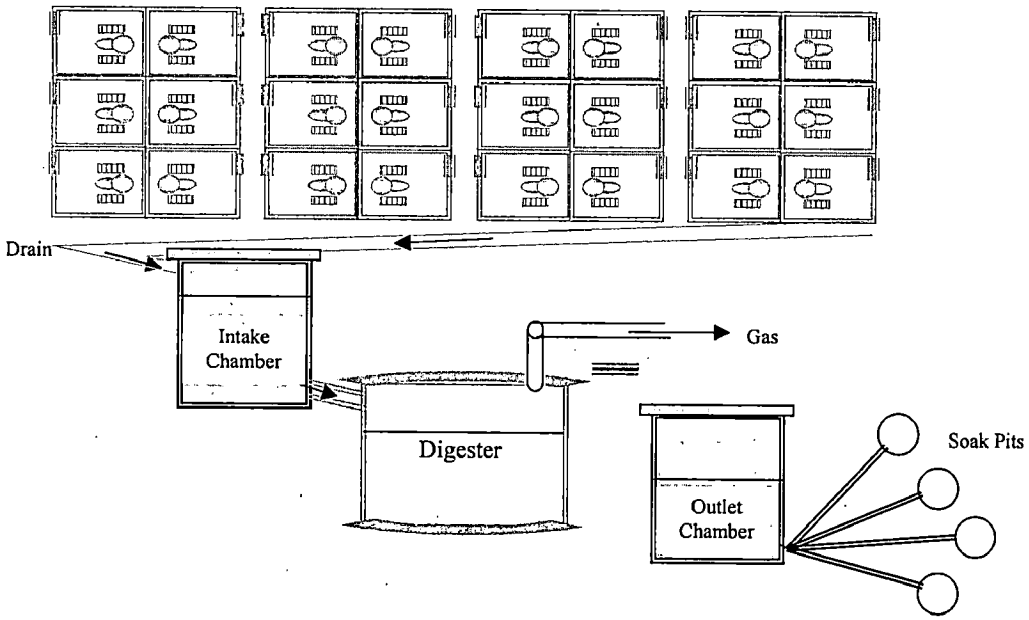



### 7.2.2 Excreta-based Biogas & Biofertilizer Technology

The first such biogas plant was set up at Patna in 1982 after almost six years of research. The successful and satisfactory functioning of this plant encouraged him to replicate the project all over the country. Excreta contain 66% methane, a burnable gas that can be used for cooking and electricity generation [8]. In the absence of sewerage facility, the best option for human waste disposal, to be used in conjunction with large public toilets, is the biogas plant. It has the added advantage of being a source of renewable energy, which is lacking in the septic tank system. Biogas so produced is used for lighting, cooking, etc and the effluent is a rich fertilizer. To the biogas plant is attached the effluent plant, that lowers down BOD of sewage from 200 mg/L to 10 mg/l. [8] The effluent is made colorless, odorless and pathogen-free, fit for discharge into any water body, promoting a better and healthier environment.

The biogas plant consists of an inlet chamber, an anaerobic digester and an outlet chamber as shown in Figure 7.4. The digester is cylindrical with arched bottom and domed top and is installed underground. Excreta from the toilet seats flow under gravity through covered drains into the inlet chamber and then into the digester. The digested slurry comes out of the digester through the outlet pipe, reaches the outlet chamber and then flows out through covered drains into soakage pits. A large round airtight manhole is provided at the top of the digester for facilitating cleaning (desludging), and other maintenance jobs. A gas outlet pipe and a safety pipe are attached to the manhole.

Figure 7.4: Excreta-based Biogas & Biofertilizer [8]




It is estimated that the 4.56kg of nitrogen, 0.55kg of phosphorus and 1.28 kg of potassium that the average human releases each year could produce enough wheat and maize for one person annually [8]. If the number of users is less than 100, then the use of two-pit toilet could be preferable, but in high-rise buildings, five star hotels and housing colonies, the biogas digesters is an environment-friendly technology that could be used.

### 7.2.3 Mobile Community Toilets

Mobile community toilets are essential to bridge the gap where it is difficult to provide the permanent community toilets and also useful for mass mellas, festival season, etc. Nine mobile community toilets are proposed in future.

# CHAPTER 8

# PUBLIC AWARENESS AND PUBLIC PARTICIPATION

*We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect.* (Aldo Leopold)

Citizens are integral part of a natural community. One needs to develop and maintain a common concern for the well being of the environment. This concern is expressed as a commitment to environment stewardship. Lack of connection is compounded because it is very difficult to see the system as a whole. Interest group tends to organize around single issue, interest or place. Thane creek and Ulhas river estuary has become a ' no one baby'. People often look towards institutions but not individual for answer. There are few groups those promote the health of the creek and estuary.

As focused out in previous chapters the problem today are multifaced, the results of multiple action degrades habitat and exacerbate creek and estuary water. At one time point sources of pollution were considered as the major contributor. Now it is essential to address significant non-point sources, coming from numerous places and actions. 'Use and throw' life style and adopting shortcut of disposing waste in to nallas, gutters, and road sides creates a serious problem. This demands that that one should access individual activities, choice and understand their impact and accordingly make changes. Effective changes are possible only if citizens have a feeling of ownership towards the city and its water bodies. Public awareness campaign will create the feeling of ownership and will help to achieve target of clean city and ultimately clean creek and estuary.

As an engineer what we think is correct but it is correct till public thinks it correct. Program looks technically feasible on paper, but sometimes may remain on paper due to conflict between various stakeholders. Various conservation measures proposed will be effective only if it is accepted and actively supported by various stakeholders. For long-term success it is necessary to identify and understand the possible conflicts and common interest. It is a duty of all Municipal Corporations concerned with Thane creek and Ulhas river estuary to bring together citizens, grass root members, environmental organisations and commercial establishment for long

term sustainability of the project. Municipal Corporation must continue to open the doors to allow the public full access to decision making process, which will increase the transparency and reduce the chances of public interest litigation. Various stakeholders should be involved in different phases of conservation project such as planning, implementation and post conservation phase, i.e., operation and maintenance.

For every conservation measure their should be equal support from citizens. After laying of the sewer network it is the responsibility of the households to connect their sewer line to main sewer. Failure of which, sewage will continue to be carried by storm drains / nallas which finally finds it way into creek and estuary. Similarly is the case with solid waste management, householders should be habitual to reduce waste , segregate the waste at the source itself and further transfer it to the community bins. Hence it is necessary to change the mindset of the people. They should understand that by paying little for the maintenance would create a healthy condition and thereby improve the living standard of entire family and society.

Public awareness and public participation program need to be associated with the training and motivation-boosting program for the grass root people managing sewerage system and solid waste management services. One should realise that they are paid only for their services and not for day-to-day deteriorating health condition, due to unhygienic condition.

**8.1 Public Awareness Generation and Public Participation**

The basic ethos of TMC Thane creek and Ulhas river estuary conservation program is "Conservation through Partnership".

In past TMC has successfully implemented lake conservation program with the co-operation of various stakeholders. Alternative Idol immersion program as a part of lake conservation was strongly supported by citizens, politicians, various government organisations, NGO's and community based organisations. It is experienced that people are ready to support for a healthy cause.

TMC with aid of expert committee framed out " Vision 2031" and " City development plan" under "Jawaharlal Nehru Urban Renewal Mission", in which various environment improvement measures are proposed including conservation of creek and estuary. This shows that TMC is serious about the conservation two water bodies, which is the beauty of Thane city.

As stated earlier people are supportive for good cause, for Thane creek conservation two NGO's has already joined hands with TMC. Enviro- Vigil, NGO, has participated by conducting survey and creating awareness campaign in various schools, college, fisherman society and school teachers. An appeal was made to college students stating the importance of survey tobe conducted ( Figure 8.1a and Figure 8.1b). Students from two colleges were involved in survey and training has been given to them regarding collection of water and sediment samples and its analysis. Exhibition was conducted on World Water Day which was attended by citizens, 1100 school and college students (Figure 8.2a and Figure 8.2b). Suggestions regarding the creek conservation from citizens were collected during exhibition. Reason for creek deterioration and measures undertaken Thane Municipal Corporation with its importance in improving creek and estuary were explained in awareness camps. An appeal is made to public to join the hands with TMC for conservation of Thane creek and Ulhas river estuary.

Figure 8.1a

Figure 8.1 b

An appeal to college students during their NCC camp at Panvel

Figure 8.2 a

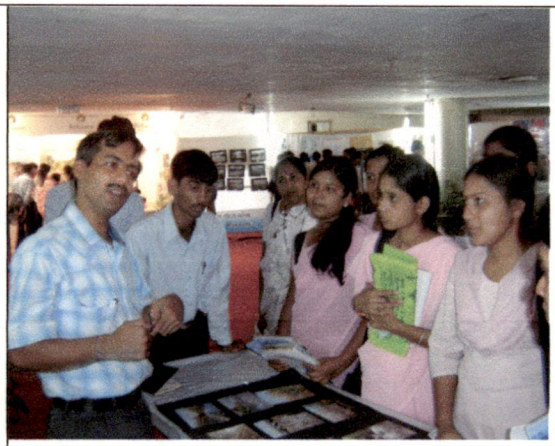


Figure 8.2 b

Awareness program on 22th March, World Water Day

TMC has published a report based on the study carried out under present work on 5th June, 2006 occasion of World Environmental Day at the hands of Shri Ganesh Naik, the Guirdian Minister for Thane .Municipal Commissioner, Mayor, local MLA and MP were also present during the occasion along with senior TMC officials and office bearers. Newspapers also covered the various aspects resulting deteriorating conditions of the Thane creek and Ulhas river estuary and covered in published report .The newspapers cutting are attached in Annexure II.

It is necessary that the importance of various conservation measure viz: sewer network and sewage treatment, solid waste management, and mangrove plantation, dredging to be marketed in a large scale. The success of any product depends upon its market acceptability and its market outreach. Similarly success of conservation depends upon how citizens accept / support it. Which demands that the program to be based on "demand –driven approach" and not as traditional "supply – driven approach". Citizens should be made confident that they would be benefited by the conservation projects. Awareness program should be carefully designed to meet specific objectives for each target group or audience and specific massage should be defined.

Women play a key role in maintaining family health and better environment, hence it is necessary to involve them and make them conscious about sanitation, hygiene, solid waste disposal and effective usage of water, etc.

"Children are known as father of men" and it is necessary to make them habitual to good hygienic practice. Education material and classroom study to be designed in such a manner that they develop sentiments towards environment and methods to conserve it.

TMC is making attempt to focus environment related issues on various special occasions such as Ganpati festival, World Environment Day, World Water Day, Earth Day, etc. Community reach out program is being conducted on every Wednesday. The efforts made by Municipal Corporation remain limited due to various constraints. Constant efforts are required, which is possible with the help of NGO's. Hence it is proposed that the responsibility of public awareness and public participation to be shared and outsourced to competent NGO.

**8.2 Objectives**

The main objective of public awareness and public participation is to seek community participation and empowers citizen to work together with Municipal

Corporation to take responsibility of Thane creek and Ulhas river estuary and thereby getting involved in a program from pre-planning stage to execution of project and thereafter operation and maintenance.

Everyone talk on 'sustainability', but it is in vain if the seriousness of the issue is not understood. People should be made realize that if proper precaution and measures are not taken now, then it will create serious problems in future and their own generation will blame on them. Public awareness and public participation should be designed in such a way that it should change the people habit, custom and made aware of fact that 'self transformation is world transformation'.

Voluntary organisations to be encouraged and motivated to participate in the program and create a sense of willingness to pay for creation of community assets and its operation and maintenance. The important goal is to convince people, value of protecting resources to gain long-term benefits that conservation can provide. Awareness program aim to provide citizens information about conservation measures, utilization of funds. Taxpayers should be given confidence that their tax has been properly utilized.

Tourist, floating population to be made aware of environment and encourage them in keeping city clean.

**8.3 Approach**

Public participation can be initiated through formulation of citizen monitoring committee and common vision to be established. Citizen monitoring committee comprising of public representatives from all political parties, senior citizens, educational institutes for technical and volunteers support, representatives of NGO's, CBO's and experts from various fields. Citizen Monitoring Committee will work with Municipal Corporation on various issues related to creek and estuary conservation.

Various public awareness programs should be planned in a mega scale and should be inaugurated by eminent personalities and celebrities and focused widely, so that people will come to know that conservation activities are blessed by all. For broad public awareness program, a multimedia approach is recommended, one that combines printed material, audiovisual presentations, and face-to-face interaction. Mass media (press, radio, television) fixed exhibits, tours, training workshop, use of promotional items such as calendars, massage printed on matchbox, bus ticket, books, T shirt, etc recreational activities with an educational focus.

Following are the various methods proposed to create public awareness:

1. Mass media
    a. Electronic
        i. Television- cable, broadcast
        ii. Radio- FM, All India Radio
        iii. Print- news paper, magazine, tourist literature, brochure, calendar etc
        iv. Information on website
    b. Hoarding- Stationary, mobile
    c. Others – mach box, school stickers, bus tickets, massage on educational books, etc.
2. Special events
    a. Puja
    b. Local festival – Ganpati festival, Gudi Padwa, etc.
    c. Exhibition and melas
    d. Cultural events
    e. Special folks, dance music, street plays etc.
3. Meetings
    a. School –competition
        i. Debate
        ii. Slogan writing
        iii. Poster making
        iv. Essay writing
    b. Localities
        i. Mohalla, social club
        ii. Housing society
    c. Social organisations – Lions Club, Rotary Club
    d. NGO's, CBO's and self help group
    e. Unions
        i. Shopkeepers
        ii. Industries
        iii. Other unions

To reachout to every citizen of Thane, the TMC has decided to start a radio service on Frequency Modulation (FM) and have made arrangements of Rs 20 lakh in

the budget. TMC has decided own 'Radio TMC' to disseminate information on education, environment, projects, drives and announcements.

The important part of awareness program is to take feedback to determine program effectiveness. Feedback provides an idea to planners and other decision makers about what is happening in the field and judge the actual outcome of various conservation measures.

**8.4 Implementation**

It has been observed that under sewerage and solid waste management program less provision has been kept for the public awareness and public participation program. In an annual budget a small fraction of a budget is kept for awareness program, hence major awareness program cannot be implemented due to shortage of funds and need to be dependent on sponsoror. It is necessary that sufficient fund to be reserved in annual budget for conducting awareness program.

Pubic officer with an attitude of creating public awareness campaigning to be given a responsibility of public awareness and public participation programs. Public awareness and public participation related activities could be outsourced. The scope of work should be well established. " Expression of interest " in proper form should be invited from the competent NGO'S by giving wider publicity in newspaper. Suitable agency can be fixed by evaluating the technical and commercial offers.

Website highlighting various aspects of the conservation measures needs to be developed. Conservation plan, priority issues, implementation strategy, progress of work, awareness campaigns, volunteer program should be hosted on the website.

**8.5 Cost Estimates**

The cost estimates for various public participation and awareness activities are given in Chapter 15. Cost estimate is only a guideline for budget reservations and framing tender for awareness program.

# CHAPTER 9

# INSTITUTIONAL DEVELOPMENT

Various agencies and organisations have jurisdiction or exert influence over the management of Thane creek and Ulhas river estuary. The problems are complex, and decision-making process is complicated and time-consuming. The issues affecting conservation program can be considered in three general groups

- Organizational and institutional factors
- Decision-making process
- Ecosystem management factors

Following are the various Issues

- Confusion regarding clear statutory authority and precise and implementable regulations.
- The decision- making cycles of most government process conflict with the longer timeframe needed to address many environmental issues. Problems requiring long-term solutions may be neglected in favour of those that appear easy to resolve or produce immediate results.
- Multiple issues compete for limited funding, and priorities are not always set. Jurisdiction are often unable to persue needed work because of insufficient funding. Pressures on budgets at all government levels make a long term coordinated approach difficult.
- Diverse cultures with multiple perspective and needs.
- Lack of shared knowledge among agencies and across levels of governing bodies regarding other jurisdiction structures, responsibilities, schedules and contact points.
- Some interested parties may be underrepresented because of poor coordination and lack of common understanding about decision-making process.

## 9.1 Indian Laws and Regulations

Apart from the Coastal Regulation Zone Notification, 1991 there are many legislations /Acts and rules related to coastal activities. The following are the important ones: Indian Fisheries Act, 1897; Indian Ports Act, 1902; Merchant Shipping Act, 1974, Wildlife (Protection) Act 1972; Water (Prevention and Control of Pollution) Act, 1974,

Air (Prevention and Control of Pollution) Act, 1981; Indian Coast Guards Act, 1974; and Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act, 1981 and Environment (Protection) Act 1986; The Petroleum Act, 1934; National Environment Tribunal Act, 1995; Hazardous Wastes (Management and Handling) Rules, 1989.

In addition to this, India has signed and ratified several international conventions relating to oceans and related activities. Some of these are related to marine environment and applicable to coastal area also. The important ones are MARPOL 1973/1978; London Dumping Convention, 1972; Convention on Civil Liability for Oil Pollution Damages (CLC 1969) and its Protocol, 1976; Fund, 1971 and its Protocol, 1979; CITES, Convention on Biodiversity, 1992 includes coastal bio-diversity also.

## 9.2 Institutional Infrastructure

### 9.2.1 Coastal Regulation Zone

The Ministry of Environment and Forests and the Department of Ocean Development are the two nodal Departments that deal primarily on the coastal and ocean areas. In addition to this, there are several Ministries, Departments, State Government Bodies looking after several issues relevant to coastal management in this country and are listed below:

| **Departments/Agencies** | **Responsibilities** |
|---|---|
| Ministry of Agriculture | Fisheries Management, Coastal Aquaculture |
| Ministry of Defence (Coast Guard) | Oil Pollution, Poaching, etc |
| Pollution Control Board | Coastal Pollution |
| Ministry of Commerce | Marine Products Development, Special Economic Zones |
| Ministry of Surface Transport | Ports and Harbours |
| Ministry of Tourism | Tourism Development |
| Ministry of Urban Development | Town and Country Planning |
| Ministry of Industries | Coastal Industries |
| Ministry of Mines | Coastal and Offshore Mining |
| Ministry of Home | Disaster Management |
| Ministry of Petroleum and Natural Gas | Exploration and Exploitation of Oil and Natural Gas |
| Ministry of Chemicals and Fertilizers | Storage and Handling of Chemicals and Fertilizer in the port areas |
| State/Union Territory Environment Department | Coast and Marine Management under Water Act, Air Act |

However, Coastal Regulation Zone (CRZ) Notification 1991 implemented by the Ministry of Environment and Forests (MoEF), is the single regulation that takes care of most of the activities in the coast (MoEF Report 2005).

As per MoEF Notification dated 19th February, 1991 (as amended up to 3rd October 2001), that coastal stretches of seas, bays estuaries, creeks, rivers and backwater which is influenced by tidal action upto 500 meters from High Tide Line (HTL) and land between the Low Tide Line (LTL) and the HTL has been declared as Coastal Regulation Zone (CRZ). Thus Thane creek and Ulhas River Estuary comes under the CRZ.

The following activities are declared as prohibited activities with in CRZ (MoEF 2001):

i. Setting up and expansion of units/mechanism for disposal of waste and effluents, except facilities required for discharging treated effluents into the watercourse with approval under the Water (Prevention and Control of Pollution) Act, 1974; and except for storm water drains.

ii. Discharge of untreated wastes and effluents from industries, cities or towns and other human settlements. Schemes shall be implemented by the concerned authorities for phasing out the existing practices, if any, within a reasonable time period not exceeding three years from the date of notification.

iii. Dumping of city or town waste for the purposes of landfilling or otherwise; the existing practice, if any, shall be phased out within a reasonable time not exceeding three years from the date of notification.

iv. Land reclamation, bunding or disturbing the natural course of sea water except those required for construction or modernisation or expansion of ports, harbours, jetties, wharves, quays, slipways, bridges and sea-links and for other facilities that are essential for activities permissible under the notification or for control of coastal erosion and maintenance or clearing of water ways, channels and ports or for prevention of sandbars or for tidal regulators, storm water drains or for structures for prevention of salinity ingress and sweet water recharge: provided that reclamation for commercial purposes such as shopping and housing complexes, hotels and entertainment activities shall not be permissible.

v. Any construction activity between the Low Tide Line and High Tide Line except facilities for carrying treated effluents and waste water discharges into the sea,

facilities for carrying sea water for cooling purposes, oil, gas and similar pipelines and facilities essential for activities permitted under Notification; and

**9.2.2 Regulation of Permissible Activities under CRZ**

1) Clearance shall be given for any activity within the Coastal Regulation Zone only if it requires water front and foreshore facilities
2) The following activities will require environmental clearance from the Ministry of Environment and Forests, Government of India:
    a. Outfall for discharge of treated waste water/cooling water
    b. All other activities with investment exceeding rupees five crores except those activities which are to be regulated by the concerned authorities at the State/Union Territory level in accordance with the Provisions of CRZ.
3) The Coastal States and Union Territory Administrations shall prepare, within a period of one year from the date of Notification, Coastal Zone Management Plans identifying and classifying the CRZ areas within their respective territories.
4) Within the framework of such approved plans, all development and activities within the CRZ shall be regulated by the State Government, Union Territory Administration or the local authority as the case may be in accordance with the CRZ guidelines.
5) In the interim period till the Coastal Zone management Plans are prepared and approved, all developments and activities within the CRZ shall not violate the provisions of Notification. State Governments and Union Territory Administrations shall ensure adherence to these regulations and violations, if any, shall be subject to the provisions of the Environment (Protection) Act, 1986.

**9.2.3 Procedure for monitoring and enforcement**

The Ministry of Environment & Forests and the Government of State or Union Territory and such other authorities at the State or Union Territory levels is responsible for monitoring and enforcement of the provisions of notification within their respective jurisdictions.

**9.2.4 Positive aspects of the CRZ Notification, 1991**

- Created awareness among the decision makers and the people regarding the importance of the coastal environment.

- Responsible in maintaining *status quo* by not permitting major developmental activities along the coast.
- Established the traditional rights of fishing community.
- Emphasized the need for planned development of the coast by disallowing polluting industries and controlling effluent/sewage disposal, the stage has been set for the control of pollution of the coastal areas.
- Protection of life and property from natural hazards such as erosion, flooding, sea level rise etc., has been largely ensured.
- Positive impact on fisheries by adopting measures , which will ensure the economic development, fisherman community in particular and the coastal areas in general.
- Enhancement of the tourism potential of the coast.

### 9.2.5 Violations of the Notification

The violations of the CRZ area includes:

- Destruction of CRZ-I areas such as mangroves, coral reefs, breeding sites of endangered species, etc.,
- Illegal constructions coming up in no development zones of CRZ.
- The State Governments have insufficient infrastructures facilities to take action against such violations.
- Lack of will of the concerned and inadequate enforcement machinery.

### 9.2.6 Constraints/Problems

- Uniform regulations for the diverse coastal environment
- Ambiguities and lack of clarity of terminologies existing in the Notification. Further, the Notification is badly structured. A common man cannot easily understand the Notification hence he is put into great difficulties even for undertaking a small dwelling unit. There had been lack of agreement on satisfactory definition of the coastal zone.
- It has been criticized that the CRZ lacks a scientific approach.
- The State Governments and development agencies complaint that the notification is too restrictive in nature and lacks statements on the objectives expected to be

achieved. Notification does not provide information sufficient for take decisions and there is no motivation for conservation of the ecosystems.

- Lack of awareness, lack of enforcement, lack of funding and attitudinal problems are enlisted as some of the reasons for the difficulties in implementing the CRZ notification.

### 9.2.7 Issues raised by Governments with regard to Coastal Regulation Zone Notification

- Demarcation of High Tide Line, permission for constructions of dwelling units for local communities, etc.
- Inability to implement the Notification due to inadequate infrastructure including funding mechanism.
- Lack of maps indicating CRZ-I, II, III and IV areas in the implementing scales, which is 1:4,000.
- Violations of the Notification due to increasing

### 9.2.7 Mechanism and Funding

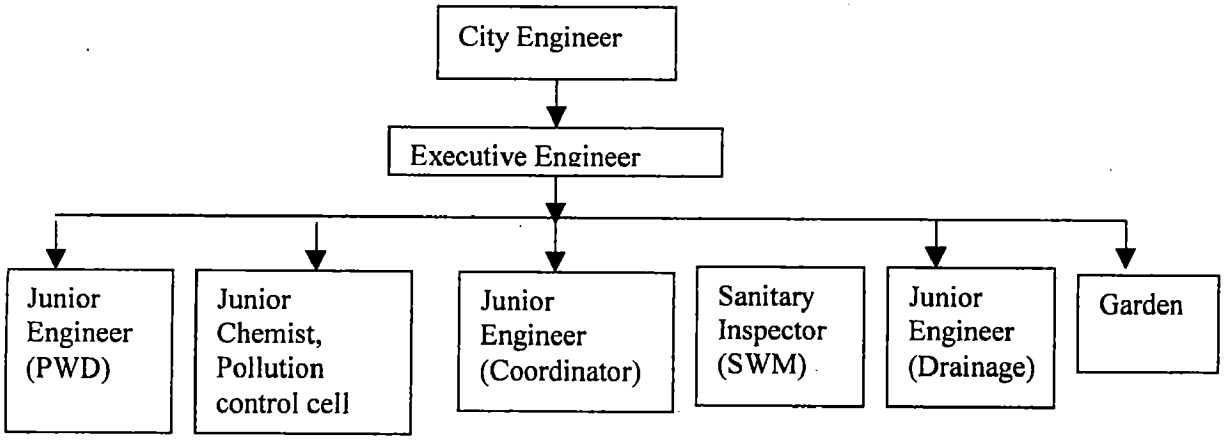
As per the Supreme Court's Order in W.P. No.664 of 1993, the Ministry has constituted the NCZMA and State CZMA for enforcement and monitoring of the CRZ Notification (MoEF 1998). These Authorities have been delegated powers under Section 5 of the Environment (Protection) Act, 1986 for taking punitive action against the violations. Further, the State Environment Departments, which also are responsible for enforcing the Notification. No funding mechanism is available under the Notification for undertaking pro-active role by the State Governments in preservation and conservation of the coastal area (MoEF Report 2005). In most of the cases, the State Governments have to depend upon the internal finance available, which is highly inadequate. It is seen that in some States scrutiny fee is being levied while assessing the development project.

### 9.2.8 Enforcement and monitoring of Coastal Regulation Zone Notification, 1991

In compliance to the same orders of the Supreme Court in Writ Petition No.664 of 1993 the Ministry has constituted National Coastal Zone Management at the Central level and 13 State and Union Territory level Coastal Zone Management Authorities under the Environment (Protection) Act, 1986 (MoEF 1998). These Authorities have about 8

Cell should comprises of Executive Engineer assisted by personnel from Public Works Department, Drainage Department, Garden Department, Encroachment Department, Town Planning Department and Pollution Control Department. It is necessary to establish a Pollution Control laboratory if any organisation does not have their own laboratory. Thane Municipal Corporation Thane Creek Conservation Cell organisation chart is given in Figure 9.1.

Figure 9.1: Organisation chart of TMC Creek Conservation Cell




The Function of coordinator engineer is to coordinate with the different in house and outside departments.

# CHAPTER 10

# SMALL HYDRO ON SEWAGE OUTFALL

Effluent from treatment unit is disposed into creek / estuary through outfall. During the survey it was observed that the sewage outfall near Kalyan Figure (10.1) has a head of 1 to 1.5 m during high tide as shown in Figure 10.2. A head of 1m is sufficient to generate electricity from effluent by small hydro plants. Hence it is proposed to set up a small hydro plant at the outfall station as shown in Figure 10.3 and judicious use the available head and site condition .

Figure 10.1:Sewage outfall station at Kalyan

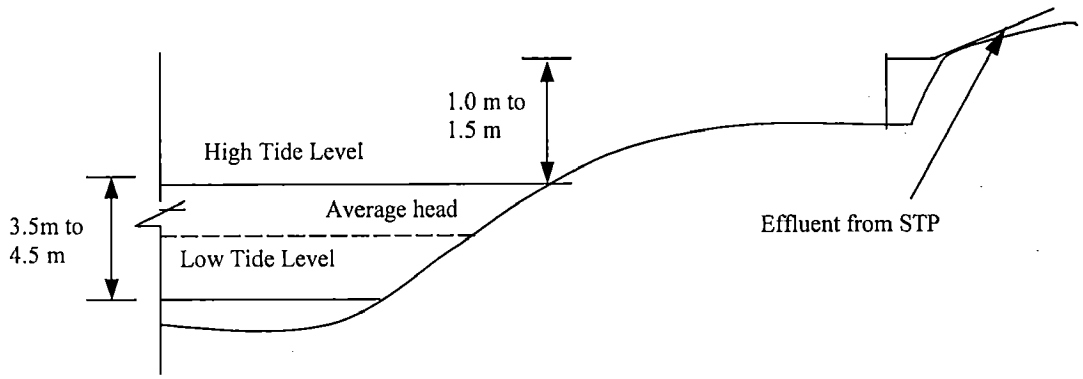



Figure 10.2 Low tide and high tide levels at sewage outfall

TMC has proposed to dispose effluent from STP at Kopari and Kharegaon. It is necessary to conduct detail study to access the potential of generating energy from wastewater at the proposed sewage outfall. Energy generated can be used for street lighting.

The detail for small hydro are as under

Average sewage flow = 0.67 $m^3/s$

| | |
|---|---|
| Peak sewage flow | = 1.49 $m^3/s$ |
| Avaliable average head | = 3.0 m |
| Installed capacity | = 3 x 1.49 x 7 = 30 kW |
| Average generation | = 3 x 0.67x 7 = 14 kW |
| Electricity generation | = 365 x 14x 0.95x 24 |
| | = 1.165 Lakh units |
| Investment | = Rs 21.0 Lakh |
| Annual expenditure @ 16% | = Rs 3.36 Lakh |
| Cost of Generation | = Rs 2.88/ kWh |
| Captive power rate | =Rs 4.50 / kWh |

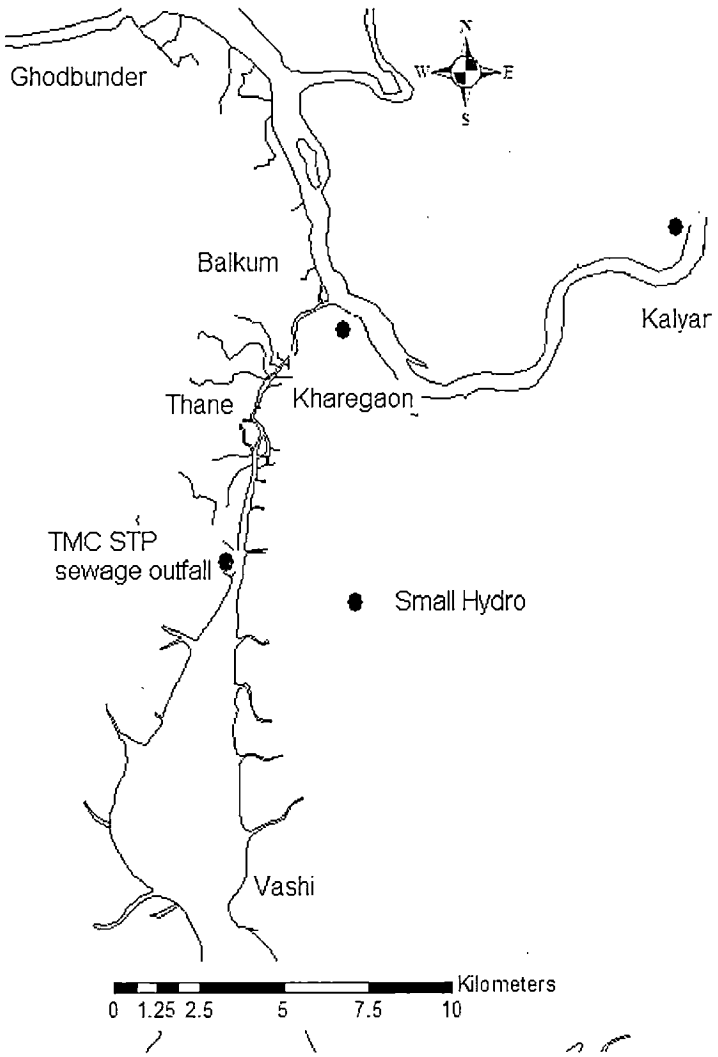



Figure: 10.3: Location of small hydro plant

# CHAPTER 11
# SHORELINE DEVELOPMENT

Thane creek and Ulhas river estuary shoreline is associated with a historical importance viz: Kalyan Fort located at Kalyan, Thane Fort was known as "Cabe de Tana" constructed by Portuguese located in Thane near Thane creek (Figure 11.1) and Ghodbunder was supposed to be a place for unloading horses. Concern about rising sea levels and need for development to be sustainable are focusing increases attention towards the coast / shoreline development. With the overall development of city it is also important to protect and conserve environmental quality and habitat along with landscape and recreational capacity of the shore. Thane creek is attracting Flamingoes ever year and NGO's are now working to get the Thane creek declared a World Heritage Site.

## 11.1 Objective

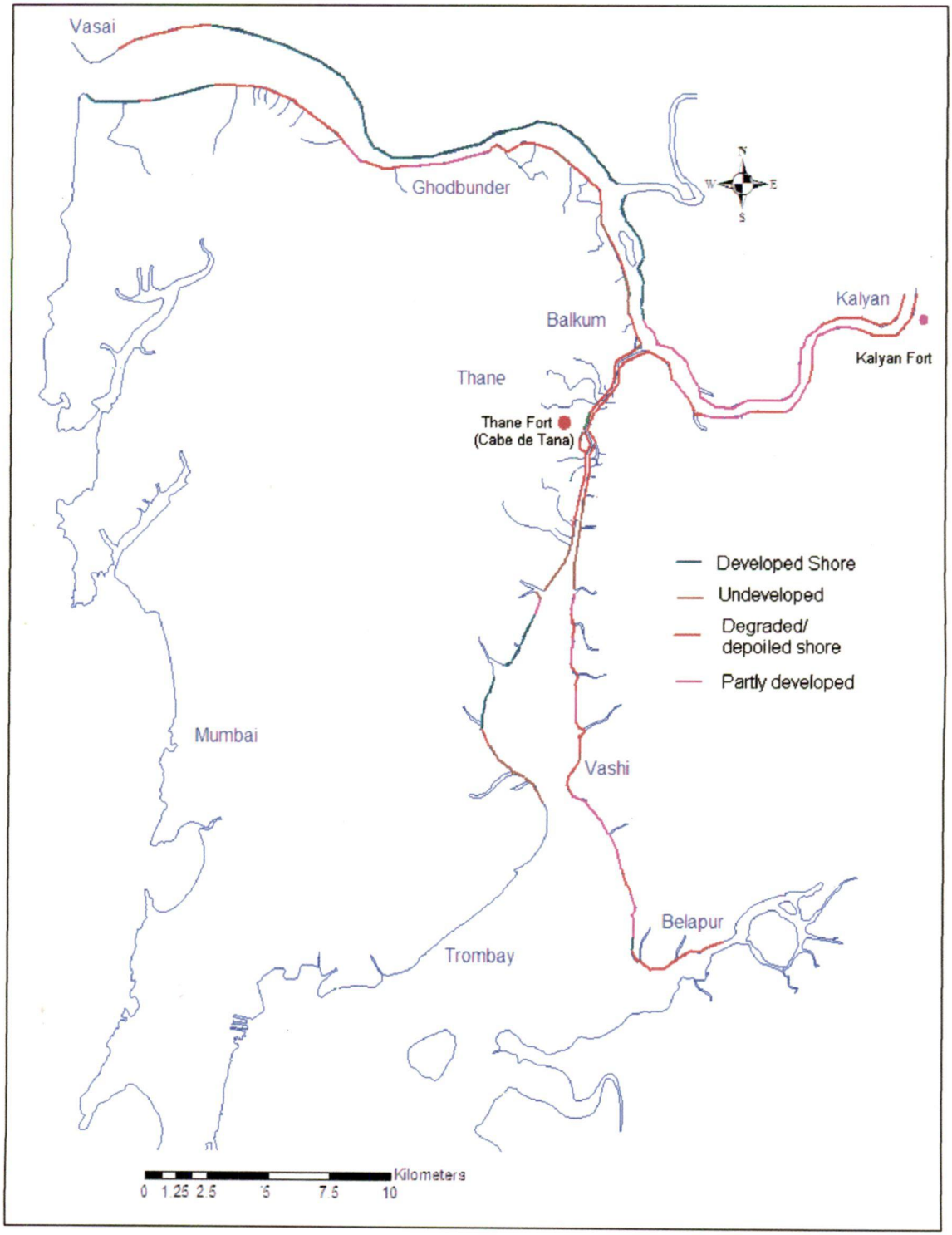
The objective of the shoreline development is to:

- conserve, protect and enhance the natural beauty of shore, including its terrestrial, marine flora and fauna, its heritage features of architectural, historical and archaeological interest;
- facilitate and enhance shore utilization for recreation , understanding and appreciation by the public by improving the extending opportunities for recreational , educational and tourist activities , which are in line with the conservation of its natural beauty and protection of valuable features;
- take into account of the needs of fishing and the economical , social need of the small communities depending on the creek as estuary through promoting sustainable forms of social and economic development, which in themselves conserve and enhance natural beauty.

## 11.2 Planning policies

Special policies should be for designated areas of high landscape values, nature conservation and scientific interest. Many of these designated areas include parts of coastal zone. Thane creek and Ulhas river estuary comes under Coastal Regulatory Zone authority.

Figure 11.1:Types of shore



### 11.2.1 Types of shore

For planning purpose the shore/ coast can be divided broadly into four types as shown in Figure 11.1:

1. Undeveloped – scarcity of mangrove.
2. Partly developed – partly conserved and mangroves planted
3. Developed – mass plantation of mangroves
4. Degraded / despoiled coast – damaged due to solid waste dumping, dredged sand and other manmade activities

### 11.2.2 Key policy issues

The key policy issues are conservation of natural environment and development of shoreline, which is subjected to high risk of floods, erosion and land instability. Another issue is to improve environment particularly of urbanised and despoiled shoreline.

### 11.2.3 Conservation policies

Policy aim to protect and enhance natural landscape of undeveloped shoreline. In areas designated for their natural landscapes policies will tend to limit development, particularly that would be visually intrusive. Coastal areas are particularly vulnerable to visual intrusions, because of the high visibility of development of the foreshore, on the skyline and affecting views along stretches of undeveloped shore/ coast.

Large development proposals results threat to shore but the cumulative effect of smaller developments can be just as damaging. Particulars care should be taken to access the impact of proposals affecting estuary and creek, not only on the immediate site and surrounding s but also of the cumulative effect on the estuary itself.

On the coast the opportunities may be limited by physical circumstances such as risk of flooding, erosion and land instability and by conservation policies.

A policy for resisting development of the shores is largely been affected due to encroachment, political will and multiplicity of authorities. Sustainable development is possible by implementation of CRZ provision.

Due to the nature of coastal geology, there are risks particularly from flooding and erosion by tidal waves. The policy in these areas should be to avoid putting further

development at risk, but even though unauthorized slum development is taking place with knowledge of various risks. Sometimes common interests are overlooked by the personnel interest. The degree of risk involved will have to be carefully considered and policies should specifically be needed to control or restrict development in low laying coastal areas. New development should not be permitted in areas, which would need expensive engineering works, either to protect development on land subject to erosion by tidal waves or to define land that might be inundated by the sea. There is also need to consider the possibility of such works causing a transfer of risks to other areas.

### 11.2.4 Measures proposed

Following are the various measures proposed:

- Development of mangrove (Figure 11.2) forest as described in detail in chapter 4.
- Clear demarcation of various zones specified by CRZ.
- Removal of encroachments (Figure 11.3).
- Shore protection from further erosion by providing gabion walls (Figure 11.3) where it is not possible to sustain by mangrove in a initial phase after the dredging work is carried out.
- Prevention of dumping of solid waste, construction debris on the shore and strict action against its violation.
- Restriction from destruction or denuding of mangroves by dumping, cutting of mangroves etc and action against its violation.

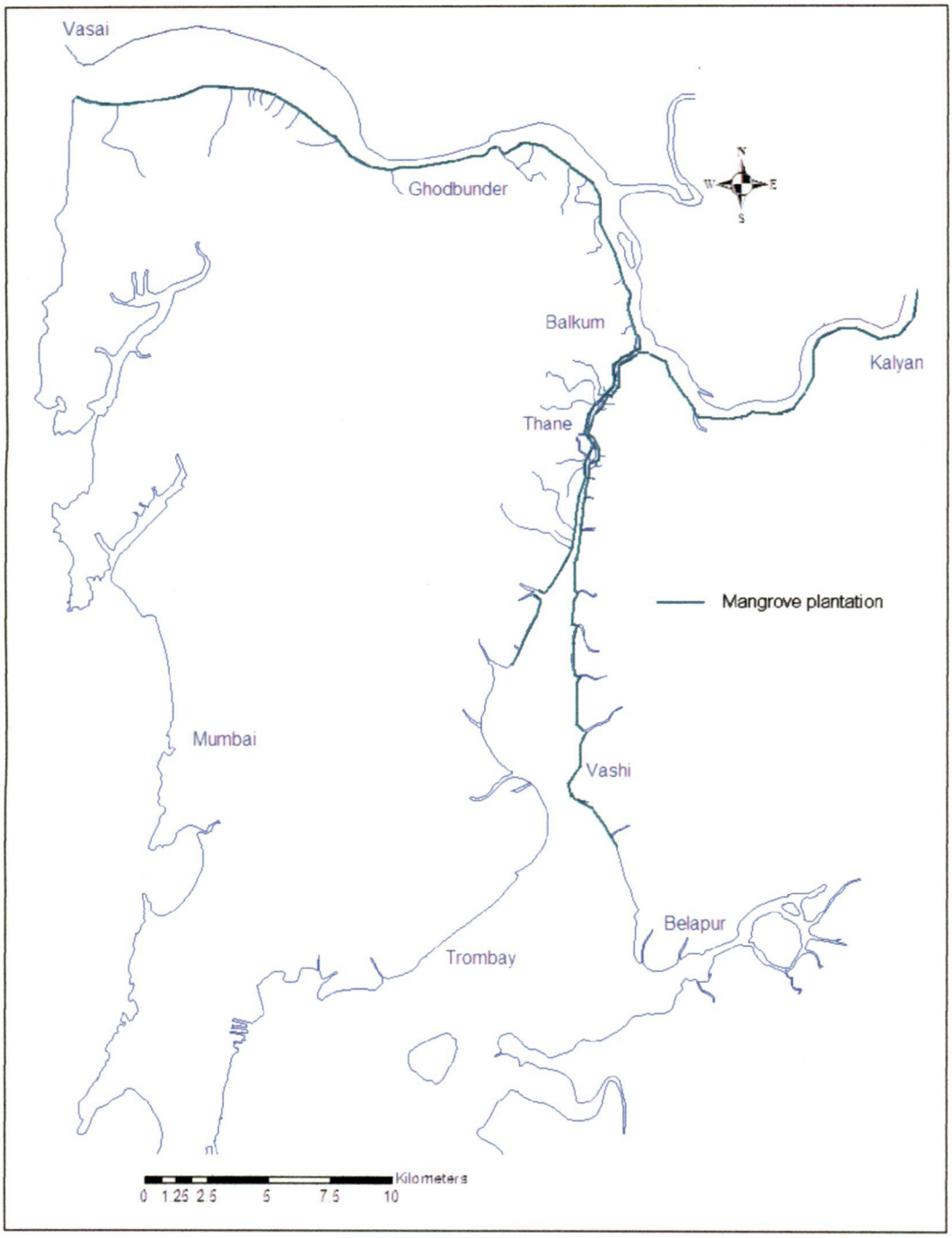



Figure 11.2: Proposed mangrove plantation

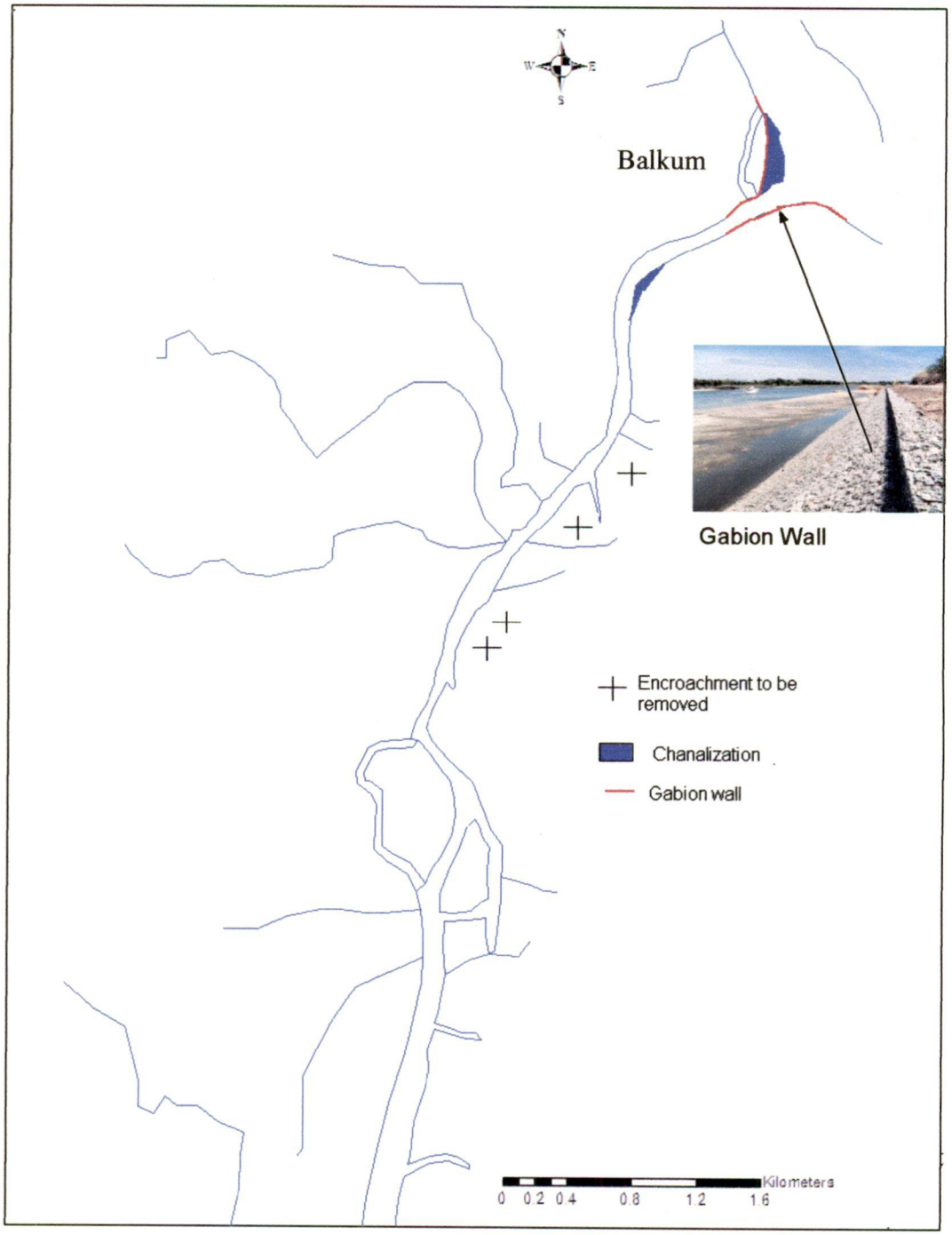



Figure 11.3: Proposed chanalization, construction of gabion wall and encroachment removal

# CHAPTER 12
# ECOTOURISM

MoEF has promoted the development of ecotourim on the coastal areas. The primary objective of the Eco-Tourism first to show case the natural resource of Thane creek and Ulhas river estuary to different segments of the society, for viewing the nature and the natural processes for educational, recreational values and to propagate the message of environmental conservation, which helps to sustain the Indigenous populace, thereby encouraging the preservation of habitats when visiting a place. To develop a responsible form of tourism, which encourages going back to natural products in every aspect of life. Which is also the key to sustainable ecological development.

The International Ecotourism Society defines ecotourism as "*responsible travel to natural areas that conserves the environment and improves the well-being of local people*" [12]. This means that those who implement and participate in ecotourism activities should follow the following principles:

- Minimize impact
- Build environmental and cultural awareness and respect
- Provide positive experiences for both visitors and hosts
- Provide direct financial benefits for conservation
- Provide financial benefits and empowerment for local people

The main activities proposed in Eco-Tourism are non-consumptive like bird watching, introduction to various mangroves and fish species and its importance, art performance and learn to live in nature.

Thus the surrounding nature becomes a live science park for the people to study and understand intricacies of the nature and its components. This understanding goes a long way in propagating the message of environmental conservation. Eco-Tourism also preaches the understanding and respecting various cultures and customs of people living in the area.

Ecotourim development should be in line with CRZ rules. The shore along the Ghodbunder road can be developed on the public private partnership basis which has high tourist potential.

## 12.1 Proposed activities

Coasts are popular destination for recreational activities and these have been growing pressure on its capacity. The natural beauty and landscape of Thane creek and Ulhas river estuary with its various natural resources for recreation makes it major attraction as shown in Figure 12.1.

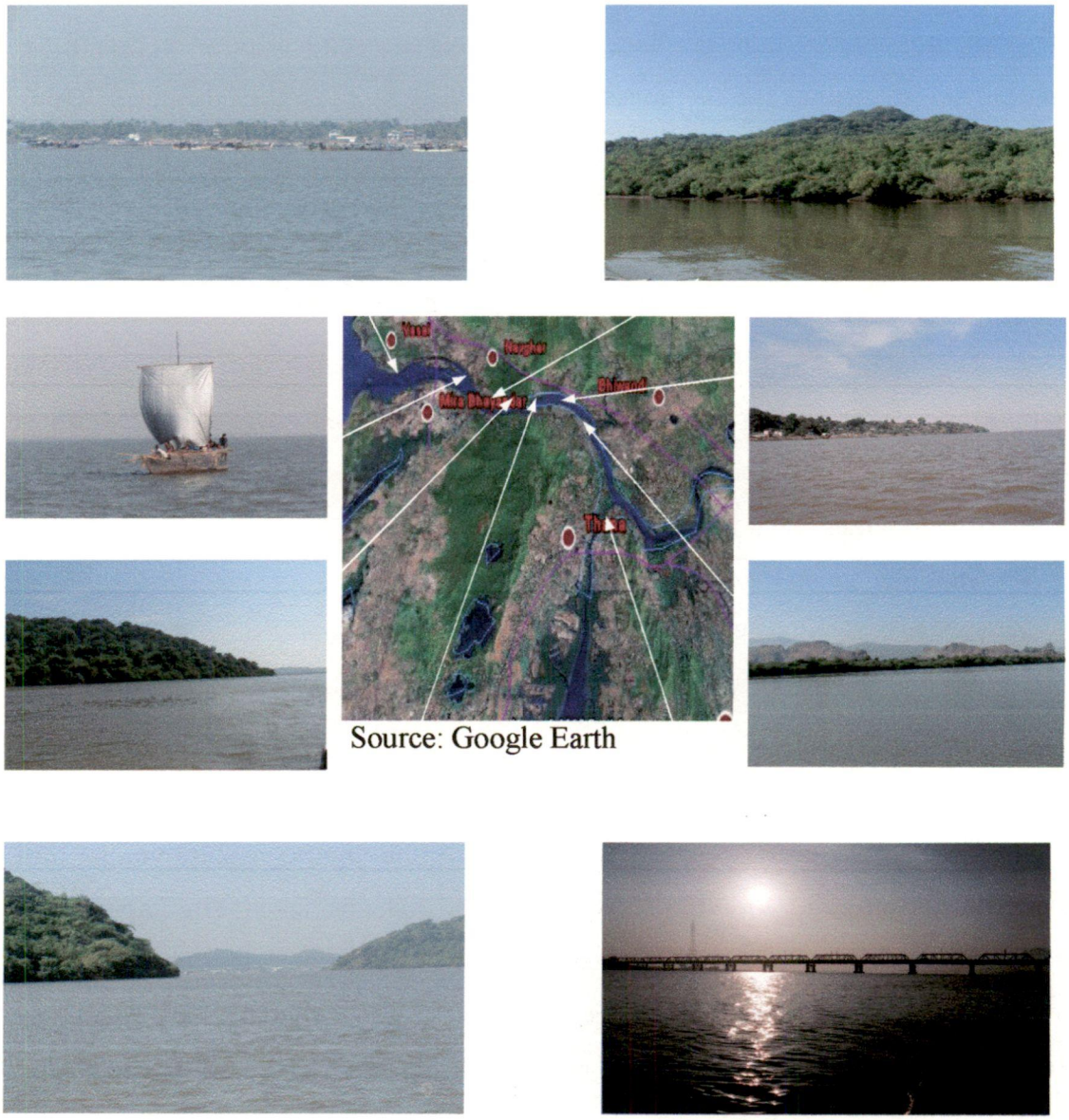



Figure 12.1: Natural beauty and landscape of Ulhas river estuary and Thane creek

Varieties of birds viz: Flamingoes, Seagulls, Avoct, Stilts , Godwit, Sandpiper, Coots, Grey Heron, Terns, Pintails, Lapwings, Kingfishers, Egrets , Plover ,etc. are observed in the Vikroli area where mangrove forest is developed (Figure 12.2) and if

it is properly developed then Thane creek will become a paradise for bird watchers. (Nitsure, 2002) reported that total of 69 species of birds belonging to 26 families and 12 orders, of which 32 species are Thane creek inhabitants. Charadriforms formed the largest group inhabiting the estuarine wetland. Maximum species diversity was observed in the month of December (49 species). Some rare visitors like Avocet (*Recurvirostra avocetta*) were observed, which is one of the important bird species according to IBA (Important Bird Area) declaration (Nitsure, 2002).

Figure 12.2: Birds

The objective of ecotourism should be to balance and reconcile recreational interest and overcome the various threats associated with recreational activities such as waste generation, etc. through appropriate management. Does and Don't for people visiting should be displaced at recreational places.

Various activities proposed are shown in Figure 12.3. Following are the various activities proposed:

- Development of the existing Rutuchakra garden with additional facilities like art gallery, music along the jogging track.
- Birds watching
- Development of ghats longs the shore.
- Ecoparks includes conservation of mangroves that creates a natural ecocycle.
- Ecopark can provide information of local flora and fauna
- Meditation Centre with greening of surrounding area
- Development of chaupaties along the shore
- Training facility for children by providing nursery
- Boat mooring
- Development of Thane backwaters like Kerala backwaters

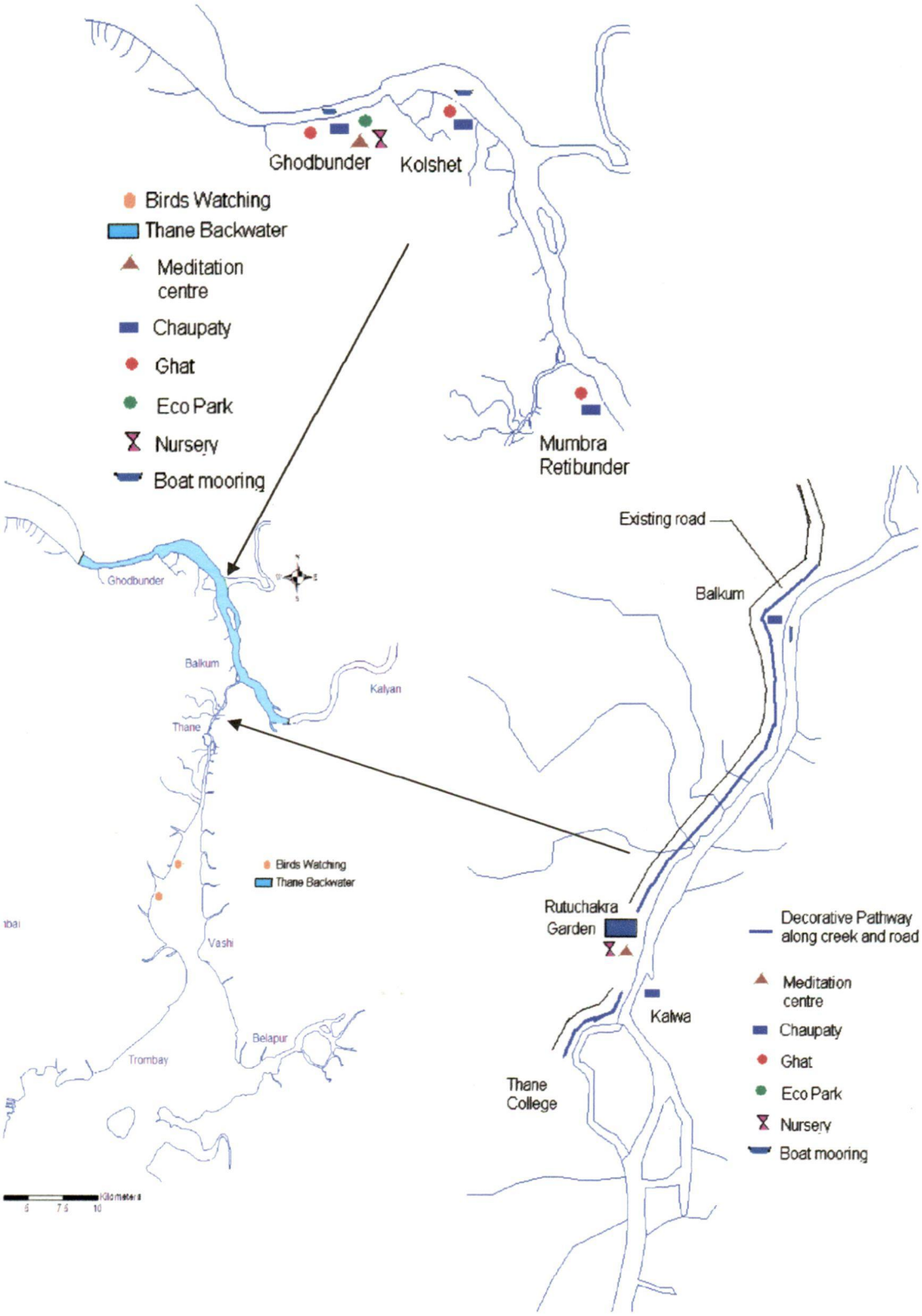



Figure 12.3: Locations of different proposed activities

# CHAPTER 13

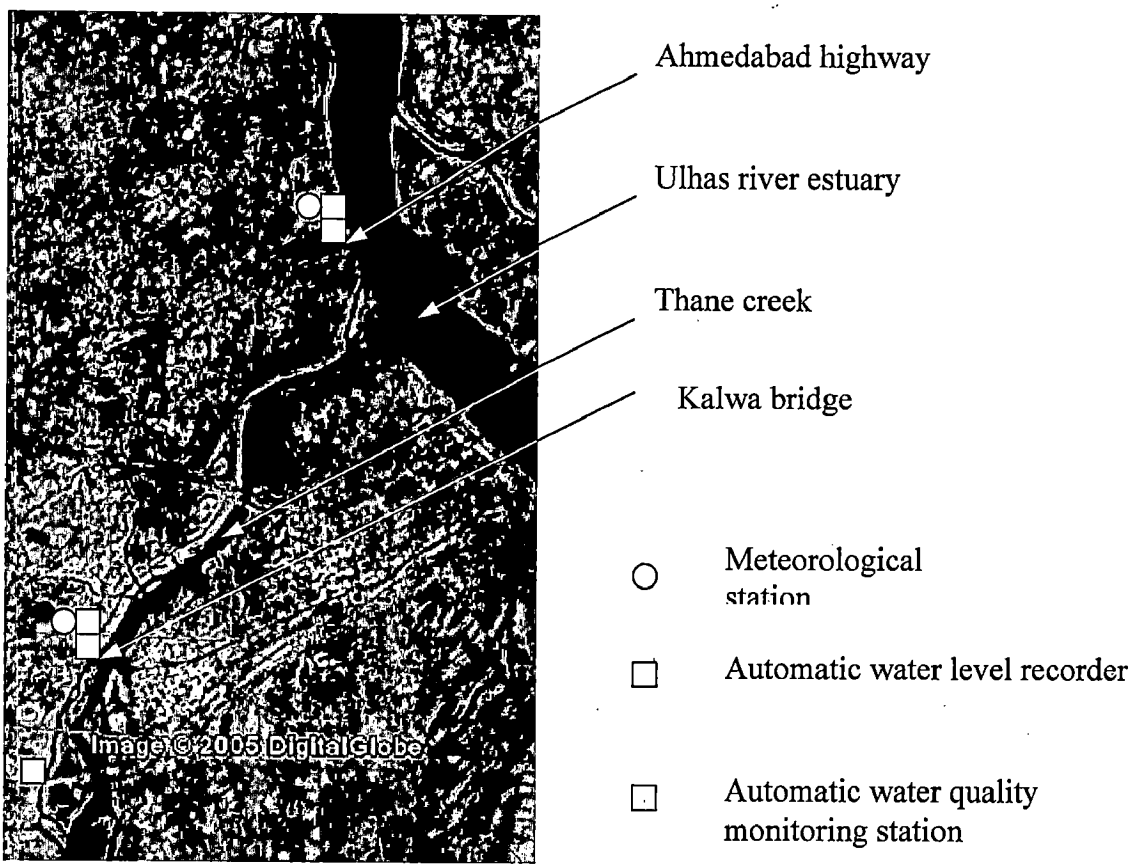
# MONITORING AND DATA MANAGEMENT

Comprehensive monitoring is a key component of management plan. Integrated environmental monitoring of Thane creek and Ulhas river estuary is currently deficient. No comprehensive, sustained and systematic environmental is in place today. Regular monitoring of water quality of Thane creek and Ulhas river estuary is done by TMC . MPCB monitor Thane creek at Elephanta Island and Ulhas river estuary at Vasai (Bassien) under Monitoring of Indian National Aquatic Resources (MINARS) program[13]. The creek and estuary conservation implementation phase includes integrated long term monitoring of creek and estuary to access water and sediment quality, physical habitat, aquatic and biological health, bed levels, tidal levels and weather conditions. Regular monitoring is an effective tool to access the effectiveness of the conservation measures undertaken. By tracking trends in the health of creek and estuary and its resources, pinpointing problem areas and assuring compliance with water quality standards, the conservation strategy need to be further designed.

It is essential to develop and maintain a pro-active and coherent approach to the management of Thane coastal resources; a long term monitoring programe is planned. It is proposed to setup automatic water quality, water level recorder and meteorological station for Thane creek and Ulhas river estuary as shown in Figure 13.1 .This will allow TMC to manage the coastline of Thane in a well-informed, factually sound manner. Integrated monitoring program is an ambitious undertaking and will require an unprecedented level of teamwork among all the involved parties. The program incorporates the regular capture and analysis of:

- Water quality
- Water level data
- Meteorological data
- Bathymetric data
- Satellite mapping of Thane

The monitoring program will be implemented in phases, based on available funding and resources, program priorities and development of new technologies.




Source: Google Earth

Figure 13.1 Proposed automatic water quality, water level recorder and meteorological station locations

Regular monitoring of water bodies with too many parameters is a time consuming, which restricts the sample size. New technologies are needed to gain and better understanding of the creek and estuary, which address unique problems. Today with a rapid progress in information technology and with real time monitoring option monitoring, data management has become simple. As a part of development phase of monitoring strategy, workshop is required to develop methods of monitoring, data sheets and deliver hands on experience for those likely to be get involve in monitoring program.

Standard formats should be developed so that data can be shared through lined system and stored for easy assess. Data assessment and reassessment could be an integral part of program to ensure that all concern have access to the results of the monitoring work.

### 13.1 Water quality monitoring

Water quality monitoring aimed at first controlling the pollution and then monitoring of creek and estuary. Water quality monitoring will help to access nature and pollution control strategies needed for various location and its prioritisation. It will help in evaluating the pollution measures already taken and its performance especially of sewage treatment plants.

#### 13.1.1 Creek and estuary water quality monitoring

Five years water quality monitoring program is proposed for Thane creek and Ulhas river estuary which could be taken in association with NGO and Educational Institutes. Funded Conservation related research program could be carried out along with the Educational Institutes. In addition to this it is propose to install automatic water quality monitoring station near Kalwa bridge and Ahmedabad highway as shown in Figure 13.1. A buoy as shown in Figure 13.2 can be kept moored to a heavy anchor which is able to take readings from a YSI multi parameter sonde Figure (13.3) fitted with sensors for temperature, pH, salinity, dissolved oxygen concentration, and Chlorophyll A [15]. Schematic diagram of sonde to data collection platform is shown in Figure 13.4.

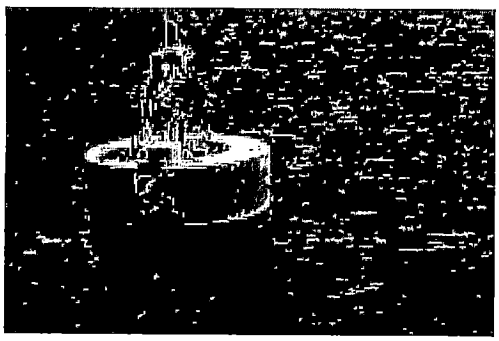


Figure 13.2: Floating buoy [14]

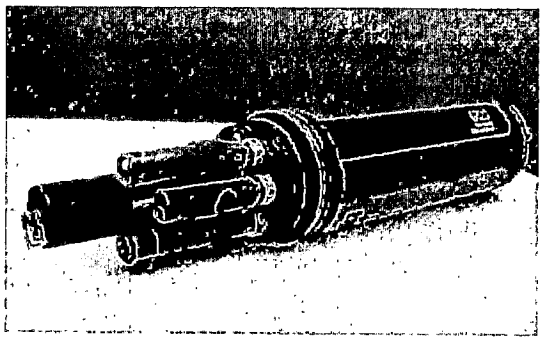


Figure 13.3: YSI multi parameter sonde[15]

Real-time data for pH, temperature, salinity and dissolved oxygen will quickly reveal any incidents of point source pollution, and chlorophyll measurements will reveal any trends that may take place as a result of diffuse or longer term pollution. Chlorophyll is the pigment that allows plants, including algae, to convert sunlight into organic compounds in the process of photosynthesis. Chlorophyll A is the predominant type found in algae and cyanobacteria (blue-green algae), and its abundance is a good indicator of the amount of algae present in water. Excessive quantities of chlorophyll A can indicate the presence of algae blooms [16].

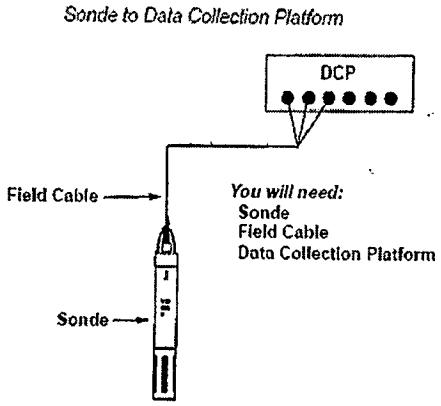



Figure 13.4: Schematic diagram of sonde to data collection platform [16]

### 13.1.2 Sewage treatment plant monitoring

Monitoring and controlling of wastewater treatment processes require frequent sample collection and sample analysis. At present, laboratory personnel manually carry out sample collection. This approach limits the frequency of sample collection and cannot provide a real time monitoring of the process and therefore the control of the process often lags behind. In recent years have shown use of classical sensors as pH, dissolved oxygen, turbidity, etc, and also the development and use of analyser systems for nutrients and organic matter have reached a level of practical use [4]. Furthermore, new technologies are introduced, most of these using the real time calculation capabilities of microprocessor systems located directly in the sensors. The typical structure used for introduction of these sensors into waste water systems for monitoring control is shown in Figure 13.5.

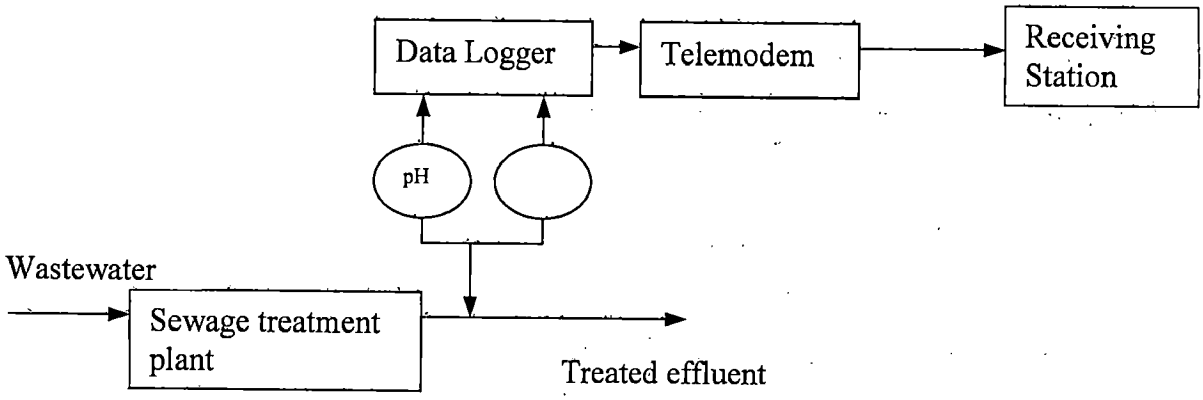



Figure 13.5: Schematic layout of Sewage treatment plant monitoring system [AHEC 2002]

## 13.2 Water Level Monitoring

Considering the damage caused due to heavy rains and inability of storm water to drain into creek during high flood it become essential to monitor the creek and

estuary water level during the high and low tides. Automatic water level data monitoring equipment could be installed one in Thane creek and other in Ulhas rive estuary as shown in Figure 13.1. Pressure digital water level recorder could be used for the same Figure (13.6)

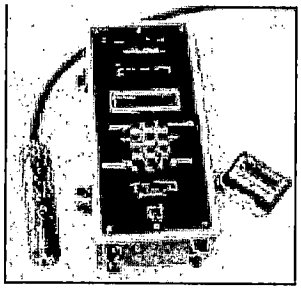


Figure 13.6: Digital water level meter model TS 1310-p[Techmes]

The reading is done using a pressure sensor housed in a closed capsule, which registers the liquid's hydrostatic pressure above the sensor. A cable joins the sensor to the datalogger. This cable consists of the electrical wire and a vent tube, which equalises the pressure in the capsule with the atmospheric pressure. In this way, variations in the atmospheric pressure are compensated. The digital solid-state memory datalogger receives the signal from the sensor, digitalises it and stores the data in centimeters along with the time in a reusable solid state memory cartridge. The instrument is housed in a dust and splash proof case, and should be installed sheltered from weathering.

**13.3 Meteorological data**

A meteorological station measuring wind speed and direction, air temperature and atmospheric pressure is required to be installed one for Thane creek and one for Ulhas river estuary as shown in Figure 13.1. Automatic Weather Station may be use of meteorological data monitoring comprises of sensors for measuring all the key weather parameters, i.e, wind speed, wind direction, air temperature, relative humidity, rainfall and solar radiation as shown in Figure 13.7. It contains a datalogger mounted within a weatherproof case on a 2m frame. Supplied complete with datalogger, 2m frame, battery pack and computer software [17].

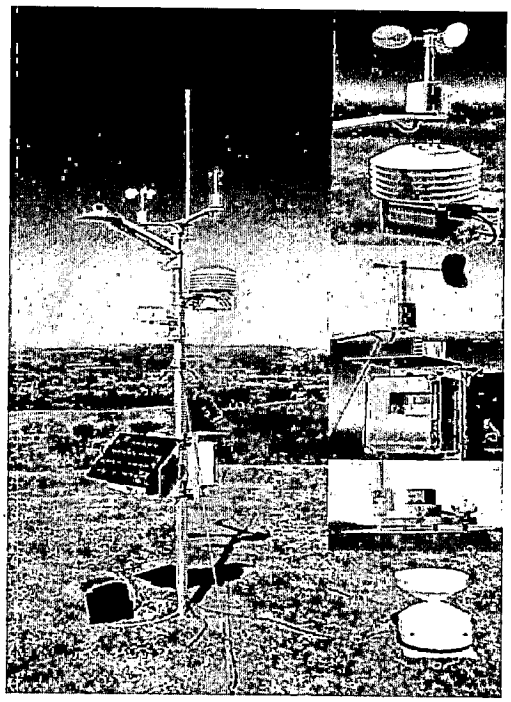


Figure 13.7: Automatic meteorological data monitoring setup [17]

### 13.4 Bathymetric data

The bathymetric survey involves coverage of a Thane creek by Hydrographer, Maharashtra Maritime Board. Areas of particular interest or concern will be resurveyed as and when necessary to monitor changes over time. Comparisons between survey data sets will assist in substantiating the existing understanding of the sediment budget and transport processes along the Thane coastline.

### 13.5 Satellite mapping of Thane

Satellite mapping of the entire Thane city covering Thane creek and Ulhas river estuary is proposed to be taken up for next five years to monitor city development, coastal water quality and mangrove-mapping.

# CHAPTER 14

# IMPLEMENTATION STRATEGIES

The role of conservation coordinating team is to consult with different stakeholders about what should be done to implement the action plan, convene appropriate parties to implement the action and assisting in implementation of action plan. Coordinator should be well positioned to provide effective collaboration and coordination among multiple efforts of different players. It is necessary to pool together technical and education efforts for strengthening and supporting implementation program and fill gaps. One must find new and better ways of governing creek and estuary.

Base program analysis and inventory is required to identify government agencies and non-government organisations with responsibilities related to different priority issues of Thane creek and Ulhas river estuary. It provides an outline of program responsibilities of those agencies. Table 14.1 gives the role of each agency. After understanding the present situation it is recommended that:

- The process of managing the natural resources of Thane creek and Ulhas river estuary should be unified and simplified under a system of co-operation. The natural and biological system should be enhanced to achieve their maximum diversity.
- Dynamic decisions making process are needed to evolve scientific knowledge and public values.
- Effective resource management requires a sustained commitment of financial and human resources.

Table 14.1: Role of various partners

| **Activity** | **Partner** | **Role** |
|---|---|---|
| Sewerage Project and Low cost Sanitation | TMC | Conceptualizing, Resolution, Planning, Designing, Funding & Implementation |
| | Govt. of India | Funding |
| | World Bank | Funding |
| | Consultants | Planning & Designing |
| | Private Contractors | Implementation & Maintenance |
| | NGO's and citizens | Public awareness and Maintenance |
| Solid Waste Management | TMC | Conceptualizing, Resolution, Planning, Designing, Funding & Implementation |

| Activity | Partner | Role |
|---|---|---|
| | Consultant | Planning & Designing |
| | BOT Operator | Implementation & Maintenance |
| | NGO's, CBO's and citizens | Public awareness and Maintenance |
| | Rag Pickers | Implementation & Maintenance |
| Mangroves Plantation | TMC | Conceptualizing , PDSIM |
| | Govt. of India, State Forest Department | Funding & Monitoring, PDSIM |
| | Private Contractors | Implementation & Monitoring |
| | NGO's, CBO's and citizens | Public awareness, implementation and Maintenance |
| Dredging Work | TMC | PDSIM |
| | Maharashtra Maritime Board | PDSIM |
| | JNURM | Funding |
| | Consultant | Planning & Designing, Monitoring |
| | Private Contractors | Implementation |
| Tourism Development Ecotourism | TMC | PDSIM |
| | BOT Operator | Monitoring, Implementation |
| | NGO's, CBO's and citizens | Awareness campaign, Implementation |
| Public Awareness and Participation | TMC | PDSIM |
| | NGO's, CBOs and citizens | Awareness campaign, Implementation |
| | Corporates | Awareness campaign, Implementation and funding |
| Satellite mapping | TMC | Sanctioning, Implementation and funding |
| | MoEF | Funding |
| | MRSAC | Technology |
| | Consultant | Planning & Designing and implementation |
| Storm Water Study | TMC | Planning, designing and Implementation |
| | NGO | Planning, designing and Implementation |
| | MMRDA | Funding |
| Bathymetric Survey | TMC | Sanctioning and funding |
| | MMB | Survey |
| Small Hydro | TMC | Sanctioning and Funding |
| | Ministry of Non Conventional Energy Resources | Sanctioning and Funding |

| Activity | Partner | Role |
|---|---|---|
| | Alternate Hydro Energy Centre | Designing |
| | CRZ Authority | Sanctioning |
| | Contractor | Construction and Installation |

PDSIM=Planning, Design, Sanctioning , Implementation and Monitoring

Implementation of the action plan will rely heavily on voluntary support from all levels. Environment problem today cross boundaries and affect almost everything we do as individual and a society. Successful conservation will take extensively voluntary efforts as well as strong laws. Other Municipal Corporations can adopt the actions proposed as a common minimum program and TMC may become a lead partner. Implementation and operation and maintenance strategy for different activities are given in Table 14.2. Five-year conservation plan is shown in Figure 14.1.

Table 2: Implementation and operation and maintenance strategy for different activities

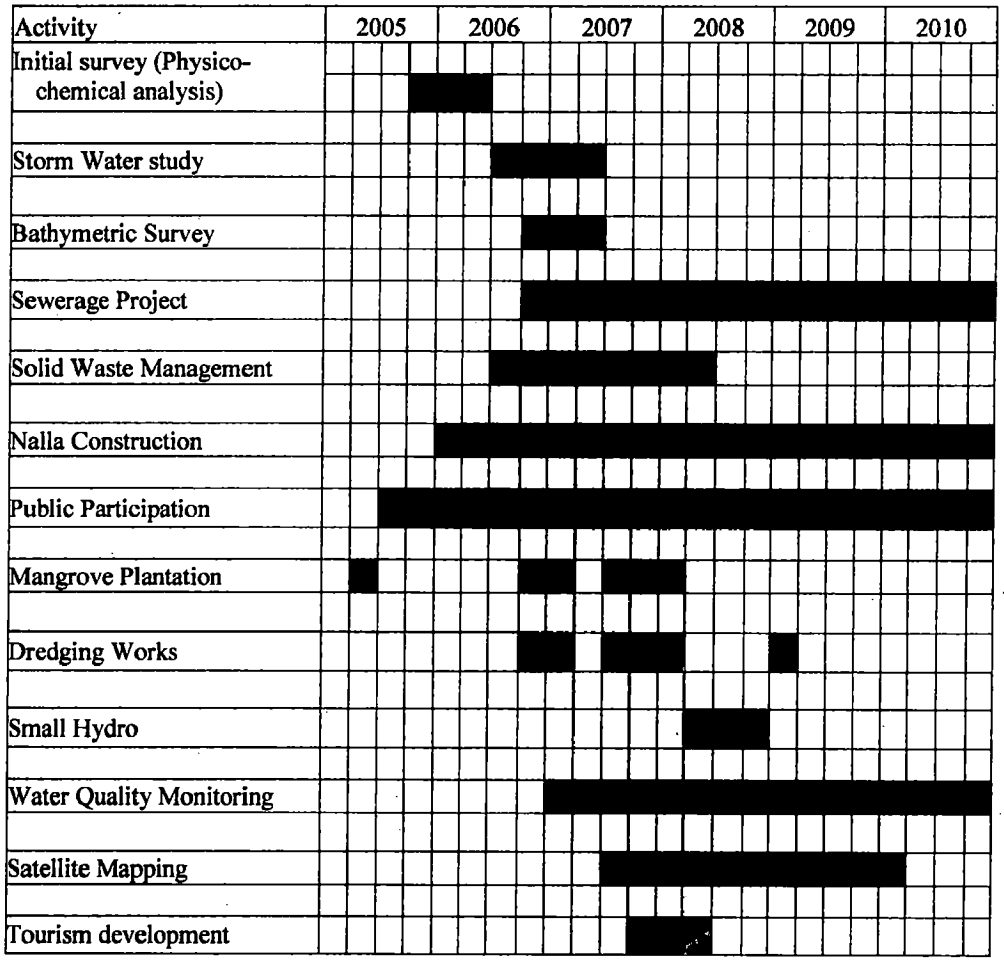
| Activity | Implementation | Operation and maintenance |
|---|---|---|
| Sewerage Project | Laying of sewer lines through Percentage rate contract, Construction of pumping station and STP through Turnkey contract and supervision by Project Management Consultant and TMC. | Initial Five years maintenance by contractors there after by maintenance contract. |
| Low cost Sanitation | Partly construction of toilets by TMC through Percentage rate contract and partly toilets through Built, Own and Operate (BOO) basis. | TMC , Community based organisations (CBO) and BOO operators |
| Solid Waste Management | Collection, transfer and transport and disposal by TMC partly through own arrangement and partly through contracted. Biomedical waste treatment plant and Biomethanisation – Built Operate and Transfer (BOT) | Street cleaning through contractor<br>Biomedical waste treatment plant and Biometanisation – BOT operators |
| Mangroves Plantation | Plantation through contractors | TMC, NGO's |
| Dreading Work | Through contractor (Item rate contract) | Through contractor |
| Ecotourism | Built Own Operate and Transfer (BOOT) basis | Through BOOT contractor |
| Small Hydro | Through Contractor | Annual maint. contract. |
| PA and PP | TMC and NGO | TMC and NGO |
| Satellite mapping | Consultant and Maharashtra Remote Sensing Applications Centre (MRSAC) | |

| Activity | Implementation | Operation and maintenance |
|---|---|---|
| Storm Water Study | TMC, NGO and Consultant | |
| Bathymetric Survey | Through MMB | |

The active involvement of citizens is important to achieve success of action plan and they play an important role in operation and maintenance phase, i.e., post project implementation period. Citizens can be effective in areas where Municipal Corporation is low to act, where role is limited or where voluntary compliances is important. Corporates should have social responsibility and can contribute towards TMC creek and estuary conservation drive by sponsoring some action planned.

At the end of every six months conservation management team should evaluate the implementation process and effectiveness of different actions. This will allow management to respond to change, needs, evolving science and current environment.

Figure 14.1: TMC Thane creek and Ulhas river estuary proposed action plan



# CHAPTER 15
# COST ESTIMATES

## 15.1 Cost Abstract

The cost of various conservation activities are calculated and abstract is given in Table 15.1. Cost estimates for sewerage project, low cost sanitation, solid waste management, dredging, public awareness and public participation and monitoring are given in Table 15.2, 15.3, 15.4, 15.5, 15.6 and 15.7 respectively. The total cost for different conservation measures comes out to be Rs 661.03 crores. Sewerage project, Low cost sanitation and Nalla construction project has been taken up by the TMC. Tenders have been called for execution of the Phase I of the Sewerage, Low cost sanitation and Nalla construction project.

The present operation and maintenance expenses for the Solid waste Management activity and estimated expenses for day to day landfill site operation given in Table 15.8. Operation and maintenance expenses for sewerage scheme after its completion is estimated to be Rs 18.45 crores per annum (TMC DPR 2005) .

Table 15.1: Cost abstract

| Sr. No. | **Activity** | Estimated Cost ( Rs, Lakhs) |
|---|---|---|
| 1 | Sewerage Project (Table: 15.2) | 40358.0 |
| 2 | Low cost Sanitation (Table: 15.3) | 491.0 |
| 3 | Solid Waste Management (Table 15.4) | 1530.0 |
| 4 | Nalla Construction | 15000.0* |
| 5 | Mangroves Plantation | 100.0 |
| 6 | Dredging Work (Table 15.5) | 2714.0 |
| 7 | Tourism Development Ecotourism | 5000 |
| 8 | Public Participation and Awareness (Table 15.6) | 734.5 |
| 9 | Monitoring (Table 15.7) | 83.0 |
| 10 | Storm Water Study | 30 |
| 11 | Bathymetric Survey | 25 |
| 12 | Small Hydro on sewage outfall | 38.0 |
| | **Total** | 66103.5 |

* Amount estimated by the consultant appointed by TMC

Table 15.2: Sewerage project cost estimate

| Sr .No | Item | Amount ( Rs, Lakhs) |
|---|---|---|
| 1 | Collection system | 13660 |
| 2 | Pumping stations | 3640 |
| 3 | Pumping mains | 910 |
| 4 | Sewage treatment plants | 6000 |
| 5 | Outfall sewers | 900 |
| 6 | Other works (including Railways & Highways crossing, staff Quarters, etc.) | 1400 |
| 7 | Extension of sewer network to slums | 4490 |
| | Total Construction Cost | 31000 |
| | **Total Construction Cost (with escalation)** | **33208** |
| 1 | Physical contingencies | 1550 |
| 2 | Project Management and construction supervision | 3100 |
| | | |
| 1 | Land Acquisition | 2500 |
| | **Total Project Cost** | **40358** |

Source: TMC Detail Sewerage Project Report

Table 15.3: Low cost sanitation estimate

| Sr No | Activity | Quantity | Unit | Rate (Rs) | Amount ( Rs, Lakhs) |
|---|---|---|---|---|---|
| 1 | Individual Toilet -Twin Pit pour Flush type | 1471 | nos | 0.05 | 73.55 |
| 2 | Community Toilet -Twin Pit pour Flush type | 300 | nos | 0.577 | 173.1 |
| 3 | Community Toilet -Excreta based biogas and biofertilizer type | 303 | nos | 0.70 | 121.1 |
| 4 | Mobile Community Toilet | 9 | nos | 3.66 | 32.98 |
| | | | | **Total** | **491.73** |

Table 15.4: Solid waste management cost estimate

| Sr. No. | Details of Item | Quantity | Unit | Rate (Rs) | Amount ( Rs, Lakhs) |
|---|---|---|---|---|---|
| 1 | **Collection and Storage System - Equipments and Vehicles** | | | | |
| 1.1 | Bins 50 lit capacity | 4140 | Number | 500 | 20.70 |
| 1.2 | Compactor Containers, HDPE 660 Liters | 329 | Number | 16500 | 54.29 |

| Sr. No. | Details of Item | Quantity | Unit | Rate (Rs) | Amount ( Rs, Lakhs) |
|---|---|---|---|---|---|
| 1.3 | Hand Cart with Bins HDPE 120 lit 2 nos. on each cart | 248 | Number | 10000 | 24.80 |
| 1.4 | Collection system at vegetable market | 4 | Number | 750000 | 30.00 |
| 1.5 | Compactor 16 GVW, 10-12 cum | 19 | Number | 1900000 | 361.00 |
| 1.6 | Compactor 16 GVW, 6-8 cum | 2 | Number | 1400000 | 28.00 |
| **2** | **Transfer Station** | 5 | Number | 5000000 | 250.00 |
| **3** | **Waste Disposal Site** | | | | |
| 3.1 | Site Clearance | | Lumpsum | | 10.00 |
| 3.2 | Boundary Wall | 2550 | Rmt. | 1800 | 45.90 |
| 3.3 | Road Construction main road | 800 | Sqm. | 3700 | 29.60 |
| 3.4 | Road Construction along periphery | 2550 | Sqm. | 1850 | 47.18 |
| 3.5 | Surface water drainage system | 2550 | Rmt. | 1000 | 25.50 |
| 3.6 | Leachate management facility | | Lumpsum | | 20.00 |
| 3.7 | 20 MT capacity Weigh bridge | 2 | Number | 2000000 | 40.00 |
| 3.8 | Bull dozer | 2 | Number | 3000000 | 60.00 |
| 3.9 | Excavator | 3 | Number | 2000000 | 60.00 |
| 3.10 | Compactor | 2 | Number | 3000000 | 60.00 |
| 3.11 | Water tanker | 2 | Number | 500000 | 10.00 |
| 3.12 | Tippers/tractor Trailers | 2 | Number | 500000 | 10.00 |
| 3.13 | Office Room | | Lumpsum | | 20.00 |
| 3.14 | Portable office | | Lumpsum | | 0.50 |
| 3.15 | Workshop | | Lumpsum | | 24.00 |
| 3.16 | Waste segregation arrangements | | Lumpsum | | 10.00 |
| 3.17 | External electric work | 85 | Number | 7000 | 5.95 |
| 3.18 | Internal lighting arrangement | | Lumpsum | | 3.00 |
| 3.19 | Water Supply arrangement | | Lumpsum | | 3.00 |
| 3.20 | Miscellaneous equipments and works | | Lumpsum | | 10.00 |
| 3.21 | Development of green belt | | Lumpsum | | 10.00 |
| 4 | Plastic recycling machine | 5 | | 1100000 | 55.00 |
| 5 | Biofertilizer project | | | | 30.00 |
| 6 | Carcass disposal arrangement | | | | 20.00 |
| | | | | **Total** | **1378.41** |

Table 15.5:Cost estimates for dredging and shore protection works

| Sr. No. | Details of Item | Quantity | Unit | Rate (Rs) | Amount ( Rs, Lakhs) |
|---|---|---|---|---|---|
| 1 | Dredging | 1901000 | Cum | 150 | 2703.0 |
| 2 | Gabion wall | 200 | Rmt | 15000 | 30.00 |
| | | | | **Total** | 2733.0 |

Table 15.6:Cost estimated for Public Awareness and Public Participation program

| Sr No. | Item | Basis of calculation, Rs. in Lakhs | Amount ( Rs, Lakhs) |
|---|---|---|---|
| A | **Mass media** | | |
| 1 (a) | Television | Films and promos | 10 |
| (b) | Advertisement in local Cable network | 15 in year I and 7.5 each in year II & III | 45 |
| 2 (a) | Radio talks | 12 lakh each year | 60 |
| (b) | Thane FM | 20 lakh each year | 100 |
| 3 | Print media publicity in local papers, magazines | 15 lakh in year I and 10 lakh each in year II & III | 55 |
| 4 | Print material for distribution - calendars, school labels etc. | 15 lakh in year I and 10 lakh each in year II & III | 55 |
| 5 | Hoarding at strategic points in the city | 20 lakh in year I and 15 lakh each in year II & III | 80 |
| 6 | Web site development with hosting and updation for three years | 0.1 lakh for three years | 0.5 |
| | **Events** | | |
| 7 | Preparation of exhibition material, posters and organising these events | 10 lakh in year I and 5 lakh each in year II & III | 30 |
| 8 | Special cultural events, performance of Folk media, street play | 5 lakh per year | 25 |
| | **Groups and Meetings** | | |
| 10 | Environmental awareness at school levels | 36 lakh per year @ Rs 3000 per school for 120 school | 188 |
| 11 | Formation of Action Groups, self help group s and support to social groups / clubs for awareness generation activities | 10 lakh per year | 50 |
| 12 | Other awareness activities like public meetings, debates, meeting with different unions, felicitation of best workers etc | 10 lakh per year | 50 |
| 13 | Awareness camps for Sanitary inspectors, Mukadam and Workers | 10 lakhs per year | 50 |
| | **Total for Public Awareness and Public Participation Activities** | | 734.5 |

Table 15.7: Cost estimate for monitoring activity

| Sr. No. | Details of Item | Quantity | Unit | Rate (Rs) | Amount ( Rs, Lakhs) |
|---|---|---|---|---|---|
| 1 | Digital Water level Recorder | 3 | Number | 50000 | 1.5 |
| 2 | Equipments for water quality | 2 | Set | 400000 | 8.0 |

| Sr. No. | Details of Item | Quantity | Unit | Rate (Rs) | Amount ( Rs, Lakhs) |
|---|---|---|---|---|---|
| | monitoring | | | | |
| 3 | Water quality monitoring | 5 | Year | 6.0 | 30.0 |
| 4 | Sewage treatment monitoring | 3 | Set | 150000 | 4.5 |
| 5 | Metrological parameter monitoring system | 2 | Set | 200000 | 4.0 |
| 6 | Setting up GIS lab | 1 | Number | Lumpsum | 35.0 |
| | | | | **Total** | 83.0 |

### 15.2 Funding Source

It is proposed to execute the conservation project with the aid of TMC own fund and from external funding from , JNURM, MoEF , MMR-MMRDA, MNES, Municipal bonds , Debt from banks / Institutions and BOT operators. Finding source for each activity is given in Table 15.8 and its year wise breakup is given in Table 15.9. Creek conservation program is included in a City Development Plan prepared under JNURM.

Funds required for each activity per year is estimated and given in Table 15.10. Projected net cash flows of the sewerage project is given in Table 15.11. Estimated annual operation and maintenance expenses for solid waste management is given in Table 15.12.

### 15.3 Cess Calculation for Solid Waste Management

Mass awareness about the importance solid waste management practices and importance of cess is required before implementation. Cess calculation is given in Table 15.13. Cess is calculated based on the following consideration:

- Increase in number of households and commercials establishments are forecasted based on population forecast.
- Future waste generation is forecasted based on population forecast.
- Rate for recyclable is considered as under
    - Compost Rs 400 per ton
    - Plastic Rs 1000 per ton
    - Metal Rs 500 per ton
    - Paper Rs 400 per ton
    - Glass Rs 200 per ton

- Present establishment and operation and maintenance expenses are taken as Rs 1200 per ton and Rs 256.0 per ton. Establishment cost for year 2010 is considered as Rs 1000 per ton due to implementation of contract system for street cleaning, transportation of waste, etc.
- Inflation rate for calculating recyclable cost , establishment and operation and maintenance expenses is considered as 5 percent.
- Slab for cess increment is kept as three years.

Table 15.8: Funding Source for each activity

| **Activity** | **Funding source** | **Amount ( Rs, Lakhs)** |
|---|---|---|
| Sewerage Project | TMC | 4070.06 |
| | Magaswarghe Nidhi | 2213.69 |
| | Govt. of Maharashtra | 9403.41 |
| | Municipal Bonds | 9403.41 |
| | Debt from banks / Institutions / Funds | 15267.43 |
| Low cost Sanitation | TMC | 49.46 |
| | Magaswarghe Nidhi | 27.0 |
| | Govt. of Maharashtra | 114.4 |
| | Municipal Bonds | 114.4 |
| | Debt from banks / Institutions / Funds | 185.74 |
| Solid Waste Management | TMC | 1475 |
| | BOT Operator | 55 |
| Nalla Construction | TMC | 4500.0 |
| | JNURM | 10500.0 |
| Mangroves Plantation | TMC | 30 |
| | MoEF and State Forest Department | 70 |
| Dredging Work | TMC | 554 |
| | MMB | 1080 |
| | JNURM | 1080 |
| Tourism Development Ecotourism | TMC | 2000 |
| | BOT Operator | 3000 |
| Public Awareness and Public Participation | TMC | 734.5 |
| Monitoring | TMC | 15.9 |
| | MoEF | 37.1 |
| | MMR-MMRDA | 30.0 |
| Storm Water Study | MMR-MMRDA | 30.0 |
| Bathymetric Survey | TMC | 25.0 |
| Small Hydro | TMC | 19.0 |
| | Ministry of Non Conventional Energy Sources (MNES) | 19.0 |

Figure 15.9: Yearwise breakup of funding source

| Funding Source | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 | Total ( Rs, Lakhs |
|---|---|---|---|---|---|---|
| TMC Contribution | 3913.0 | 2938.69 | 2907.39 | 1829.65 | 1609.57 | 13198.3 |
| Magaswarghe Nidhi | 0 | 406.75 | 460.17 | 560.17 | 813.6 | 2240.69 |
| Grant from Govt. | 0 | 1742.21 | 2918.29 | 2879.45 | 1977.86 | 9517.81 |
| Municipal Bonds | 0 | 5359.15 | 4158.66 | 0 | 0 | 9517.81 |
| Debt from banks / Institutions / Funds | 0 | 0 | 4037.49 | 7974.71 | 3440.97 | 15453.17 |
| MoEF | 0 | 35 | 35 | 0 | 0 | 70 |
| JNRUM | 0 | 3575 | 2755 | 2625 | 2625 | 11580 |
| MMB | 0 | 950 | 130 | 0 | 0 | 1080 |
| MMR-MMRDA | 30 | 12 | 6 | 6 | 6 | 60 |
| MoEF /Sponsorer | 0 | 87.1 | 75 | 75 | 75 | 312.1 |
| MNES | 0 | 0 | 19 | 0 | 0 | 19 |
| BOT operator | 0 | 1555 | 1000 | 500 | 0 | 3055 |
| **Total** | **3943.0** | **16661.0** | **18502.0** | **16450.0** | **10548.0** | **66103.5** |

Table 15.10: Activity wise cost breakup per year

| Activity | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 20010-11 | Total ( Rs, Lakhs) |
|---|---|---|---|---|---|---|
| Sewerage project | 807.16 | 8071.6 | 12107.4 | 12107.4 | 7264.44 | 40358 |
| Low cost Sanitation | 9.82 | 98.2 | 147.3 | 147.3 | 88.38 | 491 |
| Solid Waste Management | 30 | 1000 | 500 | | | 1530 |
| Nalla Construction | 3000 | 3000 | 3000 | 3000 | 3000 | 15000 |
| Mangroves Plantation | 20 | 60 | 20 | | | 100 |
| Dredging Work | 20 | 2200 | 494 | | | 2714 |
| Tourism Development Ecotourism | | 2000 | 2000 | 1000 | | 5000 |
| Public Awareness and Public Participation | 20 | 168.11 | 182.13 | 182.13 | 182.13 | 734.5 |
| Monitoring | 6 | 53 | 8 | 8 | 8 | 83 |
| Storm Water Study | 30 | | | | | 30 |
| Bathymetric Survey | | 10 | 5 | 5 | 5 | 25 |
| Small Hydro | | | 38 | | | 38 |
| **Total** | **3943.0** | **16661.0** | **18502.0** | **16450.0** | **10548.0** | **66103.5** |

Table 15.11:Projected Net Cash Flows of the Sewerage Project (Rs. Lakhs)

| | 2006-7 | 2008-09 | 2010-11 | 2015-16 | 2020-21 | 2025-26 | 2030-31 |
|---|---|---|---|---|---|---|---|
| Net surplus cash flow from operations | | | 1209.8 | 3001.0 | 4 506.4 | 6699.9 | 9881.3 |
| Interest payment for bonds | 652.0 | 650.0 | 650.0 | | | | |
| Interest payment for Debt from institutions | 181.0 | 1044.4 | 1100.6 | 341.6 | | | |
| Bonds-Principal repayment | - | - | - | - | - | - | - |
| Institutional dept principal repayment | 0 | 0 | 2024.1 | 2024.1 | - | - | - |
| Depreciation | 0 | 0 | 990.0 | 990.0 | 990.0 | 990.0 | 990.0 |
| Net Cash Flow | -833.0 | -1694.0 | -3555.0 | -354.7 | 3516.3 | 5709.9 | 8891.2 |
| Cash support required from TMC | 833.0 | 1694.0 | 3555.0 | 354.7 | | | |

Source: TMC Detail Sewerage Project Report

Table 15.12: Annual operation and maintenance cost for solid waste management

| Sr .No. | **Head** | Solid waste quantity | Unit | Rate (Rs) | Amount ( Rs, Lakhs) |
|---|---|---|---|---|---|
| 1 | Establishment * | 500 | Ton | 1600 | 2920 |
| 2 | Operation & maintenance * | 500 | Ton | 136.87 | 250 |
| 3 | Hiring charges* | 500 | Ton | 2.71 | 5 |
| 4 | Miscellaneous * | 500 | Ton | 0.63 | 1 |
| | A | Total | | 1740.21 | 3175.88 |
| **Landfill Site **** | | | | | |
| 5 | Phase development | | | | 213.60 |
| 6 | Phase operation cost | | | | 82.30 |
| 7 | Phase closure cost | | | | 73.00 |
| 8 | Post closure cost | | | | 18.50 |
| | | | | B | 387.40 |
| | | | | **Total ( A +B)** | **3563.28** |

* Rates are taken from TMC Solid Waste Management Report

** Amount is calculated based on CPHEEO (2000) Manual on Municipal Solid Waste management .

Tab le 15.13: Cess calculation for solid waste management

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cess Rs per month** | | | | | | | | | | | | |
| Buildings | 30 | 30 | 30 | 40 | 40 | 40 | 50 | 50 | 50 | 60 | 60 | 60 |
| Slum | 20 | 20 | 20 | 25 | 25 | 25 | 30 | 30 | 30 | 35 | 35 | 35 |
| Commercial | 50 | 50 | 50 | 60 | 60 | 60 | 70 | 70 | 70 | 90 | 90 | 90 |
| Project cost per year ( Lakh ) | 330 | 748 | 300 | | | | | | | | | |
| Establishment per year ( Lakh) | 2272.65 | 2386.28 | 2505.60 | 2630.88 | 2762.42 | 2900.54 | 3045.57 | 3197.85 | 3357.74 | 3525.63 | 3701.91 | 3887.00 |
| Annual O& M (Lakh) | 256.00 | 268.80 | 282.24 | 296.35 | 311.17 | 326.73 | 343.06 | 360.22 | 378.23 | 397.14 | 417.00 | 437.85 |
| **Total Expenses ( Lakh)** | **2858.65** | **3403.08** | **3087.84** | **2927.23** | **3073.59** | **3227.27** | **3388.63** | **3558.07** | **3735.97** | **3922.77** | **4118.91** | **4324.85** |
| Revenue A (Cess) ( Lakh) | 992.31 | 1028.88 | 1065.44 | 1442.69 | 1490.56 | 1538.42 | 2044.18 | 2143.16 | 2242.13 | 2796.94 | 2915.19 | 3033.44 |
| Revenue B (Recyclabe ) ( Lakh) | 254.68 | 277.05 | 301.05 | 326.74 | 354.27 | 383.72 | 422.82 | 464.92 | 510.18 | 558.77 | 610.97 | 667.00 |
| **Total revenue (Lakh)** | **1246.99** | **1305.93** | **1366.49** | **1769.43** | **1844.82** | **1922.14** | **2467.00** | **2608.08** | **2752.31** | **3355.71** | **3526.16** | **3700.44** |
| **Cash Support required from TMC ( Lakh)** | **1611.66** | **2097.15** | **1721.35** | **1157.80** | **1228.77** | **1305.13** | **921.64** | **949.99** | **983.66** | **567.06** | **592.74** | **624.41** |

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cess Rs per month** | | | | | | | | | | | | | | |
| Buildings | 70 | 70 | 70 | 80 | 80 | 80 | 90 | 90 | 90 | 100 | 100 | 100 | 100 | 100 |
| Slum | 40 | 40 | 40 | 45 | 45 | 45 | 50 | 50 | 50 | 55 | 55 | 55 | 55 | 55 |
| Commercial | 100 | 100 | 100 | 110 | 110 | 110 | 120 | 120 | 120 | 130 | 130 | 130 | 130 | 130 |
| Project cost per year ( Lakh ) | | | | | | | | | | | | | | |
| Establishment per year( Lakh) | 4081.35 | 4285.42 | 4499.69 | 4724.68 | 4960.91 | 5208.96 | 5469.40 | 5742.87 | 6030.02 | 6331.52 | 6648.10 | 6980.50 | 7329.53 | 7696.00 |
| Annual O& M, Lakh | 459.74 | 482.73 | 506.86 | 532.21 | 558.82 | 586.76 | 616.09 | 646.90 | 679.24 | 713.21 | 748.87 | 786.31 | 825.63 | 866.91 |
| **Total Expenses (Lakh)** | **4541.09** | **4768.15** | **5006.56** | **5256.88** | **5519.73** | **5795.71** | **6085.50** | **6389.77** | **6709.26** | **7044.73** | **7396.96** | **7766.81** | **8155.15** | **8562.91** |
| Revenue A (Cess) , (Lakh) | 3659.13 | 3796.42 | 3933.71 | 4865.17 | 5014.76 | 5164.36 | 5966.42 | 6134.39 | 6302.36 | 7177.89 | 7364.22 | 7550.56 | 7736.90 | 7923.23 |
| Revenue B (Lakh) | 726.94 | 791.12 | 860.58 | 934.51 | 1011.06 | 1092.88 | 1180.30 | 1272.81 | 1373.64 | 1480.35 | 1594.23 | 1715.85 | 1845.64 | 1984.07 |
| **Total revenue (Lakh)** | **4386.07** | **4587.54** | **4794.29** | **5799.67** | **6025.83** | **6257.25** | **7146.72** | **7407.20** | **7675.99** | **8658.24** | **8958.45** | **9266.41** | **9582.54** | **9907.30** |
| **Cash Support required from TMC ( Lakh)** | **155.03** | **180.61** | **212.27** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

# CHAPTER 16

# CONCLUSIONS AND RECOMMENDATIONS

## 16.1 Conclusions

The study of different aspects related to Thane creek and Ulhas river estuary is carried out. Various parameters are observed and assessed to plan conservation measures. Following conclusions are made from the study carried out:

- Water quality of both water bodies are greatly deteriorated due to disposal of untreated and primary treated wastewater.
- The water quality analysis of both water bodies has reached to an alarming stage that immediate measures are required to prevent its further degradation.
- Thane creek water quality does not meet SW (II) standards from Balkum to Vashi. BOD for both is more than permissible value of 3 mg/lit. Heavy metals are observed in water and sediments samples of both water bodies.
- High values of nitrates and phosphates are observed at the source of pollution.
- GIS is a preferred tool for to see the spatial distribution of water quality.
- Benthic community health status can be determined by using ANZI's Marine Biotic Index (AMBI). Benthic community health status of both water bodies is under pressure de to anthropogenic activities.
- Migratory birds are observed in Thane creek at Vikroli area where mangrove forests are developed. Hence if shores are properly developed then it will become a paradise for birds watchers.
- Effective waterway below the various bridges is reduced, which affects the flushing capacity. Thane creek basin at the confluence of Thane creek and Ulhas river estuary is narrows effecting free tidal flow from creek to estuary during low tide.
- Solid waste is disposed on the banks of the Ulhas river estuary at Kalyan and Mira Road. Solid waste being carried along with tidal water during high tide.
- Micro level planning is required to prevent both water bodies from point and non point sources.
- Small hydro can be set up on the sewage outfall site as conservation of energy efforts.

- Various agencies and organisations have jurisdiction or exert influence over the management of Thane creek and Ulhas river estuary. The problems are complex, and decision-making processes are complicated and time-consuming. It is necessary that each Municipal Corporation should take care of respective portion of Thane creek / Ulhas river estuary.

**16.2 Recommendations**

A holistic approach is required while planning the mitigation measures. Thane creek and Ulhas river estuary is tobe considered as whole for planning the mitigation measures. Following measures are recommended for conservation of Thane creek and Ulhas river estuary:

- Two-way approach is required for preventing the ingress for pollutants from point and non point sources. First is micro level approach, i.e., reduction of waste at source, which involves effective community participation. Second approach is at macro scale, i.e., effective wastewater treatment and proper solid waste management, etc.
- Locality wise Citizen Monitoring Committee for solid waste collection system, mangrove plantation and awareness creation, should be formulated comprising of public representatives from different political parties, senior citizens, educational institutes for technical support, National Cadet Corps students and non-government organisations as volunteers. The officials of the Municipal Corporation associated with creek conservation should also find representation in the committee.
- Before disposal of the wastewater into creek / estuary it is necessary to determine the assimilating capacity of the creek.
- The area under the bridge is required to be clean immediately to increase the waterway.
- Dredging and canalization of the creek is required to increase flushing capacity.
- Considering the depletion in the mangrove area, mangrove forest should be developed at various locations. Restriction from destruction or denuding of mangroves by dumping, cutting of mangroves etc and action against its violation.

- Provisions for composting of biodegradable waste or compact biogas system could be made mandatory while approving a new complex / locality and tax rebate could be given for the existing complexes who provide facilities for composting of waste generated by them.
- Effective measures are required to be taken to prevent the disposal of waste along the banks of water bodies.
- Considering the trend of use of plastic carry bags by the consumer and shopkeepers, awareness program should be conducted to encourage use of biodegradable paper bags. Use of plastic shopping bags may be banned.
- For Municipal crematoria grounds, new improved facilities (like Mokshda) of burning of corpse, which requires less firewood could be constructed.
- Public are ready to pay for effective solid waste management services. Cess may be charged on the same basis as drainage tax is charged. It could be included in property tax and based on the retable value, which differ from area to area and ultimately principle of affordability will follow. Adequate funds can be reserved for the tools and equipments, transport facilities, curbside containers, medical facilities and safety measures like gumboots and gloves, etc.
- Excreta-Based Biogas & Biofertilizer Technology can be adopted by coming up new residential/commercial complex in Thane, which will reduce the load on TMC STP's. Rebate in taxes may be given to those implement this technology.
- Low cost sanitation may be integrated with solid waste management planning. For using public conveniences, regular user (specially living in slum areas) should be nominally charged on monthly basis.
- Various public awareness programs should be planned in a mega scale and should be inaugurated by eminent personalities and celebrities and focused widely, so that people will come to know that conservation activities are blessed by all.
- Corporates should have social responsibility and can contribute towards TMC creek and estuary conservation drive by sponsoring some action planned.
- Conservation program can be implemented at two levels viz-individual i.e Municipal Corporation level and other in totality. Each Municipal Corporation

should raise their own funds for the conservation measures preserve their portion of the creek/ estuary. The conservation measures proposed could be adopted as a common minimum program.

- At individual Municipal Corporation level, each organisation should set up a Creek / estuary conservation Cell.
- Removal of encroachments and clear demarcation of various zones specified by CRZ.
- Development of Eco-tourism.
- Installation of Automatic water level data monitoring equipment, Automatic Weather Station, automatic sewage treatment plant monitoring system.
- Establishment of GIS lab for monitoring city development, coastal water quality and mangrove mapping.
- A total cost for Conservation plan is estimated as Rs 661 crores.
- The implementation period is estimated as 5 years.

**16.3 Future studies**

- Five years water quality monitoring program is proposed for Thane creek and Ulhas river estuary, which could be taken preferably in association with NGO's and Educational Institutes.
- Storm water study preferably in association with NGO's and Central Water and Power Research Station (CWPRS).
- Integrated modeling of Thane creek and Ulhas river estuary preferably in association with National Institute of Oceanography (NIO).
- Bathymetric data of Thane creek and Ulhas river estuary.

# CHAPTER 17

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# ANNEXURE

## CONTENTS

Annexure I.: Physico-chemical analysis of Thane creek and Ulhas river estuary water samples

| Sample No | Location | pH | DO (mg/lit) | SS(mg/lit) | BOD 3days 27°C (mg/lit) | Nitrate (mg/lit) ($No_3^-$) | Phosphate (mg/lit) ($Po_4^-$) | Chloride (mg/lit) ($Cl^-$) | Zn (mg/lit) (Zn) | Cr (mg/lit) ($Cr^{+6}$) | Cd(mg/lit) | Cu (mg/lit) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kalwa to Balkum** | | | | | | | | | | | | |
| 1 | Balkum creek | 7.5 | 1.8 | 30 | 3.8 | 0.735 | 0.464 | 62208 | 0.143 | Traces | Traces | Traces |
| 2 | Saket2 | 7.6 | 0 | 30 | 5.2 | 0.843 | 0.483 | 76032 | NA | NA | NA | NA |
| 3 | Saket creek | 7.6 | 0 | 30 | 3.8 | 0.483 | 0.449 | 44928 | 0.127 | Traces | Traces | Traces |
| 4 | Opposite Saket nalla | 7.4 | 0 | 30 | 6 | 0.512 | 0.462 | 79488 | NA | NA | NA | NA |
| 5 | pipe line nalla | 7.8 | 0 | 50 | 4 | 0.586 | 0.416 | 55296 | NA | NA | NA | NA |
| 6 | Saket 1 | 7.4 | 0 | 20 | 3.6 | 0.684 | 0.362 | 41472 | NA | NA | NA | NA |
| 7 | Manisha nagar nalla | 7.1 | 0 | 40 | 5 | 0.497 | 0.392 | 41472 | NA | NA | NA | NA |
| 8 | Manisha nagar creek | 7.9 | 1.4 | 30 | 5.4 | 0.494 | 0.392 | 48384 | 0.198 | Traces | Traces | Traces |
| 9 | Rabodi nalla1 | 7.6 | 0 | 30 | 5 | 0.49 | 0.214 | 24822 | NA | NA | NA | NA |
| 10 | Rabodi nalla2 | 7.6 | 0 | 20 | 4.8 | 0.44 | 0.213 | 38016 | NA | NA | NA | NA |
| 11 | Kharegaon nalla | 7.4 | 0 | 30 | 5 | 0.642 | 0.393 | 51840 | NA | NA | NA | NA |
| 12 | Kalwa bridge creek | 7.1 | 1.6 | 30 | 5.6 | 0.403 | 0.282 | 41472 | 0.309 | Traces | Traces | Traces |
| **Kalwa Bridge to Airoli Bridge** | | | | | | | | | | | | |
| 13 | Meghale creek | 7.6 | 1 | 30 | 3.8 | 0.764 | 0.174 | 58752 | NA | NA | NA | NA |
| 14 | ST workshop | 7.6 | 1.2 | 30 | 3.6 | 0.682 | 0.214 | 55296 | NA | NA | NA | NA |
| 15 | College backside | 7.6 | 1.4 | 80 | 4.2 | 0.382 | 0.162 | 20726 | NA | NA | NA | NA |
| 16 | College nalla outlet | 7.8 | 0 | 20 | 3.8 | 0.832 | 0.132 | 65664 | 0.149 | Traces | Traces | Traces |
| 17 | custom office nalla outlet | 7.1 | 0 | 40 | 5.2 | 0.494 | 0.221 | 31104 | NA | NA | NA | NA |
| 18 | Mulund nalla | 7.4 | 0 | 30 | 4 | 0.263 | 0.131 | 14184 | NA | NA | NA | NA |
| 19 | Kopri STP creek | 7.4 | 0 | 50 | 3.8 | 0.418 | 0.184 | 31914 | 0.285 | Traces | Traces | Traces |

| Sample No | Location | pH | DO (mg/lit) | SS(mg/lit) | BOD 3days 27°C (mg/lit) | Nitrate (mg/lit) ($No_3^{--}$) | Phosphate (mg/lit) ($Po_4^{--}$) | Chloride (mg/lit) ($Cl^-$) | Zn (mg/lit) (Zn) | Cr (mg/lit) ($Cr^{+6}$) | Cd(mg/lit) | Cu (mg/lit) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | Vitawa nalla | 7.5 | 1 | 30 | 3.8 | 0.538 | 0.361 | 81558 | NA | NA | NA | NA |
| 21 | Vitawa creek | 7.4 | 1.2 | 20 | 5.4 | 0.332 | 0.211 | 35732 | 0.185 | Traces | Traces | Traces |
| 22 | Indal Mukund nalla | 7.6 | 0 | 30 | 3.6 | 0.686 | 0.441 | 60282 | NA | NA | NA | NA |
| 23 | Indal Mukund creek | 7.5 | 2.4 | 20 | 3.6 | 0.413 | 0.208 | 31914 | NA | NA | NA | NA |
| 24 | Digha Nalla | 8.1 | 0 | 30 | 3.6 | 0.463 | 0.261 | 31914 | NA | NA | NA | NA |
| 25 | Digha creek | 7.8 | 3.6 | 20 | 4.2 | 0.382 | 0.164 | 28368 | 0.151 | Traces | Traces | 0.131 |
| 26 | Airoli powerhouse Creek | 7.8 | 3.6 | 20 | 3 | 0.418 | 0.482 | 81558 | 0.125 | Traces | Traces | 0.125 |
| 27 | Airoli nalla outlet | 7.8 | 1.8 | 40 | 4.6 | 0.464 | 0.266 | 24822 | NA | NA | NA | NA |
| 28 | Mhada colony nalla | 7.8 | 1.2 | 40 | 5 | 0.362 | 0.172 | 17730 | NA | NA | NA | NA |
| 29 | Airoli creek | 7.2 | 3.6 | 40 | 4 | 0.589 | 0.305 | 60282 | NA | NA | NA | NA |
| **Airoli bridge to Vashi bridge** | | | | | | | | | | | | |
| 30 | Airoli bridge | 7.1 | 3.5 | 20 | 4.2 | 0.269 | 0.224 | 25886 | NA | NA | NA | NA |
| 31 | Talawali MIDC at source of inlet | 7.3 | 2.4 | 40 | 4.1 | 0.254 | 0.26 | 12411 | NA | NA | NA | NA |
| 32 | Airoli nalla towords vashi bridge | 7.2 | 2.2 | 20 | 5.2 | 0.198 | 0.138 | 12411 | NA | NA | NA | NA |
| 33 | Bhandup nala at the source of inlet. | 7.1 | 0 | 20 | 7.8 | 0.18 | 0.255 | 24822 | NA | NA | NA | NA |
| 34 | Bhandup nala at middle of creek | 7.3 | 2.5 | 30 | 4 | 0.252 | 0.119 | 20566 | NA | NA | NA | NA |
| 35 | Ghansoli nalla middle of the creek. | 7.1 | 2.2 | 20 | 3.8 | 0.21 | 0.128 | 14539 | NA | NA | NA | NA |
| 36 | Ghansoli nalla at the source of inlet | 7.1 | 2.4 | 40 | 4 | 0.308 | 0.13 | 12055 | NA | NA | NA | NA |
| 37 | 1km away from Bhandup nala (before) | 7.2 | 1 | 10 | 5.4 | 0.288 | 0.197 | 25531 | 0.186 | Traces | Traces | Traces |
| 38 | 1km Koparkhairane nalla towords airoli | 7.2 | 3.8 | 30 | 3.1 | 0.215 | 0.141 | 10638 | NA | NA | NA | NA |
| 39 | Vikhroli nala 2 at the source of inlet. | 7.3 | 0 | 20 | 5.6 | 0.261 | 0.222 | 26240 | NA | NA | NA | NA |
| 40 | Vikhroli nala 2 at 2km from the source of inlet | 7.3 | 3.4 | 10 | 4.8 | 0.323 | 0.248 | 13474 | NA | NA | NA | NA |
| 41 | Koparkhairane nalla at the source of inlet | 7.1 | 2.6 | 30 | 3.1 | 0.232 | 0.132 | 17021 | NA | NA | NA | NA |
| 42 | Koparkhairane nalla middle of the creek | 7.1 | 4.6 | 30 | 3.2 | 0.196 | 0.041 | 31559 | 0.186 | Traces | Traces | Traces |

| Sample No | Location | pH | DO (mg/lit) | SS(mg/lit) | BOD 3days 27°C (mg/lit) | Nitrate (mg/lit) ($No_3^-$) | Phosphate (mg/lit) ($Po_4^-$) | Chloride (mg/lit) ($Cl^-$) | Zn (mg/lit) (Zn) | Cr (mg/lit) ($Cr^{+6}$) | Cd(mg/lit) | Cu (mg/lit) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 43 | Juigaon middle of the creek | 7.1 | 4.2 | 20 | 3 | 0.287 | 0.152 | 19148 | 0.248 | Traces | Traces | Traces |
| 44 | Juigaon at the source of inlet | 7.2 | 2.1 | 30 | 3.2 | 0.315 | 0.181 | 25886 | NA | NA | NA | NA |
| 45 | Vikhroli 1 at the source of the inlet | 7.2 | 1.8 | 20 | 4.5 | 0.263 | 0.13 | 12411 | NA | NA | NA | NA |
| 46 | Vikhroli nala 2 | 7.3 | 3.6 | 20 | 4 | 0.312 | 0.17 | 12766 | NA | NA | NA | NA |
| 47 | Vikhroli 1 middle of the creek | 7.2 | 3.4 | 20 | 4.2 | 0.212 | 0.17 | 12056 | NA | NA | NA | NA |
| 48 | Near Ghatkopar nalla middle of the creek | 7.4 | 3.2 | 20 | 4.5 | 0.382 | 0.248 | 10283 | NA | NA | NA | NA |
| 49 | 1.5km from Vashi bridge towards Airoli at middle of creek. | 7.4 | 2.4 | 20 | 5.6 | 0.193 | 0.862 | 9574 | NA | NA | NA | NA |
| 50 | Ghatkopar Nalla at source of the inlet. | 7.2 | 2.2 | 10 | 3.5 | 0.333 | 0.31 | 12767 | NA | NA | NA | NA |
| 51 | Chembur Nalla | 7.4 | 2.8 | 10 | 5 | 0.193 |  | 14893 | NA | NA | NA | NA |
| 52 | Industry outlet Vashi bridge | 7.3 | 1 | 20 | 4 | 0.539 | 0.22 | 11347 | 0.182 | Traces | Traces | Traces |
| 53 | center of creek near Vashi bridge towards Airoli | 7.4 | 3.9 | 20 | 4 | 0.261 | 0.238 | 13829 | 0.128 | Traces | Traces | Traces |
| **Vashi Bridge to Belapur** |  |  |  |  |  |  |  |  |  |  |  |  |
| 54 | Near Vashi bridge | 7.4 | 3.2 | 20 | 4.8 | 0.706 | 0.214 | 15988 | 0.197 | Traces | Traces | 0.098 |
| 55 | Vashi Gaon nalla | 7.2 | 2.2 | 30 | 3.1 | 0.211 | 1.05 | 25886 | NA | NA | NA | NA |
| 56 | Herdelia/ Nerul Nalla | 7.4 | 3.3 | 30 | 7.1 | 0.383 | 0.196 | 14635 | NA | NA | NA | NA |
| 57 | up stream of Nalla | 7.2 | 2.4 | 30 | 6.2 | 0.463 | 0.189 | 12408 | NA | NA | NA | NA |
| 58 | 2km away from Vashi bride towards Panvel | 7.4 | 5.2 | 10 | 5.2 | 0.724 | 0.179 | 9749 | NA | NA | NA | NA |
| 59 | 5km away from Vashi bride towards Panvel | 7.6 | 5 | 20 | 4.8 | 0.708 | 0.238 | 10635 | NA | NA | NA | NA |
| 60 | 7km away from Vashi bride towards Panvel | 7.3 | 3.6 | 20 | 5.1 | 0.697 | 0.233 | 18434 | NA | NA | NA | NA |

| Sample No | Location | pH | DO (mg/lit) | SS(mg/lit) | BOD 3days 27°C (mg/lit) | Nitrate (mg/lit) ($No_3^-$) | Phosphate (mg/lit) ($Po_4^-$) | Chloride (mg/lit) ($Cl^-$) | Zn (mg/lit) (Zn) | Cr (mg/lit) ($Cr^{+6}$) | Cd(mg/lit) | Cu (mg/lit) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | Before Seawoods | 7.5 | 5.8 | 20 | 5.4 | 0.701 | 0.239 | 37223 | NA | NA | NA | NA |
| 62 | Karawe | 7.5 | 6 | 40 | 5.4 | 0.481 | | 17725 | 0.196 | Traces | Traces | Traces |
| 63 | Near INS Chanakya. | 7.3 | 5.8 | 30 | 7 | 0.621 | 0.193 | 26233 | NA | NA | NA | NA |
| 64 | At Seawoods | 7.4 | 5 | 20 | 5.1 | 0.713 | 0.244 | 25170 | NA | NA | NA | NA |
| 65 | Seawoods II | 7.5 | 4.6 | 20 | 5 | 0.679 | 0.158 | 32260 | NA | NA | NA | NA |
| 66 | South of Seawoods Nalla I | 7.6 | 5.8 | 30 | 5.6 | 0.696 | 0.304 | 20561 | NA | NA | NA | NA |
| 67 | South of Seawoods Nalla II | 7.6 | 5.2 | 20 | 6.2 | 0.704 | 0.219 | 25524 | NA | NA | NA | NA |
| 68 | Diwalya Bridge | 7.4 | 5.8 | 10 | 6.1 | 0.692 | 0.233 | 19143 | 0.139 | Traces | Traces | 0.065 |
| 69 | Diwalya Nalla | 7.5 | 2.8 | 30 | 7.2 | 0.686 | 0.187 | 23043 | NA | NA | NA | NA |
| **Ulhas River Estuary** | | | | | | | | | | | | |
| 1 | PipelineBridge centre | 7.4 | 3.6 | 10 | 9.35 | | | 6203 | | | | |
| 2 | Sasigaon MIDC Kalyan | 8.2 | Nil | 40 | 180 | | | 2658 | | | | |
| 3 | Nallah dumping Ground Kalyan | 6.8 | Nil | 45 | 80 | | | 886 | | | | |
| 4 | Kalyan bridge centre | 7.4 | 3.4 | 5 | 8.68 | | | 5760 | | | | |
| 5 | Kalyan 1 nallah | 7.3 | Nil | 40 | 10 | | | 886 | | | | |
| 6 | chole nallah | 7.9 | Nil | 30 | 22 | | | 2215 | | | | |
| 7 | Thakurli power house nallah | 7.5 | Nil | 35 | 13.36 | | | 443 | | | | |
| 8 | Thakurli nallah edge | 7.4 | Nil | 30 | 10.68 | | | 1329 | | | | |
| 9 | Vasai bridge creek centre | 7.8 | 4.5 | 15 | 10.68 | | | 5760 | | | | |
| 10 | Retibander creek | 7.7 | 4.6 | 10 | 13.36 | | | 7090 | | | | |
| 11 | Dombivali MIDC nallah edge | 7.3 | Nil | 20 | 8 | | | 4431 | | | | |
| 12 | 1.5 km from Railway bridge towords Diva | 7.8 | 3.7 | 10 | 9.35 | | | 5318 | | | | |
| 13 | Datiwali creeck | 7.8 | 4.2 | 15 | 7.34 | | | 5318 | | | | |
| 14 | Datiwali/ Agason nallah | 7.6 | 4 | 5 | 8.01 | | | 6647 | | | | |

| Sample No | Location | pH | DO (mg/lit) | SS(mg/lit) | BOD 3days 27°C (mg/lit) | Nitrate (mg/lit) ($No_3^-$) | Phosphate (mg/lit) ($Po_4^-$) | Chloride (mg/lit) ($Cl^-$) | Zn (mg/lit) (Zn) | Cr (mg/lit) ($Cr^{+6}$) | Cd(mg/lit) | Cu (mg/lit) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Alimaghar | 7.8 | 3.8 | 5 | 12.69 | | | 8862 | | | | |
| 16 | Mumbra khadi centre | 7.9 | 4.1 | 5 | 7.34 | | | 7976 | | | | |
| 17 | Mumbra khadi | 7.7 | 4.2 | 5 | 10 | | | 7533 | | | | |
| 18 | Retibander Ganpatighat | 8 | 4.2 | 5 | 7.34 | | | 7976 | | | | |
| 19 | Balkum junction upstream of bridge | 7.8 | 4.1 | 10 | 11.35 | | | 13294 | | | | |
| 20 | Balkum down stream of bridge. | 7.5 | 4.2 | 30 | 5.4 | 0.295 | 0.046 | 8863 | NA | NA | NA | NA |
| 21 | Balkum nalla | 7.6 | 2.8 | 50 | 15 | 0.464 | 0.083 | 16027 | NA | NA | NA | NA |
| 22 | Balkum nalla middle of creek | 7.7 | 4.4 | 20 | 4 | 0.382 | 0.096 | 9527 | 0.284 | Traces | Traces | Traces |
| 23 | Balkum nalla at source of inlet | 7.2 | 2.6 | 40 | 10.8 | 0.657 | 0.041 | 8863 | NA | NA | NA | NA |
| 24 | Fairy - Kolshet road at middle of creek | 7.1 | 4.8 | 20 | 12 | 0.901 | 0.039 | 15181 | NA | NA | NA | NA |
| 25 | Kolshet nalla | 7.2 | 2.6 | 20 | 18 | 0.335 | 0.058 | 15181 | NA | NA | NA | NA |
| 26 | 0.5 km from Kolshet Nalla at creek | 7.1 | 3.8 | 20 | 8 | 0.682 | 0.046 | 15543 | NA | NA | NA | NA |
| 27 | Waghbil Nalla 1 | 7 | 2.8 | 30 | 6 | 0.411 | 0.109 | 13454 | NA | NA | NA | NA |
| 28 | Waghbil Nalla at the creek | 6.2 | 2.1 | 30 | 6.4 | 0.413 | 0.113 | 16217 | 0.201 | Traces | Traces | Traces |
| 29 | Waghbil Nalla 2 | 7.1 | 2.2 | 40 | 6.8 | 0.368 | 0.105 | 8980 | NA | NA | NA | NA |
| 30 | Vadavali creek center | 6.8 | 4.4 | 20 | 5.8 | 0.521 | 0.085 | 8290 | NA | NA | NA | NA |
| 31 | Vadavali | 6.5 | 2.4 | 20 | 5 | 0.412 | 0.043 | 9326 | NA | NA | NA | NA |
| 32 | Nagla creek | 6.6 | 5.6 | 20 | 3 | 0.383 | 0.054 | 6217 | 0.895 | Traces | Traces | Traces |
| 33 | Gaimukh creek | 6.7 | 4.6 | 30 | 4 | 0.414 | 0.057 | 7253 | NA | NA | NA | NA |
| 34 | Varsova creek | 6.8 | 4.9 | 30 | 4.8 | 0.162 | 0.048 | 8863 | NA | NA | NA | NA |
| 35 | Ahmadabad highway bridge | 7.1 | 4.7 | 20 | 4 | 0.232 | 0.057 | 13471 | 0.399 | Traces | Traces | Traces |
| 36 | Ghodbunder creek | 6.7 | 4.6 | 30 | 3.8 | 0.412 | 0.116 | 7944 | NA | NA | NA | NA |
| 37 | Ghodbunder nalla | 6.8 | 1.4 | 70 | 3 | 0.389 | 0.226 | 16563 | NA | NA | NA | NA |
| 38 | Mira road Nalla 1 | 6.9 | Nil | 30 | 3.6 | 0.862 | 0.076 | 15526 | NA | NA | NA | NA |
| 39 | Mira Road Nalla 1 creek | 6.7 | 2.8 | 40 | 3.6 | 0.682 | 0.047 | 8290 | NA | NA | NA | NA |

| Sample No | Location | pH | DO (mg/lit) | SS(mg/lit) | BOD 3days 27°C (mg/lit) | Nitrate (mg/lit) ($No_3^-$) | Phosphate (mg/lit) ($Po_4^-$) | Chloride (mg/lit) ($Cl^-$) | Zn (mg/lit) (Zn) | Cr (mg/lit) ($Cr^{+6}$) | Cd(mg/lit) | Cu (mg/lit) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | Mira Road nalla 2 | 6.8 | Nil | 50 | 3.8 | 0.562 | 0.095 | 14490 | NA | NA | NA | NA |
| 41 | Mara Road Nalla 2 creek | 6.9 | Nil | 20 | 4 | 0.325 | 0.105 | 8290 | 0.276 | Traces | Traces | 0.118 |
| 42 | Mira Road Nalla 3 | 6.7 | Nil | 60 | 3.6 | 0.643 | 0.216 | 12089 | NA | NA | NA | NA |
| 43 | Mira Road Nalla 3 creek 200m from bank. | 6.6 | Nil | 20 | 4 | 0.583 | 0.194 | 18980 | NA | NA | NA | NA |
| 44 | Bhayandar Nalla 1 | 6.6 | Nil | 80 | 3.8 | 0.683 | 0.212 | 18980 | NA | NA | NA | NA |
| 45 | Bhayandar Nalla 1 creek | 6.7 | 2.6 | 20 | 3.4 | 0.183 | 0.098 | 13109 | NA | NA | NA | NA |
| 46 | Bhayandar Nalla 2 | 6.8 | Nil | 10 | 3.8 | 0.782 | 0.193 | 19671 | NA | NA | NA | NA |
| 47 | Bhayandar Nalla 2 creek | 6.9 | 4.2 | 10 | 3.5 | 0.268 | 0.043 | 15526 | NA | NA | NA | NA |
| 48 | 1km away from Bhayandar railway bridge towards Vasai | 6.8 | 5 | 40 | 4 | 0.346 | 0.126 | 16127 | NA | NA | NA | NA |
| 49 | 3km from Bhayandar bridge | 7.3 | 5.2 | 10 | 8 | 0.362 | 0.092 | 18980 | NA | NA | NA | NA |
| 50 | Uttan Nalla | 7.2 | 4.2 | 20 | 15 | 0.185 | 0.093 | 26217 | NA | NA | NA | NA |
| 51 | Vasai creek center | 7.3 | 5.8 | 20 | 5 | 0.396 | 0.025 | 23471 | Traces | Traces | Traces | Traces |

Annexure II a : 7th June ,2006 Times of India



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Publication: Times Of India Mumbai; Date:2006 Jun 07; Section:Times City; Page Number 9

# Urbanisation chokes Thane Creek

*Study Conducted By Municipal Body Shows 67% Drop In Fishing Activities*

*Swati Deshpande | TNN*

Thane: Alarming levels of pollution are destroying Thane Creek, taking a heavy toll on the wetlands, marine life and the migratory and wading birds that frequent the area, according to a new study. The damage has also led to a 67% drop in fishing activities as catch in the area has dwindled.

A variety of culprits are to blame, according to the study conducted under the Thane Municipal Corporation's (TMC) Creek Conservation Programme. A team of experts analysed 125 water and 48 sediment samples from the Thane Creek and Ulhas River estuary.

The experts observed that effluents released into the creek, depletion of mangroves, presence of heavy metals like silver, increase in illegal encroachments and the release of untreated waste water contribute to the pollution, which has disturbed the ecosystem and food chain. The Ulhas River estuary is also getting damaged because of the dumping of solid waste and sand dredging.

TMC city engineer K D Lalla, who headed the survey team, said, "The survey and past studies indicate that we should take up a conservation plan. An integrated approach towards planning, utilisation and management of resources would ensure sustainable development."

The TMC is drawing up an action plan to save the creek and expects help from the maritime board, Union ministry of environment, department of ocean development and other agencies. "We have already identified around 20 major inlets that carry water to the creek and will chalk out a strategy to reduce pollution," said Vidyadhar Walawalkar, general secretary of Enviro Vigil, an NGO.

The report expresses serious concern over growing human pressure on the creek, which is literally at the receiving end of the evils of urbanisation. Pollutants discharged into the water have destroyed wetlands and harmed marine life. The quality of water and the ability of marine life to reproduce have been adversely affected.

Prawns, once found in ample quantities, have vanished from the creek bed near Thane. The stretch from Balkum to Vitawa has become a dead zone.

Waste water disposed through primary treatment units and nullahs is not getting properly flushed, noted the report. The reduction in the depth of the creek basin has affected the flushing and could also cause flooding in the city. Silt deposition is to the tune of 15 to 20 feet.

The survey has enabled a comparison between water samples collected at Vashi bridge, Belapur and Thane. The prescribed dissolved oxygen (DO) level is 4 mg/litre and samples collected from Vashi met the standard. However, the DO level was 0.9 between Balkum and Kalwa, 2.2 between Kalwa bridge and Airoli bridge and at a high of 3.1 between the Airoli and Vashi bridges. Low DO means high contamination.

The large-scale destruction of mangroves has led to the loss of wetlands and damage to the habitat of wading and migratory birds. Flamingoes, seagulls, avocets, stilts, godwits, sandpiper, coots, grey herons, kingfishers and so on, which were earlier spotted near the Thane Creek bridge, have all but disappeared.

The TMC must also curb the growth of illegal encroachments in the area if it wants to save the dwindling natural resources.

Annexure II b: 9th June , 2006, Thane Plus, Times of India

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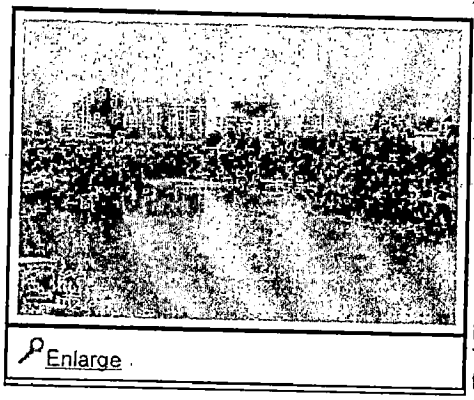

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## Urgent need to check water pollution

...says a report on Thane Creek and Ulhas River, which show high water pollution levels

*A Correspondent, Ulhas River*

The report of Vinay Nikam, the Lake Conservation Engineer (LCE), of the Thane Municipal Corporation (TMC) has strongly recommended the need for setting up of an authority of the civic bodies responsible for polluting the Thane creek and Ulhas River. The report seeks to set up the authority under the TMC to prevent further pollution of the water bodies.

The study report moots the de-silting of the creek and riverbeds so that water can flow along its natural route. In such a situation, the water would get mixed better with oxygen and once again help in the restoration of flora and fauna as well as marine life in the water bodies.

"We must widen the junctions of the creek with sea water, so that creek waters stagnating in small creek branches get circulated to improve their water oxygen level," informed City Engineer KD Lala. He added that the process would help restore the creek to the state where it was some two decades back.

Another suggestion that has come up in the report is to stop releasing untreated solid and liquid waste into the creek. The TMC is already afoot with plans to set up Sewerage Treatment Plants (STP) to overcome the problem. It wants other civic bodies to do so.

Last, but not the least is the mushrooming of encroachments along the coast of the water bodies. The report strongly recommends that such illegal activities should be kept under check.

Since the problem is of six civic bodies, the TMC wants the six civic organisations to come together to put up a united front against the problem. It remains to be seen as to how the organisations respond to the civic request.

Annexure II c : 10th June , 2005 , Thane Plus ,Times of India



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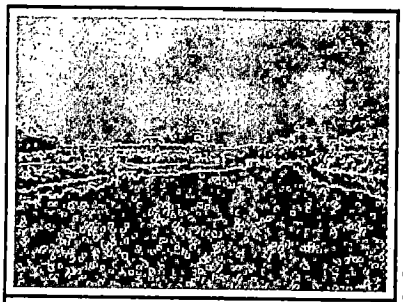

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Annexure II d: 11th June, 2006, Thane Plus, Times of India

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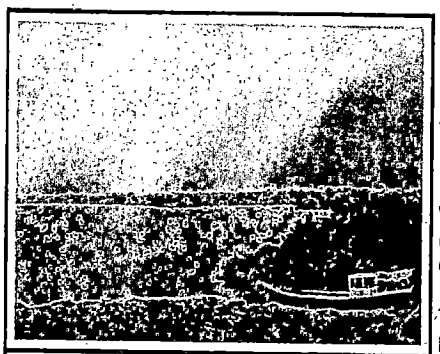

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The author of the report has found that the dumping of solid and liquid waste into the river is the primary reason for the destruction of the environment in and around the river. Hundreds of industrial units lining along the banks of the river have also been blamed for releasing toxic waste chemicals into the river water, thereby contributing to the situation.

Like the creek, even the river should have an oxygen percentage of four Milli Grams per Litre (MGL). Instead, the river hardly has 1.3-1.5 MGL of oxygen in its water. Due to this, the water plants and animals have become extinct and rare birds that used to come to the river every year are no more seen on its banks.

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The dam is situated at a height of around 20 metres above the sea level.

The river is being polluted from the stretch of the river between the dam and the creek where the river ends.

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Annexure II e : 13th June , 2006, Thane Plus, Times of India

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The benefit of the civic move was felt on the World Environment Day on June 5, when the Lake Conservation Engineer (LCE) delivered his report on the pollution level of water in the creek, around the city as well as in the Ulhas river. Vinay Nikam, the LCE conducted the study on the two water bodies for almost seven to eight months with the help of several NGOs. Nikam was deputed by the civic administration to undergo advanced training in Lake Conservation and Creek Management from the IIT, Roorkee some two years ago. The official is currently doing his Master of Technology (MTech) course from the institute and his study is to be completed by the end of this month. The corporation has borne the expense of Rs 20,000 per annum for the study.

Last year the civic administration sent two officials from its engineering cadre to the same institute for study on structural designs and concrete technology. The study is meant to improve the task of concretisation of the city roads as well as the proposal to construct flyovers at various places. This year also the civic administration has proposed to depute another two officials of the rank of Executive Engineer (EE) for a similar course in IIT, Roorkee. Like the previous officials, the new ones would also be sponsored for the MTech course in concrete technology.

The move of the civic administration to sponsor its officials for such courses was taken after the TMC began the work of restoration of 13 dying city lakes. The civic administration got a grant of Rs 3 crore from the Union Ministry of Environment and Forests (MOEF) for the purpose and restored the city lakes over a period of 11 months. At that time the MOEF also offered to sponsor civic officials for courses in reputed government institutes aimed at improving the environment. The aim of the sponsorship is to train government officials to preserve environment and introduce the system in the concerned civic bodies.

The civic administration took the opportunity to send its officials for training with the sponsorship of the union ministry. The exercise is likely to continue even in the future.

Publication: Times Of India Mumbai; Date:2006 Jun 07; Section:Times City; Page Number 9

# Urbanisation chokes Thane Creek

*Study Conducted By Municipal Body Shows 67% Drop In Fishing Activities*

*Swati Deshpande | TNN*

Thane: Alarming levels of pollution are destroying Thane Creek, taking a heavy toll on the wetlands, marine life and the migratory and wading birds that frequent the area, according to a new study. The damage has also led to a 67% drop in fishing activities as catch in the area has dwindled.

A variety of culprits are to blame, according to the study conducted under the Thane Municipal Corporation's (TMC) Creek Conservation Programme. A team of experts analysed 125 water and 48 sediment samples from the Thane Creek and Ulhas River estuary.

The experts observed that effluents released into the creek, depletion of mangroves, presence of heavy metals like silver, increase in illegal encroachments and the release of untreated waste water contribute to the pollution, which has disturbed the ecosystem and food chain. The Ulhas River estuary is also getting damaged because of the dumping of solid waste and sand dredging.

TMC city engineer K D Lalla, who headed the survey team, said, "The survey and past studies indicate that we should take up a conservation plan. An integrated approach towards planning, utilisation and management of resources would ensure sustainable development."

The TMC is drawing up an action plan to save the creek and expects help from the maritime board, Union ministry of environment, department of ocean development and other agencies. "We have already identified around 20 major inlets that carry water to the creek and will chalk out a strategy to reduce pollution," said Vidyadhar Walawalkar, general secretary of Enviro Vigil, an NGO.

The report expresses serious concern over growing human pressure on the creek, which is literally at the receiving end of the evils of urbanisation. Pollutants discharged into the water have destroyed wetlands and harmed marine life. The quality of water and the ability of marine life to reproduce have been adversely affected.

Prawns, once found in ample quantities, have vanished from the creek bed near Thane. The stretch from Balkum to Vitawa has become a dead zone.

Waste water disposed through primary treatment units and nullahs is not getting properly flushed, noted the report. The reduction in the depth of the creek basin has affected the flushing and could also cause flooding in the city. Silt deposition is to the tune of 15 to 20 feet.

The survey has enabled a comparison between water samples collected at Vashi bridge, Belapur and Thane. The prescribed dissolved oxygen (DO) level is 4 mg/litre and samples collected from Vashi met the standard. However, the DO level was 0.9 between Balkum and Kalwa, 2.2 between Kalwa bridge and Airoli bridge and at a high of 3.1 between the Airoli and Vashi bridges. Low DO means high contamination.

The large-scale destruction of mangroves has led to the loss of wetlands and damage to the habitat of wading and migratory birds. Flamingoes, seagulls, avocets, stilts, godwits, sandpiper, coots, grey herons, kingfishers and so on, which were earlier spotted near the Thane Creek bridge, have all but disappeared.

The TMC must also curb the growth of illegal encroachments in the area if it wants to save the dwindling natural resources.

Annexure II b: 9th June , 2006, Thane Plus, Times of India

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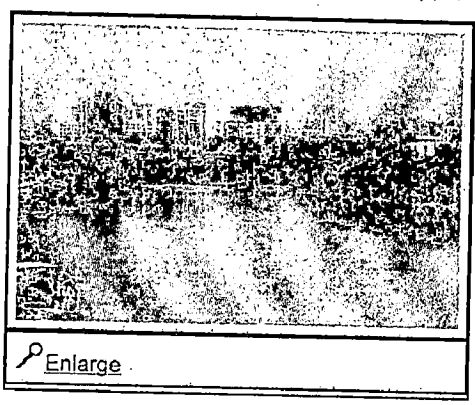

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## Urgent need to check water pollution

...says a report on Thane Creek and Ulhas River, which show high water pollution levels

*A Correspondent, Ulhas River*

The report of Vinay Nikam, the Lake Conservation Engineer (LCE), of the Thane Municipal Corporation (TMC) has strongly recommended the need for setting up of an authority of the civic bodies responsible for polluting the Thane creek and Ulhas River. The report seeks to set up the authority under the TMC to prevent further pollution of the water bodies.

The study report moots the de-silting of the creek and riverbeds so that water can flow along its natural route. In such a situation, the water would get mixed better with oxygen and once again help in the restoration of flora and fauna as well as marine life in the water bodies.

"We must widen the junctions of the creek with sea water, so that creek waters stagnating in small creek branches get circulated to improve their water oxygen level," informed City Engineer KD Lala. He added that the process would help restore the creek to the state where it was some two decades back.

Another suggestion that has come up in the report is to stop releasing untreated solid and liquid waste into the creek. The TMC is already afoot with plans to set up Sewerage Treatment Plants (STP) to overcome the problem. It wants other civic bodies to do so.

Last, but not the least is the mushrooming of encroachments along the coast of the water bodies. The report strongly recommends that such illegal activities should be kept under check.

Since the problem is of six civic bodies, the TMC wants the six civic organisations to come together to put up a united front against the problem. It remains to be seen as to how the organisations respond to the civic request.

Annexure II c : 10th June , 2005 , Thane Plus ,Times of India

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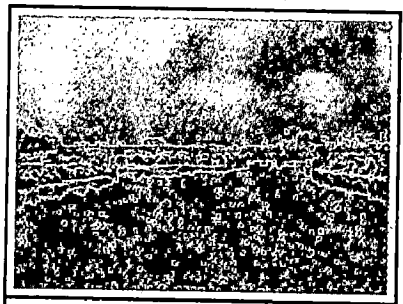

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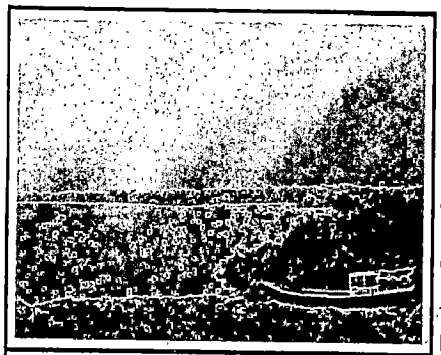

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