Environmental Status Report of Navi Mumbai Municipal Corporation

2018-19

List of Awards

Awards Received in 2018-19

- Navi Mumbai has been conferred with Open Defecation Free ++ (ODF++) status, has a 3 star rating. The city was also ranked first on the basis of Citizen Feedback in the category of cities with a population of more than 10 lakh in the Swachha Sarvekshan (Survey) – 2019
- Navi Mumbai ranked 1st in Maharashtra (West Zone) and 7th in the country as the cleanest city as per Swachha Sarvekshan (Survey) -2019.
- Navi Mumbai has been ranked 2nd in terms of Most Liveable city in the country by the Housing and Urban Affairs Ministry, Government of India

Awards Received in 2017-18

- Navi Mumbai was awarded as Best City in Solid Waste Management in more than 10 lakh population category as per Swachha Sarvekshan (Survey) – 2018

Awards Received in 2016-17

- Navi Mumbai was ranked 1st in Maharashtra (West Zone) and 8th in country as the cleanest city as per Swachha Sarvekshan (Survey) -2017
- Under Swachha Bharat Abhiyan, NMMC ranked first in Advanced Public Toilets and Information, Education and Behaviour Change Communication (IEBC) categories and received awards during 45th Skoch Award-2016 held in Hyderabad on 8th &-9th September, 2016.
- Award for Exceptional Performance in Waste Segregation on 5th May 2017 on the eve of Urban Development Day.
- Maximum Tax Recovery award on 5th May, 2017 on the eve of Urban Development Day.

Awards Received in previous years (2002-2015)

- HUDCO AWARD: For the Best Practices to Improve the Living Environment (2015-2016)
- JCB Clean Earth Award for Excellence in Solid waste Management (2015)
- Award for Solid Waste Management 2014 by EPC World Media Group.
- National Urban Water Award 2011 for contracting O &M services.
- First prize award for Family Welfare Programme, TB prevention & Control program and Second award for Mother Child Health Care Programme in Maharashtra state.
- Best Urban ICT award for E-Governance project of NMMC by Government of Maharashtra.
- Best practices award for NMMC centre of Education and Training for Handicap by Social Justice & Special aid department of Government of Maharashtra.
- EPC World Award for Outstanding Contribution in Urban Civic Amenities (STP Project).
- Sant Gadge Baba Nagri Swachata Abhiyan special Award - 2008-09 from Government of Maharashtra for best Sanitation practices in city.
- Indian Municipal Vision-2020 Award for "WISITEX Green Urban Development Award of the Decade".

- Government of India National Urban Water Awards (NUWA) 2010 for "Sanitary Improvements and Safe Disposal Practices, Integrated Storm Water Disposal System".
- Government of India National Urban Water Awards (NUWA) 2010 for "Improved Customer Satisfaction, Governance, Public Disclosure and Transparency".
- Best City Award for Improvement in Waste Water and Sanitation Services under JNNURM (2009).
- Vasundhara Award – 2009 by Hon. Chief Minister of GOM for excellence in city environment.
- National Urban Water Award-2009, by Hon. President of India for "Services to Urban Poor."
- Ranked 1st in the state for the year 2007-2008 & 2008-2009 in implementing the SARVA SHIKSHA ABHIYAAN campaign of the Government of India. (Education for All).
- National Water Award-2008 constituted by Urban Development Dept (Government of India), Administrative Staff College of India, Hyderabad and FCCI for successful implementation of 24x7 water supply in Navi Mumbai.
- 1st prize under the Sant Gadgebaba urban cleanliness campaign twice (2002-2003 & 2005-2006) with cash reward of Rs 50,00,000/-

Abbreviations

APMC	Agricultural Produce Market Complex
AQI	Air Quality Index
BEST	Brihanmumbai Electricity Supply and Transport
BOD	Biochemical Oxygen Demand
BPO	Business Process Outsourcing
CAAQMS	Continuous Ambient Air Quality Monitoring System
CAGR	Compound Annual Growth Rate
CBD	Central Business District
CIDCO	City and Industrial Development Corporation
CNG	Compressed Natural Gas
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CSIR	Council of Scientific & Industrial Research
DO	Dissolved Oxygen
EPI	Environmental Performance Index
ESR	Environmental Status Report
FAO	Food and Agriculture Organization of the United Nations
IT	Information Technology
JNPCT	Jawaharlal Nehru Port Container Terminal
LPCD	Liters per Capita per Day
LPG	Liquefied Petroleum Gas
LULC	Land Use and Land Cover
MCZMA	Maharashtra Coastal Zone Management Authority
MIDC	Maharashtra Industrial Development Corporation
MLD	Million Liters Per Day
MMR	Mumbai Metropolitan Region
MPCB	Maharashtra Pollution Control Board
MRSAC	Maharashtra Remote Sensing Application Centre
NAAQMS	National Ambient Air Quality
NAAQS	National Ambient Air Quality Standard
NAMP	National Air Monitoring Program

NEERI	National Environmental Engineering Research Institute
NMMC	Navi Mumbai Municipal Corporation
NMMT	Navi Mumbai Municipal Transport
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
NSICT	Nhava Sheva International Container Terminal
PDS	Public Distribution System
PNG	Piped Natural Gas
PVC	Polyvinyl chloride
RSPM	Respirable Suspended Particulate Matter
RTO	Regional Transport Office
SPM	Suspended Particulate Matter
SO_2	Sulphur Dioxide
STP	Sludge Treatment Pool
TERI	The Energy and Resources Institute
TTC	Trans-Thane Creek
ULB	Urban Local Body
WHO	World Health Organization

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Highlights of the Initiatives undertaken by Navi Mumbai Municipal Corporation (2018-19).

Navi Mumbai Municipal Corporation (NMMC) has undertaken numerous environment friendly initiatives towards the Sustainable development of the city and the betterment of its citizens. In the year 2018-19, NMMC took some major initiatives, primarily in the field of Waste to Energy, Air and Water pollution and Public health. Section wise highlights of these initiatives are mentioned in Table No. 1

Table No. 1: Section wise highlights of the initiatives taken by NMMC

Section	Highlights of the Initiative
1. Air, Public health and Transport	• With intent to curb the problem of air pollution and to motivate citizens to use eco-friendly transport, NMMC started a Public Bicycle Sharing System (PBSS). It would help in reducing carbon footprint (through vehicular emissions), traffic congestion and also help enhance the health index. • Under this initiative, with the help of private stakeholders, NMMC has developed necessary infrastructure for cycles at various places in the city.
2. Water	• To help curbing water loss, NMMC has continued its initiative of installation of (Automated Meter Reader (AMR) system. NMMC maintains a report of AMR fixing data on residential, commercial and institutional structures.
3. Solid Waste Management and Land	• As a mitigative measure, NMMC has commissioned a 25 Kilo-Watt Electric (kWe) 2 stage Biomass Gasifier plant at Turbhe landfill site under Eco-City project. The plant utilizes dry woody biomass (waste) and converts it into electricity though the process of gasification. • NMMC is also planning to scale up this initiative further to enhance the electricity output which then can be utilized for waste processing machines present on the site. • As a part of Swachha Bharat Abhiyan, NMMC has developed a Swachhata Park at Nisarg Udyan, Koparkhairane. The park depicts the importance of waste segregation and its processing. • NMMC has also developed a green space in the park premises. • NMMC has continued its efforts in increasing the greenery in the city and under this; the corporation has planted trees alongside roads.

About Environment Status Report

Environment Status Report (ESR) is a form of State of Environment Reporting (SoE).The report analyses the statistical data and depicts information regarding important growth factors of the city, state of natural resources within and surrounding the city, impacts of human activities on such precious resources and possible mitigative actions/measures required to tackle/minimize such impacts.

As per Section 67 A of the Maharashtra Municipal Corporations (MMC) Act, 1949, substituted for the Bombay Provincial Municipal Corporations (BPMC) act, it is mandatory for all Urban Local Bodies (ULBs) under Class I cities of Maharashtra state to submit its Annual ESR report to General Body (GB) on or before July 31st. The ESR is required to be submitted to the Ministry of Urban Development (MoUD).

As per the guidelines published in June 2009 by the Department of Environment, Government of Maharashtra, the ESR has to be developed as per the Driving Force-Pressure-State-Impact-Response (D-P-S-I-R) framework. As part of the Eco-City project, TERI has been preparing the Annual ESR for Navi Mumbai city since 2013 based on this framework.

About DPSIR Framework:

This framework was initially developed by the Organization for Economic Co-operation and Development (OECD), 1994 and has been used extensively by various national/international environmental agencies to relate effects of human activities on the state of environment[1]. The DPSIR model can be used as an analytical framework for assessing the environmental issues by examining interlinkages between each of these elements (DPSIR).

It is a most effective form of conveying environmental status to the citizens and government authorities. This framework helps policy/decision makers in getting ground level/real time feedback about the impacts of various pressures on the states thereby helping prepare a forward action plan necessary for implementation of any future changes in policies useful for mitigating environmental issues.

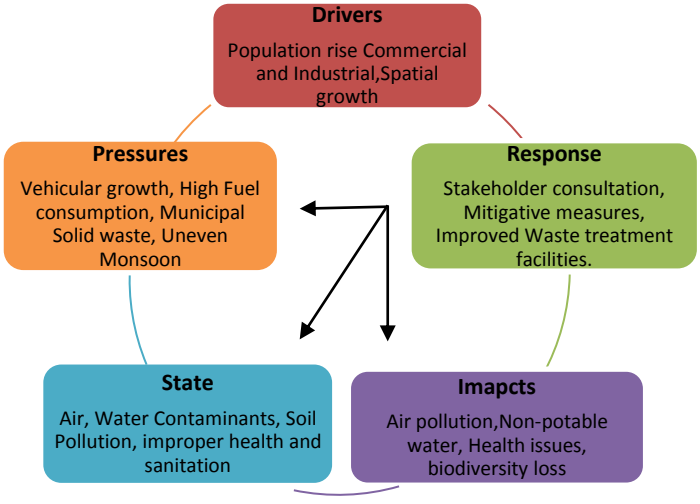


Figure No. 1: DPSIR framework
Source: TERI

Report preparation process

The report analyses the secondary data collected from various departments of the concerned Municipal Corporation, other government agencies, and published literature. A detailed questionnaire is circulated amongst the corporation departments to collect information.

[1] https://archive.epa.gov/ged/tutorial/web/pdf/dpsir_module_2.pdf

After the statistical data analysis and report writing, the draft copy of the report goes to the steering committee for approval. Changes are made in case of any improvements/additions as per the suggestions of the steering committee.

NMMC's Environment Steering Committee meeting was conducted in October 2018. The committee instructed few suggestions and the action to be taken by concerned departments along with the corporation's response towards those issues. A few important topics have been covered in Table No. 2

Table No. 2: Major points discussed during Steering committee meeting and action taken

Topic	**Feedback received from NMMC's Environment Steering Committee**	**Action taken**
Mobile tower	Addition of data on the total number of mobile towers in city and its effects on health	Data has been added in the Health section
Tree plantation	Tree plantation data to be added in the report	Data has been added in Response part of the Land section

Executive Summary

Navi Mumbai, one of the most successfully planned cities in India, has been developed as a twin city to the Megacity of Mumbai. In the course of development, a lot of emphasis has been given to sustainably manage and monitor the city's vital resources. The city is having modern facilities of urban services, solid and waste water management, public transport, healthcare, storm water management and so on. Along with the development activities, NMMC has also focussed on the city's natural resources and has maintained them through continuous monitoring and environment friendly initiatives.

The total area of Navi Mumbai is 343.70 sq. km out of which 109.59 Sq. km area falls under the jurisdiction of Navi Mumbai Municipal Corporation (NMMC). The NMMC area has well-established industrial and IT sectors which attract a large population due to the created employment opportunities. In the year 2018-19, the population of NMMC was estimated to be about 15,52,980 and registered a growth of about 5% as compared to 2017-18 (14,77,855) as per Urban Health Posts (UHP). The City has also seen an increase in the rate of urbanization. The total number of properties have also increased to 3,10,222 with residential properties having the highest share of around 82% followed by commercial buildings with ~17% share and MIDC commercial with ~ 1% share.

With the increase in population coupled with growth in industrial, educational, economic and infrastructure activities, city's vital natural resources such as water, land and air comes under pressure which may degrade/lower their quality and thereby negatively impact the overall city environment. Considering these factors, the current report is prepared as per Drivers-Pressure-Status-Impact-Response (DPSIR) framework proposed by the Maharashtra Pollution Control Board (MPCB) guidelines 2009[2].

Environmental Indices for Navi Mumbai

To obtain a comprehensive overview of the environmental performance and the state of resources NMMC has been annually calculating indices such as, Environmental Quality Index (EQI), Urban Infrastructure Index (UII) and Quality of Life Index (QOLI), for the past 18 years.

NMMC has recorded an improvement in the EQI, UII and EPI, owing to various pro-environment initiatives like effective waste segregation and management, closure of quarries Mangrove protection and development of roads within the city.

In the year 2018-19, the EQI has improved by 0.63%, QOLI by 0.64% and UII by 0.65% (Figure No. 2).Overall improvement of EQI is attributed to the improvement of air quality especially at traffic junctions, improvement in solid waste management, decrease in vector-borne diseases, completion of road construction in MIDC, increased awareness among the citizens with respect to noise and solid wastes, and so on. While an increase in UII is attributed to the development of sanitation facilities, improved waste segregation at the source and improved operational efficiency of solid waste processing plants and completed construction activities of roads and bridges within Navi Mumbai city.

[2] http://mpcb.gov.in/images/pdf/Evaluation_of_ESRs.pdf

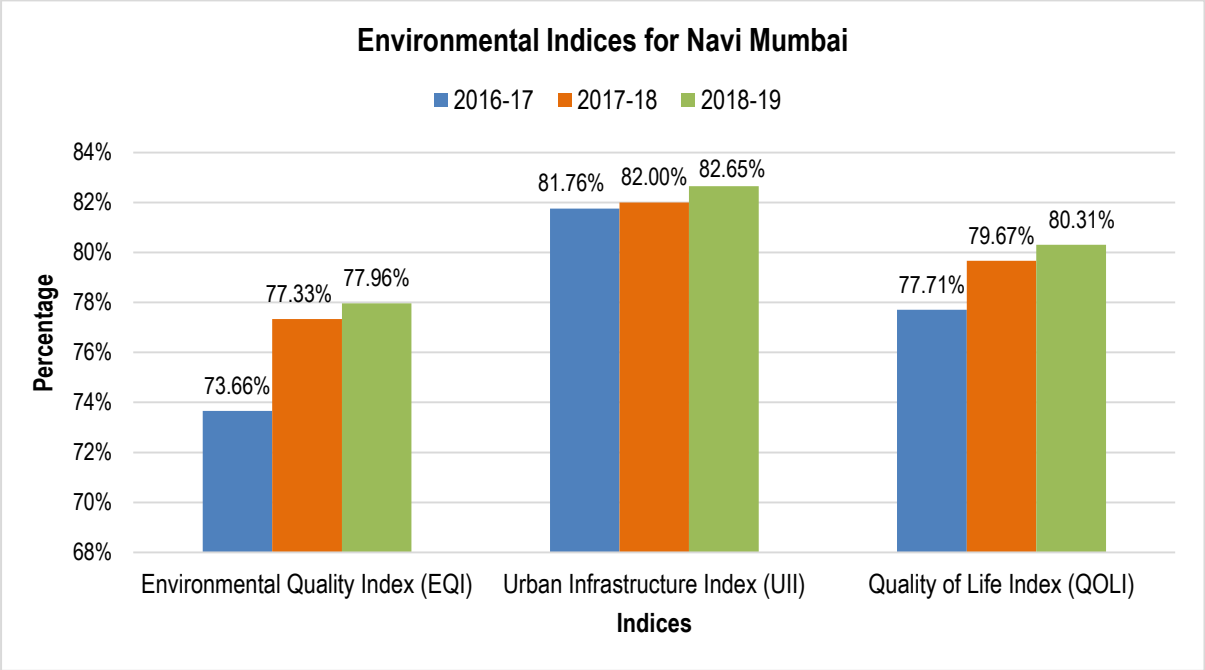


Figure No. 2: Environmental Indices for Navi Mumbai (2016-19)

In the current year, NMMC has calculated the EPI (Environment Performance Index), endorsed by MPCB for the sixth consecutive year. The calculator takes into consideration 65 data variables which are compared against the state level and national level benchmarks or averages as may be applicable. The EPI score for the NMMC area was determined to be 698.0 out of 944 and has registered an improvement of 0.64% as compared to the previous year owing to major initiatives undertaken to increase awareness related to environmental issues, public transport, effective segregation and management of solid waste, and development of roads.

Air Pollution

For monitoring air quality, NMMC has installed 3 Continuous Ambient Air Quality Monitoring Stations (CAAQMS), one each at Airoli (fire station), Turbhe (near landfill site) and, Koparkhairane (near Teen Taki). These CAAQMS monitor the concentration of air pollutants such as Sulphur dioxide (SO_2), Oxides of Nitrogen (NOx), Particulate Matter (PM), Carbon Monoxide (CO), Methane and so on. In the year 2018-19, these CAAQMS recorded data for 365 (Koparkhairane), 365 (Airoli) and 153 (Turbhe) observational days respectively*.[3]

NMMC has started Public Bicycle Sharing System (PBSS) to encourage citizens to use an alternative to public transport and to curb the problem of air pollution.

[3]* :**Data for 7 months (September to March 2019) at Turbhe station was not available due to technical issues in the current year 2018-19**

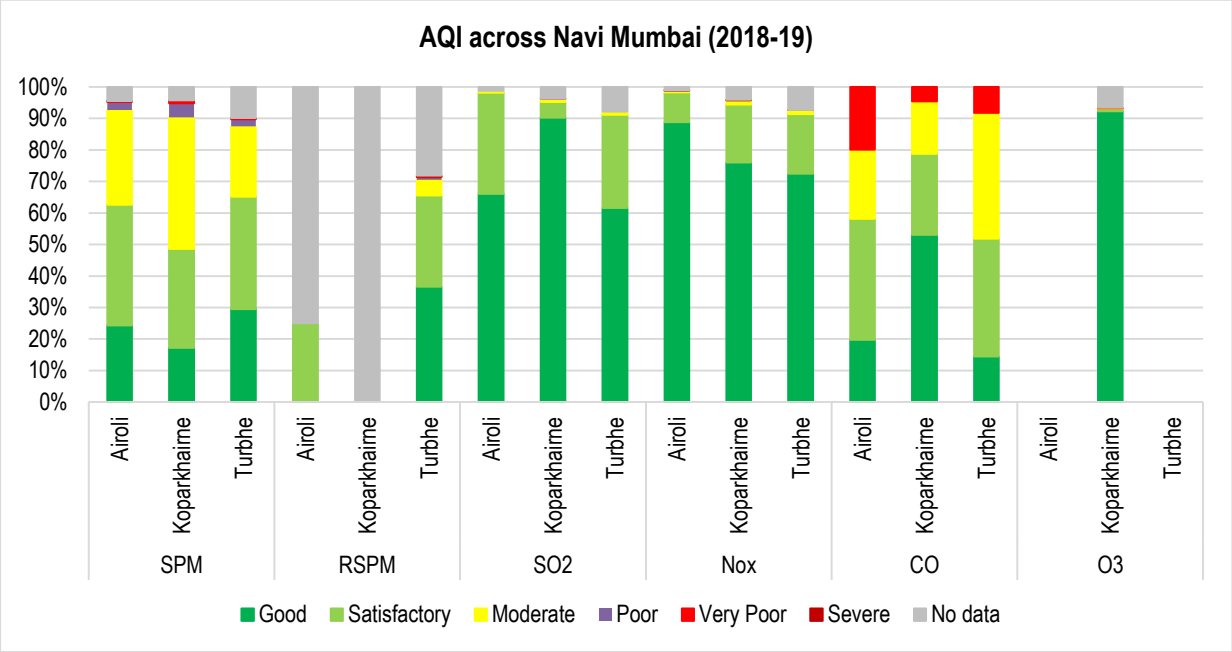


Figure No. 3: Category wise share in occurrence of various categories of Air Quality Index 2018-19
Note: Ozone concentration is measured only at Koparkhairane CAAQMS. Data for 7 months (September 2018-March 2019) at Turbhe is not available in current year 2018-19. Similarly, RSPM data for Koparkhairane is not available for the year 2018-19.

The Air Quality Index for Navi Mumbai city for the year 2018-19 is represented in Figure No. 3. The percentage of observations under the good to satisfactory category was around 48%, down from 70% (2017-18). The share of Moderate category observations was found to be 44.4% whereas the observation coming under Poor, Very Poor and Severe category were 3.28%, 0.65% and 0.16% respectively.

With an objective of encouraging citizens to use bicycles as an alternative to public transport and to reduce carbon footprint of the city, NMMC has kick started Public Bicycle Sharing System (PBSS) through a private contractor (YULU). Under this initiative, corporation has established 12 locations for these cycles. NMMC proposed to extend these services to other nodes with an objective to provide at least 1 cycle per 100 citizens or a minimum of 1 lakh cycles in the city. Citizens will have to download a mobile app (YULU Bikes) to rent the cycles and pay through online payment options like PayTM, PayPal and so on[4].

Noise Pollution

Except the commercial zones, the residential areas and silence zones violated the day time standards. The sound levels recorded across the city in different zones are presented below in Figure No. 4. In the case of commercial zones, though under permissible limit (65dB), the highest average noise level (61dB) was recorded at Ghansoligaon GSR (Ground Service Reservoir) and Airoli ESR (Elevated Service Reservoir) (Sec- 18 & 19)while the lowest average noise level was recorded at Juinagar ESR sector 11 (59dB).

In case of residential zones, all locations exceeded the day (55dB) time standards. Nerul ESR (Sector 9) recorded the highest average noise levels about 60 dB whereas Vashi showed a declining curve in average noise levels (59dB) as compared to the previous year (61dB).

[4]https://timesofindia.indiatimes.com/city/navi-mumbai/navi-mumbai-public-bicycle-sharing-system-started-at-nerul/articleshow/66464064.cms

It is important to note that, as compared to the previous year's noise levels (65-69dB), traffic zones recorded average noise levels in the range of 61-67dB. The Mahape Bridge recorded the highest noise level (67 dB) followed by the Belapur Fire Brigade, Digha Ward Office and Vashi Ward Office, Juhugaon (65 dB) The lowest noise levels were observed at Turbhe ESR, Sector 19 (61 dB).The decrease in noise levels at traffic junctions may be due to the reduction in honking due to public awareness and completion of road constructions.

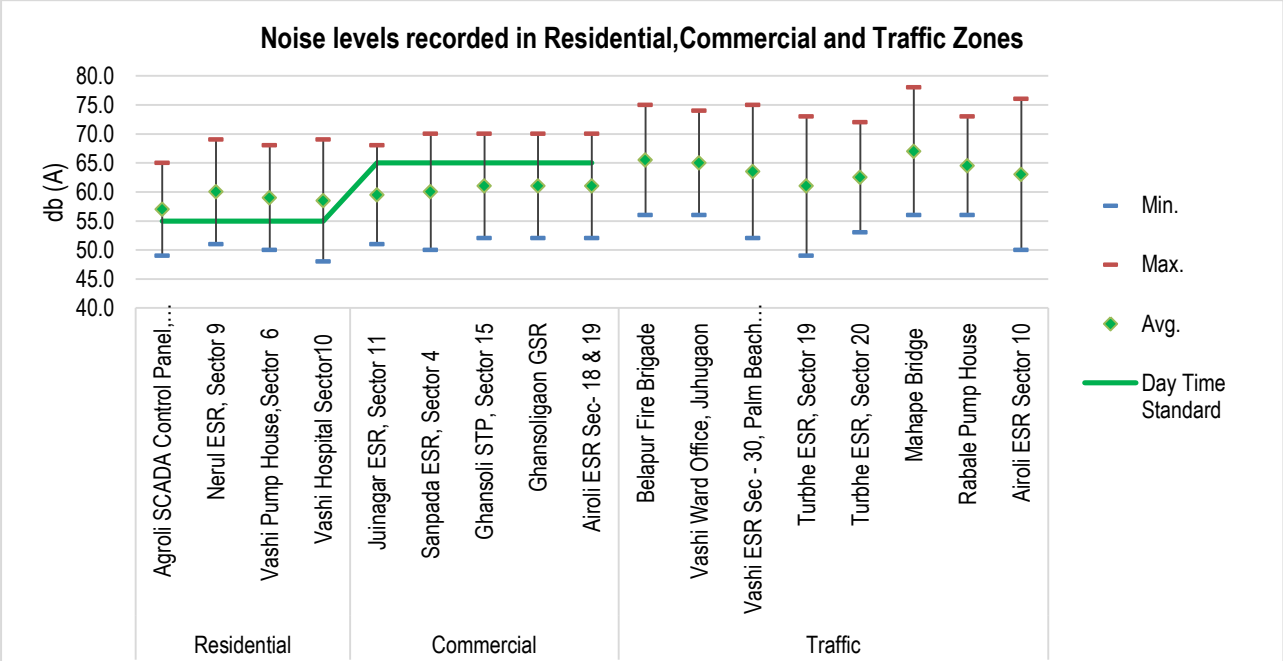


Figure No. 4: Zone wise Noise pollution levels in Navi Mumbai 2018-19

All stations in the silence zone of Navi Mumbai exceeded the average day standard limits of 50dB. Dr. D.Y. Patil Vidyapeeth, Sector 7, Nerul recorded the highest average daily noise levels of 61dB. Sanpada College of Commerce and Technology (Sector 2) and Modern School, Sector 6, Vashi, recorded lowest average noise level (54 dB.)

Water Resources and Quality

NMMC is blessed with abundant water resources in terms of both surface and ground water. The surface water resources include 24 major lakes and ponds, 11 holding ponds and creek front of about 22km, the NMMC area merits various vital environmental and physical services provided by these entities in terms of controlling the floods, water logging, and surface runoffs and so on.

NMMC regularly monitors the levels of its surface and ground water resources. The lakes in the NMMC area are maintained properly by NMMC authority with all parameters, except S.S., hardness and sulphates, exceeding in certain lakes. It is worth mentioning that, the levels of S.S. has gone down as all lakes except (Mahapegaon lake – 117mg/l) recorded annual average S.S concentration within the permissible limit (100mg/l) compared to 6 lakes which recorded higher concentration than the permissible limit in 2017-18.Similar decreasing trend was observed in case of hardness where 2 lakes namely Shirvane (889mg/l) and Vashigaon (1024 mg/l) recorded higher annual average concentration than the permissible limit (600mg/l) in 2018-19 as compared to 3 lakes in 2017-18.

Sulphate concentration, however, was found exceeding permissible limit (40mg/l) in 14 lakes. The highest annual average sulphate concentration was found in Vashigaon lake (2158 mg/l) followed by Savaligaon lake (1415.0mg/l and Shirvane lake (909.9mg/l).

All other parameters including DO, BOD, COD, pH, chloride, phosphate and nitrate were found to be within permissible limits.

In terms of ground water resources there are 132 wells regularly monitored by NMMC for their water quality. Even though all the parameters were well within the limits for groundwater, the samples detected the presence of *Escherichia coli* and faecal coliforms.

Water supply

The NMMC area gets its daily fresh water supply from Morbe dam, which is situated on the Dhavri river (*tributary of Patalganga river*) near Khalapur, Raigad district. It is the source of fresh water for NMMC jurisdiction area.In 2018-19, total average water supply to the city was recorded at NMMC supplied water 24X7 to nearly 75% of the area of the city while the remaining area is catered to water supply for about 4–8 hours per day, thus ensuring 100% coverage.

The % extent of Non-Revenue Water for the year 2018-19, is recorded at 18.61%which less than the benchmark set by Ministry of Water Resources (20%)

Year 2018-19 registered % of water loss (non-revenue water) at 18.61%, slightly up from 18.28% registered during 2017-18. Net water supply to the city is recorded at 343.36MLD. To decrease water loss, NMMC regularly conducts water audits and addresses complaint s received from citizens regarding pipe breaks, leakages and supply. Installation of Automated Meter Reader (AMR) system, water supply through a well-connected piped network and installation of Supervisory Control and Data Acquisition (SCADA) system for effective management of water supply has helped NMMC in reducing water losses to a higher extent.

In 2018-19, NMMC monitored 20,376 drinking water samples at the tap end, from all the nodes. Out of these about 5.17% (1053) samples were detected to be non–potable compared to 3.4% during 2017-18.

Sewage Treatment

It is estimated that around 210 MLD of sewage is generated in the NMMC area in 2018-19. All the sewage gets collected and treated before releasing into the creek thus ensures 100% sewage collection and treatment in the city by NMMC. The City has a total of 7 active Sewage Treatment Plants (STP) with an aggregate treatment capacity of 454 MLD. All these treatment plants are equipped with primary and secondary treatment systems which works based on the cyclic activated sludge treatment technology using Sequencing Batch Reactor (SBR) process.

NMMC regularly analyses and maintains the data of inlet and outlet water samples before releasing it into the creek. In 2018-19, the average effluent water quality released from the STPs was well within the standards for pH and Biochemical Oxygen Demand (BOD). In case of Chemical Oxygen Demand (COD), only 1 STP (Airoli sector 18) recorded outlet concentration slightly higher (54 mg/l) than the permissible limit (50mg/l). Concentration of suspended solids (S.S.) however, was found to be above the permissible limit (20 mg/l) in outlet samples of 5 STPs namely CBD Belapur sector 12 (33 mg/l), Nerul sector 50 (23 mg/l),

Sanpada sector 21 (27 mg/l), Ghansoli sector 15 (59 mg/l) and Airoli sector 18 (67 mg/l) even after treatment.

In an effort to reutilize treated sewage water, NMMC has proposed 2 tertiary treatment plants of 20MLD each which would further process the treated sewage and make it appropriate for further applications. The water would then be utilized for non-drinking purposes in the adjoining industrial sectors. This initiative would create an alternative to municipal water for industrial sector which is one of the major sectors utilizing high amount of water on daily basis. NMMC also proposes to set up similar plant of 15MLD capacity at Vashi node. The recycled sewage water then could be utilized for gardening purpose or other secondary uses.

Land use and green cover

The total area under NMMC's jurisdiction is estimated to be approximately 109.59 sq. km. Out of the total area, 56.5% of land accounts for Built Up area followed by Forests (24.22%), Wetlands (12.28%), wastelands (5.33%), Agricultural land (1.27%) and water bodies (0.32%).Out of 8 nodes, Turbhe and Vashi has more than 75% of the total area under built up category indicating higher population density in these 2 nodes as compared to other nodes of city. Forest areas are predominantly found in Digha, Ghansoli, Koparkhairane, Nerul and Belapur node while agricultural activities, though on a small scale are being carried out in Ghansoli, Kopakhairane, Nerul and Belapur node.

Green spaces and Tree plantation

There are 163 gardens and 80 open spaces which cover a total area of 8,16,967 sq.meters and 2,84,917 sq. meters respectively. Gardens act as microhabitats for a variety of city dwelling fauna such as birds and butterflies and also play an important role in enhancing the physical, emotional and spiritual wellbeing of citizens necessary to build healthy and socially sustainable communities.

NMMC frequently undertakes tree plantation drives wherein trees are planted along roadsides, open spaces and gardens. In 2018-19, NMMC has planted 67,552 saplings in various areas of city which included indian species such as Neem, Bakul, Kadamba, Karanja, Mango, Chikoo and many others. NMMC has also developed Swachhata Park at Nisarg udyan, Koparkhairane.

Picture No. 1: Green space in Swachhta Park Premises

Restoration of Stone Quarries

Quarrying activities and abandoned stone quarries in Navi Mumbai have affected the air quality and aesthetic beauty of the city; more over the lease of the sites have also expired in 2016 rendering all the sites vacant. Towards this, NMMC has a proposed action plan for restoration of abandoned quarries and protection of hills. In collaboration with The Energy and Resources Institute (TERI), NMMC has proposed a stone quarry restoration project on a pilot scale.

The project would involve pre-feasibility study and use of slope stabilization technique (after feasibility study) which may involve geotechnical survey and civil work. The project would be beneficial not only for Parsik hills but would also pave the way for utilizing construction and debris (C&D) waste (generated in and around the city) and compost (generated at landfill site) as these could be used as fillers. Plantations can be carried out using native species.

Looking at the extent of quarrying, there is a great possibility to further scale up this initiative once done on a pilot scale. It would be a huge opportunity to bring together stakeholders from various backgrounds such as educational, institutional, and residential and government sectors.

Mangrove Ecosystem

Mangroves are important natural ecosystems for Navi Mumbai since they act as natural barriers against possible natural calamities like cyclones, floods and tsunamis and play a vital role by reducing carbon footprint owing to its carbon sequestration potential.

NMMC proposes to install CCTV's in mangrove area to have surveillance check on illegal activities and mangrove plantation drives. The corporation also offers a cash reward to people who report illegal dumping of debris or garbage in mangrove areas.

Municipal Solid Waste

NMMC has always given more importance to municipal solid waste (MSW) management and has a very effective strategy dealing with the issue of MSW that is generated in the city. It involves segregation at source, color coded dustbins for dry, wet and e-waste, Effective waste collection and transportation mechanism, scientific landfilling and various initiatives undertaken by the corporation under Swachha Bharat Abhiyan.

Generation and Collection

In the year 2018-19, the daily average MSW generated in NMMC's jurisdiction area was 753 Metric Tons (MTs). Out of all the waste categories, biodegradable waste holds the major share of about 73% (60% organic matter + 13% coconut shells) followed by plastic waste (10%). It is important to note that the share of plastic waste has been decreased from 11.7% (2017-18) to 10% in the current year. Out of 8 nodes, Turbhe node generated the highest daily average MSW (134.0MTs/day) followed by Koparkhairane (124.0MTs/day) and Belapur and Nerul node (113.0MTs/day each).

To deal with increasing MSW and cost associated with its collection and transportation, NMMC has initiated the concept of decentralized waste composting, starting from slum areas in 2018-19

NMMC ensures 100% of MSW collection from housing societies with door to door collection method. The corporation also collects waste from commercial and educational institutions and from industrial premises. Node wise, NMMC has provided dustbins with a capacity of 120 litres (Total 7011; 3660 green and 3351 blue) and 240 litres (Total 8572; 4084 green and 4488 blue). NMMC has also initiated red bin initiative on a demonstration scale specifically for e-waste and hazardous wastes. Waste from roads is collected through sweeping while household waste is mechanically collected and loaded in refuse transportation vehicles by transportation contractors.

MSW Disposal

NMMC's waste collection vehicles bringspecific types of waste on site which includes wet, dry, mixed and green wastes. Mixed wastes come from roadside dustbins and few community bins which get segregated onsite once received. Wet wastes gets converted into compost on site while plastic from dry waste undergoes a baling process which converts plastic waste into small beads and granules which corporation supplies further to plastic recycling vendors or uses as a component in road construction.

Citizens also proactively participate in composting with more than 40 residential welfare associations and 19 bulk generators (>100 kilograms/day) which includes hotels, colleges and commercial units, installing composting units for treating wet waste at source.

Initiatives under Swachha Bharat Abhiyan

NMMC has commissioned a 2 stage biomass gasifier of 25kWe capacity in collaboration with TERI at Turbhe landfill site which converts green waste (dry woody biomass) into electricity. The corporation is in process of scaling up this waste to energy initiative and a project for installation of 100kWe gasifier is under process.

Navi Mumbai was ranked 1st on the basis of Citizen Feedback in the categories of cities having population more than 10 lakhs during Swachha Sarvekshan 2019.

NMMC has developed a Swachhata Park at Koparkhairane with an aim to create awareness about Solid waste management among citizens.

NMMC has developed a Swachhata Park at Nisarg udyan, Koparkhairane for educating and creating awareness among the children and citizens regarding MSW management. Information regarding MSW types, sources, its segregation and scientific management has been depicted in the form of banners, posters and pictures.

To counter the problem of plastic pollution, NMMC has conducted anti-plastic drives in city area. In the year 2018-19, around 3126 shops/commercial establishments were checked by NMMC; out of which 969 units were fined and around 39,210 kg of plastic was seized. The corporation collected fine amount of INR 46,99,650/- during 2018-19.

NMMC has been conferred with Open Defecation Free ++ (ODF++) status and has received a 3 star rating. As of 2018-19, The Corporation has constructed 92 public toilets, 369 community, 6 smart "she toilets" and 20 smart "E-toilets".

Biomedical and Hazardous Waste

Navi Mumbai, a planned city has better medical infrastructure with the presence of government and private hospitals, nursing homes, medical research laboratories, pharmacy shops which produce biomedical wastes on a daily basis. In the year 2018-19, around 14,899 kg. (14.9 tons) of biomedical waste was generated in the NMMC area from NMMC affiliated hospitals. The collection and disposal is managed by Mumbai Waste Management Limited (MWML), a private contractor empanelled by Maharashtra Pollution Control Board (MPCB) and disposed of at the hazardous waste disposal facility at Taloja.

In case of hazardous wastes, NMMC has established TTC industrial areas which houses multiple industrial units related to petrochemicals, pharmaceuticals, chemicals, textile processors, dyes and intermediates which generates hazardous waste like spent oil, ETP sludge, pesticides, lead batteries and so on. It is estimated that around 1, 30,954 MTs of hazardous wastes was generated and collected in the year 2018-19 which was disposed of by Trans Thane Creek Waste Management Association (TTCWMA) in their land fill site. The incinerable waste is managed by MWML.

Health

The status of the health of citizens is one of the most important indicators of a city's environmental status. People living in better environments tend to live long and healthy lives as compared to those living in polluted environments. Navi Mumbai city has well equipped health care and medical facilities accompanied by well-trained medical professionals and support staff. Apart from private medical services, Navi Mumbai also has NMMC affiliated hospitals. Corporation, through its network of health centres, provides free medicines and vaccines to the citizens free of charge especially for vector (malaria/dengue) and air borne diseases (TB). NMMC's health department regularly conducts therapeutic as well as preventive measures to prevent the occurrence of diseases.

In 2018-19, there was a steep decline observed in vector borne disease, for instance, malarial cases declined by almost 33% from 138 cases in 2017-18 to 92 in current year whereas dengue cases deceased from 6 (2017-18) to 4 in 2018-19. In case of water borne disease, however, typhoid cases increased by almost 5 times (from 7 to 39) and Hepatitis B from 0 to 9 in 2018-19.

In case of TB, 790 new cases were recorded compared to 767 (2017-18). Similar increasing trend was recorded in case of extra pulmonary TB with 13% surge from 677 cases (2017-18) to 762 (2018-19). NMMC is collaborating with PATH organization on a program called 'Joint Efforts for Elimination of TB' (JEET). Under this program, TB patients get free of charge diagnosis and medicines in city's health centers.

Conclusion

As it has been observed, the growing demand for resources has exerted pressure on air, water and land resources, but NMMC has undertaken the necessary initiatives to meet these increasing demands which have also reduced the threats on the resources. Various initiatives are also under consideration which could further pave the way towards sustainable development of Navi Mumbai city. Thus it could be concluded that NMMC, through sustainable development, is on its way to become India's first successful Eco City.

Environmental Indices for Navi Mumbai

Environment is the sum of all the things that makes up our surroundings which includes natural forces and other living things providing suitable conditions for overall growth and development as well as damage. Environment, as a whole a very wide concept and for a common man, Understanding environment, its types, various factors and parameters involved in each type is very difficult and technical. Environment is crucial for overall development of human survival hence it is our duty to keep our environment liveable and hospitable to all living beings. For this, it is important to maintain a balance between resource use and resource availability. In today's world, the idea of sustainable development is becoming mandatory and necessary due to the ever increasing rate of environmental degradation by increasing anthropogenic pressures. It is important to assess the status of the environment to understand the effect of such activities which are proving detrimental to the environment.

The aim of assessing status of environment is sustainable development while maintaining environment quality. Many indices have been developed globally to determine an environmental index (absolute value) using various parameters. These indices can be used to calculate a baseline value for essential factors and then set up a trend for those factors that could be monitored for next consecutive years to track the development and address the gaps accordingly. NMMC is calculating 3 indices annually for the last 16 years namely EQI (Environmental Quality Index); UII (Urban Infrastructure Index); and QOLI (Quality of Life Index). NMMC has also calculated the EPI (Environmental Performance Index), which reveals a relation between 2 fundamental dimensions of sustainable development namely

- Environmental health with respect to economic growth and prosperity and
- Ecosystem vitality with respect to industrialization and urbanization[5].

The computation of these indices has been presented in Annexure 1 for calculating EQI, parameters such as ambient air quality; drinking water quality, sewage treatment facilities, and extent of solid waste management are taken into consideration. For assessing UII, population density, water supply system, health and education facilities, transport systems, employment opportunities, parks and gardens, entertainment facilities and public grievance redressal mechanism have been used as parameters. In case of QOL, availability of infrastructure facilities and environment quality decides the overall quality of life. The trend of the EQI, UII and QOLI for the past 3 years is presented in and Table No. 3.

Table No. 3: Environmental Indices of Navi Mumbai

Sr. No	Index	2016-17	2017-18	2018-19
1	Environmental Quality Index (EQI)	73.66%	77.33%	77.96%
2	Urban Infrastructure Index (UII)	81.76%	82.00%	82.65%
3	Quality of Life Index (QOLI)	77.71%	79.67%	80.31%

[5] https://epi.envirocenter.yale.edu/downloads/epi2018policymakerssummaryv01.pdf

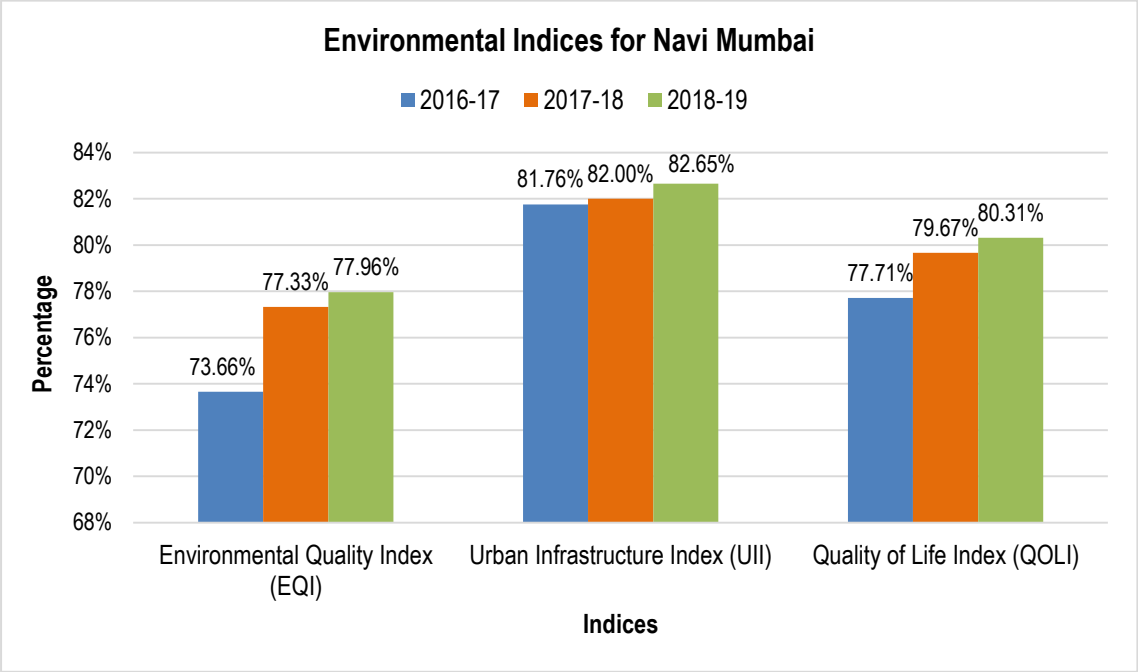


Figure No. 5: Environmental Indices of Navi Mumbai

Environmental Performance Index

The Environmental Performance Index (EPI) indicates the overall environmental performance of a city. The EPI has been calculated based on the model developed by MPCB using MS™ Excel software. As per the framework, there are 4 thematic groups namely - Growth of city, State of resources, urban services and Initiatives taken to improve the city environment. These groups are subdivided into 65 variables each of which is allotted with definite score. The bench mark which set according to national, state or the defined average as per international standards against which the allotted score is compared. The score are then added up which gives a unique score known as Environmental Performance Index. The maximum of the score will show the best environmental performance of the city.

For example, the population growth is one of the key indicators of the environment and if it exceeds the limits, it exerts pressure and adversely impacts the environment and, hence, the score given would be less in such a situation. Vice-a-versa, a pro-environment initiative is given better score. Hence, better the EPI score better is the state of environment of that city.

The EPI score for NMMC area was determined to be 698 out of 944 in the year 2018-19 (Table No. 4) and recorded an improvement of 0.65% as compared to last year 2017-18 which was 693.50. This improvement is attributed to the initiatives taken by NMMC for increasing awareness related to environmental and health issues, Management and monitoring of Solid waste.

Table No. 4: Environmental Performance Index

Gap Analysis		
Environmental Score	**Achievable Score**	**Achieved Score**
Thematic Indicators	**944**	**698**
Growth of cities	250	166.00
State of natural resources	300	225.60
Urban Services	250	196
Initiatives for improving city environment	144	110.40

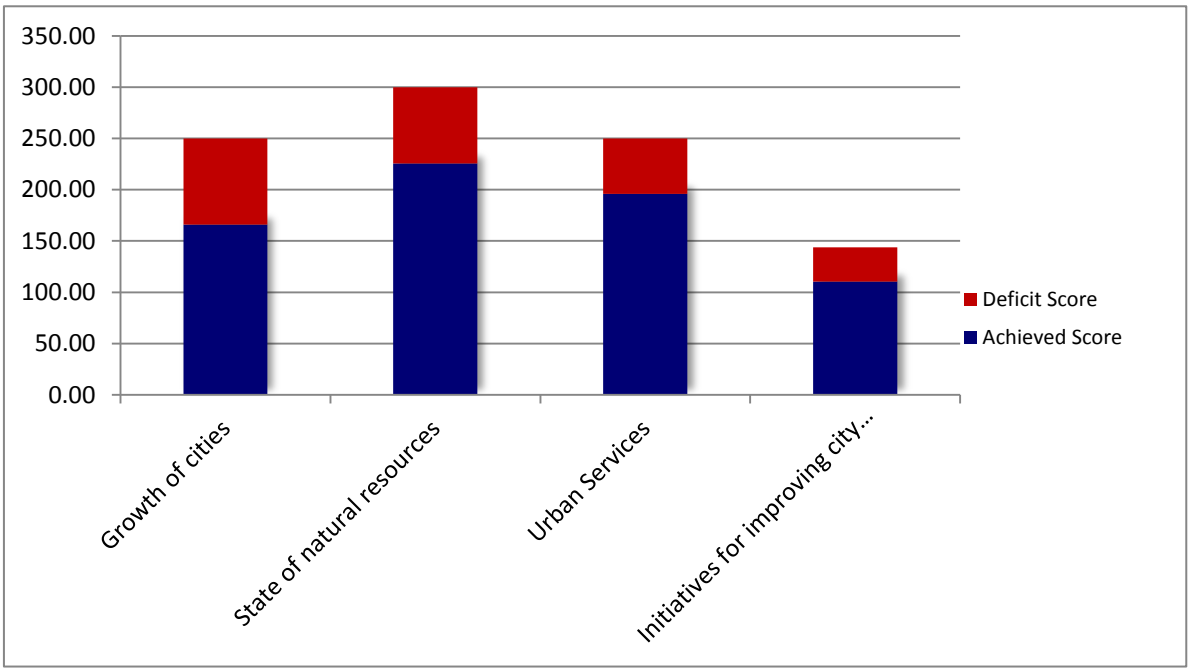


Figure No. 6: Environmental Performance Index

Navi Mumbai – City Profile

Lying on the west coast of Maharashtra in the Konkan Division, Navi Mumbai is the world's largest planned city. It has never stopped growing and boast of great residential areas, large industrial and commercial areas with offices/facilities and stores of numerous national and international industrial and commercial brands. This city is also termed by many as the Twin City of Mumbai.

History of Navi Mumbai

The city of Mumbai was not able to increase its development inputs with the steep increase in the growth of the population in the early 1970. The rapid rate of growth rate owing to the increasing industrial and commercial importance of the city had resulted in a very rapid deterioration in the quality of life for a majority of the population. Development inputs could not be developed as to keep up with the rapidly growing population, industry, trade and commerce. Since Mumbai was built on a long and narrow peninsula, there were physical limitations for expansion.

In 1970,City and Industrial Development Corporation (CIDCO), a State Public Sector Undertaking (PSU) was incorporated with the purpose to plan, develop and maintain the city of Navi Mumbai under the Companies Act of 1956. CIDCO prepared a development plan for Navi Mumbai covering 95 villages from Thane to Raigad district with an estimated area of 343.70 sq. km^2. CIDCO had planned to develop the given land into 14 nodes[6].

Designed to decongest Mumbai, one of the largest planned city of India-Navi Mumbai was conceived in 1972. The rise in employment opportunities due to the development of the numerous industries attracted a large population. Due to the ease of connectivity to Mumbai, the newly developed city witnessed quick progress in terms of urbanization.

About NMMC

Founded in 1991, Due to the rapidly growing population in Navi Mumbai, there was a need for a local governing body that could work towards the welfare of the citizens and provide them with affordable living amenities and excellent municipal facilities. For more efficient governing, 8 out of 14 nodes were given to Navi Mumbai Municipal Corporation (NMMC) for maintenance in 1991. Their newly constructed head quarter is India's first green administrative building.[7]

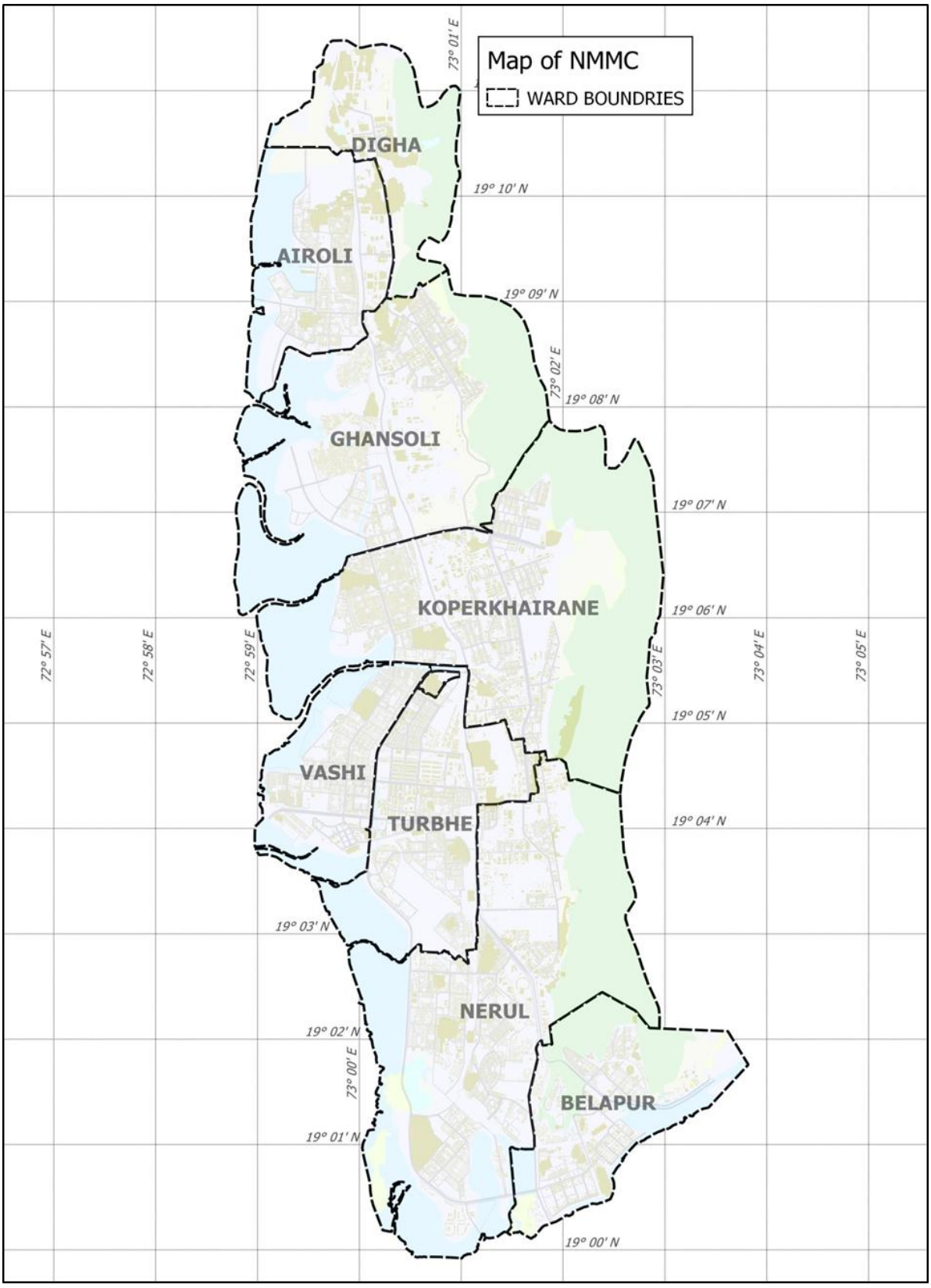
The city is located in the centre of the Mumbai Metropolitan Region (MMR) with Thane Creek on the west, Parsik Hill ranges on the east, Thane city on the North and Panvel on the South. Navi Mumbai has a total area of 343.70 sq. km^2 out of which 109.59 sq. km^2 comes under the jurisdiction of NMMC. The Urban Health Post (UHP) report for the year 2018-19 suggests that the population residing within various nodes of NMMC is more than 15.5 lakhs with an average population density of about 14,171 persons per sq. km. Koparkhairane UHP tops in the terms of population with 1,44,621 individuals while Indira Nagar UHP (Turbhe) is having the lowest population of about 35,708 individuals among all UHP's. The geographic and demographic profile of Navi Mumbai is represented in Table No. 5.

[6] https://shodhganga.inflibnet.ac.in/bitstream/10603/192809/14/14_chapter%205.pdf
[7] https://timesofindia.indiatimes.com/life-style/spotlight/Indias-first-green-government-building/articleshow/30781605.cms

Table No. 5: Geographic and demographic highlights of Navi Mumbai

Heads	**Attributes**
Longitude Latitude	72°58′ to 73°03′E 19°00′ to 19°12′N
Mean Height above Sea Level	3.25 Metres
Nodes under NMMC	Belapur, Nerul, Turbhe, Vashi, Koparkhairane, Ghansoli, Airoli and Digha.
Total area under NMMC jurisdiction	109.59 sq. km
Estimated Population 2018-19*(UHP Survey)*	15,52,980
Population Density (*UHP Survey*)	14,171 persons per sq. km
Population *(Census of India-2011)*	11,20,547
Population Density *(Census data-2011)*	10,315 persons per sq. km
Sex Ratio *(As per census data-2011)*	837 Females per 1000 Males

Source: Census of India 2011 and NMMC UHP Survey



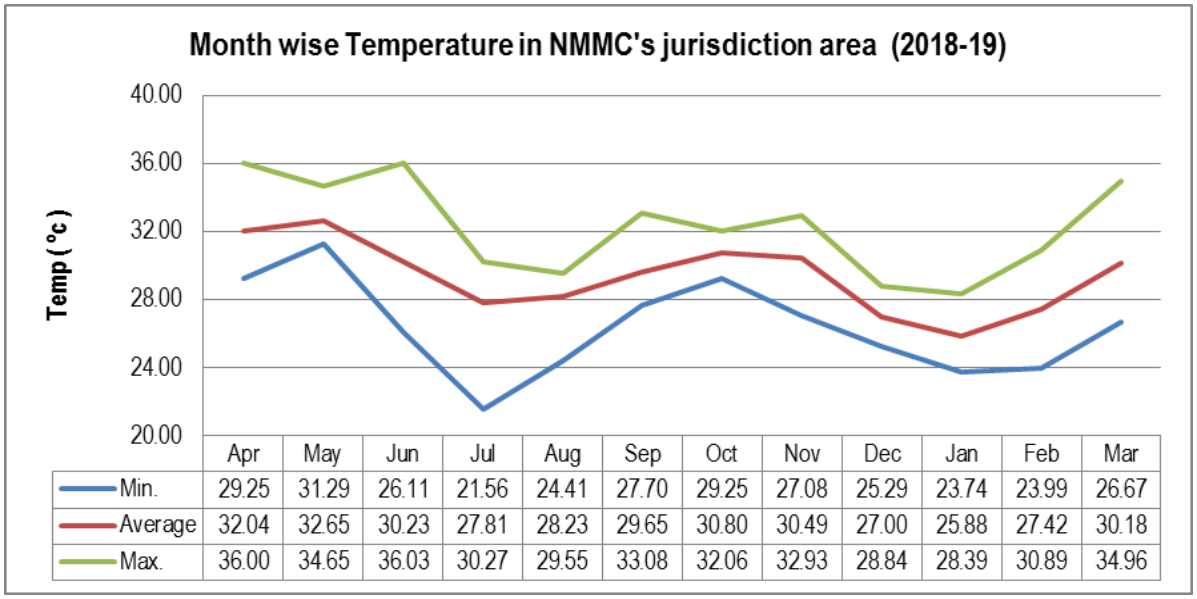
Map No 1: Wards of NMMC along with latitude and longitude

Climate

Climate is the average state of weather conditions over a long period. It is measured by assessing various patterns of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in an area over long periods of time. Along with these variables, the climate of an area also depends on manmade factors such as presence of industrial complexes, population density, transportation network and the amount of green cover present. It is a key decisive factor, which makes a place liveable.

The climate of Navi Mumbai is hot and humid. It has a high humidity throughout the year. It lies in the tropical climatic zone and has three seasons namely summer, monsoon and winter. The annual temperature in Navi Mumbai varies from 22°C to 36°C while in summers the maximum temperature ranges between 36°C to 41°C and the minimum temperatures in winter ranges between 17°C to 20°C. The average annual rainfall is 2000-2500 mm and humidity is 61-86 %. Based on Indian Meteorology Department's (IMD) observations recorded at Thane Belapur Industry Association's (TBIA) premises, the predominant wind direction in Navi Mumbai is southwest in monsoon and north-east during rest of the year.[8]

Based on the data recorded at the Continuous Ambient Air Quality Monitoring Stations (CAAQMS), for NMMC, the monthly average temperatures (Figure No. 7) were recorded to be between 25.8°C to 32.6°C for the year 2018-19 as compared to 26.1°C to 31.4°C; recorded for the year 2017-18. The highest maximum average temperature of 32.6°C was recorded in the month of May (summer season) and the lowest temperature of about 25.8°C was recorded in the January month.



	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Min.	29.25	31.29	26.11	21.56	24.41	27.70	29.25	27.08	25.29	23.74	23.99	26.67
Average	32.04	32.65	30.23	27.81	28.23	29.65	30.80	30.49	27.00	25.88	27.42	30.18
Max.	36.00	34.65	36.03	30.27	29.55	33.08	32.06	32.93	28.84	28.39	30.89	34.96

Figure No. 7: Month wise temperatures recorded in NMMC area 2018-19

Data source: CAAQMS of NMMC at Airoli, Turbhe and Koparkhairane

[8]http://www.nmmconline.com/web/guest/climate

Navi Mumbai, being a coastal city, experiences heavy rainfall which generally starts from first week of June and continues till the end of September. In the year 2018, Navi Mumbai received around 2636.78 mm of rainfall which was around 16% lower compared to 3123.78 mm in 2017-18 (Figure No. 8). Navi Mumbai has experienced highest rainfall in the month of July (1304.1 mm) followed by June (851.63 mm) and August (360.9 mm) and September (83.15 mm). Months of November and December received no or very negligible amount of rainfall. (Figure No. 9).

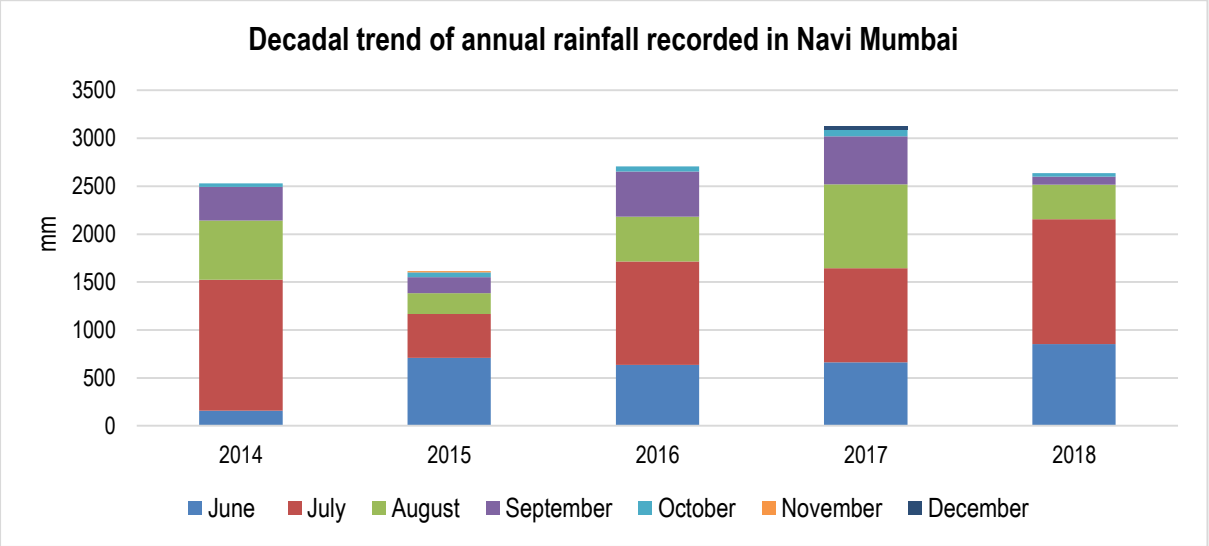


Figure No. 8: Decadal trend of annual rainfall recorded in Navi Mumbai

Source: Environmental Laboratory, NMMC

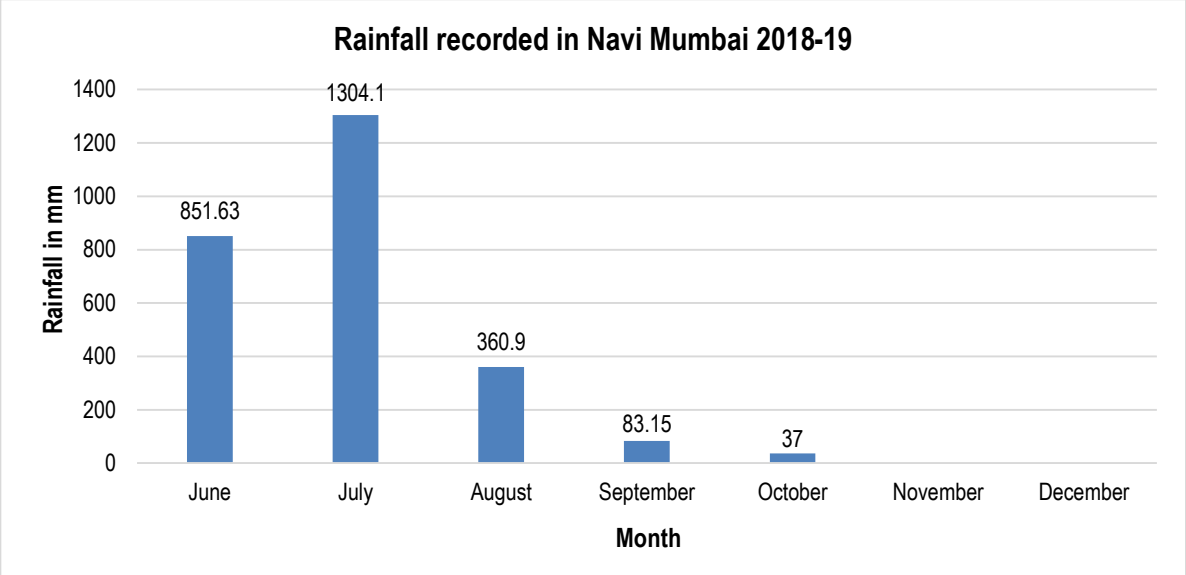


Figure No. 9: Rainfall recorded in Navi Mumbai

Source: Environmental Laboratory, NMMC

Drivers and Pressures

If not managed properly, drivers (anthropogenic pressures) can create pressures that have either immediate or long term consequences on the surrounding environment. The extent to which the drivers lead to the environmental impacts depends upon a range of factors which includes population growth rate, standard of living, rate of resource consumption, and management of waste products.

Population growth acts as crucial driver to urbanisation, which may impact various resources. These resources have been analysed in separate sections for their status, the pressures being exerted on them, the —Impact of various urban activities on these resources, and the —Response taken by NMMC to reduce the impacts.

Land use and Land cover

Land use change is considered as fundamentally important factor in determining range of physiological, ecological, social and climatic consequences. In major metropolitan cities, diversion of forest land for creating housing and industrial infrastructure is one of the major trends in land use change. Thus the physical changes on forest cover/natural areas also have implications on climatic conditions.

In case of Navi Mumbai city, the land use pattern consists of built up area, agricultural land, forests, wastelands, water bodies, roads, and so on. Table No. 6 illustrates break up of Land Use and Land Cover (LULC) pattern of area coming under NMMC's jurisdiction which is spread across 109.59 sq. km. out of which built up area constitutes major portion which accounts to about 61.97 sq.km. This area comprises of residential, commercial, industrial, administrative constructions and infrastructure such as crematoriums, water supply, sewage disposal, roads, and railways. Out of all nodes, Ghansoli node is predominantly witnessing higher development. Forest covers around 26.55 sq.km of area. Wetlands are an important feature of the city with 13.46 sq.km areas under lakes, mangroves, wetlands, creeks, mudflats and manmade water bodies.

Table No. 6: Break up of Land Use and Land Cover pattern in NMMC

Sr. No	Land Use Land Cover	Area in km²
1	Built Up	61.97
2	Forest	26.55
3	Wetlands	13.46
4	Wastelands	5.85
5	Agricultural Land	1.4
6	Water Bodies	0.36
Grand Total		**109.59**

Source: NMMC Town Planning Department

Though NMMC is a planned city, increase in population would pose a challenge for the communities not only in case of land availability but also in case of availability of city's other important natural resources which must be managed and mitigative measures must be in place in advance to reduce the effects of increasing anthropogenic pressures on city's vital natural resources.

Population growth and Urbanization

Like any other metropolitan city, Navi Mumbai has also witnessed tremendous growth in population due to planned development, ample job opportunity, high standard of living and its location connecting nearby metro cities such as Mumbai and Thane. Working class people from neighbouring urban areas commute on daily basis to the city due to its established industrial and commercial sectors thus there is increase in the inflow of people in the city along with the citizens that are already residing in Navi Mumbai.

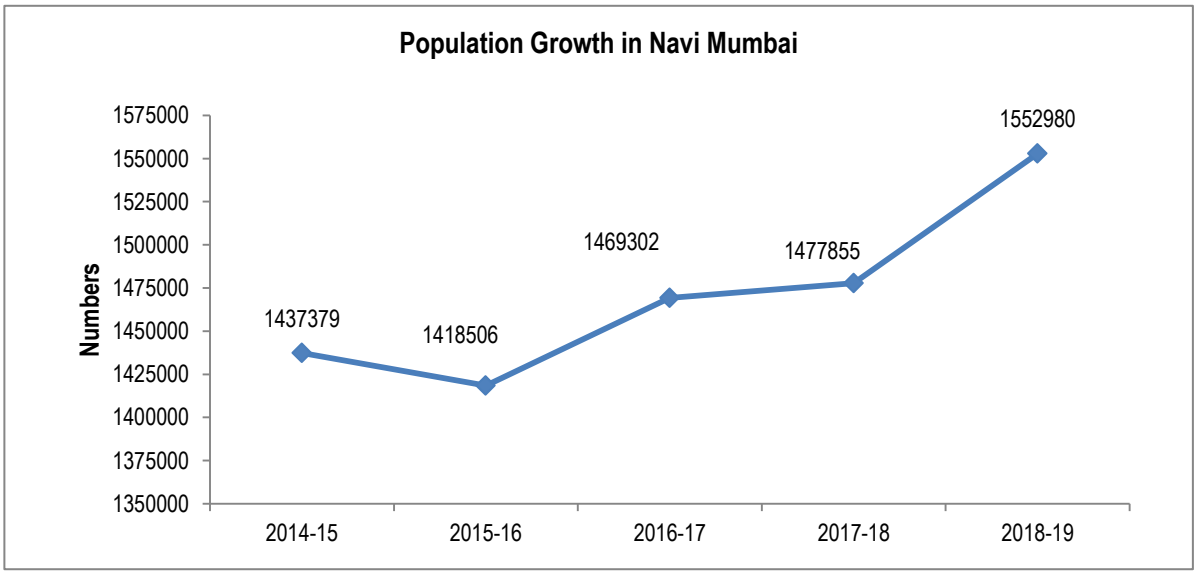


Figure No. 10: Population trend in Navi Mumbai city

The rapid expansion of urban area pertaining with population growth puts additional demand on natural resources thereby causing land use changes in such cities. Looking at the population growth, the trend is expected to grow in all nodes of the city at faster pace.

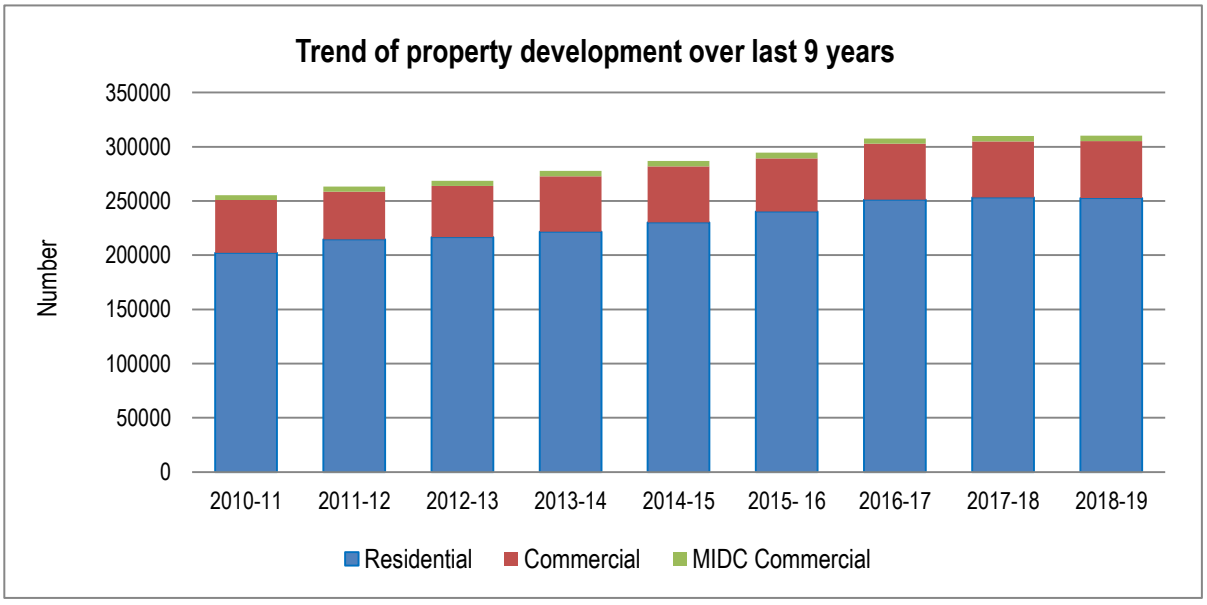


Figure No. 11: Increasing trend of Property development in Navi Mumbai

Source: Property Tax Department, NMMC

Since last 9 years, the city has witnessed over 21% rise in properties. In 2018-19, total number of properties rose to 3, 10,222 from 3,09,841 in 2017-18 (Figure No. 11). Residential sector holds major share of the properties (~82%) followed by commercial (~17%) and then MIDC commercial with least of 1% share.

Industrial and Commercial sector

Navi Mumbai witnessed rapid industrialization after the development of an industrial belt often called as Trans Thane Creek –Maharashtra Industrial Development Corporation (TTC-MIDC) area. The estate is spread over an area of around 27 sq kms and houses more than 2200 industrial units of various categories which includes manufacturing units of chemicals, dyes, pharmaceuticals, petrochemicals, textile and engineering. Besides this, the city is having well established Information Technology (IT) sector especially in Airoli, Ghansoli and Vashi node.

Apart from these industries, there is a presence of Central Business District (CBD) at Belapur node of the city. Major government agencies such as NMMC headquarters, City Industrial and Development Corporation (CIDCO) head office, Konkan Bhavan, Konkan Railway headquarters; Regional office of Reserve Bank of India (RBI) are located in Belapur. Along with the offices of the government agencies, CBD is home to offices/branches of several private firms especially shipping companies and call centres. Navi Mumbai has witnessed population growth/relocation of people from other parts due to job and business opportunities and better lifestyle.

Industrial and commercial sectors also exert pressure on city's natural resources and infrastructure facilities. Higher industrial activities also create environmental problems like air, water pollution and health issues associated with pollution. Migrating workforce also utilizes transport systems which puts an additional pressure on city's road infrastructure and also creates problems of traffic congestion, noise and air pollution.

Agriculture Produce Market Committee (APMC)

Apart from the industrial sector, CIDCO reserved certain areas for suitable commercial and trade establishments. One such establishment is Agricultural Product Market Committee (APMC) established on 160 HA land at Vashi by The State Government of Maharashtra in 1993[9]. It is one of the biggest centralized facilities for marketing agricultural produce. Agricultural produce from various parts of the country arrives at APMC which attracts a lot of wholesalers as well as retailers as it gets distributed to various suburbs of the city. APMC comprises of four markets divided into two phases.- Phase-I comprises Market I and Market –II for wholesale dealing of onion & potato and fruit & vegetable respectively whereas Phase-II has Market-I which is the commodity market and Market-II which is the grain, rice and oilseed market [10].

APMC gets its supply of fruits and vegetables from adjacent districts such as Nashik and Pune through trucks and tempos hence supply of food produce is associated with increased number of vehicles that are travelling to and fro APMC. The area also produces an average of 56-60MTs of organic waste per day which needs to be managed properly[11].

[9] http://shodhganga.inflibnet.ac.in/bitstream/10603/7214/7/07_chapter%203.pdf
[10] http://www.navimumbai.com/apmc.aspx#
[11] https://www.recity.in/apmc-waste-management

Jawaharlal Nehru Port Trust

Jawaharlal Nehru Port Trust (JNPT), one of the largest container port in India is located south to Navi Mumbai just approximately 10 kms from Belapur. This port, alone handles around 55% of the container cargo across all major ports in India[12]. JNPT has undertaken various developmental projects that would turn the surrounding area in to a major tourist destination and would generate nearly 1.25 lakhs jobs[13].

Efficient port system is necessary for economic development of the country but ship traffic, handling of goods; port related operations including transfer of goods from port via heavy vehicles also create negative impacts on port environment as well as its surrounding area.

Educational institutes

City also houses numerous educational institutes providing good quality education in engineering, medical and other professional field. Looking at this, students from all over the country come in the city for education. This not only increases the population of the city but it also puts pressure on existing infrastructure.

Malls and Retail stores

There are adequate utility services, malls, retail shops, multiplexes in Navi Mumbai. Vashi is the leading node compared to others having big and famous malls like Centre One, Raghuleela mall and Inorbit mall which are the best shopping destinations with stores like CROMA Electronics, Pantaloons Fashion store, Food Bazaar, Shoppers stop and many more reputed brands. There are 6 major operational malls in this zone. In addition to this there are many medium to small format retail outlets in Navi Mumbai.

Though malls and retail shops are convenient places for shopping, one must consider the negative impacts of such structures because these structures are also a source of pollution including air pollution, plastic pollution. Malls are one of the biggest consumers of electricity thus also acts as a greenhouse gas generators. To overcome such problems, following strategies must be applied to minimize the pressure on environment

- Green rating certification for such structures which helps in minimizing energy consumption and pollution.
- Zero discharge waste management system
- Use of environment friendly products as alternatives to traditional products.

Connectivity

Being a planned city, all nodes of the city are well connected to neighbouring Mumbai and Thane by roads and rapid transit system. In case of rail network, Navi Mumbai is well connected to Thane through Thane – Belapur rail link, similarly has an independent mainline rail terminal connecting the city directly to Chhatrapati Shivaji Maharaj Terminus (town side) as well as western parts of Mumbai.[14].

Recently, first phase of Nerul-Seawood-Uran railway line has started. Along with the existing stations of Nerul, Seawood and Belapur, this line connects two new stations namely

[12] http://www.jnport.gov.in/
[13] https://www.livemint.com/industry/infrastructure/jnpt-development-works-will-generate-1-25-lakh-jobs-nitin-gadkari-1550422996785.html
[14] http://www.nmmconline.com/nmmt

Bamandongri and Kharkopar. Targhar, another station which is under construction will soon be ready for commuting. The entire line is of about 27 km out of which first phase (12km) is complete and is in use. This line would further connect Navi Mumbai city to Uran.

Along with this, CIDCO is also working on 3 metro corridors namely Belapur-Pendhar, Pendhar-Taloja and Taloja-Khandeshwar which would increase the connectivity of Navi Mumbai area to places of Kharghar and Taloja. Once fully functional, these corridors would help in improving connectivity and also would reduce the traffic experienced currently by existing roads and highways[15].

The city is having network of roads across NMMC jurisdiction area including National Highway 4 (NH4) which passes through Dahisar (Navi Mumbai) and Kharghar which connects the city further to Pune and other parts of Maharashtra[16].

Transport

Being close to the vicinity of NMIA, which is under development, city's transport sector is witnessing major upliftment Along with road and rail routes, government is also planning to open water ways wherein the passengers from Mumbai, Navi Mumbai and Alibaug can commute using speed boat taxis.

Table No. 7: Overview of NMMT Bus service

Sr. No.	Item	Type	Nos
1.	Buses (Non - AC)	Diesel	280
		CNG	131
2.	Buses (AC)	Diesel	80
		CNG	--
		Hybrid	02
3.	Number of Depots		3
4.	Number of Routes		71
5.	Number of passengers travelling in a month		6274695
6.	Distance travelled by buses per day	Diesel	246km/bus
		CNG	246km/bus

Source: NMMT

[15] https://indianexpress.com/article/cities/mumbai/mumbai-cidco-mobility-plan-to-improve-connectivity-5478806/

[16] http://lib.unipune.ac.in:8080/xmlui/bitstream/handle/123456789/3068/11_chapter%203.pdf?sequence=11&isAllowed=y

Effective transport system makes commuting easy but it is also associated with rise in vehicles and its impacts on environment. Environment regulation in developed countries has reduced the individual vehicle's emission but this has been offset by an increase in the number of vehicles, and increased use of each vehicle.

City expansion and its connectivity and transport to other surrounding areas makes commuting smooth but it also creates problems of traffic congestions, increased pollutant emissions associated with the vehicles, noise pollution and health effects associated with air and noise pollution.There has been a steady increase in number of vehicle registration. Compared to previous year (2017-18), around 9% increase was recorded in vehicle registration in current year.

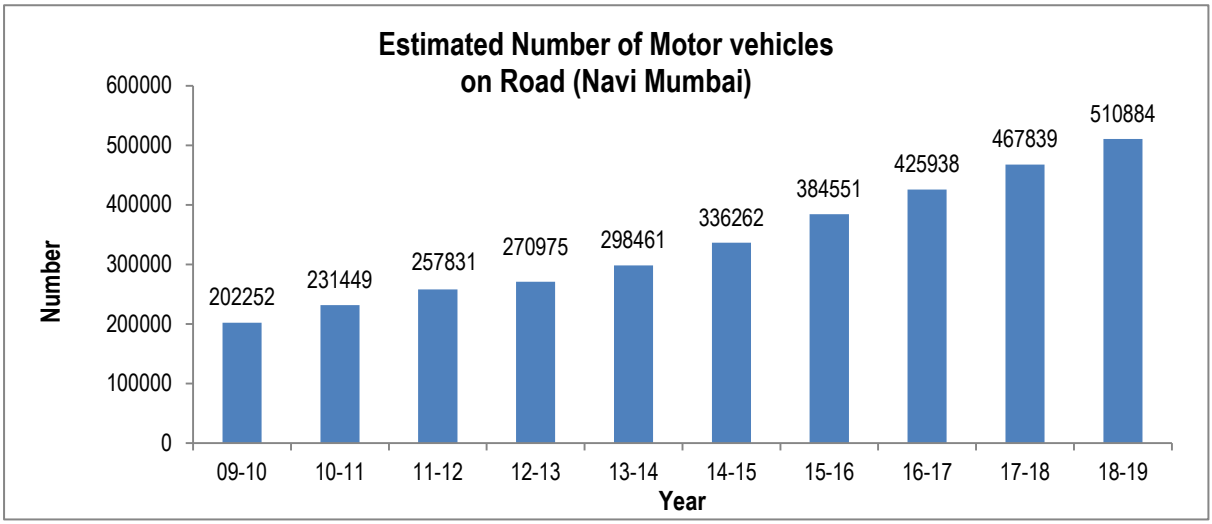


Figure No. 12: Estimated number of Motor vehicles on Road in Navi Mumbai

Source: Dy. Transport Regional Office, Navi Mumbai

Tourist places in and around Navi Mumbai

There are many tourist places in and around Navi Mumbai which gets visited by number of tourists/visitors every year. Few of these locations are mentioned below

- Swachhata park, Koparkhairane
- Coastal and Marine Biodiversity Centre, Airoli
- D.Y.Patil stadium
- Wonder park, Nerul
- Mango garden, Belapur
- Gavlidev trek and waterfall, Ghansoli
- Pandavkada fall, Kharghar to name a few.

Tourism creates many job opportunities and helps in economic development but it also one of the major factor which puts pressure on resources and the environment. Tourism alone accounts for 5% of CO_2 emissions globally[17]. Tourism also affects aesthetic quality of environment by improper disposal of litter and harming vegetation. To avoid such issues, promotion of eco-tourism is required.

[17] https://greentumble.com/environmental-impacts-of-tourism/

Air Quality

The earth is surrounded by the atmosphere which is composed of several gases. This mixture of gases is known as air. It contains roughly 78% nitrogen and 21% oxygen, 0.97% argon and 0.04% of carbon dioxide along with trace amounts of other gases, and water vapour. Emission of pollutants in air results in air pollution. The presence of any air pollutant (means any solid, liquid or gaseous substance [(including noise)] present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment) is termed as air pollution[18]. Air pollution arises from natural sources like volcanic eruptions, forest fires, combustion gases and dust storm. Mainly anthropogenic activities like combustion of fossil fuels, construction activities and. emissions from power plants, industries and automobiles are main contributors which deteriorate the air quality[19].

About 91% of the world's population lives in places where air quality exceeds WHO (World Health Organisation) guideline limits. As per the estimates by WHO, there are about 4.2 million deaths every year as a result of exposure to ambient (outdoor) air pollution[20]. As per the Global Burden Report, in 2017 outdoor and indoor air pollution contributed to 1.2 million deaths in India[21].Air pollutants like Fine particles (PM2.5, particles < 2.5 microns in diameter; Ultra-Fine Particles) can penetrate deeper into the lungs and cause asthma, bronchitis, as well as premature death from heart ailments, lung disease, and cancer. The other pollutants like Sulphur dioxide, oxides of Nitrogen, Ozone, Carbon Monoxide and can cause eye irritation, worsens asthma, increases susceptibility to respiratory infections, and impacts the cardiovascular system[22].

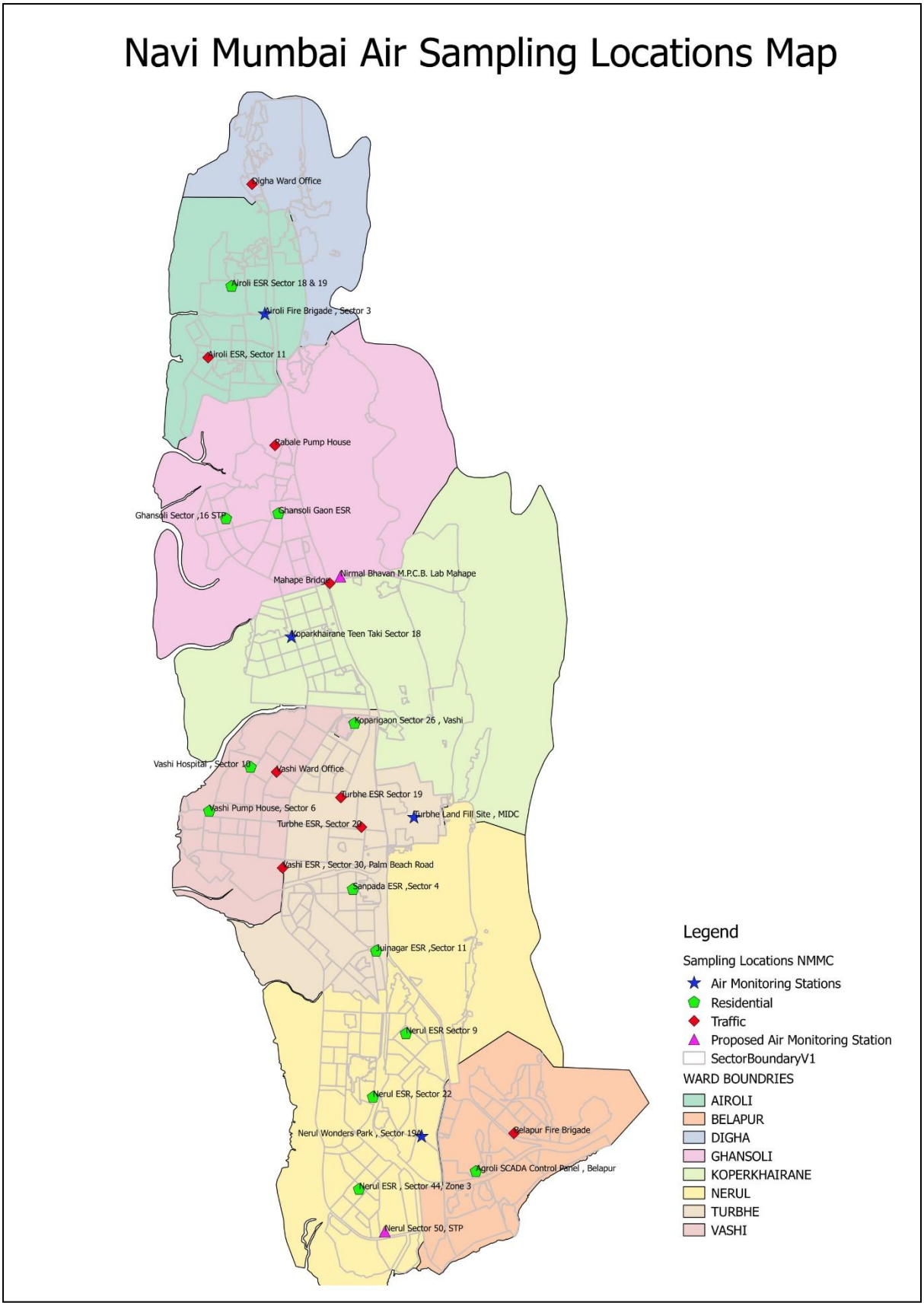
In order to monitor the air quality at National level, the CPCB (Central Pollution Control Board has established Ambient Air Quality Monitoring Network. At state level this network is monitored by MPCB (Maharashtra Pollution Control Board) and at city level NMMC also monitors the air quality parameters. The status of the active air monitoring network and air quality in Navi Mumbai is discussed in sections below:

Status

Air Quality Monitoring Network

In order to monitor the air quality across the city, NMMC has established a network of 3 CAAQMS (Continuous Ambient Air Quality Monitoring Stations) at Airoli, Koparkhairane and, Turbhe. In addition, the corporation also operates a mobile monitoring van which is deputed at various locations in the nodes of Navi Mumbai to monitor the air quality. These stations monitor various parameters like SO_2 (Sulphur-dioxide), NOx (Oxides of Nitrogen), PM (Particulate Matter), Methane, CO (Carbon Monoxide) and so on. MPCB in collaboration with NMMC has also proposed installation of AAQMS at Nerul Sector 50 and Mahape Industrial Area. The tally of active and proposed ambient air quality monitoring stations and their spatial representation is depicted in Map No 2

[18] The Air (prevention and control of pollution) act, 1981
[19] https://sciencing.com/difference-between-human-natural-air-pollution-23687.html
[20] https://www.who.int/airpollution/en/
[21] https://www.thehindu.com/sci-tech/energy-and-environment/over-12m-early-deaths-in-india-in-2017-due-to-air-pollution-report/article26719117.ece
[22] https://www.edf.org/health/health-impacts-air-pollution



Map No 2: Spatial representation of existing and proposed CAAQMS in NMMC area

Source: Environment Laboratory, NMMC

Trend in SO_2 concentrations

Sulfur dioxide (SO_2), a non-flammable highly toxic, colourless gas is primarily emitted from anthropogenic sources like burning of fossil fuels by power plants and other industrial facilities as well as fuel combustion in mobile sources such as locomotives, ships, and other equipment[23,24]. Health effects caused by exposure to high levels of SO_2 include breathing problems, respiratory illness, changes in the lung's defences, and worsening respiratory and cardiovascular diseases. People with asthma or chronic lung or heart disease are the most sensitive to SO_2. It also damages trees and crops. SO_2, along with nitrogen oxides, are the main precursors of acid rain. This contributes to the acidification of lakes and streams, accelerated corrosion of buildings and reduced visibility. SO_2 also causes formation of microscopic acid aerosols, which have serious health implications as well as contribute to climate change[25].

As seen in Table No. 8 and Figure No. 13, the annual SO_2 concentrations for all the 3 continuous monitoring stations are well below the annual average standards for SO_2 (50µg/m³) as per National Ambient Air Quality Standards (NAAQS) set by CPCB. In the current year 2018-19, the levels of SO_2 concentration at Koparkhairne and Airoli has increased by 1.26 times as compared to previous year 2017-18.

Table No. 8. Yearly trend of concentration of SO_2 at CAAQMS in Navi Mumbai

Year	Koparkhairne ((µg/m³)	Airoli (µg/m³)	Turbhe (µg/m³)
Annual Standard	50	50	50
2012-13	32.245	21.25	50.08
2013-14	20.3	22.00	45
2014-15	14.46	17.92	42.79
2015-16	37.36	26.05	44.46
2016-17	28.84	25.50	36.24
2017-18	22.33	26.18	35.61
2018-19	28.11	33.30	35.00

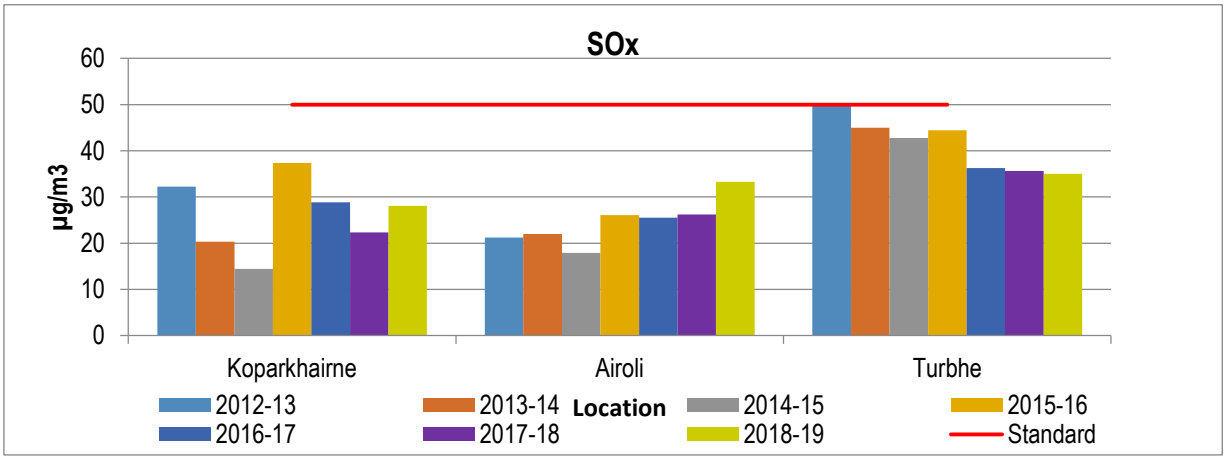


Figure No. 13: Yearly Trend in concentration of SO_2 at AAQMS in Navi Mumbai
Source: Environmental Laboratory, NMMC
Kindly note that data for 7 months (September to March 2019) at Turbhe station was not available due to technical issues in the current year 2018-19

[23] https://www.pca.state.mn.us/air/sulfur-dioxide
[24] https://www.epa.gov/so2-pollution/sulfur-dioxide-basics

Trend of NOX concentrations

Nitrogen oxides are a group of seven gases and compounds composed of nitrogen and oxygen. The two most common and hazardous nitrogen oxides are nitric oxide (NO) and nitrogen dioxide (NO_2). Vehicular exhaust, emissions from coal-fired power plants , combustion of fossil fuels and solid waste are primary contributors of NOx[26].Short term exposure to this pollutant can result in nausea, headache and irritation of eyes and skin, whereas long term exposure can cause asthma and other respiratory disorders.

From Table No. 9 and Figure No. 14, it is observed that NOx concentrations were found to be within permissible limit (40 µg/m³) in 2018-19 across all the CAAQMS. The decline curve in NOx levels is observed at Airoli by 1.5 times the observation recorded in previous year 2017-18. Koparkhairne station shows increase in NOx concentrations by 1.1 times as compared to previous year 2017-18. Kindly note that the data at Turbhe station for 7 months is not available due to technical issues.

Table No. 9: Yearly trend in concentration of NO_X at AAQMS in Navi Mumbai

Year	Koparkhairne (µg/m³)	Airoli(µg/m³)	Turbhe (µg/m³)
Annual Standard	40	40	40
2012-13	80.34	77.69	22
2013-14	63.83	46.38	30
2014-15	42.53	27.25	35
2015-16	57.40	42.35	33.30
2016-17	28.00	40.00	29.00
2017-18	34.12	34.47	37.80
2018-19	37.61	22.64	34.30

Source: Environmental Laboratory, NMMC

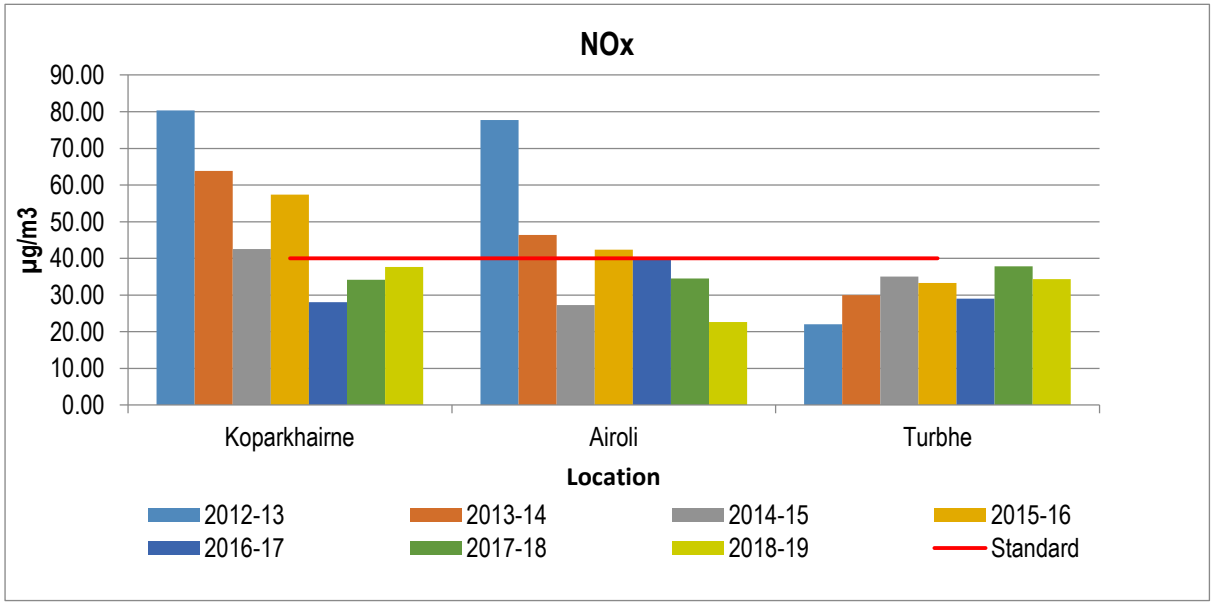


Figure No. 14: Yearly Trend in concentration of NOx at AAQMS in Navi Mumbai
Source: Environment Laboratory, NMMC.
Kindly note that data for 7 months (September to March 2019) at Turbhe station was not available due to technical issues in the current year 2018-19

[26] https://toxtown.nlm.nih.gov/chemicals-and-contaminants/nitrogen-oxides

Particulate Matter (PM)

Particulate matter (PM) is microscopic solid or liquid matter suspended in the Earth's atmosphere. This complex mixture is sum of all solid and liquid particles suspended in air which includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets. Depending on their size, composition, and origin, these particles are divided into two major categories- Suspended Particulate Matter (SPM) and Respirable Suspended Particulate matter (RSPM).

Trend of SPM concentrations

It is observed that levels of SPM exceeded the annual standard (60µg/m³) at all CAAQMS. However, the decrease in levels of SPM concentrations is observed at all CAAQMS in Navi Mumbai. Koparkhairne shows 14% decrease in level of SPM as compared to last year. This may be due to closure of construction activities in the node and various initiatives taken by the corporation to curb the air pollution. Kindly note due to technical issues data for 7 months (September to March 2019) at Turbhe station is not available.

Table No. 10: Yearly trend in concentration of SPM at AAQMS in Navi Mumbai

Year	Koparkhairne	Airoli	Turbhe
Annual Standard	60	60	60
2012-13	176.41	161.41	204.64
2013-14	135.53	74.60	151.20
2014-15	137.31	139.67	187.86
2015-16	138.62	78.43	154.95
2016-17	99.44	55.81	97.69
2017-18	133.87	90.33	154.22
2018-19	114.74	90.67	84.00

Source: Environmental Laboratory, NMMC

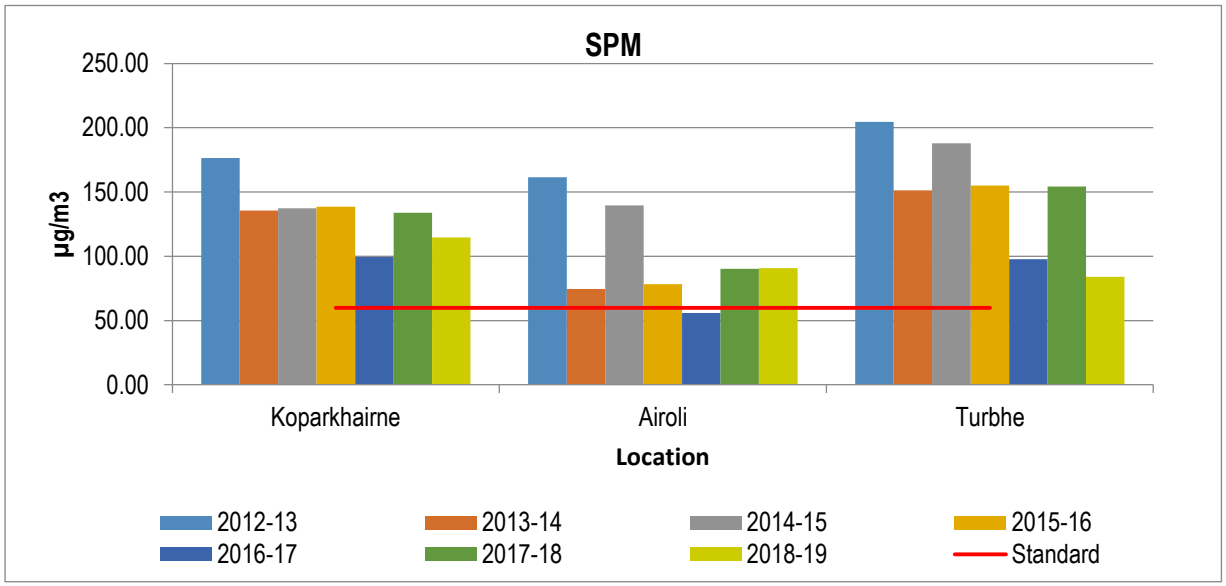


Figure No. 15: Yearly Trend in concentration of SPM at AAQMS in Navi Mumbai
Source: Environment Laboratory, NMMC
Kindly note that data for 7 months (September to March 2019) at Turbhe station was not available due to technical issues in the current year 2018-19

Trends in RSPM concentrations

From Table No. 11 and Figure No. 16, RSPM levels in Navi Mumbai are within the prescribed limits (40 µg/m³). The trend in Turbhe node has decreased by 1.6 times as compared to previous year 2017-18. Though under permissible limits, Airoli CAAQMS recorded increase in RSPM levels from 15.75 µg/m³ to 22.06 µg/m³ in 2018-19.

Kindly Note Data for 7 months (September 2018 to March 2019) is not available due to technical issues at Turbhe Station. For the current year, data for RSPM levels at Koparkhairne was under "No data" category.

Table No. 11: Yearly trend in concentration of RSPM at AAQMS in Navi Mumbai

Year	Koparkhairne	Airoli	Turbhe
Annual Standard	40	40	40
2012-13	74.89	50.46	71.16
2013-14	64.63	18.11	54.20
2014-15	63.98	42.82	71.57
2015-16	61.62	31.85	65.50
2016-17	40.92	24.03	49.79
2017-18	29.16	15.75	58.46
2018-19		22.06	36.77

Source: Environmental Laboratory, NMMC

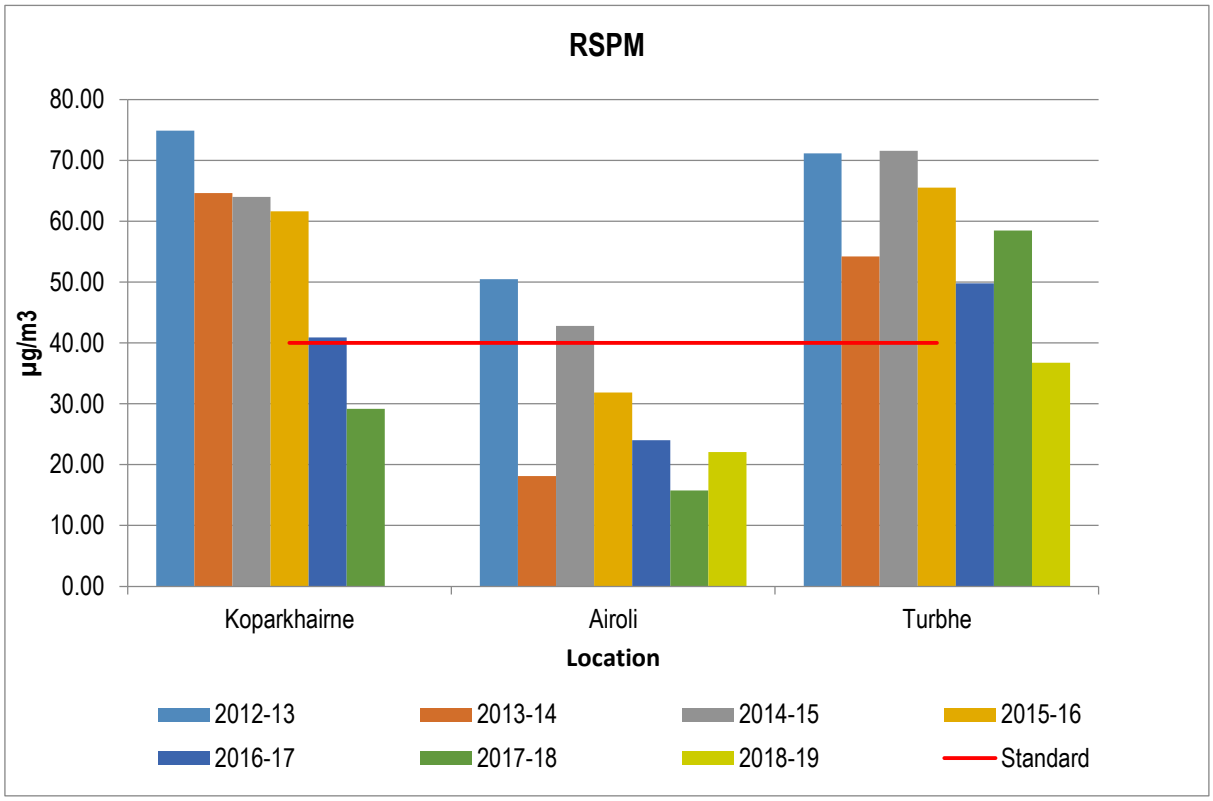


Figure No. 16: Yearly Trend in concentration of RSPM at AAQMS in Navi Mumbai
Source: Environment Laboratory, NMMC

Note: Data for 7 months (September to March 2019) at Turbhe station was not available due to technical issues in the current year 2018-19

Inter Station Analysis

SO_2

The interstation analysis for concentration of SO_2 presented in Figure No. 17and Table No. 12 indicates that the annual SO_2 concentrations at all the 3 stations are under the annual standards (50µg/m³). The 98th percentile values for daily concentrations at Airoli (59.76 µg/m³) slightly exceeded 1.2 times the annual standard, followed by Koparkhairane which recorded 52 µg/m³.

Table No. 12: Concentration of SO_2 across NMMC region (2018-19)

Station Name	Max of SO_2	98 Percentile	Average of SO_2	Min of SO_2	Daily Standard	Annual Standard
Airoli	642.05	59.76	33.30	1.01	80	50
Koparkhairne	881.24	52.17	28.11	5.56	80	50
Turbhe	200.9	25.14	35	1.5	80	50

Source: Environment Laboratory, NMMC

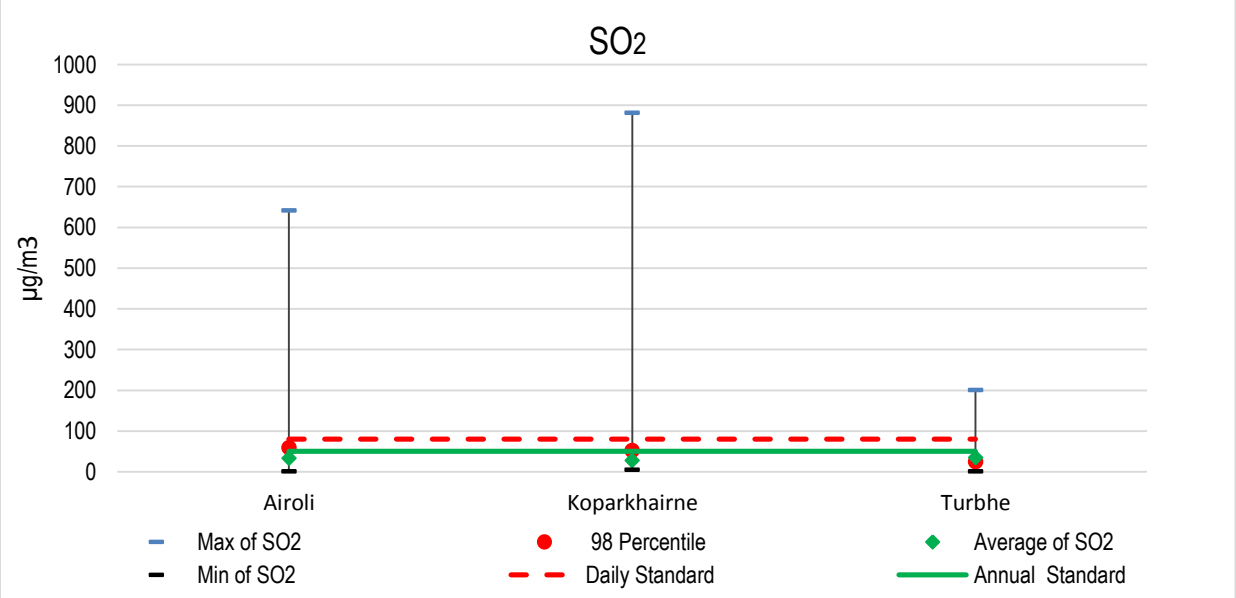


Figure No. 17: Concentration of SO2 in NMMC region for the year 2018-19
Source: Environment Laboratory, NMMC

Note: Data for 7 months (September 2018 to March 2019) is not available due to technical issues at Turbhe Station.

NOx

The interstation analysis for concentration of NOx displayed in Table No. 13 and Figure No. 18 indicate that all 3 stations are within the annual standard (40µg/m³). The 98 percentile values of all 3 stations were recorded within the limit (80 µg/m³). The daily highest peak was noted at Koparkhairne (1023.79 µg/m³) followed by Airoli and Turbhe (863 µg/m³) in 2018-19.

Table No. 13: Concentration of NO_X across NMMC region (2018-19)

Station Name	Max of NO_X	98 Percentile	Average of NO_X	Min of NO_X	Daily Standard	Annual Standard
Airoli	863.77	52.51	22.65	1.21	80.00	40.00
Koparkhairne	1023.79	75.49	37.61	0.34	80.00	40.00
Turbhe	863.77	77.87	34.30	3.40	80.00	40.00

Source: Environment Laboratory, NMMC

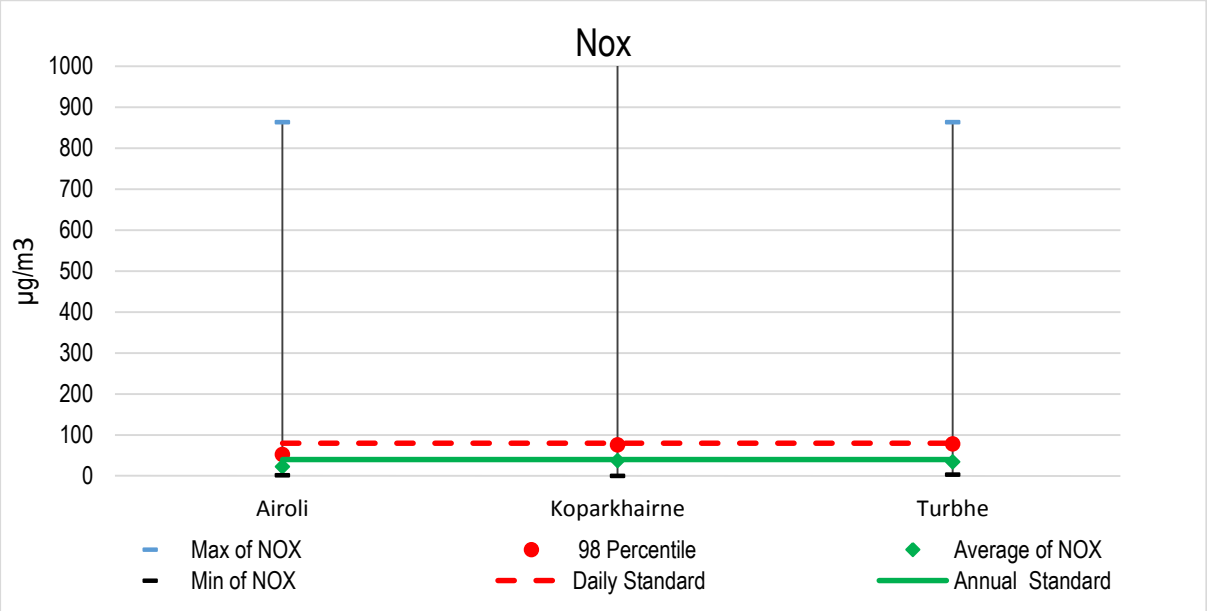


Figure No. 18: Concentration of NO_X in NMMC region for the year 2018-19
Source: Environment Laboratory, NMMC
Note: Data for 7 months (September 2018 to March 2019) is not available due to technical issues at Turbhe Station.

RSPM

Interstation analysis for concentration of RSPM is represented in Table No. 14 and Figure No. 19. All 3 CAAQMS were observed to be within the permissible limit (40 µg/m³). The analyses indicate that the 98 percentile for Turbhe station exceeds the.1.5 times the Daily standard (60 µg/m³). The daily highest levels of RSPM were recorded at Turbhe with 954 µg/m³, followed by Airoli which recorded 58 µg/m³.

Table No. 14: Concentration of RSPM across NMMC region (2018-19)

Station Name	Max of PM 2.5	98 Percentile	Average of PM 2.5	Min of PM 2.5	Daily Standard	Annual Standard
Airoli	58.25	53.23	22.06	29.15	60.00	40
Koparkhairne					60.00	40
Turbhe	954.90	89.12	36.78	1.40	60.00	40

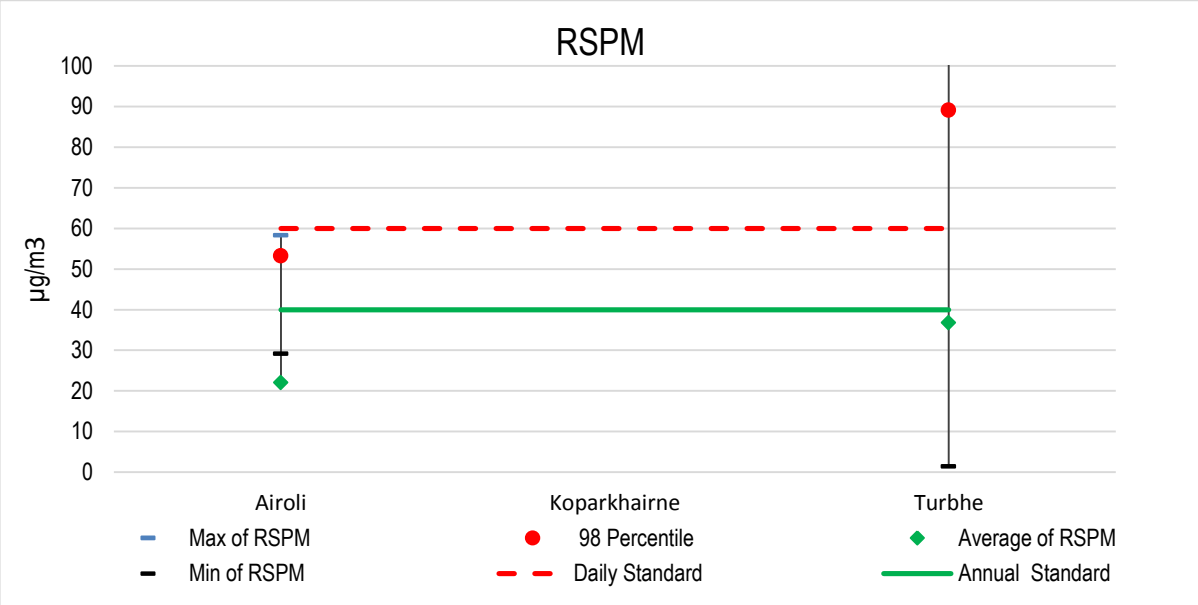


Figure No. 19: Concentration of RSPM in NMMC region for the year 2018-19
Source: Environment Laboratory, NMMC

Note: Data for 7 months (September 2018 to March 2019) is not available due to technical issues at Turbhe Station

SPM

The interstation analysis for concentration of SPM is depicted in Table No. 15 and Figure No. 20. The average concentration of SPM was found to be highest at Koparkhairne (114.74 µg/m³), followed by Airoli (90.67µg/m³) by 1.9 times and 1.5 times respectively as compared to standard prescribed by CPCB (60 µg/m³). The 98 percentile readings also exceeded the daily standards (100µg/m³) for all the stations.

The highest reading was noted at Turbhe (985 µg/m³) followed by Airoli (871.5 µg/m³.) and Koparkhairne (820.19 µg/m³).

Table No. 15: Concentration of SPM across NMMC region (2018-19)

Station Name	Max of PM10	98 Percentile	Average of PM10	Min of PM10	Daily Standard	Annual Standard
Airoli	871.5	263.79	90.67	0.22	100	60
Koparkhairne	820.19	315.08	114.74	0.5	100	60
Turbhe	985	269.26	84.00	0.23	100	60

Source: Environmental Laboratory, NMMC

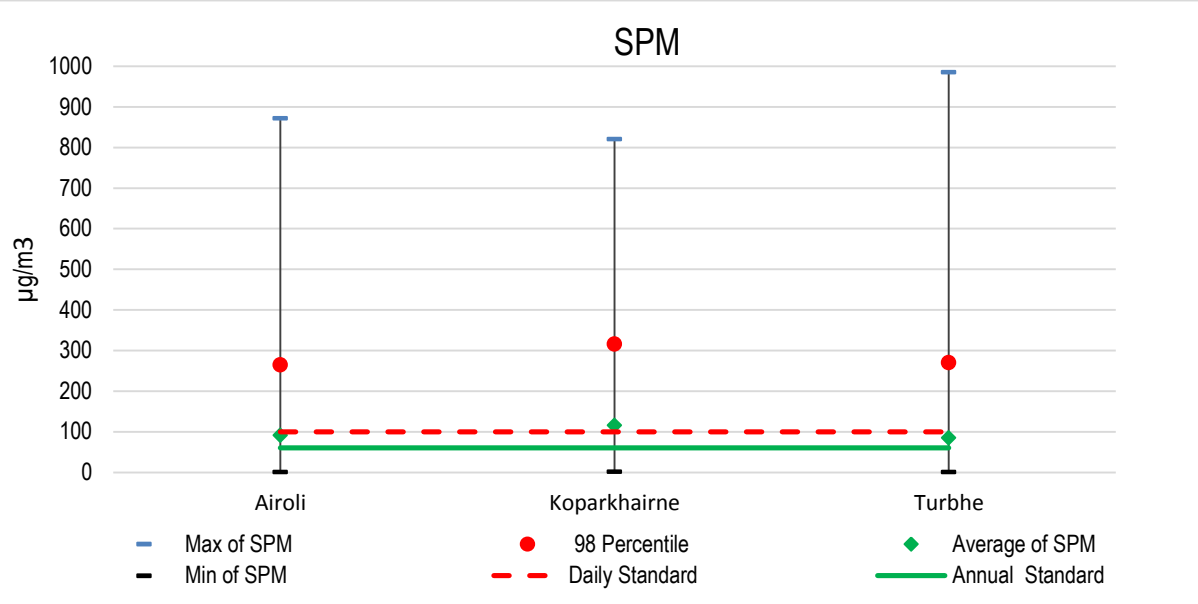


Figure No. 20: Concentration of SPM in NMMC region for the year 2018-19
Source: Environment Laboratory, NMMC

Note: Data for 7 months (September 2018 to March 2019) is not available due to technical issues at Turbhe Station

Carbon monoxide

From Figure No. 22, it is observed that all CAAQMS exceeded the concentration levels of Carbon Monoxide in few months as prescribed by CPCB (2 mg/m^3). A seasonal pattern can be observed in the concentration of CO as recorded by all stations. The maximum 8 hourly CO concentration was recorded at Koparkhairne AAQMS in February (3.2 mg/m^3) during 0-8 hours, followed by Turbhe which recorded 2.6 mg/m^3 in May month during peak hours (16-24 hours).

Ozone

The levels of ozone recorded by the station at Koparkhairane are represented in Figure No. 21. The ozone concentration is well below the standards (100 µg/m^3). The annual average concentration is observed in month of November (29 µg/m^3). Overall Navi Mumbai was non polluted in terms of ozone concentrations.

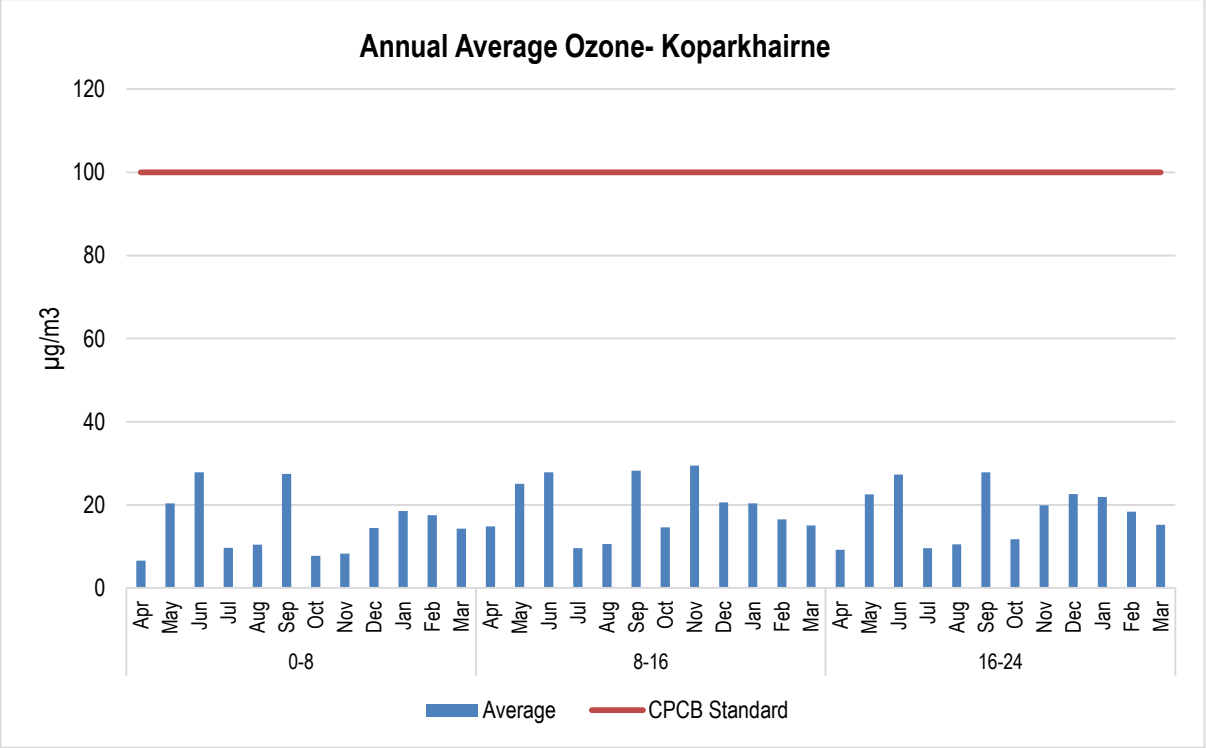


Figure No. 21: Concentration of Ozone in NMMC region for the year 2018-19

Source: Environment Laboratory, NMMC

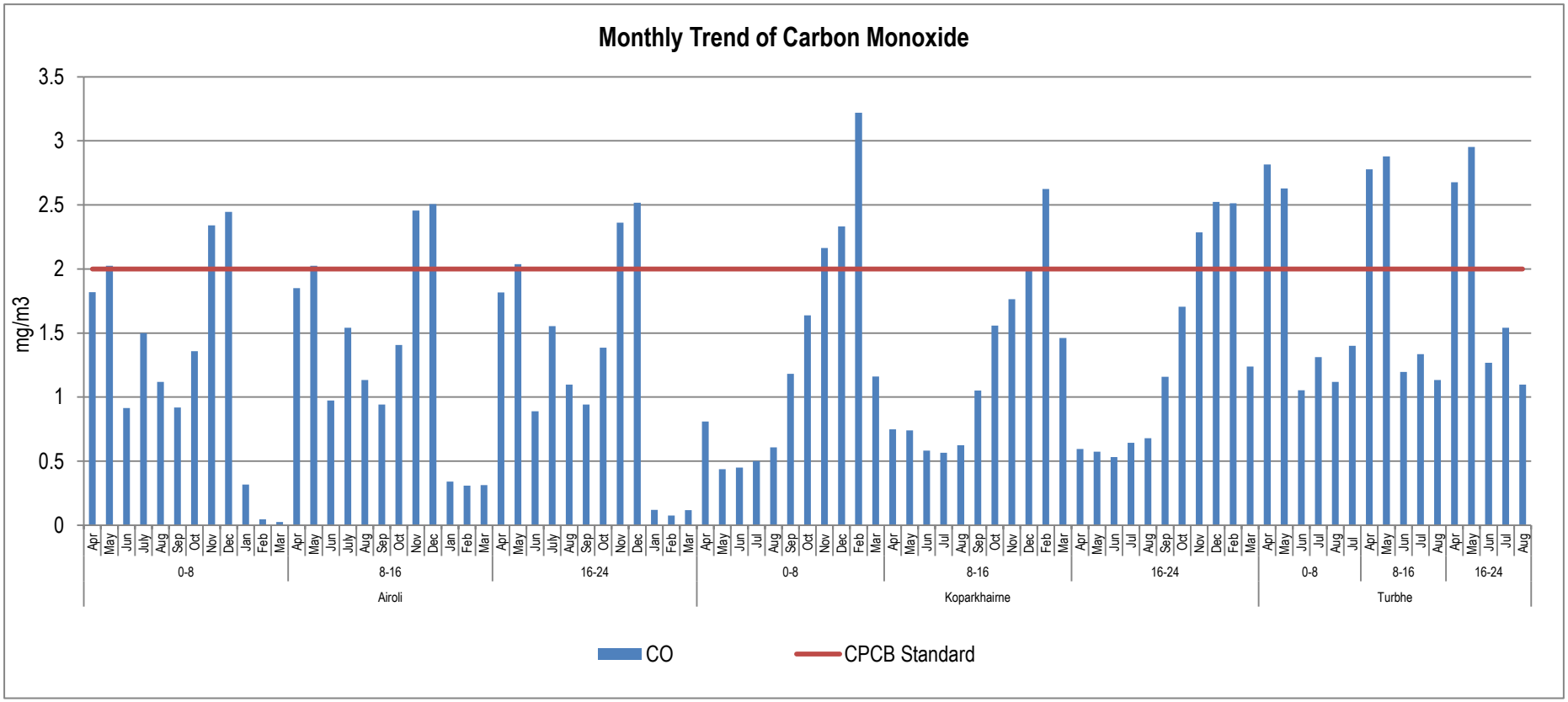


Figure No. 22: Concentration of Carbon Monoxide in NMMC region for the year 2018-19

Source: Environment Laboratory, NMMC

Air Quality Index

Air Quality Index (AQI) is effective tool to study status of the air quality in the region. It transforms complex air quality data of various pollutants into a single index value, which are easy to understand by common people. The AQI is expressed in terms of the air quality being Good, Satisfactory, Moderate, Poor, Very Poor or severe based on the concentrations of various pollutants and their health impacts at various concentrations. The AQI for Navi Mumbai has been calculated based on the calculation of AQI developed, specifically for India, by CPCB in consultation with IIT (Indian Institute of Technology) Kanpur in the year 2014[27].

From Figure No. 23, it is observed that Navi Mumbai is clean for NOx, SO_2 and Ozone pollutants as most of the observations are either in Good or Satisfactory category. In terms of Carbon Monoxide (CO), 23% of total observations were recorded under Moderate category.

In terms of SPM, about 38% of observations are under Satisfactory category followed by 30% under Good category at Airoli node of Navi Mumbai. At Koparkhairne about 42% of observations were seen under Moderate category followed by 31 % under Satisfactory and 17 % under Good category. Similarly Turbhe node recorded 36%under satisfactory category followed by 30% of observations under Good category. However no data was available for 7 months (September 2018 to March 2019) at Turbhe Node in the current year 2018-19.About 9% of observations was recorded under Poor category in terms of SPM for all 3 CAAQMS. About 5% of total observations for SPM were recorded under No data category.

For RSPM, Turbhe showed 37% of air quality was recorded under Good category whereas 29% observations were observed under satisfactory category. 5% of observations under Moderate category and only 1% were seen under Poor category in Turbhe node. The air quality at Airoli was observed under satisfactory category with 25% of total observations. No data was recorded for Koparkhairne in terms of RSPM in the current year 2018-19 due to technical failure.

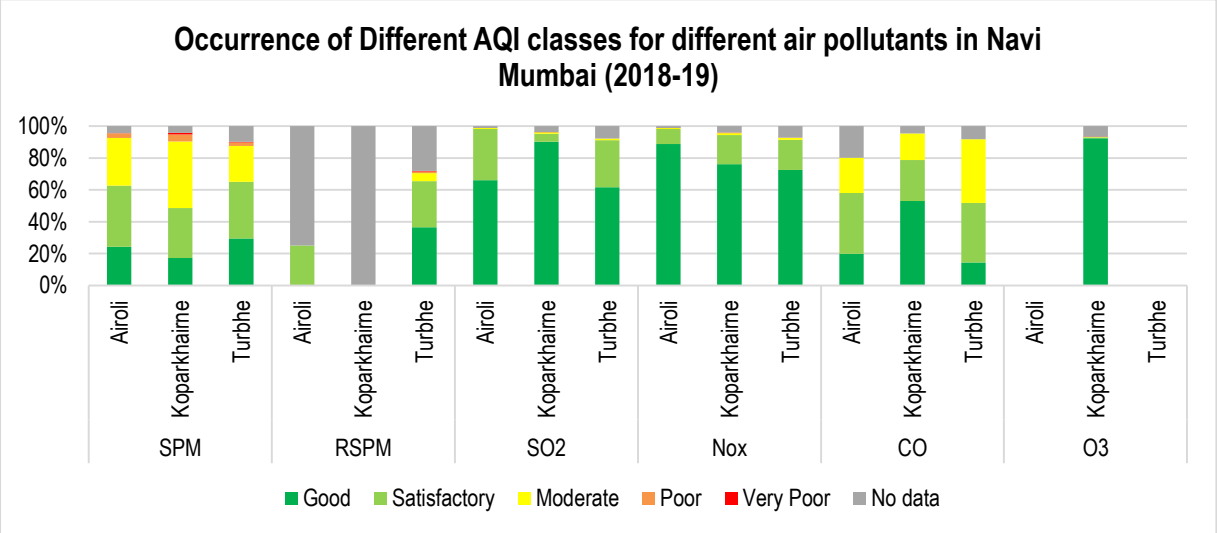


Figure No. 23: Occurrence of AQI classes for air pollutants in NMMC (2018-19)
Source: Environment Laboratory, NMMC
**Note: Ozone was not monitored at Airoli and Turbhe in 2018-19 and Data for 7 months (September 2018-March 2019) at Turbhe is not available in current year 2018-19*

[27] CPCB 2014, *National Air Quality Index*, Central Pollution Control Board, Ministry of Environment & Climate Change, Government of India

Noise Pollution

The noise levels monitored within Navi Mumbai city is represented in Figure No. 24. All locations under commercial zones recorded within the permissible limit (65 dB) as per The Noise Pollution (Regulation and Control) Rules, 2000[28]. The area near Ghansoli STP (Sector 15), Ghansoligaon GSR and Airoli ESR (Sec- 18 & 19) recorded the highest average noise level (61 dB). The lowest average noise level was recorded at area near Juinagar ESR, Sector 11 (59 dB).

All locations within the residential zones violated the day (55dB) time standards. The Nerul ESR (Sector 9) recorded the highest average noise levels about 60 dB. The decline curve has been observed in Vashi Hospital, Sector 10 (59 dB) by 3% as compared to previous year (61 dB).

The traffic zones recorded noise levels in range of 61-67 dB. The Mahape Bridge recorded the highest noise level (67 dB) followed by the Belapur Fire Brigade, Digha Ward Office and Vashi Ward Office, Juhugaon (65 dB) The lowest nosie levels were observed at Turbhe ESR, Sector 19 (61 dB).

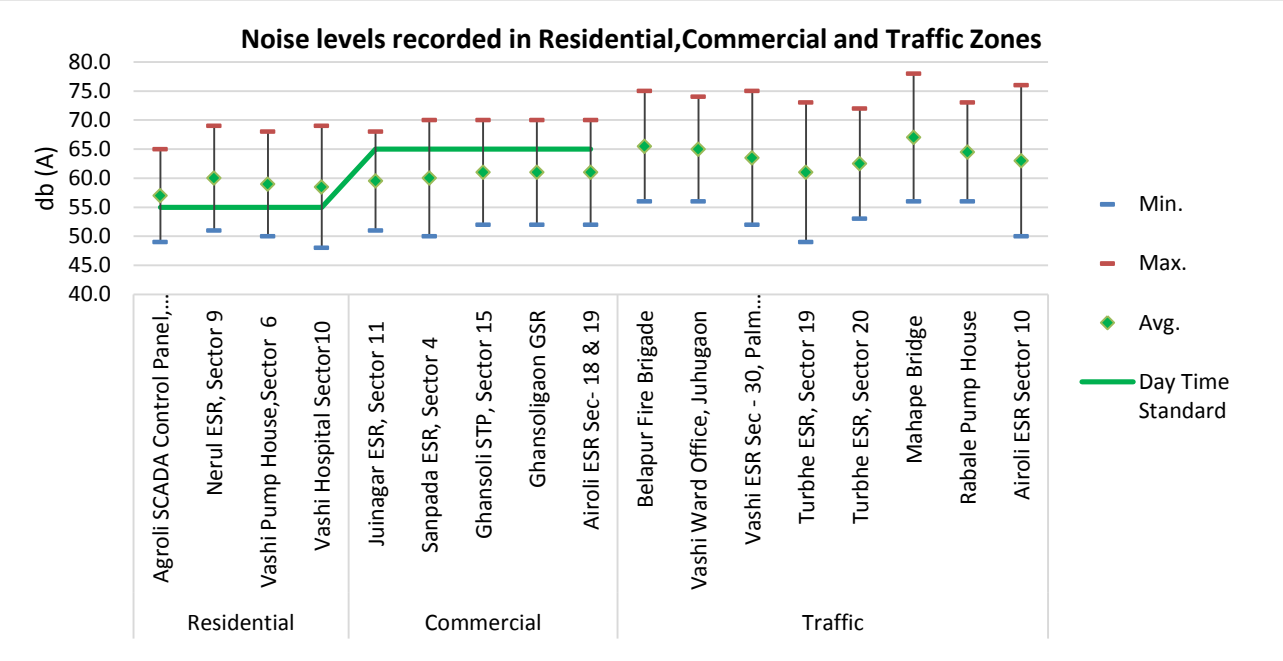


Figure No. 24: Level of noise pollution in various areas of Navi Mumbai

Source: Environment Laboratory, NMMC

[28] The Noise Pollution (Regulation and Control) Rules, 2000

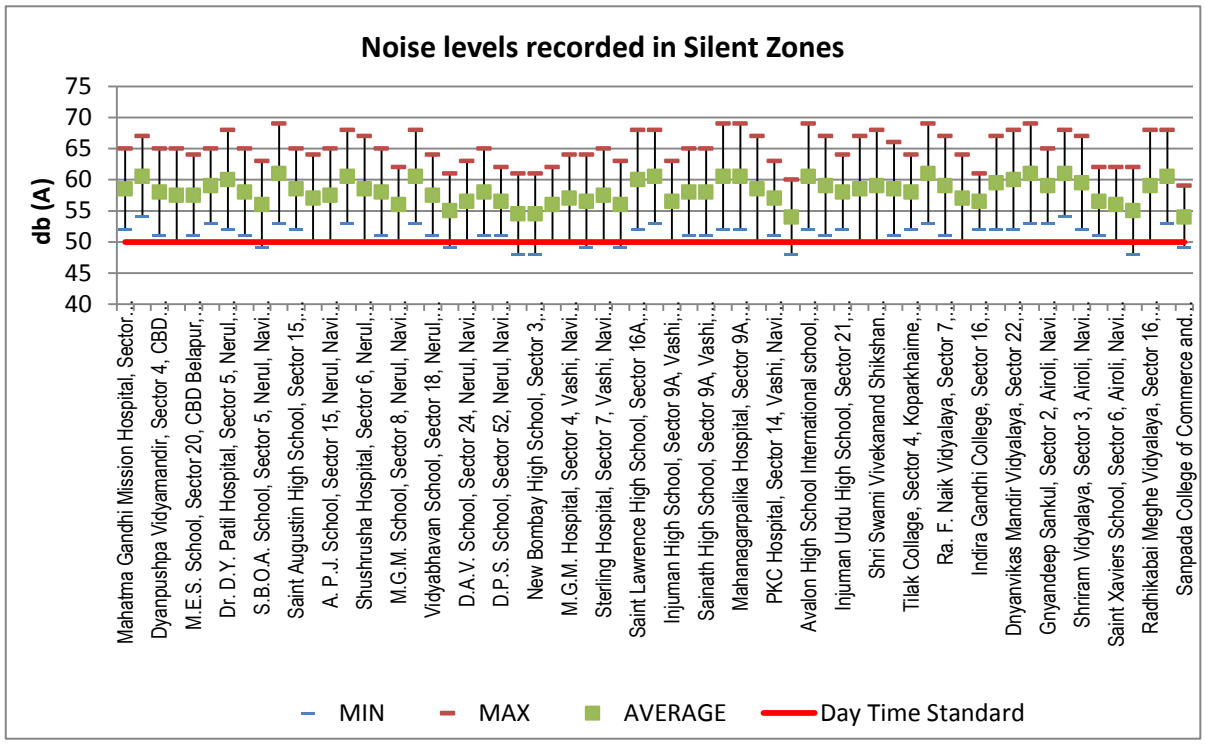


Figure No. 25: Level of noise pollution in silent areas NMMC area

Source: Environment Laboratory, NMMC

All stations in silence zone of Navi Mumbai exceed the average day standard limits of 50dB as represented in Figure No. 25. Dr. D.Y. Patil Vidyapeeth, Sector 7, Nerul recorded the highest average daily noise levels of 61dB. Sanpada College of Commerce and Technology (Sector 2) and Modern School, Sector 6, Vashi, recorded lowest average noise level (54 dB.)

The noise levels at St. Mary Junior college (61 dB) shows increasing trend by 8% as compared to previous year (56 dB).Similarly 7% increase in noise levels is observed at Bharitya Vidyapeeth (61 dB) as compared to previous year (57 dB).The noise levels at New Horizon,Sector 19 Airoli (54 dB) has decreased by 6% as compared to previous year 2017-18 which recorded 57.5 dB.

Pressures

Vehicular Growth

As per the Figure No. 26, there has been a steady increase in the number of vehicle registrations, and an overall increase in vehicle population on road, which has increased to about 43,045 (9.2%) as compared to previous year.

In the current year 2018-19, about 48% growth in number of Taxi/Auto rickshaws followed by 13% increase in number of other heavy vehicles is observed as compared to previous year. The Buses and 4 wheelers have decreased by 23% and 18% respectively as compared to previous year.

The total number of vehicles registered in Navi Mumbai (Category wise) is presented in Annexure 2.

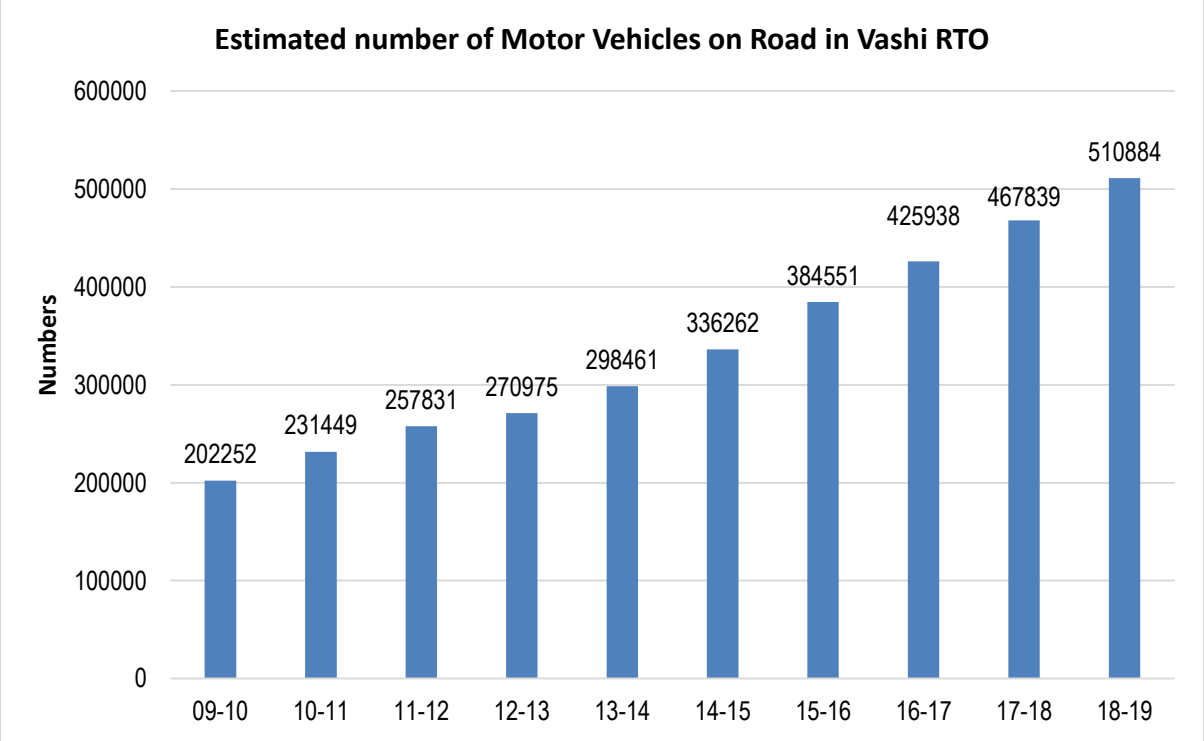


Figure No. 26: Estimated number of Motor Vehicles on Road in Vashi RTO

Source: Dy, Regional Transport office, Navi Mumbai

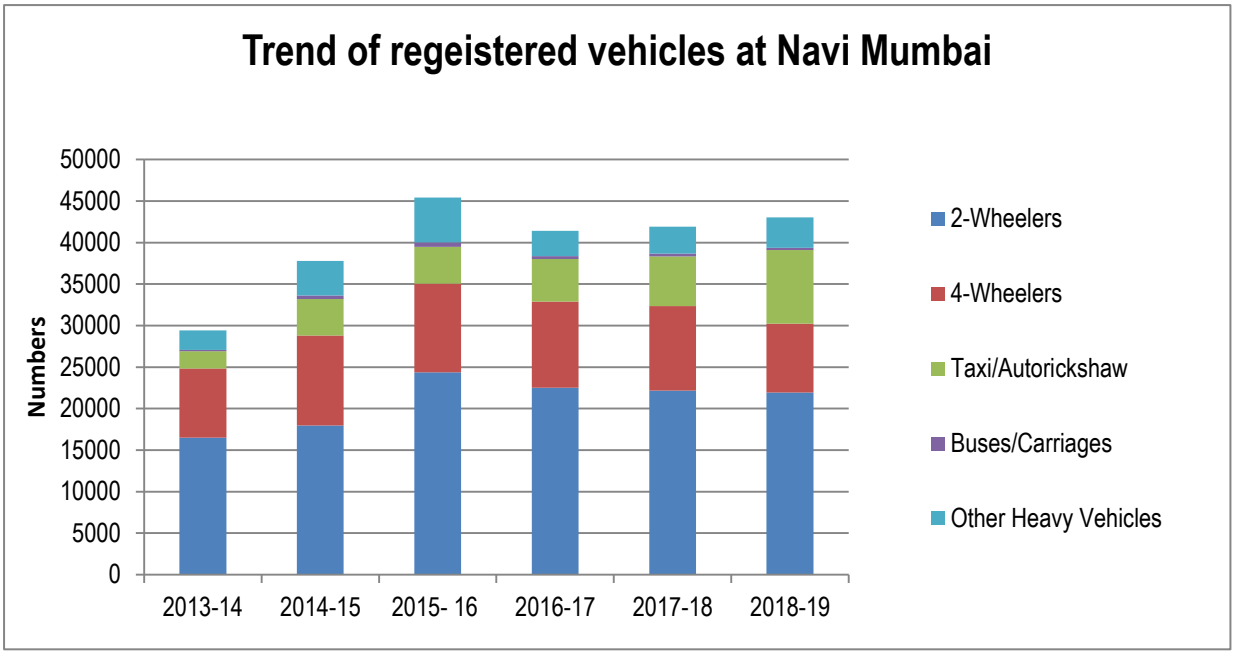


Figure No. 27: Decadal trend in annual vehicle registrations in Navi Mumbai

Source: Dy, Regional Transport office, Navi Mumbai

Fuel consumption by NMMC buses

Navi Mumbai Municipal Transport is a major Transportation Service serving people in Navi Mumbai and its outskirt cities. Compressed natural gas (CNG) and Diesel are used as source of fuel for transportation within Navi Mumbai.

As seen in Figure No. 28, major consumption of diesel is observed (65%) as compared to CNG (35%) is noted. As compared to previous year (2017-18), consumption of Diesel has increased by 6%, whereas use of CNG has decreased by 12% in 2018-19.

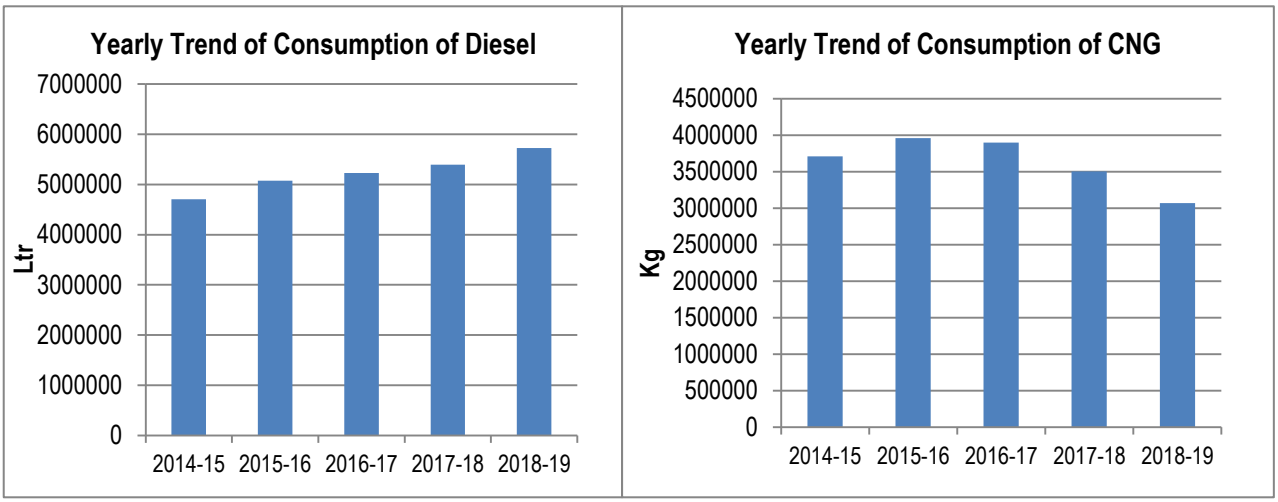


Figure No. 28: Fuel consumption by NMMC buses 2018-19

Source: NMMT

Impact

Diseases caused by air pollution

Depending on the exposure and duration, air pollutants can have impacts on human health at different levels. The air pollutants emitted in the atmosphere enter the human body through inhalation and gets absorbed in the blood which affects the vital organs. Respiratory and lungs diseases like Chronic Obstructive Pulmonary Disease (COPD), Leukemia, Pulmonary cancer, Pneumonia, Cardiovascular problems and Neurobehavioral disorders[29] are caused due to exposure of polluted air. Table No. 16 represents the effects of respective air pollutants.

Table No. 16: Effects of air pollutants on human health

Suphur Dioxide (SO_2)	• Affects respiratory system and lung function. Coughing, mucus secretion, asthma and chronic bronchitis. • Causes acid rain
Oxides of Nitrogen (NO_2)	• Bronchitis in asthmatic children. • Reduced lung function
Particulate Matter (PM_{10} & $PM_{2.5}$)	• Cardiovascular and respiratory diseases, • Lung cancer, • ALRI (Acute Lower Respiratory Infections)
Carbon Monoxide (CO)	• Reduces the oxygen carrying capacity of blood, • Causes headaches, nausea, and dizziness • Can lead to death at high levels
Ozone -Troposheric (O_3)	• Breathing problems, asthma, reduced lung function
Lead (Pb)	• Affects brain development in children, • At very high doses leads to poisoning, • May lead to brain and organ damage.

It is important to monitor these diseases in order to know the status of health condition of the city. However, there are gaps in collection and maintenance of the data regarding the above mentioned diseases in NMMC area. Thus it is recommended that NMMC should coordinate and maintain data for patients suffering from these disorders through a joint

[29] https://www.environmentalpollutioncenters.org/air/diseases/

effort between the private and public hospitals. A survey could also be conducted to determine the baseline and formulate new guidelines to regulate air pollution in the city.

Initiatives by NMMC

The Navi Mumbai Municipal Corporation (NMMC) has taken an initiative by initiating Public Bicycle Sharing System (PBS) to encourage the citizens to use bicycles as an alternative to public transport thereby reducing the carbon footprint of the city. The Corporation has established 12 locations for these cycles (Table No. 17).The NMMC proposed to extend these services to other nodes with an objective to provide at least 1 cycle per 100 citizens or minimum 1 lakh cycles in the city.

Table No. 17: List of Locations for Public Bicycle Sharing System

Sr No.	Location	Number of Cycles
1	Nerul Railway Station, Sector 20,Navi Mumbai 400706	20
2	Nerul Sector 26, Near Jewels of Navi Mumbai (Left Side Gate) , Navi Mumbai	20
3	Nerul Sector 26, Near Jewels of Navi Mumbai (Right Side Gate) , Navi Mumbai	10
4	Service Road,Sector 16,Navi Mumbai	10
5	Shankarnarayan Marg Darshan Society,sector14,Nerul, Navi mumbai	10
6	Sector 6, Nerul, Navi Mumbai	10
7	Wonder Park,Sector 19,Nerul, Navi Mumbai	20
8	Nerul Reginal Office, Sector4,Nerul,Navi Mumbai	20
9	Wadhawa Society, Sector4,Nerul	10
10	Great Eastern Gallery Corner, Sector 4, Nerul, Navi Mumbai	10
11	Dr.D.Y Patil College Gate,Nerul , Navi Mumbai	10
12	Chhatrapati Shahu Maharaj Udyan ,Sector 18, Nerul, Navi Mumbai	10

The scheme is being executed by Private Contractor (Yulu Bikes Pvt Ltd). Citizens will have to download a mobile app (Yulu Bikes) to rent the cycles and automatically pay through online techniques like PayTM, PayPal and so on[30].

Picture No. 2: Public Bicycle Sharing System (PBS) – at Navi Mumbai Municipal Corporation Head Quarters, CBD Belapur

Image Source: TERI

[30] https://timesofindia.indiatimes.com/city/navi-mumbai/navi-mumbai-public-bicycle-sharing-system-started-at-nerul/articleshow/66464064.cms

Water Resources

Water is one of the most vital renewable resources on the earth. Water resources include lakes, rivers, streams, groundwater and oceans. Humans have been exploiting this precious resource more than any other resource for sustenance of life. Only 2.5% of the total amount of water available on the earth consists of fresh water. Around 2/3rd of this 2.5% is in the frozen form and trapped in ice caps and glaciers. Water is required for our daily activities like drinking; cleaning, cooking and all industries require water for their operations. Due to an ever increasing population and urbanization, there is growing pressure on this vital resource and problems like water shortage and water quality deterioration is constantly on the rise. Hence, more attention and care needs to be taken on conserving and managing this resource.

Status of Water Resources

Both surface and ground water resources are available in the NMMC region. The surface water includes multiple lakes, ponds, dams and reservoirs while groundwater resources include wells and bore wells. NMMC conducts regular water monitoring of these resources and maintains the data of their water quality.

Surface Water

Dams (Reservoir)

There are 3 dams, Morbe, Hetawane and Barvi dam, situated in the NMMC region out of which city gets water from Morbe dam for its daily requirement. Morbe dam, a gravity dam, on the Dhavri River (tributary of Patalganga River) near Khalapur, Raigad district. The height of the dam above the lowest foundation is 194 ft. while the length is 11,220 ft. It covers the surface area of about 9,780 sq km. It was constructed by MJP (Maharashtra Jeevan Pradhikaran), Government of Maharashtra in 1999, who then granted possession of Morbe dam to NMMC in November 2002. The feature of Morbe dam is given Table No. 18.

Table No. 18: Speciation of Morbe Dam

Specifications	Attributes
Name of the dam	Morbe
Distance from city (NMMC Jurisdiction)	31 km
Type of dam	Gravity
Impounds	Dhavari river
Height	53.40 m
Length	3,250 m
Dam volume	18,075 x 10^3 m^3
Total capacity	19,089 x 10^4 m^3
Surface area	978 hectares

Source: Central Water Commission[31]

[31] http://www.cwc.nic.in/main/downloads/National%20Register%20of%20Large%20Dams%202009.pdf

NMMC has developed a water treatment facility at Bhokarpada which receives raw water from Morbe dam for treatment before its supply to the city on a daily basis. NMMC ensures good water quality by monitoring the quality of both raw and treated water. Table No. 19 below represents the average quality of raw and treated water supplied by NMMC as per BIS standards.

Table No. 19: Average water quality of raw and treated water before supply

Sr.No	Test Parameters	Units	Raw Water (Bhokarpada)	Pure Water (W.T.P)	BIS Specifications 10500:2012 Normal Values	
					Desirable Limits	Permissible Limits
1	Physical Appearance		Clear	Clear		
2	Odour		Odourless	Odourless	Agreeable	Agreeable
3	Turbidity	N.T.U	2.4	0.5	1	5
4	pH Value		7.1	7.2	6.5-8.5	No relaxation
5	Free Residual Chlorine	mg/l	nil	0.8	0.2	1.0

Source: District Public Health Laboratory, Konkan Bhavan, Belapur, Navi Mumbai

Lakes and ponds

Lakes and Ponds, also called 'lentic systems' are a diverse set of inland fresh water habitats. These resources exist across the globe and support terrestrial and aquatic ecosystems. These resources are responsible for domestic, industrial, agricultural purposes as well as for food. Lakes and ponds not only support biodiversity but also helps regulate the processes of soil formation, groundwater recharge and flood protection. But these resources are now under threat due to rising freshwater demand and increasing pollution due to anthropogenic activities. Hence it is very important to conserve these freshwater resources. There are total 24 lakes with coverage of 2.23 lakh sq.m area within the NMMC jurisdiction.

The Belapur node has 5 lakes, the highest number amongst all the nodes, and accounts for around 28% of the lake area share in NMMC jurisdiction. This is followed by the Ghansoli node with 4 lakes amounting to 25% of the lake area share area. The Gothivali lake in Ghansoli is the biggest lake and has a surface area of 32,635 sq. m. The Mahape lake in Koparkhairane node is the smallest lake with an area of 1,338 sq. m. Node wise details of lakes along with their coverage area are described in the Table No. 20 below. Most of the lakes are observed to be surrounded by residential areas and have Gabion wall structures.

Table No. 20: Node wise details of lakes and their coverage in NMMC area

Node	Name of Lake/Pond	Riparian zone	Surrounding area	Area of lake (Sq m)
Airoli	Airoli Naka	Concrete wall	Residential	3,988
	Diva	Gabion wall	Residential	2,042
Belapur	Agroli	Gabion wall	Trees and Garden	12,693
	Belapur	Concrete wall	Residential and a temple	17,905
	Darave	Gabion wall	Residential	5,724
	Karave	Concrete wall	Residential	23,506
	Killegaonthan	Gabion wall	Residential	2,650
Digha	Borol			1,500
	Khokad	Gabion wall	Residential and Highway	17,842
Ghansoli	Gothivali	Gabion wall	Residential and Informal hutments	32,635
	Gumali	Concrete wall	Residential	3,596
	Rabada	Gabion wall	Residential and Highway	7,823
	Talvali	Gabion wall	Residential	11,590
Koparkhairane	Khairne	Concrete wall	Residential	13,870
	Koparkhairane	Concrete wall	Residential	2,231
	Mahape	Concrete wall	MIDC area	1,338
	Savaligaon	-	Slums	6,060
Nerul	Nerul Sector 20	Gabion wall	Residential	9,894
	Shirvane	Gabion wall	Residential	13,686
Turbhe	Sanpada	Natural	Residential	2,500
	Turbhegaon	Gabion wall	Residential	8,482
Vashi	Juhugaon	Concrete wall	Dense residential area on all four sides	1,486
	Kopari	Gabion wall	Trees and Garden	10,000
	Vashigaon	Gabion wall	Residential	10,620
Total				**2,23,661**

Source: Environmental Laboratory, NMMC

NMMC conducts a periodic monitoring of water quality of lakes that are coming under NMMC's area of jurisdiction (Table No. 21 and Table No. 22). On analysing the samples, it is observed that the pH levels for all the lakes are well within the permissible limit. In case of suspended solids (S.S), only Mahape gaon lake at Koparkhairane node registered high levels (117 mg/l), with 100mg/l is the permissible limit, compared to 71 mg/l recorded in 2017-18. It is important to note that a total of 6 lakes recorded SS levels above the permissible limit in 2017-18, Darave (102 mg/l), Shirvane (122mg/l), Vashigaon (148mg/l), Juhugaon (107mg/l), Savaligaon (150 mg/l) and Bonkode (115mg/l)} recorded SS levels within the permissible limits in 2018-19 with concentration recorded at 53mg/l, 33mg/l, 55mg/l, 32mg/l, 52mg/l and 36mg/l respectively. Similarly, in 2017-18, Savaligoan lake which recorded total dissolved solids (TDS) level of 2921mg/l, above the permissible limit of 2000 mg/l, recorded a concentration level of 902mg/l which is around a 68% decrease as compared to the previous year. In the case of hardness, 2 lakes namely Shirvane and Vashigaon lakes recorded concentrations 889mg/l and 1024mg/l respectively which are above the

permissible limits (600mg/l) while sulphate levels are found to be above permissible limit (400mg/l) in 14 out of 23 lakes. The levels of all the other parameters were found to be within permissible limits.

Table No. 21: Annual average water quality of lakes in NMMC area (1 of 2) 2018-19

Node	Name of Lake	PH	S.S (mg/l)	TDS (mg/l)	D.O (mg/l)	B.O.D (mg/l)	C.O.D (mg/l)
CPCB Limits[32]		5.5-9.0	<100	<2000	4.0-7.0	<100	<250
Airoli	Airoli Naka	7.7	19	521	6.0	2	32
	Diva	7.6	42	846	5.5	4	45
Belapur	Belapur	7.7	10	372	6.6	6	55
	Darave	7.5	53	696	6.6	5	45
	Karave	7.5	16	354	5.8	4	26
	Killegaonthan	7.7	45	473	6.0	9	72
	Agroli	7.2	19	436	7.0	4	38
Digha	Khokad	7.6	31	635	6.4	1	17
Ghansoli	Rabada	7.8	14	518	6.6	3	31
	Gumali	7.4	43	787	5.7	2	23
	Talvali	7.4	29	663	6.1	2	34
	Gothivali	7.8	37	375	6.0	1	19
Nerul	Nerul Sector 20	7.6	16	669	6.4	5	38
	Shirvane	7.7	33	1369	5.8	7	58
Turbhe	Turbhegaon	7.7	41	1243	6.6	5	35
	Sanpada	8.1	32	1118	6.4	4	37
Vashi	Vashigaon	7.9	55	1662	6.1	6	35
	Juhugaon	7.8	32	459	7.3	4	41
Koparkhairane	Koparkhairane	7.8	30	546	6.9	8	49
	Khairne	8.1	39	1291	6.9	4	31
	Savaligaon(Kopari)	7.8	52	902	6.7	4	37
	Bonkode	7.8	36	847	6.9	3	29
	Mahapegaon	8.0	117	676	7.2	3	39

Source: Environmental Laboratory, NMMC

[32] http://cgwb.gov.in/Documents/WQ-standards.pdf (CPCB standards IS 10500: 2012)

Table No. 22: Annual average water quality of lakes in NMMC area (2 of the 2)

Node	Name of Lake	Nitrate	Nitrite	Phosphate	Chloride	Hardness	Sulphate
		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
CPCB Limits[33]		**<45**		**<5**	**<1000**	**<600**	**<400**
Airoli	Airoli Naka	0.487	0.049	0.051	37.35	295	513.49
	Diva	1.158	0.328	0.057	50.15	454	674.78
Belapur	Belapur	0.346	0.169	0.141	35.57	174	228.89
	Darave	0.510	0.028	0.105	40.05	439	515.18
	Karave	0.363	0.010	0.123	30.26	223	267.53
	Killegaonthan	0.391	0.007	0.208	37.33	187	200.27
	Agroli	0.705	0.016	0.016	26.69	280	406.61
Digha	Khokad	0.672	0.007	0.066	41.88	403	725.75
Ghansoli	Rabada	0.480	0.057	0.058	56.51	366	502.96
	Gumali	0.408	0.339	0.145	40.78	487	772.12
	Talvali	0.529	0.466	0.105	45.53	299	344.18
	Gothivali	0.524	0.231	0.117	40.92	173	186.63
Nerul	Nerul Sector 20	0.368	0.031	0.105	29.68	412	506.79
	Shirvane	0.494	0.043	0.155	42.07	889	909.92
Turbhe	Turbhegaon	0.948	0.019	0.148	33.29	524	880.79
	Sanpada	0.805	0.017	0.114	34.43	332	447.36
Vashi	Vashigaon	1.544	0.296	0.107	34.13	1024	2158.0
	Juhugaon	1.209	0.350	0.352	48.49	214	340.02
Koparkhairane	Koparkhairane	0.171	0.070	0.141	46.07	477	193.77
	Khairne	0.456	0.018	0.039	40.44	172	77.74
	Savaligaon (Kopari)	0.793	0.049	0.022	60.61	453	1415.09
	Bonkode	1.387	0.163	0.140	46.13	282	188.93
	Mahapegaon	0.441	0.016	0.094	67.51	422	681.90

Source: Environmental Laboratory, NMMC

[33] http://cgwb.gov.in/Documents/WQ-standards.pdf (CPCB standards IS 10500: 2012)

Creek

NMMC has set up monitoring stations at 6 different locations in order to analyze creek water samples. (Map No 3). The annual average water quality of creeks in the NMMC area has been tabulated below in Table No. 23. From the annual average values of the water quality tests, it has been observed that the creek water samples from all 6 locations have very high levels of chlorides, exceeding the limit for chloride (<600mg/l).

Creek water samples collected from Belapur (3.8mg/l), near Palm Beach Road (2.0mg/l) and near Airoli bridge (2.2mg/l) recorded less amount of Dissolved Oxygen (DO) levels in the water samples. The DO concentration at the creek near Airoli bridge decreased by more than 50%, from a concentration of 4.8mg/l in 2017-18 to 2.2mg/l in 2018-19.

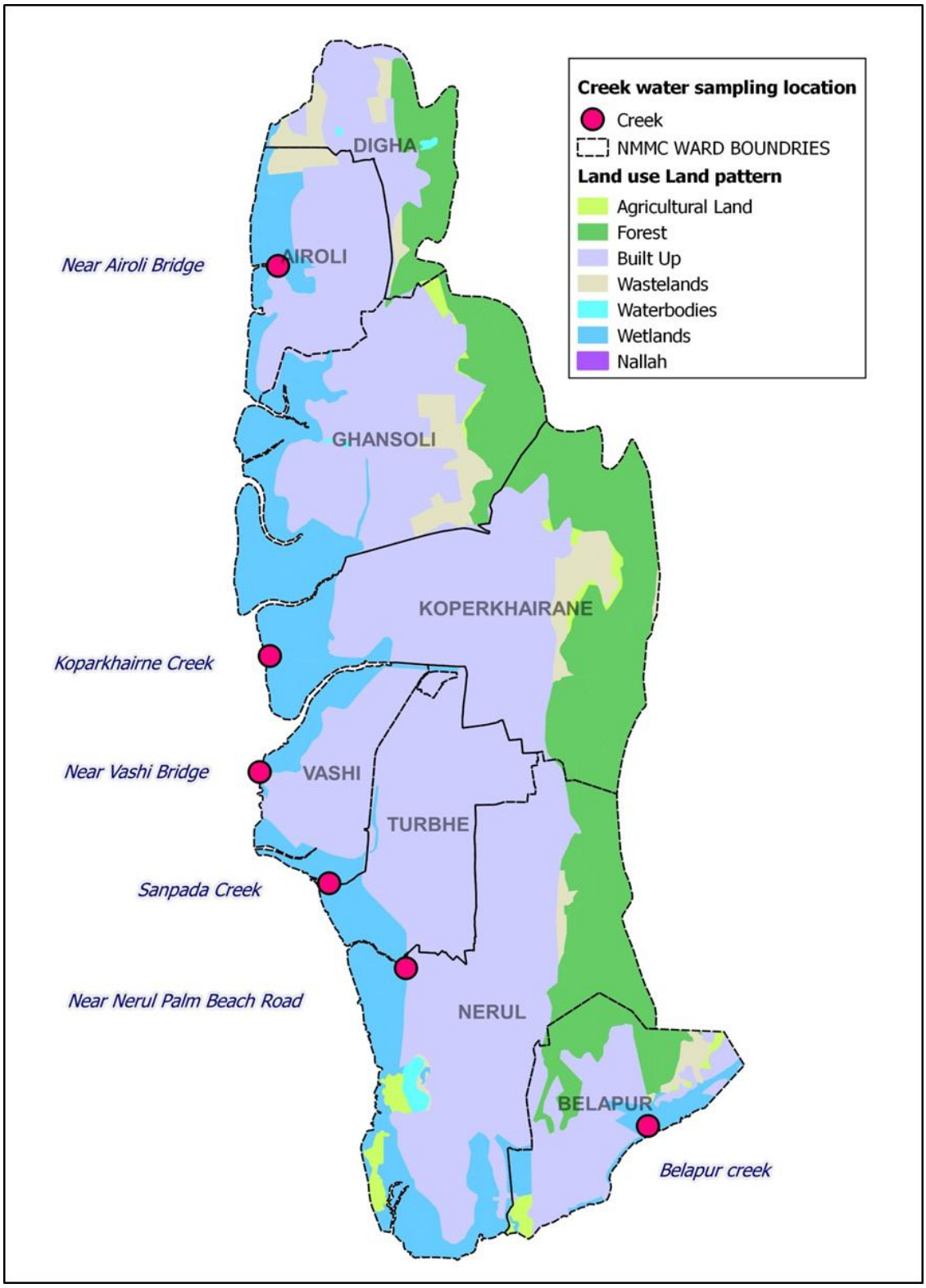
BOD, TKN, Nitrate and Phosphate concentrations are found to be within their respective permissible limits in all locations.

Table No. 23: Annual average water quality of creek water samples in NMMC area (2018-19)

Location	Parameters							
	pH	SS	DO	BOD	TKN	Nitrate	Phosphate	Chloride
		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
CPCB Limits[34]	**5.5-9.0**	**<100**	**4.0-7.0**	**<100**	**<100**	**<45**	**<5**	**<600**
Belapur	7.4	678	3.8	66	7.038	1.480	0.567	5949.48
Near Nerul Palm Beach Road	7.7	516	2.0	92	7.078	2.064	0.117	4417.34
Near Vashi Bridge	7.6	700	5.5	64	5.718	2.030	0.259	6535.23
Sanpada	7.4	364	4.2	80	4.986	1.385	0.295	6959.07
Koparkhairane	7.4	489	4.7	45	4.637	1.205	0.310	6368.43
Near Airoli Bridge	7.6	310	2.2	41	11.854	3.549	0.846	3875.59

Source: Environmental Laboratory, NMMC

[34] https://cpcb.nic.in/industry-effluent-standards/



Map No 3: Water Quality Monitoring Stations along creeks in NMMC area

Source: Environment Laboratory, NMMC

Ground Water

NMMC region's dependency on ground water is low as compared to other regions due to a planned and established chain of water supply and a low water loss rate. NMMC periodically monitors the water quality of wells and bore wells present within its area of jurisdiction. Monitoring involves the analysis of parameters like pH, DO, BOD, residual chlorine, hardness, sulphate and fecal coliform and their quantity. In the year 2018-19, NMMC conducted a water quality test for around 22 wells in the NMMC area (Table No. 24). All samples collected from wells and bore wells (landfill site-Table No. 25) detected the presence of E-coli and fecal coliform.

Table No. 24: Well water quality recorded in NMMC area in 2018-19

Sr. No.	Location	PARAMETERS											
		pH	Turbidity	Residual Chlorine	DO	BOD	COD	Chloride	Hardness	Sulphate	MPN Count /100 ml	E.Coli	F.Coli
			NTU	(mg/l)	mg/l	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)			
	CPCB Limits[35]	6.5-8.5	10.0	0.2mg/l	4.0-7.0	<100	250	1000	600	400			
1	Agroligaon, Sector 29	7.9	4.6	Nil	7.1	1	19	71.3	479	1532.08	23	+ve	+ve
2	Shahabazgaon, Sector 19	7.8	6.4	Nil	5.1	2	29	77.8	133	194.72	23	+ve	+ve
3	Shiravane, Sector 1, Nerul	7.5	3.5	Nil	4.7	2	29	97.3	133	207.92	23	+ve	+ve
4	Sarsole, Sector 6, Nerul	7.5	0.3	Nil	4.9	2	29	77.84	275	115.47	23	+ve	+ve
5	Karavegaon, Near Lake, Nerul	7.3	3.1	Nil	5.8	1	19	129.7	194	233.96	23	+ve	+ve
6	Daravegaon, Sector 23, Nerul	7.0	1.9	Nil	5.2	1	19	103.7	194	171.70	23	+ve	+ve
7	Turbhegaon, Sector 21	7.5	4.4	Nil	6.8	3	49	97.3	765	1418.87	23	+ve	+ve
8	Ganpatipada, Turbhe	7.8	2.6	Nil	6.7	1	29	103.7	275	106.79	23	+ve	+ve
9	Tin Taki, Sector 18,Koparkhairane	6.7	0.6	Nil	6.7	0.1	19	97.3	143	167.55	23	+ve	+ve

[35] https://www.indiawaterportal.org/sites/indiawaterportal.org/files/drinking_water_standards_bis_10500_2004_by_bis.pdf

Sr. No	Location	PARAMETERS											
10	Infront of P.C.Patil's House, Sector 19, Koparkhairane	6.8	2.2	Nil	4.0	0.4	9	103.7	245	124.91	23	+ve	+ve
11	Near Keshav Uncle's House, Sector 19, Koparkhairane	6.6	4.9	Nil	6.3	1	10	77.8	245	222.64	23	+ve	+ve
12	Anant Patil, Chinchali, Ghansoli	7.4	4.6	Nil	5.9	1	19	71.35	571	1735.85	23	+ve	+ve
13	Old Video Center. Talvalinaka, Ghansoli	7.6	2.2	Nil	4.6	0.3	10	64.8	275	262.64	23	+ve	+ve
14	Rabadagaon behind GSR/ESR, Rabada	7.8	5.6	Nil	6.2	1	19	58.3	92	95.09	23	+ve	+ve
15	Near Vitthal Mandir, Divagaon, Airoli	7.7	7.5	Nil	4.8	0.4	10	45.40	133	57.36	23	+ve	+ve
16	Vitbhatti, Airoligaon, Airoli	8.0	1.7	Nil	5.6	2	29	84.33	275	298.87	23	+ve	+ve
17	Near Hanuman Mandir, Chinchpada, Airoli	8.0	1.3	Nil	4.7	1	19	103.79	316	81.13	23	+ve	+ve
18	Ilathanpada, Digha	8.0	1.9	Nil	5.0	0.4	10	129.74	306	91.70	23	+ve	+ve
19	Subhashnagar, Digha	7.9	8.9	Nil	5.5	0.2	10	246.50	204	159.62	23	+ve	+ve
20	Sanjay Gandhi Nagar, Digha	8.0	5.5	Nil	4.6	1	19	116.76	214	950.94	23	+ve	+ve
21	Juhugaon, Sector 11, Vashi	8.0	6.2	Nil	6.1	2	39	97.30	286	520.75	23	+ve	+ve
22	Vashigaon, Sector 6, Vashi	8.1	4.4	Nil	4.6	2	39	110.27	694	1592.45	23	+ve	+ve

Source: Environmental Laboratory, NMMC

Table No. 25: Water Quality of Turbhe bore well (2018-19)

Location of Well (Turbhe)	pH	Turbidity	Residual Chlorine	DO	BOD	COD	Chloride	Hardness	Sulphate	Salinity	MPN Count/ 100 ml	E.Coli	F.Coli
		NTU	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)		
Turbhe Landfill site Bore well	7.1	2.1	Nil	5.0	0	10	127.0	211	105.66	<5.85	23	+ve	+ve
	7.3	3.2	Nil	7.7	0	9	154.20	185	124.53	<5.85	23	+ve	+ve
	7.6	4.0	Nil	7.0	1	9	154.20	52	23.40	<5.85	23	+ve	+ve
	7.7	4.7	Nil	6.0	1	9	49.13	268	156.60	<5.85	23	+ve	+ve
	7.4	3.7	Nil	6.2	4	35	49.13	319	89.40	<5.85	23	+ve	+ve
	7.2	5.6	Nil	6.6	2	17	57.32	371	66.80	<5.85	23	+ve	+ve
	7.1	3.9	Nil	6.8	2	26	51.05	175	73.60	<5.85	23	+ve	+ve
	6.8	4.6	Nil	6.8	4	40	89.33	240	115.40	<5.85	23	+ve	+ve
	7.3	3.2	Nil	6.6	7	51	19.46	220	107.90	<5.85	23	+ve	+ve
	7.0	0.7	Nil	6.5	2	29	51.89	214	50.28	<5.85	23	+ve	+ve
Average	**7.3**	**3.6**	**0.1**	**6.5**	**2.4**	**23.5**	**80.3**	**225.5**	**91.4**	**<5.85**	**23**	+ve	+ve

Source: Environmental Laboratory, NMMC

Water Resource Management

Water supply (Network)

During the financial year 2018-19, 421.85 million liters/day (MLD) water was supplied by NMMC to the city. During the procedure of supplying, the total loss of water during processing and distribution is estimated to be around 18.61%. So, the net water supply for the year 2018-19 can be estimated to be about 343 MLD. NMMC supplies water through a very well-connected distribution network (1130 km). The total number of booster pumps installed throughout the network is 145. (Table No. 26) A water booster pump provides the desired water pressure required to move water through a network from storage till the end point.

Table No. 26: Highlights of the water supply network at a glance

Head	Details
Total Average water supply in 17-18	421.85 MLD
Processing and Distribution losses	~18.61%
Net Water Supply to Navi Mumbai (NMMC limits)	343.36 MLD
Per capita water supply	~ 221 LPCD
Length of distribution network	1130 Km
Number of booster pumps	145
Water supply breakup	Metered: 343.36 MLD Unmetered: 78.49 MLD
Water supply sectoral break up	Domestic: 231.93 MLD Commercial: 36.82 MLD Gaothan& Slums: 74.61 MLD
Unit cost of water supply (INR/kL/year)	Domestic: 4.75 Non-Domestic 30.0
Number of complaints received in 2009-2018	Received - 5312 Attended - 5312 Pending - Nil
Manpower Total staff in Water supply department Total skilled staff	 616 527

LPCD: Liters Per Capita per Day

Source: NMMC Water supply department

Drinking water quality at the tap end

Morbe dam, the primary source of drinking water for the NMMC area gets treated at the Bhokarpada water treatment plant before its supply and distribution to the NMMC area. The city area is categorized into 3 sections namely domestic, commercial, gaothan & slums. NMMC regularly checks and monitors the potability of drinking water at various points across the city. In case of any contamination, mitigative measures were undertaken by the corporation. In the year 2018-19, a total of 20,376 samples were analysed out of which 5.17% (1053) samples were detected to be non- potable (Figure No. 29). The rate of non-potability increased from 3.4% in 2017-18 to 5.17% in 2018-19.

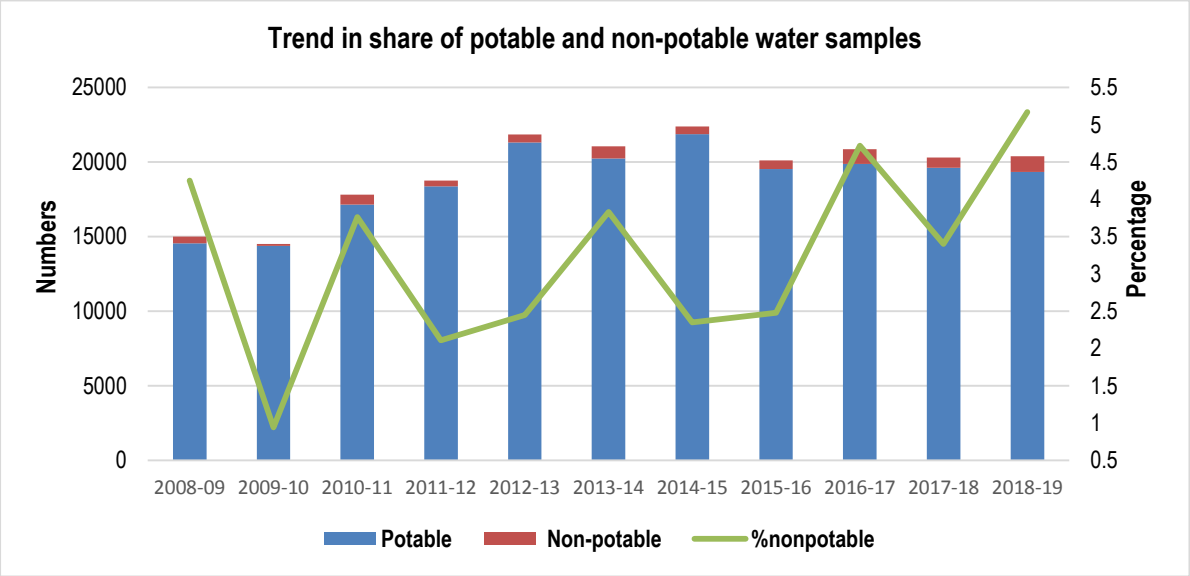


Figure No. 29: Trend in share of potable and non-potable water samples in NMMC area

Source: Environmental Laboratory, NMMC

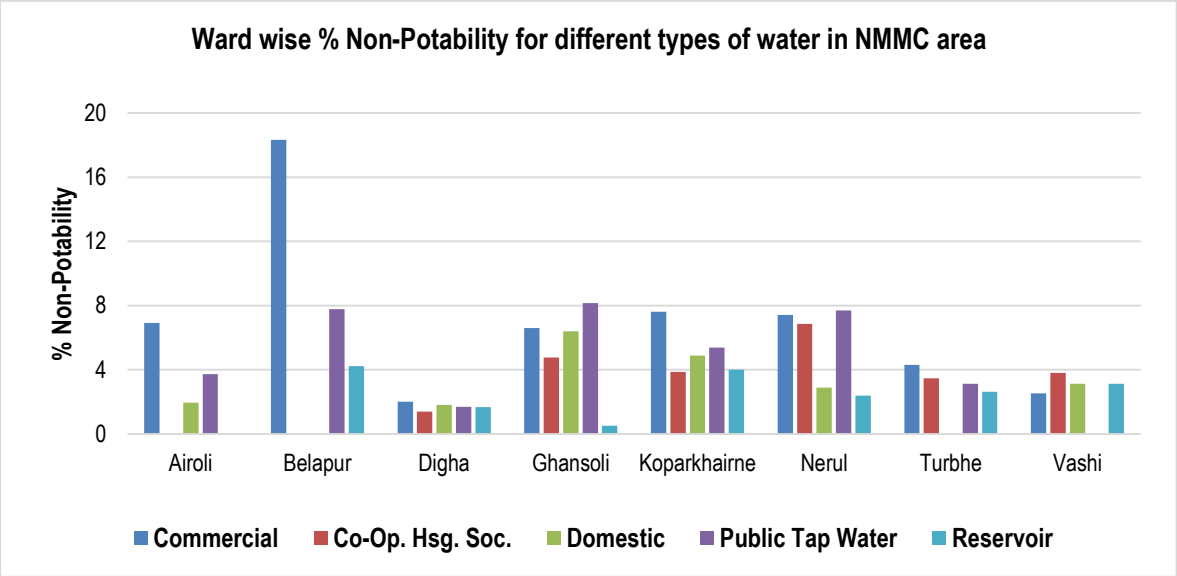


Figure No. 30: Ward wise % Non-Potability in NMMC area

Source: Environmental Laboratory, NMMC

From Figure No. 30, it can be observed that the Airoli node registered around 7% non-potability in commercial water samples, ~3.7% in public tap water samples and around 2% in domestic water samples while not even a single water sample from Co-op. housing societies of Airoli and Belapur was found to be non-potable. The Belapur node registered the highest non potability amongst commercial water samples (18.3%) followed by Public tap water (~7.8%).

Sewage treatment

NMMC has a well-planned underground sewage network which caters to about 2,66,766 connections. The total length of sewer lines is 448.37 km. Nodal areas of the city have sufficient sewage lines. NMMC has a dedicated workforce of around 343 members working in the sewerage department and responsible for the smooth functioning of the same.

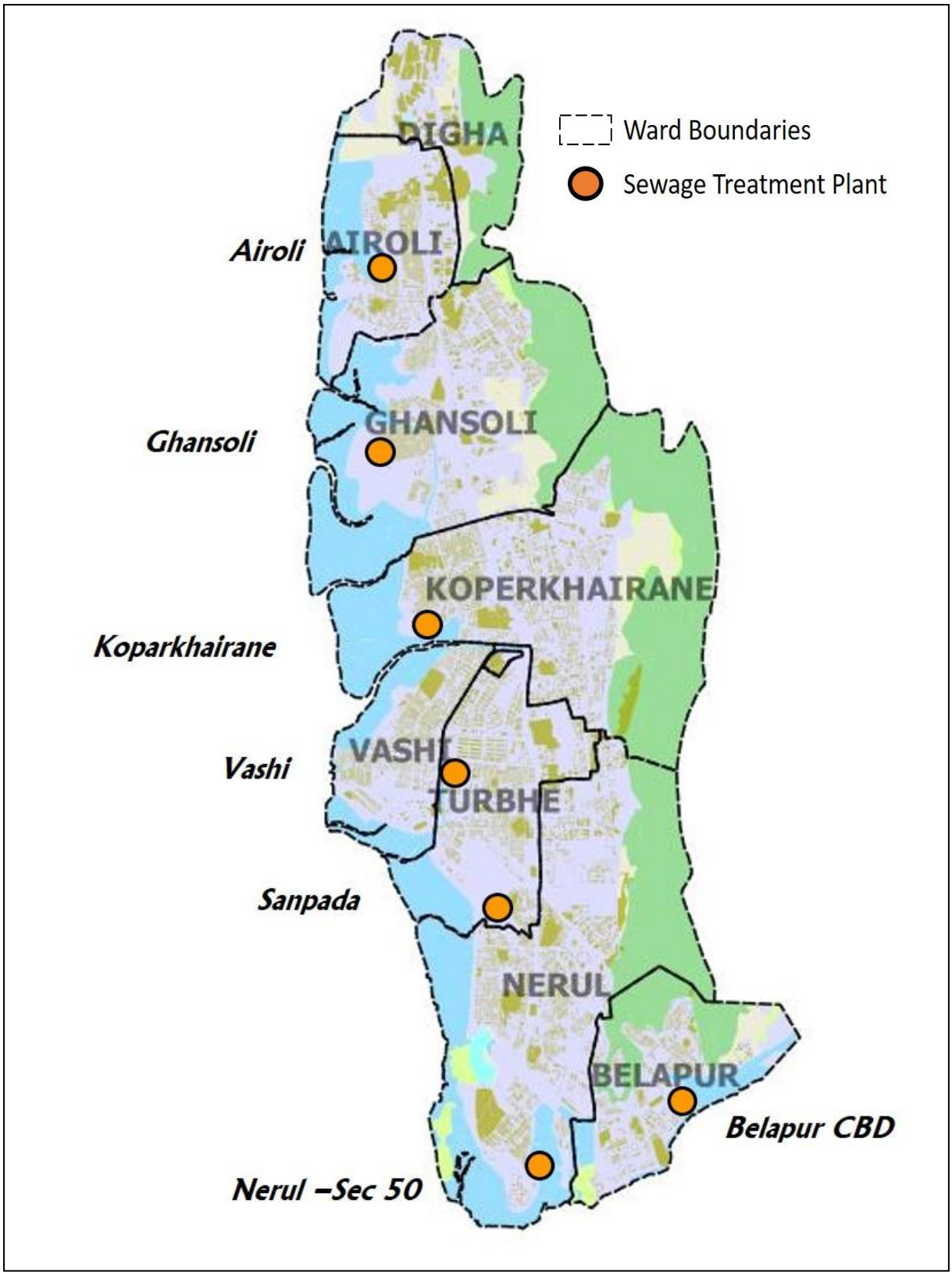
Sewage Treatment Facilities

NMMC jurisdiction area generates around 210 MLD sewage on a daily basis, which gets treated at the city's 7 Sewage Treatment Plants (STP) (Map No 4). The combined capacity of these STP is around 454 MLD. All these treatment plants possess primary as well as secondary treatment systems which work based on the Cyclic Activated Sludge Treatment technology using the advanced Sequencing Batch Reactor (SBR) process. Water quality tests are conducted daily during secondary treatment at an ISO certified laboratory. A brief detail of the STP situated in Navi Mumbai under the NMMC jurisdiction is provided in Table No. 27.

Table No. 27: List of functional Sewage Treatment Plants in NMMC area (2018-19)

Sr. No.	Node & Sector	Design Capacity (MLD)	Treatment technology
1	CBD Belapur - 12	19	Cyclic Activated Sludge Process (SBR Tech)
2	Nerul - 50	100	
3	Sanpada - 21	37.5	
4	Vashi - 18	100	
5	Koparkhairane - 14	87.5	
6	Ghansoli -15	30	
7	Airoli - 18	80	
Total		**454**	

Source: Environmental Laboratory, NMMC



Map No 4 : Location of STPs in NMMC areas

Performance of Sewage Treatment plant

NMMC regularly analyses and maintains the data of the quality of treated water (from STP) before its discharge into the creeks. This enables the tracking of levels of various parameters which affect water quality and also enables NMMC to check the working efficiency of STP. The data for the inlet and outlet is presented in Table No. 28. In the case of COD, only Airoli STP recorded a slightly higher concentration (54 mg/l) than the permissible limit (50mg/l) even after treatment. Belapur and Vashi STP which had recorded a high COD in the previous year registered concentrations which were within the permissible limits in the current financial year (2018-19).

In case of suspended solids (SS), except Vashi and Koparkhairane STP, the 5 remaining STP registered a high concentration than the prescribed permissible limit with Airoli STP (67mg/l) and Ghansoli STP (59 mg/l) with the highest concentration among these 5 STP. Biological Oxygen Demand (BOD) and pH was found to be well within the permissible limit (<10 mg/l) at all STP.

Table No. 28 Average performance and efficiency of STPs in NMMC area

STP	PH		B.O.D(mg/l)		C.O.D(mg/l)		S.S(mg/l)	
	6.5-9		<10		<50		<20	
	In	Eff	In	Eff	In	Eff	In	Eff
CBD Belapur Sector 12	7.2	7.3	28	4	137	31	59	33
Nerul Sector 50	7.4	7.4	31	4	179	29	109	23
Vashi – Sector 18	7.1	7.6	21	4	157	38	63	17
Sanpada Sector 21	7.2	7.5	15	5	104	46	50	27
Koparkhairane Sector 14	7.5	7.7	25	4	169	38	82	17
Ghansoli Sector 15	7.4	7.5	12	3	117	34	123	59
Airoli Sector 18	7.2	7.6	28	5	161	54	145	67

Source: Environmental Laboratory, NMMC

Standardssource:http://envfor.nic.in/sites/default/files/Draft%20notification%20of%20Sewage%20Treatment%20plan.PDF

Storm water Management

The NMMC area has storm water drainage networks of a total of 550 km (Table No. 29) in total length. The main features of the storm water drains are the Nallahs and the unique holding ponds of the city which prevent flooding of water in the city. NMMC regularly monitors the water quality in these Nallahs as well as the holding ponds.

Table No. 29: Ward wise length of storm water drains in NMMC area

Sr.No	Ward Name	Ward Number	Storm Water Drain Length (Km)
1	Belapur	A	82.00
2	Nerul	B	111.00
3	Vashi	C	90.15
4	Turbhe	D	82.00
5	Kopharkhirane	E	79.00
6	Ghansoli	F	40.00
7	Airoli	G	65.85
8	Digha	H	0
9	MIDC		0
Total			**550**

Source: Environmental Laboratory, NMMC

Nallahs

Storm water gets collected in nallahs which originates in the MIDC area and carry industrial effluents to the creeks. There are 10 major nallahs in the NMMC jurisdiction area. (Map No 5). These nallahs originate in the MIDC area and carry industrial effluents to the creek. The list of nallahs is tabulated in Table No. 30 and the water quality of the samples collected from nallahs is presented in Table No. 31.

Table No. 30: Details of open Nallahs in NMMC area

Sr. No	Nallah	Node	From	To	Length (meters)
1	Nalla No-1	Belapur	Sector-1	Sector-12	2418
			Artist Village Branch		726
			Sector-1a Nalla		430
2	Nalla N0-2		CBD Railway St- Sector-15		1105
3	Nalla N0-3	Nerul	Sector-9	Palm Beach Marg	4273
			Sector-15a		2661
4	Nalla N0-4	Sanpada	MIDC	Sector-4	7233
			Railway Branch		1418
			Sector-4 Branch		1403
			Herdilia Branch		1550
			MIDC Branch		1875
5	Nalla N0-5	Vashi	Sector-12	Vashi R/W Station	7310
6	Nalla N0-6	Koparkhairane	Khairane Nalla		7990
			Branch-1		3709
			Branch-2		739
			Branch-3		1678
			Branch-4		1470
7	Nalla No-7		Mahpe Nala		2036
8	Nalla No-8	Ghansoli	NOCIL Nalla		4690
			Branch-1		1360
			Branch-2		2937
			Branch-3		1615
			Branch-4		1620
9	Nalla No-9	Airoli	Bharat Bijlee Nalla		1891
			MSEB Nalla		1911
			Branch-1		732
			Branch-2		670
10	Nalla No-10	Digha	Ilthanpada Nalla		3500
			Thane Boundry-Digha		3332
				Total	**74282**

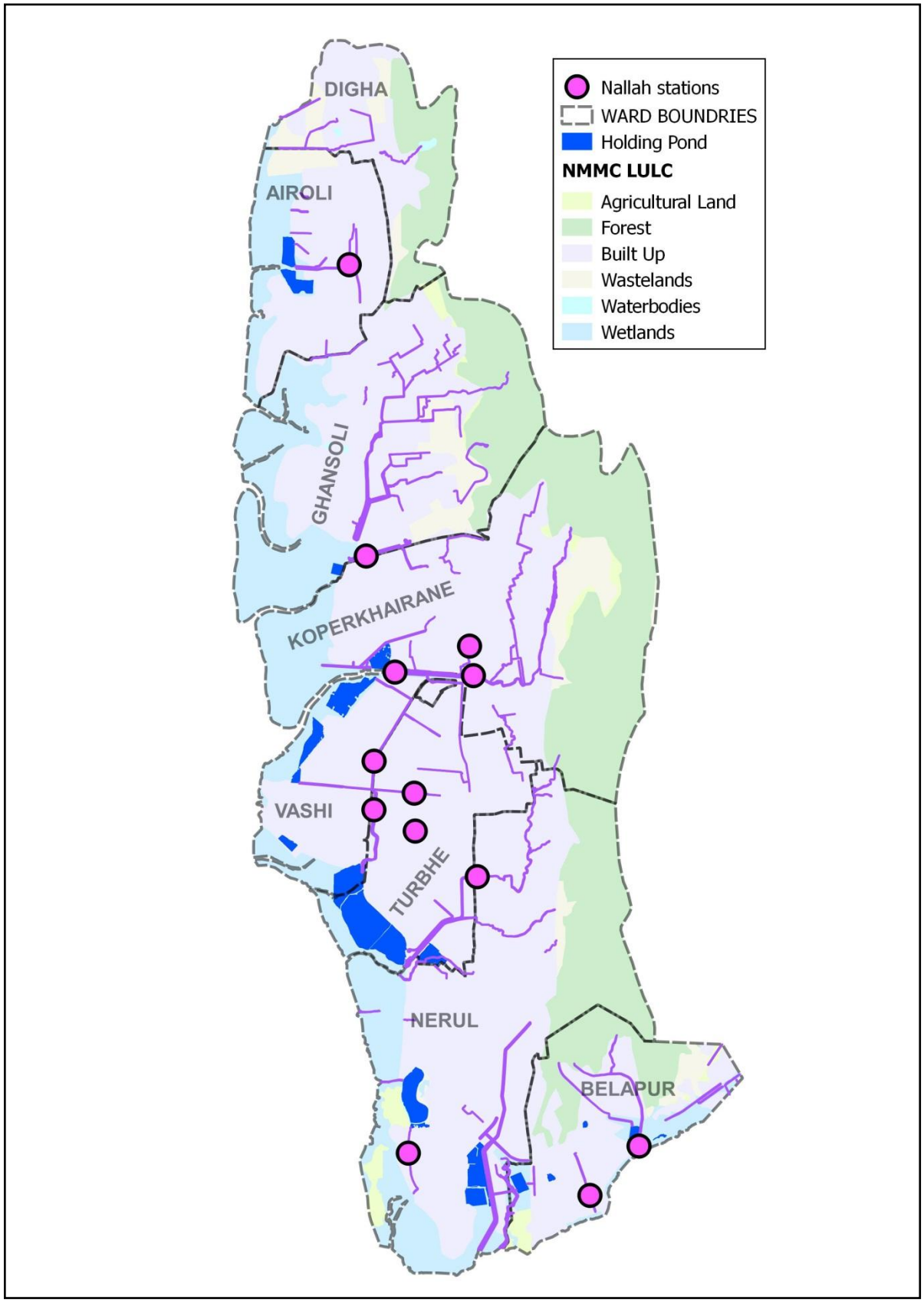
Source: Environmental Laboratory, NMMC

Table No. 31: Annual Average water quality of water samples collected from nallahs (2018-19)

Zone	Name of Nallah	Parameters								
		pH	S.S.	D.O	B.O.D	C.O.D	Nitrate	Nitrite	Sulphide	Chloride
				(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
CPCB Standards	**Limits**	**5.5-9.0**	**<600**	**-**	**<350**	**-**	**<45**	**-**	**-**	**<1000**
Belapur	Belapur Sector 12	7.9	13	5.5	16	242	2.619	0.014	5.92	100.99
	Belapur Sector 15A	7.5	79	3.8	21	161	0.748	0.066	6.08	133.93
Vashi	Vashi Sector 18 (Khairne Nallah)	7.5	71	1.3	8	127	0.520	0.052	27.44	233.01
Turbhe	Turbhe Mafco Nallah sector 17,18	7.7	112	0.7	8	125	1.400	0.046	28.08	216.71
	Pavane MIDC Nallah	7.3	50	1.5	28	291	0.461	0.043	9.12	251.46
	Turbhe Sector 19	7.5	165	1.2	44	388	0.622	0.085	17.08	244.01
	Turbhe Sector 24	7.3	254	1.6	22	372	2.230	0.095	7.64	196.22
	Juinagar Herdillia Nallah	8.1	88	0.8	37	322	1.003	0.055	16.53	260.16
Kopar khairane	Koparkhairane Sector 11	7.8	202	0.6	31	476	1.818	0.035	25.92	248.52
	Mahape Bridge Nallah	7.5	163	2.7	29	215	2.134	0.081	16.53	354.45
Airoli	Airoli Bharat Bijali Nallah	7.3	58	0.7	35	162	2.190	0.142	11.41	129.66
Ghansoli	Nocil Nallah	7.3	67	1.0	23	197	1.099	0.060	22.51	225.36
Nerul	Nerul Palm Beach Road	7.3	73	1.1	21	166	0.516	0.026	5.68	704.81

Source: Environmental Laboratory, NMMC

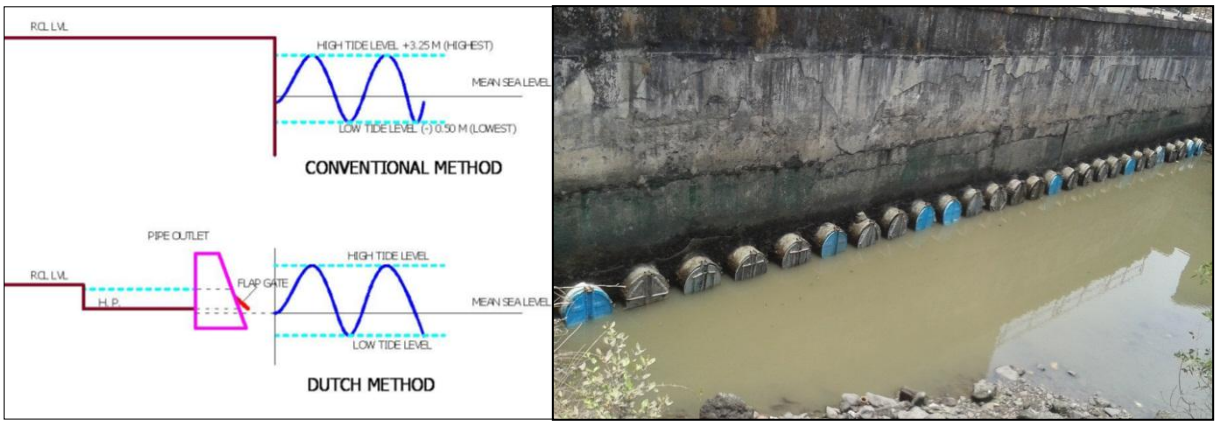
Standards Source: http://cpcb.nic.in/GeneralStandards.pdf



Map No 5: Water Quality Monitoring stations along Nallahs in NMMC area

Holding Ponds

Holding ponds are an integrated drainage system which acts as a retention basin in normal conditions and as storage during high tides thus helping in avoiding water logging. Since certain areas of Navi Mumbai are located below the high tide level, CIDCO opted for the Dutch technology for flood control to optimise the reclamation levels of the city. This method is used to control the ingress of seawater during high tides and allowing excess water to flow in to the sea during low tide naturally or by pumping with the help of high capacity pumps during high tides. For the disposal of rainwater, holding ponds have been constructed in different nodes. Bunds have been constructed around these ponds and control mechanism for release of water during low tides has been installed (Picture No. 3). These holding ponds act as a buffer between the storm water drainage and the creek. There are a total of 11 holding ponds which have been constructed in Belapur, Vashi, Turbhe, Koparkhairane and the Airoli node (Table No. 32).



Picture No. 3: Schematic of the Dutch dyke (Left) and its actual photograph with flap gates (right)

Table No. 32: Details of holding ponds in NMMC area

Sr. No.	Node	Location	Area in hectare
1	Belapur (CBD)	Sector 12	5.5
2	Belapur (CBD)	Sector 15A	13.85
3	Vashi	Sector 8A	2.3
4	Vashi	Vashigaon	1.93
5	Vashi	Sector 10A	15
6	Vashi	Sector 12	24
7	Koparkhairane	Sector 14	9
8	Airoli	Sector 18	16
9	Airoli	Sector 19	14
10	Vashi	Behind Rly. Station	77
11	Sanpada	Sector 30A	22
Total			**200.58**

Source: Environmental Laboratory, NMMC

Table No. 33: Annual average quality of water samples collected from holding ponds (2018-19)

Holding Ponds	PARAMETERS						
	pH	S.S	D.O	B.O.D	Nitrate	Nitrite	Phosphate
		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
	6.5-8.5	<100	4.0-7.0	<100	<45		<5
Belapur Sector 12	7.4	310	3.1	61	0.584	0.013	0.540
Belapur Sector 15A	7.9	621	6.3	58	0.749	0.319	0.104
Vashi Sector 8	7.7	376	3.5	27	2.622	0.497	0.148
Vashi Sector 10A	8.0	678	6.6	103	2.031	0.207	0.253
Vashi Sector 11 & 12	7.4	394	2.6	46	2.263	0.321	0.160
Vashi Sector 30	7.7	504	3.9	69	1.414	0.625	0.090
Koparkhairane Sector 14	7.1	353	2.0	33	0.576	0.255	0.621
Airoli Sector 18	7.5	556	2.2	36	0.442	0.586	0.588
Airoli Sector 19	7.4	971	4.4	37	2.209	0.389	0.605
Sanpada Sector 18, 19 & 20	7.2	422	2.6	105	1.251	0.700	0.287

Source: Environmental Laboratory, NMMC

Table No. 33 depicts the water quality monitored at the holding ponds in the year 2018- 19. Suspended solids concentration was found to be above the permissible limit of 100mg/l in all holding pond samples with the highest concentration recorded at the holding pond of Airoli (971 mg/l) followed by Vashi sector 10A (678 mg/l) and Belapur sector 15 A (621 mg/l).

Levels of DO were found to be below the permissible limit (4 – 7 mg/l) in samples collected from Sector 14 in Koparkhairane(2.0 mg/l), Sector 18 in Airoli (2.2 mg/l), Vashi and Sanpada (2.6 mg/l), Sector 12 in Belapur (3.1 mg/l), Vashi sector 8 (3.5 mg/l) and sector 30 (3.9 mg/l).

The remaining parameters such as pH, nitrites, nitrates and phosphates were well within the permissible limits.

Pressure and Impacts

As per the United Nation's World Water Development Report, as demand for fresh water increases, the availability of the same would decrease and due to climate change, this condition will become severe in the future. According to the report, anthropogenic pressures on our precious water resources would worsen the economic disparities between certain countries as well as between sectors or regions within the countries[36]. Some of the main driving forces that create negative impacts on water resources are

1. Population growth, especially in water scarce regions
2. Major demographic shifts from underdeveloped to developed areas
3. Increased demand for food production and food security
4. Pollution from industrial, agricultural and municipal sources

The NMMC area has a presence of well-established industrial, residential and commercial areas which are growing at a rapid pace due to better infrastructure, job opportunities and better quality of living available here, thereby constantly increasing the water demand. From 2010-11 to 2018-19, the city has witnessed around 28% increase in the water demand which would increase further owing to an increase in population growth. In case of less rainfall (which occurred in 2016-17), the situation could become more severe as the city gets its water supply primarily from the Morbe dam which is the single major source available for the city. A high demand would put this source under tremendous pressure and hence it is necessary to implement ways to conserve water through proper water management and technology. `

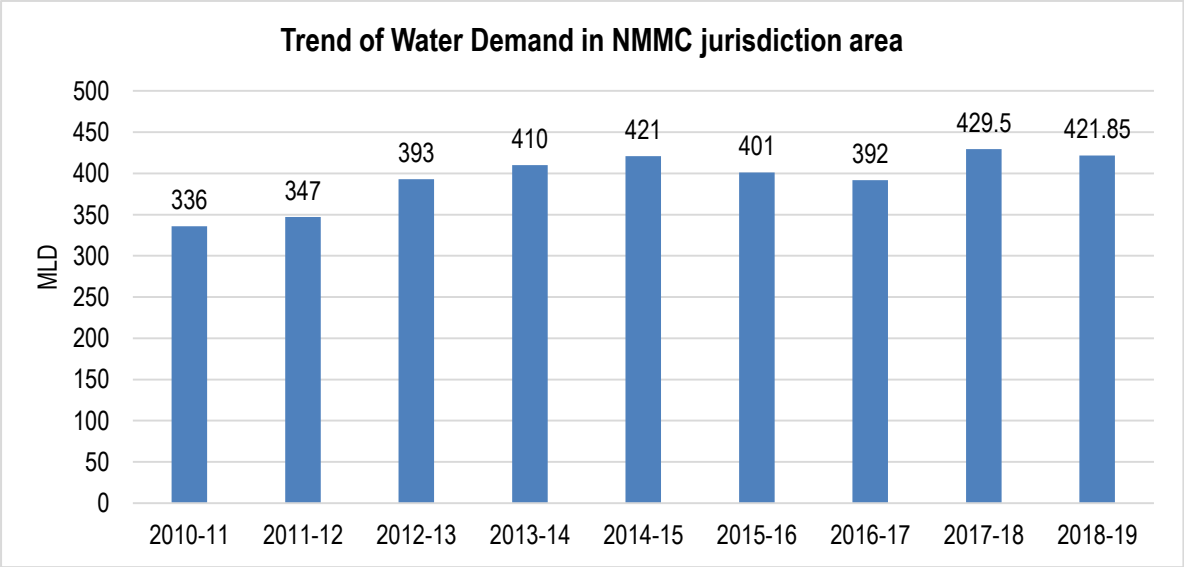


Figure No. 31: Trend of water demand in NMMC

Source: NMMC Water Supply department

[36] http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/WWDR4%20Background%20Briefing%20Note_ENG.pdf

Distribution losses and leakages

Reducing water losses is a priority for every municipal corporation. Generally, water loss happens in the form of leakages on transmission and distribution mains, reservoir and storage overflows and leakages on service connections. According to the Ministry of Water Resources, the set benchmark for losses in Non-Revenue Water (NRW) is 20%[37].This year too, NMMC has maintained the rate of water loss which stood at around 18.61% which is 1.39% less compared to the set benchmark (Figure No. 32).

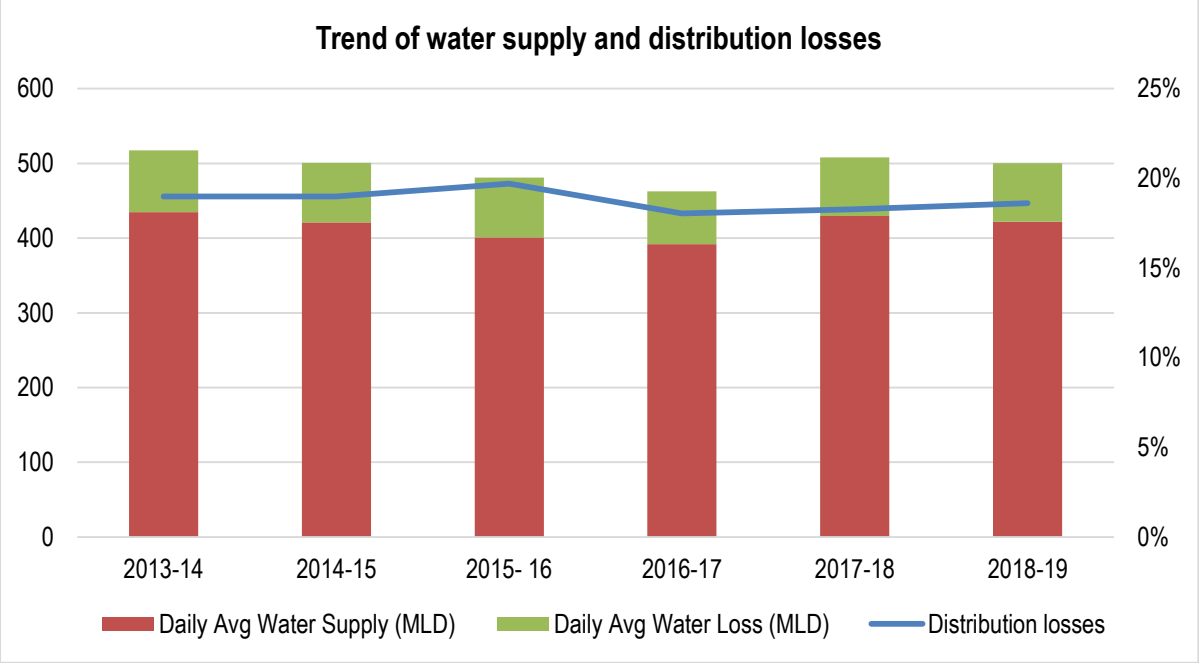


Figure No. 32: Trend of water supply and distribution losses in NMMC

Source: NMMC Water Supply department

Response

To decrease water loss, NMMC conducts a periodic water audits and addresses complaints received from citizens regarding pipe breaks, leakages and supply. To address water loss and theft, NMMC has made it mandatory to install AMR systems. NMMC maintains a report of AMR fixing and disconnection on residential, institutional and commercial structures of Navi Mumbai nodes. Installation of Automated Meter Reader system (AMRs), water supply through a well-connected pipe network and installation of Supervisory Control and Data Acquisition (SCADA) system for effective management of water supply, has helped in curbing water loss to a high extent.

Electricity consumption of STP in NMMC

The losses incurred due to distribution losses and leakages induce pressure on the water supply system. They not only cause losses in terms of absolute water requirements and financial losses but also losses in terms of energy requirements at the pumping stations, booster pumps treatment consumables and so on. The electricity consumed by the STP is provided below in Table No. 34.

[37] WaterAid India, State of Urban Water Supply in India, 2018, Pg no. 24

Table No. 34: Consumption of electricity by the STP's in NMMC

No	Electricity Consumption parameters	Units	Node						
			CBD-12	Nerul-50	Vashi-18	Kopar khairane- 14	Airoli-18	Sanpada - 20	Ghansoli
1	Total Capacity	MLD	19	100	100	87.5	80	37.5	27
2	Total Load	MLD	10-12	40-45	40-45	35-38	30-35	18-20	12-15
3	Total Pumps	Nos.	0	8	8	7	6	6	6
4	Total capacity of pumps	HP	0	1400	1400	1225	1050	480	760
5	Total units consumed	Kwh	568490	2964613	2818870	4393561	1785946	2020890	1205080

Source: Water Department, NMMC

Release of Sewage and industrial effluents

City's Industrial area generates industrial effluents along with domestic sewage from residential and commercial sector on daily basis. Such sewage and effluents contains variety of pollutants which once mixed with water source, contaminates it and degrades the overall water quality. With rapid expansion of Navi Mumbai city from last few years and increase in water supply, the quantity of wastewater generated has increased. It is observed that, the city has generated around 210MLD of sewage during 2018-19. The treatment of sewage is necessary before its release as it can lead to water pollution which can have an adverse impact on marine and costal ecosystem.

Response

Recycling of treated sewage water

In an effort to re-utilize treated sewage water, NMMC, under Amrut Yojana, plans to recycle it in accordance with the guidelines provided by the Ministry of Urban Development. In first step, 2 tertiary treatment plants of 20MLD capacity have been proposed at Koparkhairane and Airoli which would recycle treated sewage from the treatment plants (Koparkhairane and Airoli). These tertiary treatment plants would use ultra-filtration and ultra-violet technologies to treat coliforms present in the sewage. The recycled water thus produced will be supplied for non-drinking purpose to the MIDC area.

On similar lines, a tertiary plant has also been proposed to be set up at Vashi node. The capacity of the proposed plant would be 15 MLD. The recycled sewage water would then be utilized in gardens for watering purposes.

Thus, once fully functional, NMMC would be able to recycle and reuse around 55 MLD of treated sewage water on daily basis which would become a huge milestone in waste water management at the city level.

Pre monsoon Works

To avoid water logging during monsoons, NMMC begins de-silting work as part of pre-monsoon preparations every year. Respective departments are instructed to clear the waste collected outside gutters and nallahs to avoid water logging.

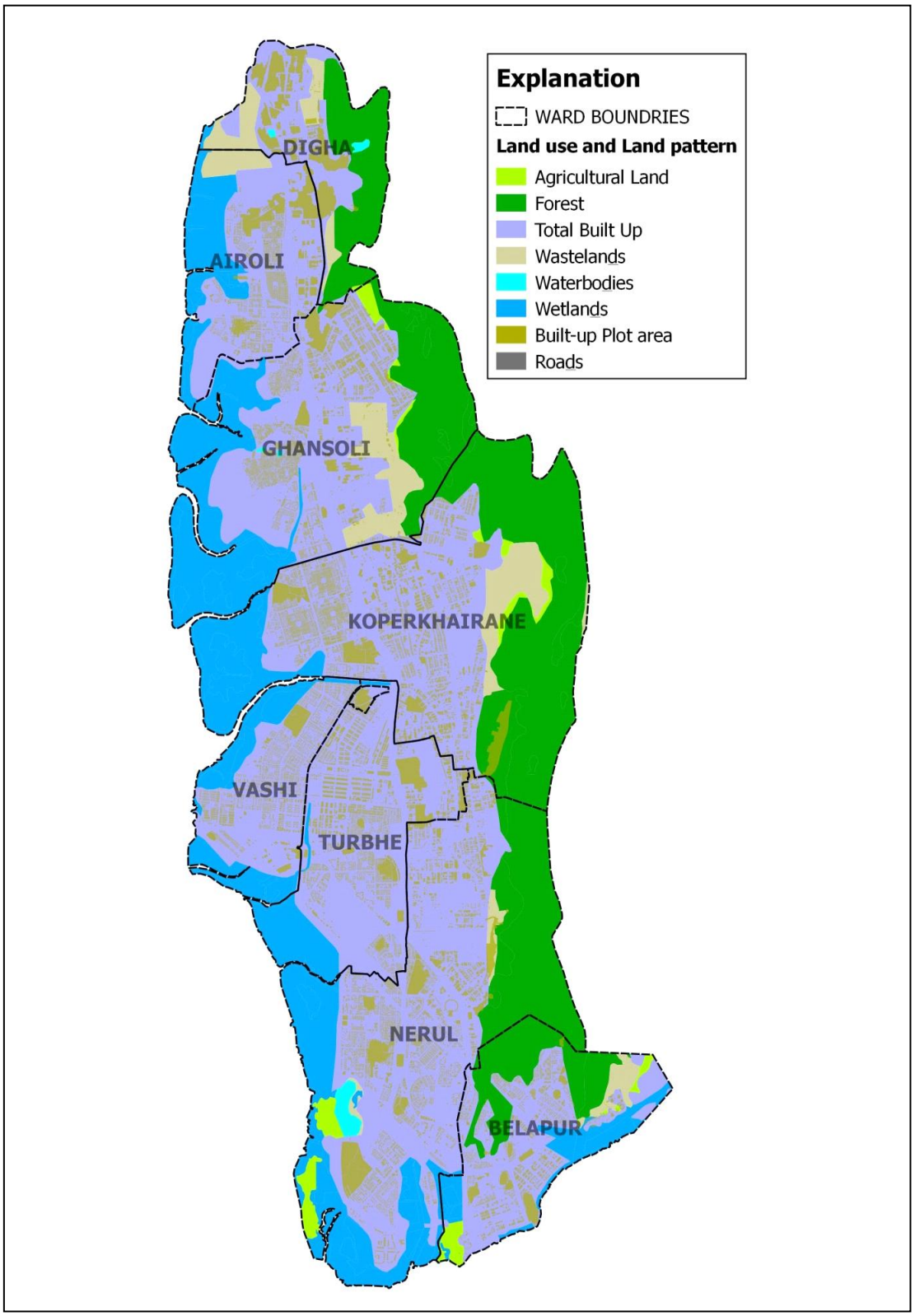
Other Key Initiatives

Realizing the importance of conservation and preservation of water resources in the city, NMMC has undertaken several initiatives which not only help in reducing the pressure on water resources in the city but also help in energy conservation.

1. NMMC has adopted a method of "Back flushing" of water at the Bhokarpada water treatment plant. Around 10- 12 MLD of water is back treated and the water is used for various purposes. The stored water can now fulfil the needs of around 50,000 people in the city. This initiative has also resulted in savings amounting to INR 1,08,000 per day which shall help cover the cost of installation of the tank and other equipment approximately in the next 2 years.

2. 24x 7 water supply with the help of gravity helps save a lot of electrical energy as all the Elevated Service Reservoirs (ESRs) & Ground Service Reservoir (GSRs) could be bypassed.

Land Resource



Map No 6: Land Use Land Cover pattern of Navi Mumbai

Land resources, also termed as Natural resources occur naturally within environments that exist relatively undisturbed by mankind, in natural form. Land resources refers to the terrestrial surface area and includes all attributes of the biosphere immediately above or below this surface, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes and swamps), the near-surface sedimentary layers and associated groundwater and geo hydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity. Land is a finite resource and over centuries, people have been exploiting land resource for their ever growing needs. Land resource is a subject to competing anthropogenic pressures such as urbanization, infrastructure development, increased agricultural activities and so on.

Since Navi Mumbai is a planned city, CIDCO has already put in a lot of planning and thought into its development. During designing, appropriate plans were formulated for setting up industrial belt, residential zones and green spaces. This section highlights the current situation of land resources in NMMC and also discusses the effects of various developmental activities on them.

Status

The land use pattern of the city consists of built up area, agricultural land, forests, wastelands, water bodies, roads, and so on (Map No 6). Total area under NMMC's jurisdiction is 109.59 sq. km (Table No. 35 and Figure No. 33) of which built up area constitutes major portion (56.54%) and accounts for about 61.97 sq.km. This comprises residential, commercial, industrial, administrative constructions and infrastructure such as crematoriums, water supply, sewage disposal, roads, and railways. Forest cover is around (24.22%) covering around 26.55 sq.km of area. Wetlands are an important feature of the city with 13.46 sq.km areas under lakes, mangroves, wetlands, creeks, mudflats and manmade water bodies. Agricultural land holdings account for only 1.27%, covering an area of 1.4sq.km.

Table No. 35: Break up of Land Use Land Cover pattern in NMMC

Sr. No	Land Use Land Cover	Area in km²	% Share of land cover
1	Built Up	61.97	56.54
2	Forest	26.55	24.22
3	Wetlands	13.46	12.28
4	Wastelands	5.85	5.33
5	Agricultural Land	1.4	1.27
6	Water Bodies	0.36	0.32
Grand Total		**109.59**	**100**

Source: Town Planning Deprtment, NMMC

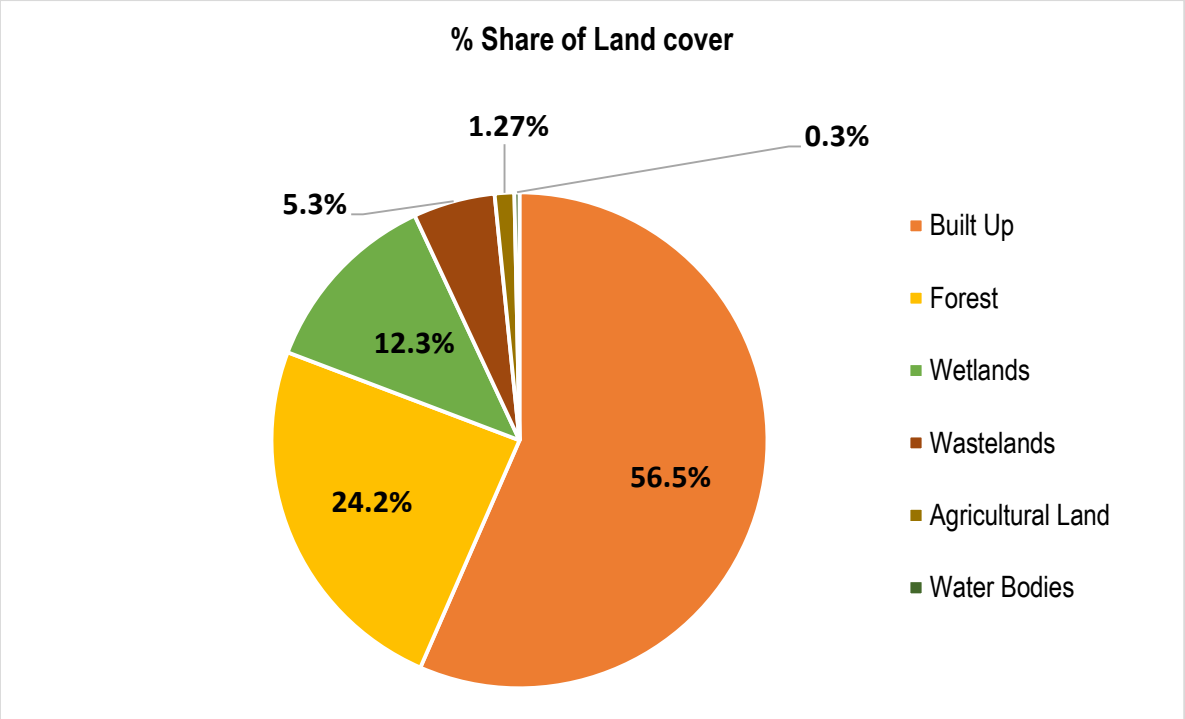


Figure No. 33: % Share of Land cover – NMMC city 2018-19

Source: Town Planning Department, NMMC

In Vashi and Turbhe node, more than 75% of the total area is built up which indicates a higher population density in these 2 nodes as compared to other nodes in the city. Forest areas can be observed at Digha, Ghansoli, Koparkhairane, Nerul and Belapur node which needs to be protected to maintain the city's air quality and the overall health of the environment. There are marginal farmlands present in Ghansoli, Koparkhairane, Nerul and Belapur indicating agricultural practices being carried out in the city, even though it is on a small scale.

Built up area

More than half of the city's overall area (61.97 sq.km = 56.54%) comes under the built up area. This area includes industrial, residential and commercial zones of each node in the city. Majority of the built up area comprises of residential zones which were created to support the ever increasing population of the city. The built up area also includes various infrastructural development projects such as railways, roads, solid waste related projects, water treatment plants and so on. The current status of these infrastructural projects has been elaborated in their respective sections.

Wetlands

As defined by Ramsar convention, wetlands are areas that are seasonally or perennially covered by water[38]. Wetlands usually consist of lakes, rivers, mangroves, and coral reefs. Artificial man-made wetlands consist of paddy fields, dams, saltpans and so on. Wetlands play an important role in the environment, mainly in water purification, flood control, as carbon sinks and helping strengthen shoreline stability. It also plays a major role in

[38] https://www.ramsar.org/cda/en/ramsar-about-faqs-what-are-wetlands/main/ramsar/1-36-37%5e7713_4000_0__

maintaining and supporting avian and aquatic biodiversity. Healthy wetlands also attract tourists due to their natural beauty. Navi Mumbai is rich in several wetland areas such as lakes, ponds, holding pond, mangrove wetlands, marshlands & so on.

Water Bodies

Navi Mumbai consists of several water bodies such as 24 lakes, creek, ponds and wells. These water bodies are useful for various domestic and industrial purposes in the city. These water bodies have been further discussed and their quality status been presented in the water resources section of the report.

Mangroves

Mangroves are a taxonomically diverse group of salt tolerant, mainly arboreal, flowering plants that grow primarily in tropical and subtropical regions[39]. Mangrove ecosystems are highly productive yet sensitive and fragile and shelter many plants and animal species[40]. Mangroves are biodiversity hotspots as these ecosystems act as a nesting and breeding habitat for numerous fish, amphibians, reptiles, birds and turtle species. Around 80% of the global fish catch relies on mangrove ecosystem directly or indirectly[41].

Mangroves are important to maintain water quality as the roots of these mangroves and surrounding vegetation filter and trap sediments, heavy metals and other pollutants. This ability prevents further contamination of the downstream water ways and protects sensitive habitats like coral reef and sea grass beds.

Mangroves are the first line of defence for coastal communities as they stabilize the shorelines and are a natural barrier against these calamities. Mangroves act as a buffer zone between land and sea and protect the land from erosion and play an important role as a protective shield against ecological disasters like flooding, cyclones, and other natural calamities. Robust mangrove forests are natural protection for communities vulnerable both to the sea level rise and the more intense and infrequent weather events caused by climate change. This is particularly significant for Navi Mumbai due to its geographical location.

Developed adjacent to the Thane creek, Navi Mumbai city has a presence of mangroves along the creek. The dominant mangrove species recorded in the area include *Avicennia marin, a* a mangrove weed *Acanthus ilicifolius* and *Sonnertia alba*. Research studies of NMMC area documents species of true mangroves representing approximately 3 genera and 3 families while 10 species of mangrove associates belonging to 8 genera under 6 families and 1 species of non-mangrove halophytes have been recorded[42].

[39] http://cmsdata.iucn.org/downloads/managing_mangroves_for_resilience_to_climate_chan
[40] http://agritech.tnau.ac.in/forestry/forest_mangrove_index.html
[41] https://ecoviva.org/7-reasons-mangroves-matter/
[42] Pawar (2011). Floral Diversity Of Mangrove Ecosystem From Coastal Environment Of Uran (Raigad), Navi Mumbai, Maharashtra. Electronic Journal of Environmental Sciences Vol. 4, 113-117 (2011) ISSN: 0973-9505

Picture No. 4: **Dense mangroves cover along Thane creek**

Habitats in the city

Natural Areas

Navi Mumbai city has around 26.55 sq.km of natural forests which accounts for 24.22% of the city's total area. Natural forests are a major component of green areas and the city encompasses various habitats ranging from low hills with tropical semi-evergreen, tropical moist deciduous, tropical dry deciduous, to marshlands, estuary and mangroves. The Parsik hill is situated in the city and runs parallel to the Thane creek. . These green areas have a very high ecological and environmental significance and play a pivotal role in maintaining the city's overall environment.

NMMC periodically conducts a tree plantation drive in each node and has maintained greenery by developing numerous parks, gardens. NMMC has also planted trees along roadside and road dividers. As these green areas work not only as lungs for the city but also provide various environmental services, conservation of these areas is of key importance in order to ensure sustainable environment of the city.

Man-made Areas

Growing urbanization has resulted in the loss of natural green areas in the city. The presence of gardens and parks in a city act as regulators to clean the environment of the city. They not only help in reducing the city's pollution but also contribute to the environment by providing oxygen, enriching the climate, conserving water, helping preserve soil, and acting as micro habitats for a variety of city dwelling fauna such as birds and butterflies. Gardens also play a significant role in enhancing the physical, emotional and spiritual well-being of citizens, necessary to build healthy and socially sustainable communities. Towards this,

NMMC has developed a network of gardens and parks in the city and periodically takes initiatives such as conducting afforestation programs and creation of new green spaces within the city limits. Other than gardens, NMMC has also undertaken initiatives like tree plantations on the other open spaces/areas present in the city such as the circles, Road dividers and T belts (Table No. 36).

Table No. 36: Ward wise open spaces along with their area in NMMC

Sr. No	Area	Garden		Open spaces		Circle		T belt	
		No. of Garden	Area (sq. m)	No. of Open spaces	Area (sq. m)	Circle	Area (sq. m)	T belt	Area (sq. m)
1	CBD Belapur	38	260028	22	47428	3	3436	1	7027
2	Nerul	33	145582	7	6196	1	780	2	7473
3	Sanpada and Turbhe	13	70705	1	500	-	-	-	-
4	Vashi	33	166023	11	26126	-	-	2	9778
5	Koparkhairane	15	50108	11	26858	1	437	-	-
6	Ghansoli	5	9872	7	18243	-	-	-	-
7	Airoli	25	109549	9	14178	1	110	3	5578
8	Digha	1	5100	-	-	-	-	-	-
9	Palm beach road	-	-	10	84976	-	-	-	-
10	Thane Belapur Road	-	-	2	60412	1	267	-	-
Total		**163**	**816967**	**80**	**284917**	**7**	**5030**	**8**	**29856**

Source: Garden Department, NMMC

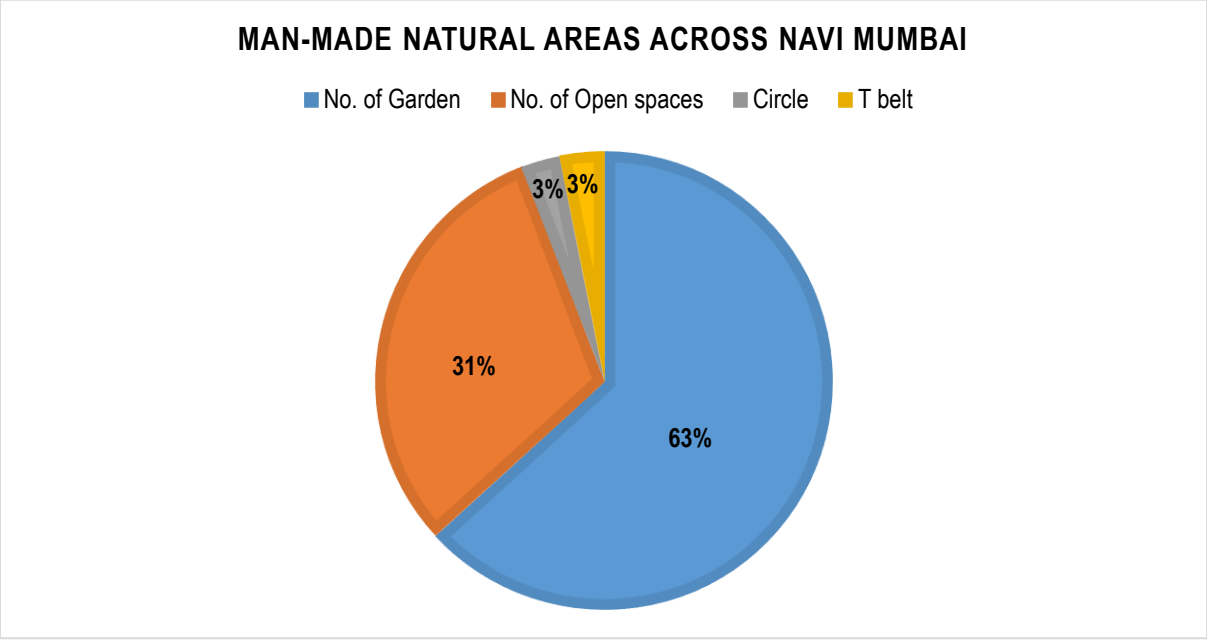


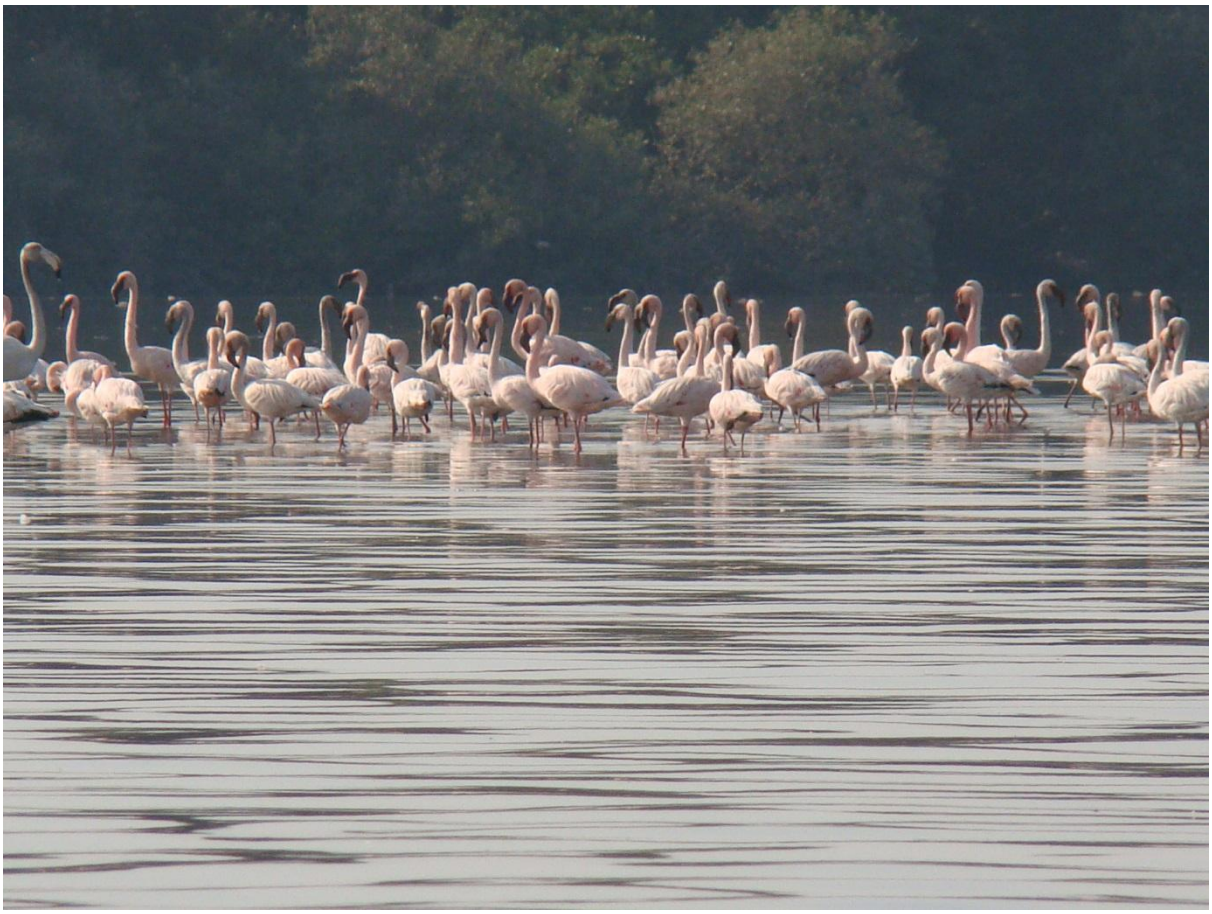
Figure No. 34: Manmade natural areas across Navi Mumbai

Biodiversity of NMMC

Biodiversity encompasses ecosystems or community diversity, species diversity, and genetic diversity. The biodiversity of an area is an indicator of the rich environment of the area & Navi Mumbai is one such area with a variety of habitats. Being a tropical ecosystem, it is bestowed with a rich biodiversity. The presence of the lush green Parsik hills in Navi Mumbai provides the city with a significant amount of green cover. The city also has mangrove patches along the Thane creek which supports avian as well as aquatic ecosystems. Despite such high biodiversity, except for the mangroves, there is no legal protection for the green cover in the area. There is a need for Parsik hill to be demarcated as a 'protected area', especially due to the threat posed by stone quarrying activities. Karnala bird sanctuary is the nearest protected area located at a distance of 30 km. The important highlights of biodiversity in Navi Mumbai area are as follows:

Birds

Navi Mumbai has an abundant green cover ranging from forest patch to mudflats and mangroves in the coastal region making it an ideal spot for bird watching. Different species of water birds, local migrant birds, passage migrant birds & so on are spotted at several places in Navi Mumbai during the course of the year. More than 168 species of birds are present in the area out of which many are migratory in nature. Part of Thane Creek and Uran Creek are key biodiversity hotspots to observe migratory birds. Nerul's Talave, Airoli & Ghansoli mudflats are also home to some exotic birds. The presence of a total of 77 species of birds belonging to 35 families and 14 orders has been recorded from the Uran mudflats. The recorded avifauna comprised of resident (48%), local migrant (23%) and migrant (29%) bird species but Pawar (2011) observed a total of 56 species of birds representing 11 orders, 29 families and 46 genera from the mangroves of the Uran mudflats. Migratory and threatened birds such as Lesser Flamingos visit Navi Mumbai in large numbers. Flocks of flamingos can be observed from Belapur to Airoli in high numbers along the mangrove patches from November to May. Ornithologists have also observed a substantial rise in their population and attribute the reason for this to availability of sufficient food and conducive habitat (Picture No. 5).



Picture No. 5: **Lesser flamingos at Navi Mumbai**

Other Taxa

Other lesser known taxa of Navi Mumbai have been studied to an extent. The data on species diversity of fin fishes from Uran coast shows the presence of 31 species, which includes 3 species of Chondricthyes (Cartilaginous fish) representing 2 genera and 2 families and 28 species of Osteicthyes (Bony fish) representing 28 genera and 23 families were recorded. Pawar (2012) has also studied the decapod and molluscan diversity of the Uran Coast where 26 species of decapods were found and 55 species of molluscs representing 13 orders, 30 families and 39 genera were also recorded.

Pressure, Impact and Response

1. Quarrying

Mining and quarrying extracts a wide range of useful materials from the ground such as coal, metals and stones which are used widely in building and manufacturing industries but at the same time are destructive to the environment. Land Degradation is one of the significant impacts arising from these activities which are mainly in form of land alteration due to excavation, soil pollution due to dumping of mine wastes. Navi Mumbai also faces pressures from mining and quarrying activities. Quarrying causes a significant impact on the environment. It is one of the major contributors exerting pressure on resources like air, water and land which ultimately affects the local ecosystem and human beings.

Impact

A total of 70 leases have been provided in Parsik Hills[43]. In case of Navi Mumbai, CIDCO stone quarries are located on an area of around 138.07 Ha of forest land. All these quarries are currently non-operational due to the excessive air pollution arising due to quarrying operations. Continuous quarrying has degraded the pristine patches of Parsik hill. Though all sites are abandoned/non-operational currently, they have left behind distorted hillocks/slopes which degrade the beauty of Parsik hills. These sites need to be restored at the earliest to limit further damage and for environmental and aesthetic reasons.

Response

Proposed Initiative

For restoring these quarry sites, NMMC has proposed a pilot scale restoration project in collaboration with TERI wherein a small part of a suitable quarry would be restored using scientific and technical stabilization techniques and afforestation using local trees. This initiative can be further scale up on a broader scale with the participation of local stakeholders including corporate, educational and government sector in and around Navi Mumbai. It would also help increase the aesthetic beauty of Parsik hills and improve air quality due to the increased green cover.

Table No. 37: Quarry details in Navi Mumbai

Quarry Location	Survey no	Area in Ha
Pawane Village	163	21.23
Bonsari Village	203	30.81
Shirwane Village	323/A	18.59
Turbhe Village	387	47.74
Kukshet Village	183	19.70

Source:http://environmentclearance.nic.in/writereaddata/Online/TOR/11_May_2016_163544700PDPNITUAPFR.pdf **(Pre-feasibility report of CIDCO Stone Quarries)**

[43] https://timesofindia.indiatimes.com/city/navi-mumbai/all-eyes-on-ngt-verdict-over-parsik-hills-quarrying/articleshow/58600025.cms

The project would require conducting a pre-feasibility and feasibility study to understand the existing topography of the quarry site, slope angle and other technical details which is required for final implementation of slope stabilization technique/techniques which may involve complex geotechnical analysis and civil work.

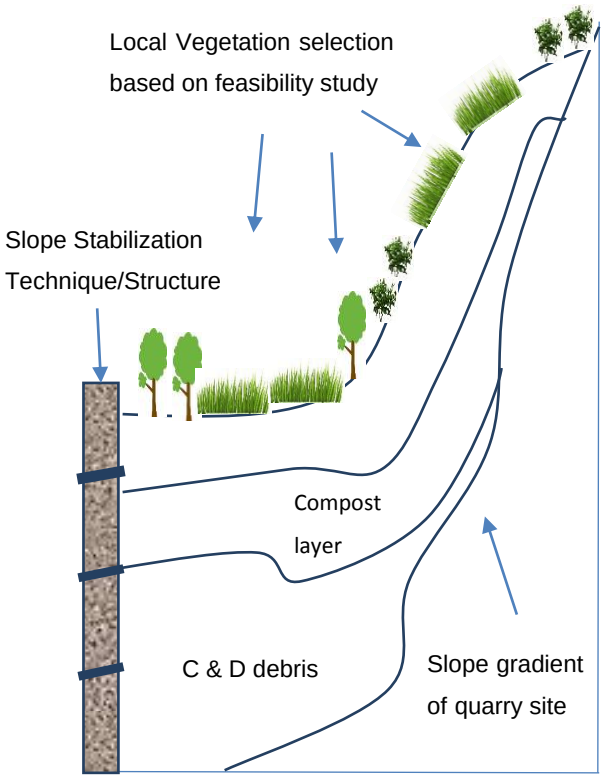


Figure No. 35: Schematic representation of Quarry restoration

Note: Slope stabilization technique and vegetation species based on Feasibility study.

The main highlight of this project would be the utilization of C&D (Construction and Debris) wastes and use of compost. Like every other type of solid waste, the problem of C&D waste in the city is pretty grave, especially in major urban areas like Mumbai and Navi Mumbai. Through quarry restoration, the corporation could utilize the C&D waste which getting generated in and around Navi Mumbai on a daily basis. It could form a first layer in the restoration activity.

The corporation can utilize compost as a second layer which is readily available from the Turbhe landfill site which converts wet waste into compost. According to NMMC, around 40 MTs (Metric Tonnes) of compost get generated on a daily basis at the Turbhe landfill site.

2. Dumping of debris and Mangrove destruction

Debris dumping is a serious issue for the city's wetlands and mangroves. The dumping is carried out in mangrove areas and holding ponds creating a pressure on these areas. Mangrove areas are an important habitat for migratory birds such as flamingos and other wader bird species which visit the city during the winter season. Dumping of debris in these areas will impact the activities of these birds, possibly causing them to migrate to other areas.

Response

In order to protect the mangrove patch from illegal dumping of waste, NMMC has offered cash reward to those people who report illegal dumping of wastes in the city especially mangroves. The corporation has recommended that people click photographs of vehicles dumping the debris and send the same to the corporation to ensure that strict action can be taken against them in a swift and transparent manner. The corporation also plans to convert the temporary arrangement present currently into a concrete boundary in order to protect the area from encroachment by slums.

Other initiatives by NMMC

Creation of New green spaces

NMMC has developed a Swachhata park at Nisarg Udyan, Koparkharaine. NMMC has developed this park to serve as an educational tool for children and adults. The park has several interesting installations which give a message of cleanliness, waste segregation and its management. In the park premises, the corporation has developed a green space and planted various trees having medicinal properties.

Picture No. 6: green space developed at Swachhata Park, Koparkhairane

Tree plantation

In highly urbanized areas such as Navi Mumbai and other metropolitan cities, increasing spaces dedicated to green areas/vegetation is a key to improve the city's air quality. NMMC, as a responsible corporation working towards bettering the environment, has undertaken several tree plantation drives with the active involvement of various stakeholders of the city. In the year 2018-19, NMMC planted around 67,500 saplings in areas under the NMMC jurisdiction as a step towards improving the city's air quality (Table No. 38)

Proposed Activities

- Increase Mangrove cover by undertaking mangrove plantation drives
- Installation of CCTVs in the mangrove areas to maintain a surveillance check on trespassers and illegal activities
- Informative sign boards and signages to be put up in mangrove forests indicating the punishment for trespassers

Table No. 38: List of number of trees planted across Navi Mumbai area

Sr.No	Plantation areas	No. of Saplings planted
1	Areas coming under Forest department at Advali-Bhutavali, Rabale (coming near NMMC jurisdiction area) as per tripartite agreement	25000
2	Tree plantation in Morbe dam area	3800
3	Ghansoli sector 9 (near Gharonda nallah)	3998
4	Ghansoli sector 1 to 6 roadside	800
5	Ghansoli sector 6 nallah site	1200
6	Ghansoli sector 5 nallah site	1000
7	Ghansoli Sadguru Hospital tree belt	2000
8	Ghansoli sector 16 ground	550
9	Ghansoli sector 21 ground	400
10	Ghansoli (Anthony garage to Rajyog road)	1000
11	Ghansoli 6 and 7 ground	1550
12	Jewel park, sector 26, Nerul	1924
13	Near Shri. Sami Narayan Temple, sector10A, Vashi	6000
14	Open space at sector 30A, Vashi	
15	Sion Panvel highway	6000
16	Belapur node	1000
17	Nerul node	1000
18	Open space near ETC centre, sector 30A, Vashi	500
19	Turbhe/Sanpada node	1000
20	Turbhe flyover and nearby area	1000
21	Open space near Pudhari press, sector 30, Sanpada	1000
22	Open space near Turbhe flyover	1000
23	Koparkhairne-Mahape Police station to Indiranagar Turbhe MIDC	2000
24	Digha Ramnagar, Plot no, OS/1	500
25	Open space near crematorium ground, airoli	380
26	Sarsole signat to Moraj circle	1000
27	Central park, Ghansoli	500
28	Raghuleela mall, sector 30, Vashi	800
29	Sector 17 underpass, Vashi	100
30	Nerul railway station area	150
31	Koparkhairane fire station to Yash hotel, MIDC	400
	Total	**67552**

(Note: Planted saplings included trees of indian species such as Neem, Bakul, Kadamba, Spathodea, Karanja, Bahava, Tabebuia, Coconut, Supari, Banyan, Mango, Chikoo, and Jackfruit)
Source: Garden department, NMMC

Solid Waste Management

Solid Waste Management (SWM), particularly in urban areas, is a standout amongst the most basic issues nowadays. As per the United Nation's (UN) World Urbanization Prospects 2018, about 34% India's population now lives in urban areas[44]. The extent is projected to grow further and by 2050; over half of India's population will be living in urban areas. Solid Waste alludes to junk or rubbish disposed of as undesirable emerging from residential, institutional, commercial, industrial activities. SWM is a discipline that is associated with control of generation, storage, collection, transport, processing and disposal of solid waste materials while considering public health, economics and environmental aspects. Apart from residential and commercial regions, Navi Mumbai has a strong network of hospitals and medical facilities that generate diverse categories of waste.

Municipal Solid Waste

Exponential growth of population and urbanization, improvement in standards of living coupled with expanding economy has resulted in an increase in amount of Municipal Solid Waste (MSW) generation throughout the world. As per CPCB Central Pollution Control Board, in 2016, India produced around 52 million tonnes of MSW every year, out of which 23% of MSW got processed using scientific processing technologies[45]. Majority of the MSW goes unprocessed in dumping grounds. If not disposed properly, this waste accumulation may lead to various environmental as well as health issues. Navi Mumbai city however, has a scientific landfill site at Turbhe which process wet and dry waste separately thereby reducing the load of waste which goes in landfilling. The corporation gives more importance to on site segregation for better waste management

Apart from sprawling residential and commercial sector, Navi Mumbai city also has a well-established industrial sector and has well equipped network of medical infrastructure which generates diverse categories of wastes. NMMC has appointed private contractors for collection, transportation and disposal of MSW generated day after day or daily from all 8 nodes coming under NMMC jurisdiction area. Turbhe's scientific landfill site receives the MSW on daily basis which gets processed and disposed off at site. The site has leachate collection and treatment facility, composting unit and 2 stage Biomass Gasifier system which generates electricity using woody biomass (waste).

Source and Composition

According to the estimates, in 2018-19, NMMC area generated around 753 MTs (Metric Tonnes) of solid waste/day on an average. As seen in Figure No. 36, among all the waste categories, the share of biodegradable waste is around 73% which includes organic matter (60%) and coconut shells (13%). In 2018- 19, the share of plastic waste is recorded at around 10% which was found to be lower as compared to 11.7% estimated during the year 2017-18 thus witnessed decrease in quantity of plastic waste. At 0.6%, Metal waste possesses the lowest share in total solid waste composition.

[44] https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html
[45] https://cdn.downtoearth.org.in/library/0.89650700_1463994246_sample-pages.pdf

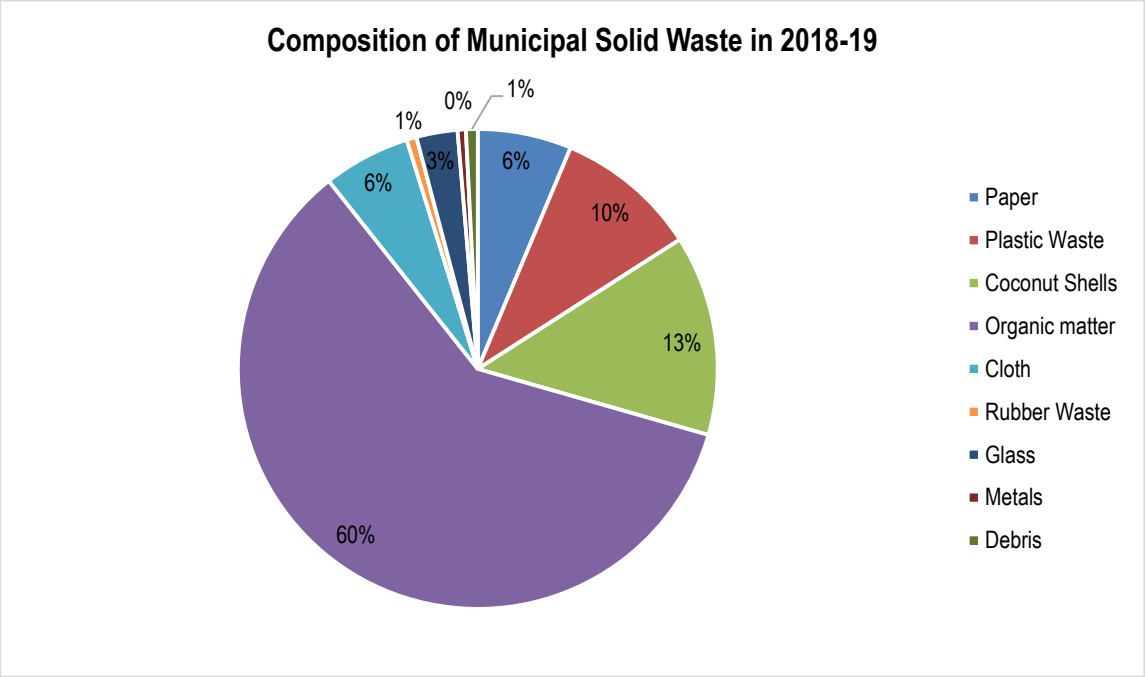


Figure No. 36: Composition of solid waste in NMMC

Source: Environment Laboratory, NMMC

In 2018-19, highest quantity of solid waste (daily average) gets generated by Turbhe node (134.0 MTs/day) followed by Koparkhairane (124.0 MTs/day). Digha node generated lowest quantity (24.0 MTs/day) of solid waste.

Table No. 39: Node wise quantity of daily MSW generated & number of dustbins in NMMC (2018-19)

Sr. No	Node	Ward	Average daily MSW generation (Metric tons)	Number of Dustbins				
				120 Litres (green)	120 litres (blue)	240 litres (green)	(240 litres blue)	Total Dustbins
1	Belapur	A	113.0	1149	1076	801	897	3923
2	Nerul	B	113.0	576	566	776	787	2705
3	Vashi	C	85.0	544	459	495	550	2048
4	Turbhe	D	134.0	237	242	521	485	1485
5	Koparkhairane	E	124.0	642	575	471	557	2245
6	Ghansoli	F	78.0	75	98	392	373	938
7	Airoli	G	82.0	421	318	594	772	2105
8	Digha	H	24.0	16	17	34	67	134
Total			**753.0**	**3660**	**3351**	**4084**	**4488**	**15583**

Source: Department of Solid Waste Management, NMMC

Collection

Along with solid waste collection and transport, NMMC's Solid Waste Management department performs daily road sweeping (twice/day) and cleans storm water drains prior to monsoon every year. These operations are conducted by private contractors appointed by the corporation.

NMMC ensures 100% garbage collection from housing societies through door to door collection method. The corporation also collects waste from commercial and educational institutions and from industrial premises. NMMC has provided 120 litre bins (green colour for wet and blue colour for dry garbage) for the same. A significant numbers of dustbins are provided in each node of NMMC and at market places. The node wise distribution of green and blue dustbins, 120 Litres and 240 litres has been presented in Table No. 39 and the transportation vehicles used for the collection and transportation of solid waste is provided below in Table No. 40.

Table No. 40: List of vehicles used for collection and transportation of solid waste

Sr. No	Type of vehicle	Total no. of vehicles
1.	16 TGVW Compactor	45
2.	10- 11 TGVW Compactor	24
3.	15 GVW Mini Truck	50
4.	Green waste vehicle	8
5.	Inspection vehicle	5
6.	Washing Jet hyper spray vehicle	2

Source: Solid Waste Department, NMMC

Sweeping

Daily sweeping in NMMC area is undertaken through private contractors. The city has been divided into 8 administrative divisions which are divided into 91 sub-divisions for monitoring purpose. A total of 1317 km length of road is swept every day. The total number of sweepers employed for this purpose is 2646 and sweeping is conducted daily for about 8 hours starting in the morning.

NMMC has 8 mechanical sweepers for efficient sweeping of roads. The sweeping machines are fitted with suction technology, water sprinklers and brushes which are used to collect dirt, sand, pebbles and scattered leaves from the road. A list of equipment owned by the contractor is Fibre bins (1856), Hand Containers (148), Grass cutting Machines (89) and Flippers (408).

Segregation, Processing & Scientific Disposal

Landfill Site – Basic Details

NMMC's Turbhe landfill site is spread over 65 acres which has state of the art composting facility, leachate collection tank and treatment plant, baling unit along with other machineries and equipment necessary in waste processing and disposal. NMMC collects municipal solid waste on daily basis through private contractors and transfers the waste to this site for further processing. Each waste carrying truck gets weighed on weighing bridge for maintaining the data of waste amount on daily basis. It is estimated that in the year 2018-19, the Turbhe landfill site received around 753 MTs waste per day.

Picture No. 7: Truck being weighed on weighing bridge at landfill site

Source: TERI image

NMMC has installed rotating trommel machines on site (Picture No. 8). These machines are a part of waste separation technique. These machines are sloped, rotating, screen covered drums which rotates the feed (waste) and separates recyclable materials, municipal solid waste components and finished compost from windrows. This machine helps the waste processing facilities to decrease the amount of solid waste going for landfill.

NMMC, in collaboration with TERI has also installed a 2 stage biomass gasifier plant at site which generates electricity from dry woody biomass which gets generated in the city on daily basis Dry Biomass includes tree cuttings, (branches, twigs) collected from housing complexes and garden and roadside areas. NMMC plans to further scale up the capacity of plant from 25kWe to over 100kWe by installing 1 more gasifier plant of capacity 100kWe.

Picture No. 8: Rotating trommels at the Turbhe landfill site

Source: TERI image

The sanitary landfill has been protected, from stray dogs and trespassers, by constructing a compound wall along the periphery. Trees of various species are planted around the periphery of landfill site. Completed phases of sanitary landfill are covered with grass and reduce the direct emissions of 'Greenhouse gas', the landfill gas (majorly methane) is flared. Air Quality Monitoring Station present at this site helps to monitor air pollution from this integrated solid waste disposal facility at Turbhe.

Quantification, Segregation and Disposal

Once the waste reached at the processing plant at Landfill site, it gets segregated into 3 sections namely dry, wet and mixed waste. Plastic waste gets segregated from the dry and mixed waste and transferred to the Baling unit which converts plastic waste pieces into small beads called Low Density Polyethylene (LDPE) granules. NMMC uses these granules for the construction of roads. Other dry waste such as paper, metal and glass goes for recycling.

NMMC has constructed a compost unit at landfill site wherein the wet waste gets converted into compost on daily basis. The unit works on windrows technology and around 40MTs/day of compost gets generated on site. This compost may be utilized in TERI's proposed quarry restoration project.

A schematic of the processing and the overview of the segregation and disposal process are elaborated inFigure No. 37. While disposing the solid waste, de-odorant is sprayed to minimize the stench and nuisance which may be caused by flies and pests.

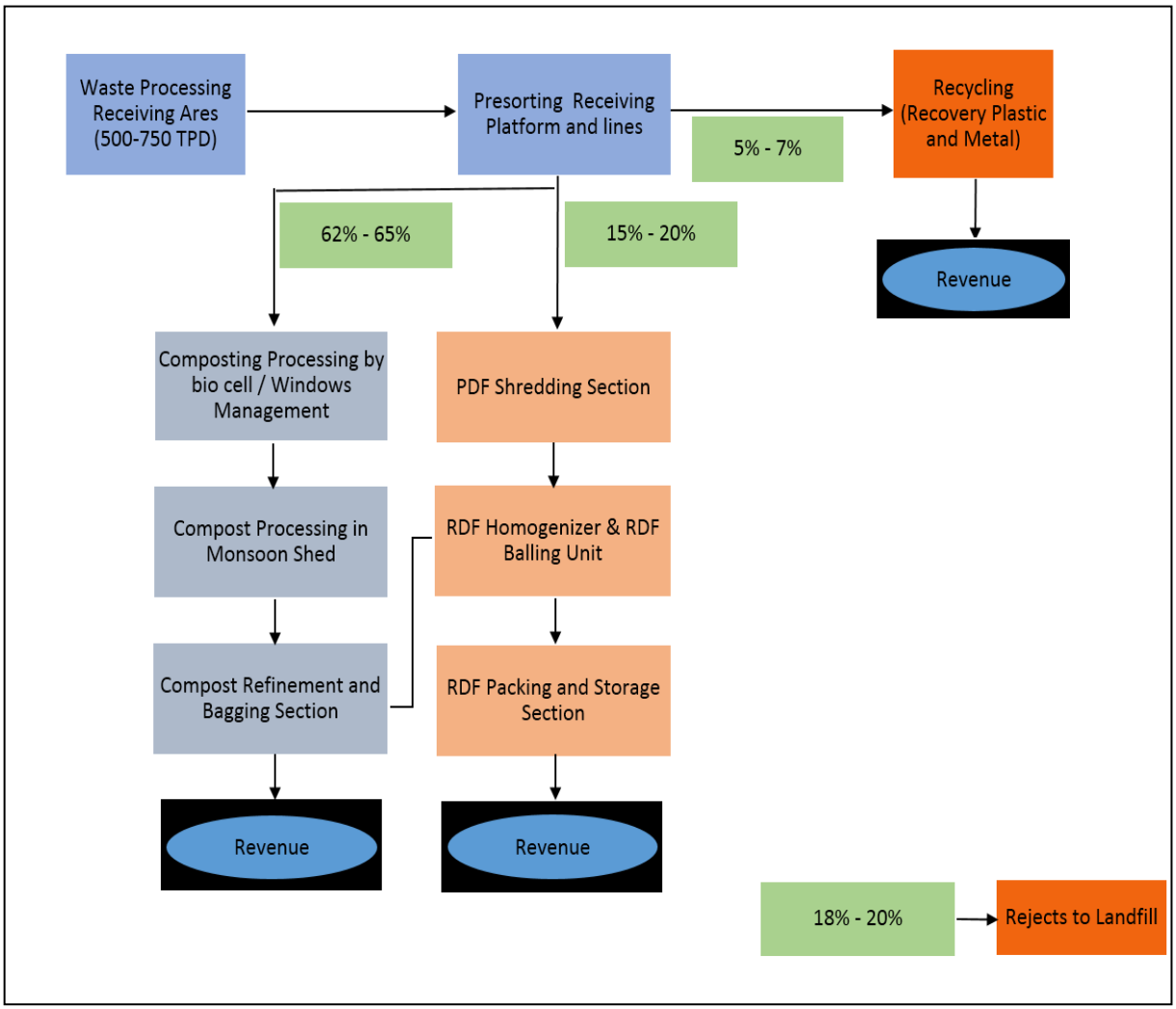


Figure No. 37: The process flow diagram of the Municipal solid waste

Source:Solid Waste Department, NMMC

Picture No. 9: Composting Unit (left) and Plastic Baling machine (right) at Turbhe landfill site.

Source: TERI images

Leachate, a liquid which seeps from a landfill waste gets collected at Leachate collection tank constructed at site. The collected leachate then gets transferred to the Leachate treatment plant which works on Sequencing Batch Reactor (SBR) technology which treats the leachate and reduces the levels of contaminants and Biochemical Oxygen Demand (BOD) to an acceptable level for discharge to the environment.

Picture No. 10: Leachate collection tank (left) and Leachate treatment plant (right) at Turbhe landfill site

Table No. 41: Leachate analysis report at Turbhe site in NMMC

	Parameters						
	pH	D.O	B.O.D	C.O.D	Chloride	Hardness	Sulphate
Influent	7.6	0.7	1539	4709	1211.09	892	718.58
Effluent	7.4	7.4	21	121	436.75	274	582.68

Note: All Values are in mg/l except pH
Source: Environment Laboratory, NMMC

Response Initiatives

Inauguration of 25kWe capacity 2 stage Biomass Gasifier (Pilot scale)

With an increasing urban population, there is an increment in the solid waste generated in the city. The disposal of the solid waste generated is becoming a big challenge, particularly for a NMMC. In order to overcome these challenges NMMC is proactive in its approach and planned to pursue waste to energy projects, initially as demonstration projects. This in turn would reduce NMMC's carbon footprint and also provide an opportunity to showcase and promote clean and climate-friendly technologies.

Picture No. 11: Woody biomass being cut using wood cutter on landfill site (TERI image)

As part of the Eco-City project, (a collaboration between NMMC and TERI), NMMC commissioned a 2 stage Biomass gasifier at Turbhe landfill site. As per the study, around 20MTs of green waste gets generated in the NMMC jurisdiction area on daily basis which consists of mainly woody dry biomass. This waste wood (dry biomass) has a very high calorific value and can be a source of electricity which can partially meet the energy needs of the landfill site. As per the estimates, the average calorific value of tree cuttings (dry biomass) is approximately 3500-4000 Kcal/kg. Such biomass contains very less moisture (~8%) and ash content (~2%) which is suitable for biomass gasifier based technology. In biomass gasification, solid biomass material is subjected to partial combustion in the presence of a limited supply of air or oxygen.

The combustion takes place inside a closed vessel called 'Gasifier'. The product thus formed is termed as 'Producer Gas', a mixture of carbon mono-oxide (20-22%), hydrogen (12-15%), methane (2-3%), carbon dioxide (9-11%) and nitrogen (45-50%).The system currently generates around 20kWe electricity. The energy thus produced gets supplied to the connected loads in the administrative block of the campus, as well as other lighting facilities. Furthermore, it is capable of supplying energy to three high masts, conference halls, and for other similar lighting needs on the site.

Picture No. 12: Conference facility (left) and High mast street lighting (right) at Turbhe landfill site

Source: TERI images

On the eve of World Environment Day, (June 5th, 2018), NMMC commissioned the pilot plant and the inauguration of the gasifier plant was done at the hands of Dr. N. Ramaswamy, (IAS) *Commissioner, NMMC* with presence of other dignitaries from TERI, NMMC and Swiss Development Corporation (SDC). The technologically advanced two-stage biomass gasifier system for power generation has been developed by TERI in partnership with the Danish Technological University (DTU) and "Effin'art", a Swiss energy efficiency consulting firm. The two-stage gasifier power plant is financed by the Swiss Agency for Development and Cooperation under its project on accelerated diffusion of biomass based clean energy systems in India.

Picture No. 13: 25kWe 2 stage Biomass gasifier commissioning at the hands of Dr. Ramaswamy N. (IAS). ***Commissioner, NMMC;*** **and other dignitaries (Dr. Shirish Sinha,** ***Deputy Director of Co-operation, SDC*****; Mr. Mohan Dagaonkar,** ***Chief City Engineer, NMMC,*** **Dr. Anjali Parasnis,** ***Associate Director, TERI-WRC)*** **at Turbhe landfill site on 5th June 2018.**

Picture No. 14: 25kWe 2 stage biomass gasifier on landfill site.

Source: TERI images

Decentralized Waste Composting

NMMC is having a robust mechanism for collection and transportation of waste from source area to the landfill site. Still with increasing population and change in life style, amount of MSW (Municipal Solid waste) generated in the city is increasing for which the corporation has to consider the alternative strategies. The corporation also has to work on possible cost increase associated with the waste transportation. Looking at the scenario, NMMC has started the concept of Decentralized Waste composting, starting from slum areas[46].

At first, NMMC has targeted around 2000 households from Indira Nagar slum where the concept is introduced. The corporation, after analyzing the issues, started constructing compost pits, and provided bins and started engaging local community from Indira nagar slum. Similar process was carried out in Advali Gaon. In this initiative, appointed workers collect and segregate waste and operate composting units.

Scale up of this initiative is 100% possible and with the same approach; NMMC is planning to launch this initiative in small pockets in the city. This initiative, on a large scale, would not help in solving the waste problem but also help in creating awareness and could generate employment opportunities as well. It would also help corporation in the form of cost involved in collection and transportation. As of now, NMMC initiated this approach in 2 areas having more than 4000 households and plans to cover all areas wherein segregation of waste at source and/or composting is a major task.

Segregation at Source

Waste segregation is the basic and primary step of scientific waste management. Waste segregation almost reduces the problem of waste by around 80% as more and more materials at the disposal end can be retrieved for recycling[47]. NMMC's Solid waste department always gives importance to the waste segregation which gets reflected through the working approach of the department and through the numerous initiatives taken on annual basis.

As a part of waste segregation, at city level Waste, the corporation has kept dustbins of various sizes (80,120 and 240 litres) and colors (Green – Wet waste) and (Blue – Dry waste) at each node. Looking at the problem of e-waste, NMMC has also started demo initiative wherein red bins are kept at few locations especially for the e-waste and hazardous wastes.

Green bin (wet waste)	Blue bin (dry waste)	Red bin (E-waste and Hazardous waste)
• Leftover food items • Cotton • Match sticks • Fruit peels, egg shells • Green waste (small tree branches, leaves	• Plastic items,cups styrofoam, • Glass pieces • Metal cans, pots • Milk, fruit juice cartons • Paper gift wraps and packaging materials • Cardboard boxes, tissue papers	• Electric batteries, wires • Cell phones, laptop, printer parts • Tubelights and bulbs • Insecticide, Pesticide, deodeorant cans • Paint cans, sprays, room freshners

Figure No. 38: Type of wastes as per the color coded bins

[46]Decentralized Composting Report of NMMC
[47]http://resolvetrash2cash.org/segregation-at-source/#.XQxmw-szbIU

Construction of Road from Solid Waste

Turbhe's landfill site has a Baling unit wherein the plastic waste gets converted into small granules (LDPE granules). These granules can be used as filler in road construction. NMMC has already adopted this technique in which these plastic granules are mixed with tar (6% concentration) and the mixture is then used for making roads. NNMC has undertaken construction of 10 such roads like the ones at Ghansoli underpass, MIDC Turbhe road and near Mahape Lake. For making plastic roads, plastic granules is mixed with tar and small stones (ashpalt), then they are mixed together on very high temperature, this ready mixture is used as wearing cot, on roads[48]. This technique helps increasing the durability of the road and also lowers the road maintenance cost. Research shows that such roads have higher resistance to deformation; water induced damages and has high strength compared to usual roads.

Initiatives under Swachha Bharat Abhiyan

As a part of Swachha Bharat Abhiyan, NMMC has constructed Swachhata Park in Nisarg Udyan, Sector 14, Koparkhairane. It is constructed with an objective of creating awareness about the garbage problem and to depict importance of waste segregation.

Picture No. 15: Types of pollution and its effects in posters and picture format at Swachhata Park

Source: TERI image

Anti-Plastic drive

To control the use of plastic and to avoid harmful effects of plastic on environment, NMMC has initiated Anti-Plastic drives in all nodes. Under this, all ward officers are instructed to conduct such drives in their respective wards. Table No. 42 shows monthly record of fine collected and amount of plastic seized by NMMC during 2018-19.

[48] http://www.freepressjournal.in/mumbai/navi-mumbai-municipal-repairing-roads-with-granules-made-out-of-waste-plastic/994341

Table No. 42: Monthly record of fine collected and amount of plastic seized by NMMC during 2018-19

No.	Month	Total number of shops/establishments checked	No. of shops/establishmentsfined	Amount of fine collected(INR)	Amount of Plastic seized (Kg)
1	April 2018	200	21	105000	2
2	May 2018	150	2	10000	0
3	June 2018	560	364	1567400	6721
4	July 2018	260	86	430000	821.5
5	August 2018	163	12	60000	187
6	September 2018	172	2	10000	9.8
7	October 2018	345	170	860000	20933
8	November 2018	289	65	335000	277
9	December 2018	175	37	180000	10
10	January 2019	235	40	157250	8
11	February 2019	215	40	235000	26
12	March 2019	362	130	750000	10215
	Total	**3126**	**969**	**4699650**	**39210.1**

Source: Swachha Maharashtra Abhiyan Kaksha, NMMC

Construction of Toilets

Along with constructing and maintaining community toilets (CT) and Public Toilets (PT),NMMC has formed 'Good Morning' Team on node level to maintain the status of Open Defecation Free Plus Plus (ODF + +) city. People defecating openly will not only be fined (Rs. 1200) but also have to face strict action.

Between April 2018 to March 2019, corporation also successfully conducted around 90 Thematic Cleanliness Drives which included around 321420 man hours.

Table No. 43: Smart She Toilets with rest room (Exclusively for Women)

Sr.No.	Node	Location
1	Belapur	CBD Belapur Bus Terminus, Sector 6
2	Nerul	R.R.Patil Udyan, Nerul
3	Vashi	Opp Center One Mall, Sector-30, Vashi
4	Vashi	Vashi bus terminus, Sector-9
5	Koparkhairane	Near D-mart circle, Sector-7
6	Airoli	Near Airoli bus terminus, sector-3

Table No. 44: Number and Locations of Smart E Toilets (Single seated, unisex)

Sr.No.	Node	Number	Locations
1	Belapur	4	Near T. S Chanakya Signal, Palm Beach Road
2			Near NRI Signal, Sector 50 Bus Terminal, Palm Beach Road
3			At Uran Junction, Sector 15, CBD Belapur, Palm Beach Road
4			Near DAV School, Sector 48, Nerul
5	Nerul	3	Near Vajrani Sports Signal, Palm Beach Road
6			Near D Y Patil Sports Stadium, Sion Panvel Highway
7			Opp. Nerul Bus Terminus, Sector-3
8	Vashi	2	Mini Sea Shore (North), Sector 10-A
9			Mini Sea Shore (South), Sector 10-A
10	Turbhe	2	Opp. Gokul Dairy, Palm Beach Road
11			Near Moraj Signal, Palm Beach Road
12	Koparkhairane	5	Near Lokmat Bus Stop Thane Belapur Road
13			Mahape over Bridge, Thane Belapur Road
14			Pawane near Zydus Company, Thane Belapur Road
15			Near Pawane Police Chowki, Thane Belapur Road
16			Near Bawkaleshwar Temple, Pawane MIDC
17	Ghansoli	3	Near Rabale Police Station, Thane Belapur Road
18			Talavali Naka, Thane Belapur Road
19			Ghansoli Naka, Thane Belapur Road
20	Airoli	1	Near Reliable Company, Thane Belapur Road

Table No. 45: Summary of Public/Community Toilets in areas under NMMC jurisdiction

Node	Community Toilets (CT)				Public Toilets (PT)											
	General				General				E/She Toilets		Moving Toilets		Toilets (BOT basis)			
	Nos.	Seat	Urinal	Bathroom	No	Seat	Urinal	Bathroom	No.	Seat	Nos.	Seat	No.	Seat	Urinals	Bathroom
CBD Belapur	48	675	47	2	20	67	77	2	5	5	2	22	1	7	5	
Nerul	39	515	32	7	13	61	38	2	4	4			1	13	5	2
Vashi					30	264	52	1	4	4	3	30	5	37	35	5
Turbhe	39	558	80	5	10	59	27		2	2	5	44	1	6	10	3
Koparkhairane	50	648	8		7	18	19		6	6			1	10	5	3
Ghansoli	79	989	16		2	32	3	1	3	3						
Airoli	45	594	21		10	73	21		2	2						
Digha	69	819	29													
Total	**369**	**4798**	**233**	**14**	**92**	**574**	**237**	**6**	**26**	**26**	**10**	**96**	**9**	**73**	**60**	**13**

BOT: Build, Operate, Transfer

Note: Periodic maintenance and cleanliness of toilets built by the corporation is recommended.

Picture No. 16: Public and Community toilet facilities constructed by NMMC

Proposed Initiatives

1. Scaling up of gasifier system to a 100kWe biomass gasifier system

NMMC is in process to further scale up the capacity of power generation from gasification. The proposed system at the Turbhe landfill site will generate electricity upto 100kWe, up from its current capacity of 25kWe (pilot). TERI shall install and commission the gasifier and provide all the necessary training to the concerned workforce on site. The electricity generated from the 100kWe gasifier can be utilized to power various processing machines in the composting/leachate unit and RDF (Refuse Derived Fuel) unit. The list of machines available in various processing units is given in following Table No. 46.

Table No. 46: Motive load in Turbhe landfill site

S.No	Equipment	No.of motors	Connected Load (kW)	Duration of operation per day
1	Segregator - 1	7	40	10
2	Segregator - 2	4	39	10
3	Plastic unit	6	23	7
4	Compost Plant	1	7.5	7
Total			**109**	

Source: NMMC

Apart from the motive loads the landfill campus also has several other loads such as lighting, fans and air conditioning loads in the administrative block, Laboratory, kitchen and other facilities in the campus.

2. Decentralized biogas plants of 10-30 MT capacity to be installed at the ward level in order to generate energy which could be used for area lighting at the ward level.
3. Initiative to achieve 100% segregation of Municipal solid waste at source from all nodes under NMMC jurisdiction.

4. Under the banner of Swachha Bharat Abhiyan, NMMC has planned to install a Waste to Energy plant in the module of 600 TPD which shall help convert the Refuse derived fuel (RDF) to Energy.
5. NMMC is planning to set up a construction and demolition waste debris recycling plant realizing the need for conservation of environment.
6. Setting up of an E-waste recycling plant has been proposed by NMMC.

Initiatives by Navi Mumbai Citizens

To tackle the problem of waste, it is very important to segregate and process waste at source itself to reduce the burden of waste on landfill sites. It would also decrease in carbon emissions associated with the transport of the waste from the generation point to the processing sites. NMMC's approach towards the waste management is very proactive through the medium of awareness campaigns and Swachha Bharat Abhiyan. Along with the corporation, the citizens of Navi Mumbai are also proactively participating in waste management. Various bulk generators which include housing complexes, institutions and hotels which produce more than 100 kg/day of wet waste have installed composting units in their premises which converts wet waste into compost at the source itself. It is a very novel approach which must be scale up further to a great extent.

Picture No. 17: Composting units installed in Housing complex (left) and wet waste being processed at source (right)

Source: Solid Waste Management Department, NMMC

Biomedical Waste

Biomedical waste is generated during the diagnosis, treatment or immunization of human beings or animals or during research activities. Medical care is vital for human wellbeing. Good health and effective medical care can increase life expectancy by improving an individual's functional ability and quality of life. According to the EPA, one hospital bed generates approximately 13 pounds of medical waste per day[49]. Other estimates put this number even higher at as much as 23 pounds per bed, per day[50] . As per the Bio Medical Waste Management Rules, 2016, waste is segregated into four categories based on the segregation pathway and colour code. The waste related with medical facilities causes a direct effect on community; workers associated with healthcare industries and on overall environment as it may be infectious, poisonous, pointed, sharp, un-sterile, etc. Hence it is crucial to scientifically manage and dispose biomedical waste to reduce its direct impact on the environment as well as humans.

[49] http://hwmusa.com/medical-waste-generation/
[50] http://bit.ly/2W5jZ5s

Biomedical waste generation

The Navi Mumbai city generates sizable amount of biomedical waste due to presence of various and advanced healthcare facilities like hospitals, blood banks, dispensaries, research laboratories and so on in Navi Mumbai city limits. In 2018-19, the average biomedical waste generated by the government run hospitals in NMMC, was around 14899.44Kg (Table No. 47)

Table No. 47: Composition of biomedical waste generated by NMMC hospitals

Categories (% evaluation)	Disposal Method	Vashi Hospital, Vashi	Mata Bal Hospital, Nerul	Mata Bal Hospital, Airoli	Total Biomedical waste (in MTs)
Needle, Lancet, Scalpel Veinflor, Discarded Glass wares- Tube, Pipettes, Syringes, Slides, Coverslips, Disposal Waste- IV Sets, Disposal syringes, Injection Vials, Amp. Glass, Bio Catheters, Plastic Bottles	Autoclaving & Shredding	9487.60	266.57	203.44	**9,957.61**
Microbial Waste, Highly Infectious Waste, Isolate, Discarded Medicines, Solid Waste, Liquid Waste	Incineration	4616.12	208.47	117.24	**4,941.83**
Total		**14,103.72**	**475.04**	**320.68**	**14,899.44**

Source: Health Department, NMMC

Collection, Treatment & Disposal

MWML (Mumbai Waste Management Limited) is the sole agency responsible for collection transportation and disposal of Bio Medical Waste generated within the city. MWML has the consent issued by MPCB (Maharashtra Pollution Control Board) and an agreement with NMMC for the same. Scientific treatment on biomedical waste is mandatory before waste being disposed off. There are various treatments for treating biomedical waste such as autoclaving, incineration, chemical and microwave treatment (based on nature of the biomedical waste). These methods can be used for disinfecting the waste and help prevent infection.

MWML's facility is equipped with Incineration Systems with equipment like Primary Combustion Chamber with temperature range of 800°C to 850°C, Secondary Combustion Chamber with temperature range of 1050°C to 1100°C, Ventury Scrubber, Spray Quencher, ID Fan & 30 mtrs. Chimney, Autoclave, Shredder, Gas Monitoring Device, Effluent Treatment Plant and Computerisation.

Construction and Demolition Waste

Construction and Demolition waste is produced at a point where development/demolition activity takes place, for example, building roads, bridges, flyovers, subways, remodelling and so forth. It comprises for the most part of dormant and non-biodegradable material, for example, solid, mortar, metal, wood, plastics and so forth. Greater part of this waste gets dumped along the roadside, wetlands, water bodies, nallahs and storm water channels, subsequently choking them. Waste from small C & D waste generators like individual house

development or destruction, discover its way into the close-by city container/tank/waste stockpiling stops, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery.

Under Swachha Bharat Abhiyan, NMMC is in the process of establishing a 20 tons/day capacity C&D recycling plant at its Turbhe Landfill facility. Around 5 acres of areas has been reserved to construct the facility. The plant shall segregate the waste into sand, metals and stone dust and also use part of it to manufacture paver blocks/tiles.

Hazardous Waste

Hazardous waste is a waste with properties that make it dangerous or fit for harmfully affecting human wellbeing or nature. Hazardous waste is generated from numerous sources, extending from modern assembling process wastes to batteries and may come in numerous structures, including fluids, solids, gases, and mucks. They can be side-effects of assembling forms or just discarded commercial products, such as cleaning liquids or pesticides. The United States Environmental Protection Agency (US - EPA) classifies liquid, solid and gaseous discarded materials and emissions as hazardous if they are toxic, flammable, corrosive or chemically reactive at levels above specified safety threshold[51]

Trans Thane Creek (TTC) industrial area comes under NMMC area. The area having presence of industries of diverse profile including petrochemical, pharmaceutical, R&D laboratories, and chemical industries which generates hazardous wastes on daily basis. Towards this the Trans Thane Creek Waste Management Association (TTCWMA) provides support for disposal of hazardous waste though secured landfill. This association was established on 30th, November, 1998. The centre possesses various testing and calibration facilities for biological and chemical testing. The well-equipped laboratory is having analytical instruments like Gas Chromatography (GC), Gas Chromatography-Mass Spectrometry (GC-MS), Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES) and other conventional equipment. The laboratory is NABL (ISO 17025) accredited and OHSAS (ISO 18001) certified.

Generation, Collection and Disposal

- Industries register their membership with TTCWMA upon which the member industry sends their waste representative sample of waste for analysis to identify "Disposal Pathway".
- As of 2018-19, total 665 industries have registered themselves for the membership. Majority of industries are Chemical, Petrochemical, Research/Analytical labs, Engineering and Pharma industries.
- Registered members supply their hazardous waste for treatment and disposal and the major category of hazardous waste treated by facility is ETP Sludge/ Sludge from Waste Water Treatment Plant which has a Solid or semi-solid texture.
- In the year 2018-19 about 130954.780 MTs of hazardous waste was collected and treated by this facility and disposed at the secured landfill site at this facility while the incinerable waste send to MWML, Taloja for incineration
- TTCWMA has a National accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory for characterization of waste, effluent and other environmental parameters.

[51] http://science.jrank.org/pages/3237/Hazardous-Wastes.html

- After analyzing it, TTCWMA send MPCB authorized Hazardous Waste Transport Trucks to the company.
- Company fills Form No. 10 (Manifest form) [as per Hazardous Waste Management Rule 2016] and sends the consignment to TTCWMA.
- When this consignment comes to TTCWMA site, TTCWMA representative draw samples from truck and again do the analysis to cross check the parameters and concentration.
- Treatment of waste is done by addition of Lime, Cement and Fly ash.
- TTCWMA has facility for secured landfilling. These wastes are disposed in scientifically prepared secured landfill cells.
- The total area allotted by MIDC to TTCWMA is 83,000 Sqr. Mtr and about 60,000 Sqr. Mtr of the area is utilized for landfill cells. The expected lifespan of landfill cell is about 5-6 Years (depending on incoming Quantum of waste)

The center as a part of Corporate Social responsibility (CSR) has planted around 20000 trees in collaboration with a NGO at Mouje and Dhamtan village, Kalyan.

As a part of Environmental Sustainability, The center is interested in Co-Processing if incinerable hazardous and non-hazardous waste in cement plant as fuel. Accordingly, it has sent a formal application to the MPCB. Once approved, it would help the center in achieving greater environmental sustainability.

Health

Environment and Health

There is a growing tendency of migrating towards urban areas as these areas offer good education and job opportunities and a higher standard of living. Although urban populations, on an average, enjoy better health than their rural counterparts, today's urban environment can concentrate health risks and introduce new health problems. As per the estimation of the World Health Organization (WHO), around 36 million deaths per year, accounting for 63% of global mortality, is due to the Non-Communicable Diseases (NCD). A major proportion of these deaths can be attributed to risks triggered by urbanization[52]. This could be a result of cardiovascular, pulmonary or respiratory diseases caused due to urban air pollution, heat strokes and heat wave related ailments and lifestyle disorders such as obesity and diabetes due to change in eating habits. Along with NCD, unhealthy and polluted urban environments also give rise to communicable diseases especially vector and water borne diseases that spread due to unsafe potable water and improper sanitation.

To counter these diseases, all urban settlements must have proper healthcare facilities along with a trained workforce in place along with better environmental conditions. Such facilities are important to take care of citizens especially during any medical emergencies or during any epidemic outbreak. Navi Mumbai has several private and government hospitals which are equipped with latest technologies and specialist doctors, experienced staff who can handle any emergency cases. Day and night chemists are also available in the city. The following section presents the list of healthcare facilities (Table No. 48), status of various diseases, actions taken to overcome or minimize such problems for the year 2018-19.

Table No. 48: Health care facilities in NMMC

	2014-15	2015-16	2016-17	2017-18	2018-19
No. of Private Hospitals	188	197	198	216	217
Registered With NMMC	186	197	194	214	216
Dispensaries	191	184	135	153	254
Ayurvedic Clinics	386	377	315	329	405
Homeopathy Clinics	158	152	191	249	272
Bachelor of Dental Surgery	85	80	73	91	242
Pediatricians	75	75	75	100	100
Gynecologists	83	83	83	81	81
NMMC Hospitals	5	6	6	6	6
NMMC Dispensaries	21	21	22	22	23
NMMC Mobile Dispensaries	2	2	1	1	1
Private Dispensaries	920	920	849	886	1461
Private Nursing Homes	81	81	81	81	81

Source: Health Department, NMMC

[52] https://www.who.int/sustainable-development/cities/health-risks/about/en/

Water Borne Diseases

Water borne diseases are caused due to water contamination, either by pathogenic bacteria, viruses or protozoa. These agents are transmitted to people when the water is used for drinking, cooking or other domestic or recreational purposes. Health of an individual gets compromised when such harmful pathogens contaminate drinking water either at source or through seepage of contaminated runoff water or within the piped distribution network. Along with this, unhygienic handling of water during transportation or within home may also contaminate clean water.

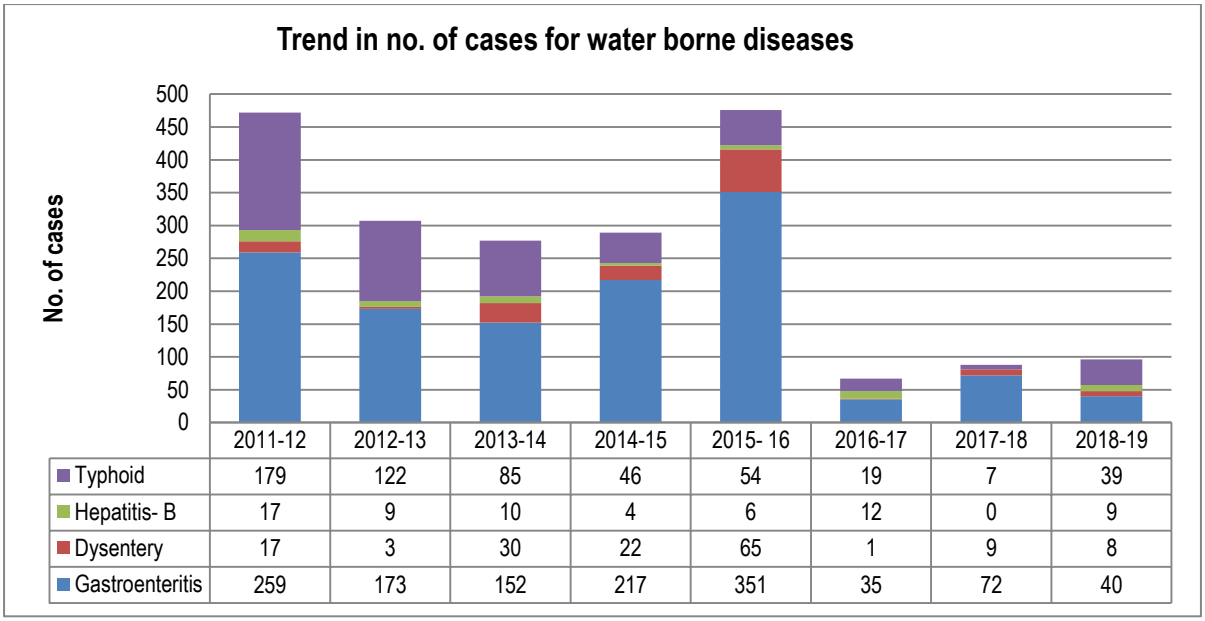
NMMC's Health department has been proactive in tackling the spread of such diseases and its dedicated trained workforce has been working tirelessly towards the mitigation of such diseases through their annual preventive measures. The annual trend of the total number of persons residing in NMMC's jurisdiction area getting affected by water borne diseases is given below in Table No. 49

Table No. 49: Persons affected by Water borne diseases in NMMC

Area	Patients Per node							
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
CBD Belapur	10	8	5	8	12	2	0	0
Karave	7	6	1	4	8	12	23	11
Nerul I	4	8	6	5	12	1	3	1
Nerul II	15	5	7	4	16	0	0	1
Shiravane	17	5	51	42	33	2	3	6
Sanpada	15	7	6	10	21	1	3	0
Indiranagar	35	26	29	32	36	5	3	0
Turbhe	63	6	25	30	55	8	1	6
Vashigaon	16	22	18	12	14	3	11	5
Juhugaon	28	33	1	1	26	7	1	28
Khairne	23	28	52	48	41	11	2	0
Mahape	63	37	24	26	28	1	2	0
Pawane	7	28	18	12	18	4	9	6
Ghansoli	38	21	18	16	34	4	9	0
Rabade	6	8	13	11	12	1	2	7
Katkaripada	2	2	0	5	19	2	9	17
Airoli	86	40	25	25	34	1	0	0
Chichpada	8	3	3	2	12	0	4	0
Digha	13	9	10	8	21	1	1	2
Nagaon	-	-	2	0	0	0	0	0
Ilthanpada	16	5	4	1	16	1	1	6
NOCIL Naka	0	0	4	0	8	0	1	0
Total	**472**	**307**	**318**	**302**	**476**	**67**	**88**	**96**

Data source: Health Department, NMMC

As seen in Figure No. 39, Gastroenteritis has showed a major decrease from 72 cases in the previous year to 40 cases in 2018-19. Dysentery cases decreased marginally from 9 (2017-18) to 8 in 2018-19. However, in case of Hepatitis-B and Typhoid, an increase in the number of cases was observed. There were no cases of Hepatitis- B reported in the previous year (2017-18), but there were 9 cases reported in 2018-19. The number of Typhoid cases has also risen from 7 in the year 2017-18 to 39 cases in 2018-19. This increase could be due to consumption of contaminated food and drinks.



	2011-12	2012-13	2013-14	2014-15	2015- 16	2016-17	2017-18	2018-19
Typhoid	179	122	85	46	54	19	7	39
Hepatitis- B	17	9	10	4	6	12	0	9
Dysentery	17	3	30	22	65	1	9	8
Gastroenteritis	259	173	152	217	351	35	72	40

Figure No. 39: Trend in cases of water borne diseases reported in NMMC area

Source: Health Department, NMMC

Vector Borne Diseases

Diseases are caused by vectors, living organisms that transmit infectious diseases between humans and animals. Many of these vectors are arthropod species and include bloodsucking organisms such as mosquitoes, ticks and fleas. These vectors ingest disease producing microbes from an infected host (human/animal) and later inject it into a new host thereby continuing the spread of such diseases. Malaria, Dengue, Japanese encephalitis, Leishmaniasis and Yellow fever are some of the most common and widespread diseases globally.

Malaria

The *Plasmodium* parasites, the cause of malaria, are spread to people through the bites of the infected female *Anopheles* mosquitoes, active mainly during dusk and dawn. Out of the 5 malaria causing parasite species, *P. falciparum* and *P. vivax* are the most common *P. falciparum* is the most dangerous with the highest rate of mortality. In 2017, nearly half of the world's population was at risk of malaria[53]. The intensity of transmission of Malaria greatly depends on climatic conditions. Malaria is more common in Tropical and subtropical climates. In 2017, there were an estimated 219 million cases of malaria registered in 87 countries with majority of the cases reported in African countries[54] As per WHO's World Malaria Report 2018, India accounted for 4% of malaria cases out of the total cases registered worldwide[55]

[53] https://www.who.int/news-room/fact-sheets/detail/malaria
[54] https://www.who.int/news-room/fact-sheets/detail/malaria
[55] https://www.who.int/malaria/media/world-malaria-report-2018/en/

Table No. 50 enlists UHP wise total number of malaria cases reported by NMMC's health department in the last 5 years. As seen in the table, a decreasing trend is been observed continuously in malaria cases for the 5th year straight from 2014-15. In 2018-19, around 33% decrease in malarial cases has been reported with the number of cases decreasing from 138 in 2017-18 to 92 in 2018-19.

Table No. 50: UHP wise reported malarial cases in past five years in NMMC area

Nodes/Year	2014-15	2015- 16	2016-17	2017-18	2018-19
CBD Belapur	20	30	13	5	3
Karave	34	31	24	8	9
Nerul	18	12	11	3	1
Nerul II	27	19	5	4	1
Shiravane	26	17	8	4	2
Sanpada	20	14	11	7	3
Turbhe	26	20	24	13	16
Pawane	24	24	23	14	13
Indiranagar	39	27	41	36	14
Juhugaon	3	3	1	0	0
Vashigaon	5	4	2	1	0
Koperkhairne	20	19	15	11	6
Mahape	6	6	6	3	3
Ghansoli	16	17	13	5	5
Rabade	6	5	6	5	3
Katkaripada	14	9	7	3	3
Airoli	8	10	6	3	3
Chinchpada	9	7	3	5	2
Digha	16	7	7	3	1
Ilthanpada	13	11	8	3	3
NOCIL naka	6	9	8	2	1
Total	**356**	**301**	**242**	**138**	**92**

Source: Health Department, NMMC

Dengue

Dengue or Dengue fever is a mosquito borne viral infection which causes flu like symptoms and occasionally develops into a potentially lethal complication called 'Severe Dengue'. The occurrence of this disease has grown drastically with about half of the world's population is at risk of acquiring infection. Dengue virus is transmitted by female mosquitoes mainly of the species *Aedes aegypti* and, to a lesser extent, *Aedes. albopictus*[56].

Dengue is spread throughout the tropics and its intensity of occurrence is influenced by rainfall, lack of hygiene and sanitation, unplanned urban growth. Dengue fever is severe with symptoms like severe headache, nausea, vomiting, muscle joints and skin rashes. In the absence of effective medical treatment, it may cause the death of an individual. The disease could be prevented by following good practices like covering and cleaning domestic water storage tanks periodically, preventing the formation of mosquito breeding sites through proper environmental management and so on.

[56] https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue

As shown in the Figure No. 40, in the financial year 2018-19, the number of persons getting affected by Dengue in NMMC area has decreased with only 4 persons having been affected with dengue compared to 6 during the previous year (2017-18). This is due to the sincere efforts made by NMMC's health department to prevent the occurrence of vector borne diseases.

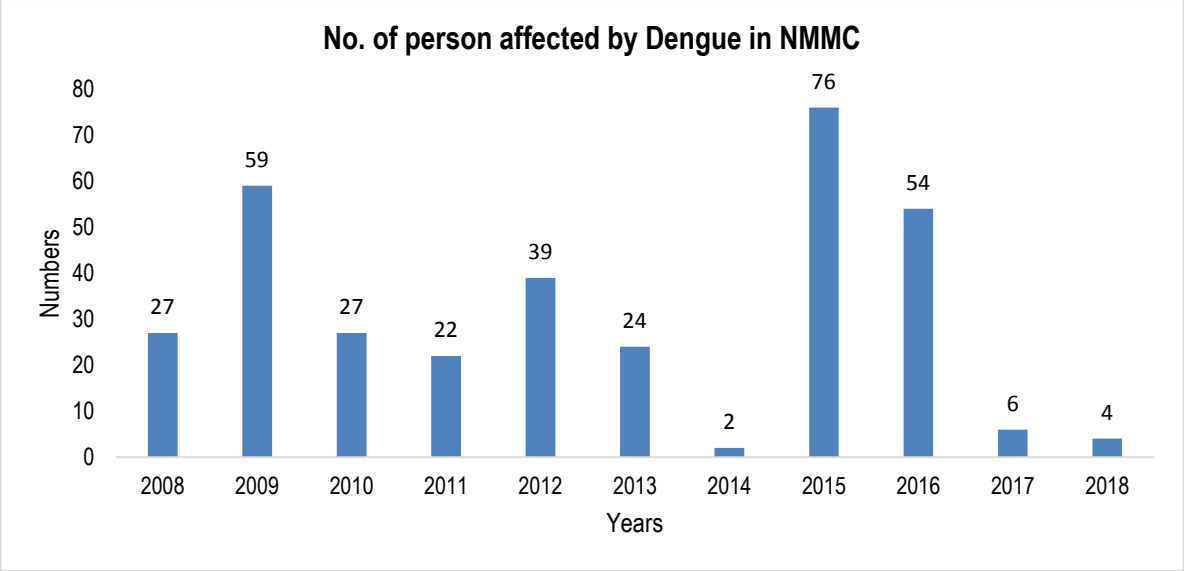


Figure No. 40: Total number of Dengue cases reported in Navi Mumbai

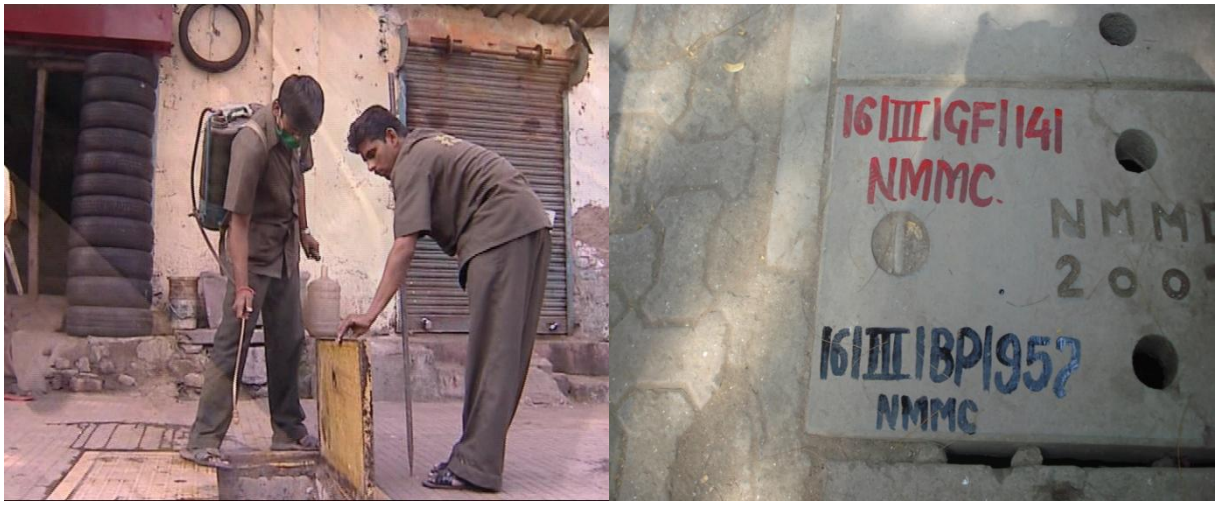
Source: Health Department, NMMC

Response

NMMC has a well-trained group of medical experts and a technical workforce which works continuously to eradicate diseases such as Malaria, Dengue, TB and water borne diseases. The department continuously keeps a check on the status of the diseases mentioned above and implement strategies to prevent the occurrence of such diseases through a variety of preventive and therapeutic measures. The department also conducts several health education camps, seminars and workshops to use education as a tool to support behavioural changes that could enable citizens to protect themselves from infections and to tackle an environmental source of infection. Under the 'National Vector Borne Disease Control Program', many preventive measures against malaria and dengue are being undertaken by NMMC.

Regular Preventive measures

- Weekly anti-larval spraying and fogging through private contractors
- The promotion and cultivation of guppy fish and their periodic introduction into potential breeding sites to control the growth of mosquito larvae. A detailed inventory (Picture No. 18) of such breeding sites conducted before and after monsoon. Every worker possesses information regarding Mosquito breeding sites, and map locations.



Picture No. 18: Anti-Larval Spraying activity (Left) Inventory of Guppy Fish Breeding place (right)

- Action undertaken for appropriate treatment of affected patients as well as patients in the window period, by NMMC through a dual pronged approach.

  Direct surveys by visiting the patient's home, collecting blood samples and providing medication. Indirect survey includes examining the blood samples of the patients suffering from fever and visiting the primary health care centres, women and child hospitals and other government hospitals.

- Mosquito surveys- Conducted periodically to prevent or control any occurrence or spread of mosquito borne disease, in specific areas to check the status of mosquito breeding. This is done by conducting a survey of mosquito infected areas for 15 minutes per site and taking immediate measures if the mosquito density is high.

Picture No. 19 Indoor Mosquito survey (left) and larval density check (right) by NMMC's Health officials

Therapeutic measures

NMMC hospitals and health centres provide medicines and vaccination drives are carried out in these NMMC affiliated centres free of charge.

Addressing community through Information, Education and Communication (IEC) activities

- Under IEC, NMMC's health officials conduct various workshops in schools, residential societies and complexes where training is provided on taking preventive measures against vector borne diseases. NMMC's health officials conduct awareness campaigns among the citizens of Navi Mumbai through the medium of banners, posters and distribution of pamphlets. Along with this, health department conducts mass awareness programs during festivals like Ganesh-utsav and Navratris.

Picture No. 20: Awareness workshop for students (left) and awareness drive (right) against vector borne diseases under IEC program.

Preparedness for Swine Flu outbreak

1. Screening centres – NMMC has 27 Screening centres for detection and diagnosis of swine flu in case of a swine flu outbreak. 23 health posts are in civilian medical centres, 3 in general hospitals and 1 in Maternal and Childcare Centre (MCH)
2. NMMC has an isolation ward in Vashi Public Hospital (8 beds)
3. Vaccinations of isolation ward staff for prevention against swine flu.
4. Medicines and other important equipment in case of swine flu outbreak have been provided in stock with the screening centres and hospital authorities.
5. Training to people from various sectors has been provided through workshops and posters few of them are listed in Table No. 51.

Table No. 51: List of places and number of trainees trained against swine flu

Sr No	Venue	Participants
1	Arvato India Limited	412 workers
2	Sai Snehdeep hospital in Koparkhairane	38 staff members
3	Schools	162 Principals and students
4	Civil medical centre, CBD belapur	345 women
5	Private hospitals	197 Private hospitals
6	Dr. D.Y. Patil hospital	21 staff members

Air Borne Disease - Tuberculosis

Airborne diseases are caused by pathogenic microbes small enough to be discharged from an infected person via coughing, sneezing, laughing and close personal contact. The discharged microbes remain suspended in the air on dust particles, respiratory and water droplets. Illness is caused when the microbe is inhaled or contacts mucus membranes or when secretions remaining on a surface are touched. As a result it becomes difficult to check the spread of such diseases and control outbreaks. Common cold, Chickenpox, Influenza, Diphtheria and Tuberculosis are some of the common air borne diseases.

Tuberculosis is caused by a Mycobacteria species, called *Mycobacterium tuberculosis*. The bacteria can attack any part of the body, particularly lungs. TB thrives and spreads mainly in crowded areas with a population having relatively low immunity or weak immune systems, conditions often found in low and middle income countries. There are 2 kinds of TB infections, namely Latent and Active TB.

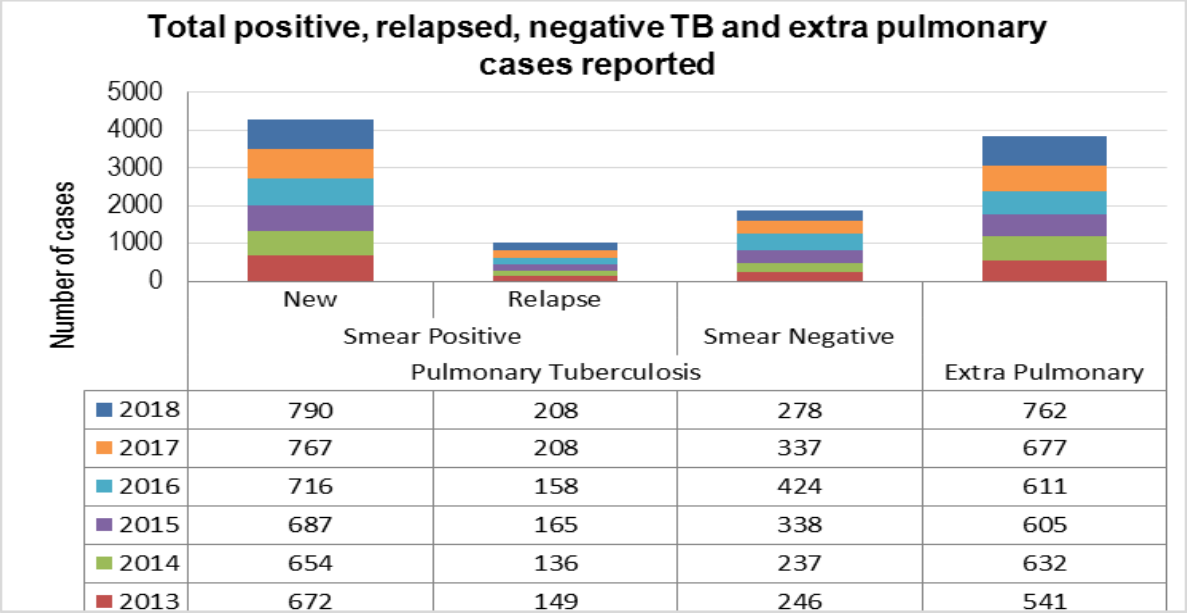
- Latent TB is a state where the bacteria remain inside the body in an inactive state. It shows no symptoms and generally are not contagious but it can become active at a later stage
- In the case of an active TB infection, the bacterium shows symptoms and the disease becomes contagious.

India is a country with the highest burden of TB. As per a WHO report, in 2016, 2.79 million cases of TB incidence (number of new cases of active TB disease recorded during a certain period of time) were recorded in India[57]. India also has the greatest number of cases of Multi-Drug Resistant-Tuberculosis (MDR-TB) with an estimated 1,47,000 cases recorded in the year 2016[58]. These bacteria can attack any part of the body, particularly the lungs causing a condition called as Pulmonary TB. The common symptoms of Pulmonary TB include fever, chest pain, Loss of appetite, cough, and weight loss. When an infection occurs in any other part of the body, outside lungs, then the condition is called extra pulmonary TB.

NMMC has been continuously implementing a TB eradication program in the region. It can be observed from that the number of cases recorded for tuberculosis has shown an increase for the past 5 years. In the year 2018-19, a decreasing trend was observed in the case of

[57] https://www.tbfacts.org/tb-statistics-india/
[58] https://www.usaid.gov/what-we-do/global-health/tuberculosis/technical-areas/tuberculosis-india

smear negative patients while emergence of 790 new cases and 208 relapse cases of Pulmonary TB were recorded. Prevalence of Extra-Pulmonary TB cases have increased by around 13% from 677 cases in 2017-18 to 762 cases in 2018-19. Along with preventive measures, NMMC is also planning to conduct awareness programs to sensitize citizens about the impacts and threats of TB. All civic hospitals in NMMC are well equipped to treat TB patients.



	New Smear Positive Pulmonary Tuberculosis	Relapse Smear Positive Pulmonary Tuberculosis	Smear Negative Pulmonary Tuberculosis	Extra Pulmonary
2018	790	208	278	762
2017	767	208	337	677
2016	716	158	424	611
2015	687	165	338	605
2014	654	136	237	632
2013	672	149	246	541

Figure No. 41: Total number of cases reported due to TB in the past five years

Source: Health Department, NMMC

Response

NMMC's Health department is regularly monitoring the spread of air borne disease like Tuberculosis (TB). The department has undertaken various initiatives and providing facilities like free medical checkup for TB detection and free medicines from NMMC affiliated hospitals, health posts, NGOs. The NMMC has undertaken preventive as well as therapeutic measures to eradicate TB.

Active case finding: TB services at the doorstep'

With the aim of eliminating TB by the end of 2025, NMMC's health department started the 'Active Case Finding of Tuberculosis' campaign from May 2018 to November 2018. Health department targeted 55,000 houses coming under the jurisdiction of 22 Civilian primary health centres in NMMC area through intensive door to door campaign. The drive also included screening of around 1,79,000 people showing symptoms of TB such as severe cough, drastic weight loss and fever during evening time. The sputum of such patients also collected and tested.

Apart from such initiatives, every year on March 24 during World TB day, NMMC organizes TB awareness program for increasing awareness among the citizens regarding TB and also provides training to medical staffs regarding medical treatment.

There is a Provision of Providing DOTS (Directly observed treatment, short course), also known as TB-DOTS everyday instead of 3 days in a week from 2016. These DOTS are available in NMMC affiliated hospitals, NGOs, heath posts.

Provision of Conducting Cartridge Based Nucleic Acid amplification Test (CB-NAAT) on Multi-Drug Resistance (MDR) and Extensively Drug-Resistant (XDR) TB patients and providing medicines free of cost.

Under the program called 'Joint Efforts for Elimination of TB' (JEET), NMMC is collaborating with PATH organization. Under JEET, TB patients get free of charge diagnosis and medicines.

Mobile Towers in Navi Mumbai

The effects of radiation from mobile towers on human health are an important topic and a matter of grave concern. A committee appointed by the Maharashtra government had recommended restrictions on the installation of mobile phone towers in 2015[59]. With the growing number of mobile phone users in India, the wireless communication density and its network has escalated at a rapid pace over the past few years. The Indian telecom sector is the second largest in the world in terms of the number of subscribers. As per Telecom Regulatory Authority of India (TRAI), there are total 906.56 million subscribers in India, Out of which 493.96 million are Internet subscriber base while remaining 412.60 million are broadband subscriber base[60].

There are around 552 Mobile towers in Navi Mumbai. The highest number of mobile towers (138 Nos.) are seen in Nerul node followed by Vashi (125 Nos.) and Airoli (72 Nos.). The lowest number of mobile towers was observed at Digha (6 Nos.)

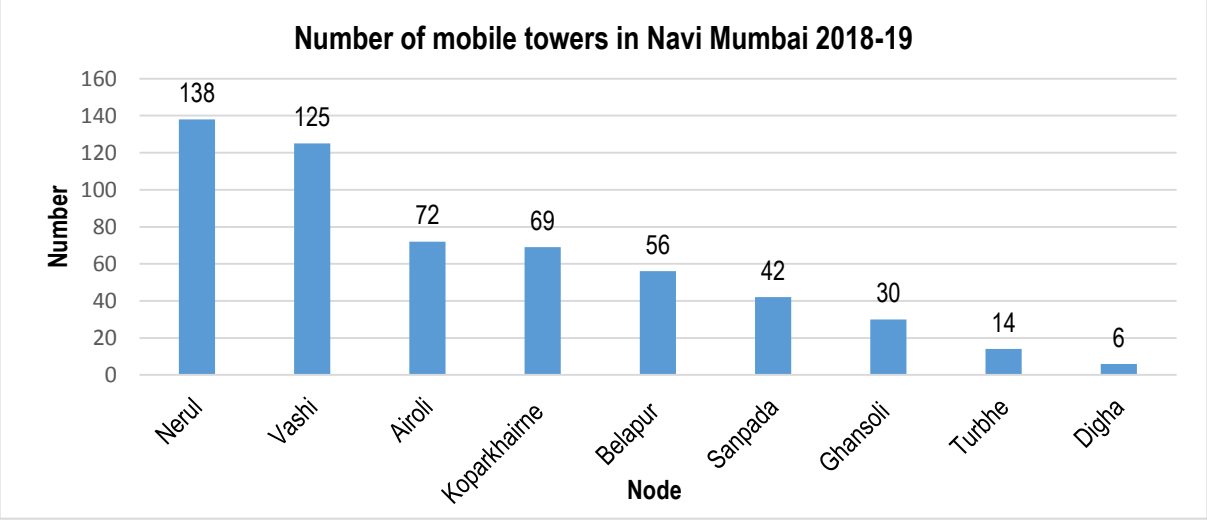


Figure No. 42: Node wise number of mobile towers in Navi Mumbai in 2018-19

Source: NMMC

There are about 21 service providers out of which the highest numbers of towers belongs to Vodafone Essar Limited (101 Nos.) followed by Reliance Jio Infocom Ltd (99 Nos.).

[59] https://www.downtoearth.org.in/news/cell-towers-a-health-risk-1859
[60] Telecom Regulatory Authority of India, Annual Report 2017-18

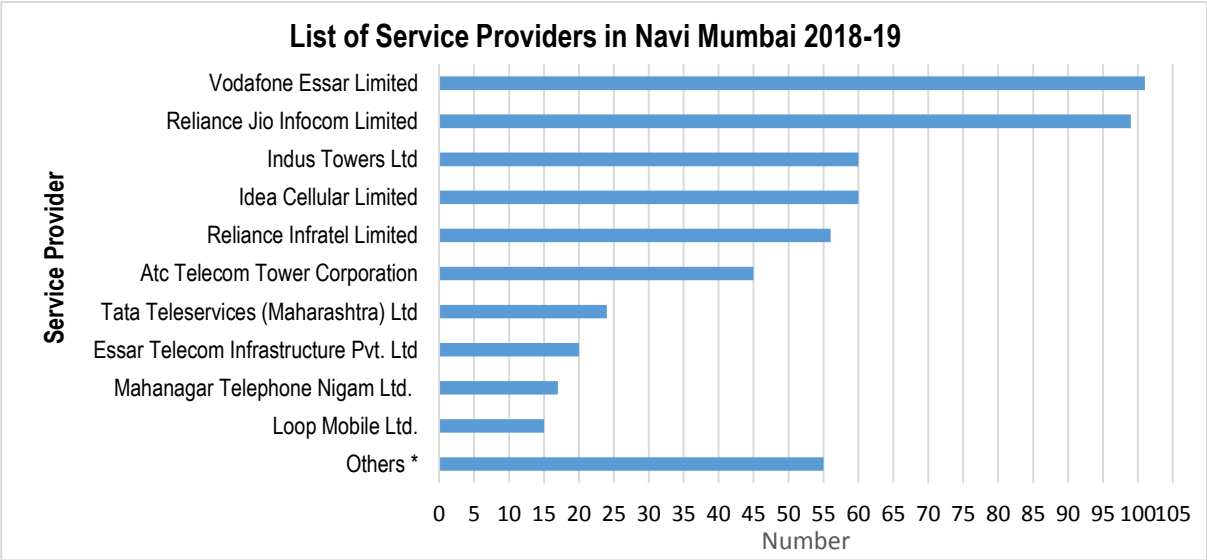


Figure No. 43: List of service providers in Navi Mumbai in 2018-19
Source: NMMC

Effect of radiation on Human health from mobile towers

Mobile phones emit radiofrequency (RF) energy, a form of non-ionizing electromagnetic radiation, which can be absorbed by tissues close to the phone. The amount of radiofrequency energy emitting from mobile phones depends on many factors such as the technology of the phone, the distance between the phone and the user, the extent and type of mobile phone use and the user's distance from cell phone tower. In 2011, International Agency for Research on Cancer (IARC) classified mobile phone radiation as possibly carcinogenic, which means there could be some risk of carcinogenicity, so additional research into the long-term, heavy use of mobile phones needs to be conducted[61]. The possible effects of mobile tower radiations on the health of humans and other living organisms are mentioned in the article
http://172.16.5.103/terragreen_new/index.php?option=com_terragreen&task=detail&section_id=2938&category_id=9&issueid=118

Proposed Initiative

Canteen for Teen (CfT)

The good health of its demography is one of the major assets a city can have. Along with the quality of Environment, health of its citizens is equally important. Even the United Nation focusses more on overall nutrition and health and dedicated 2nd and 3rd Sustainable Development Goal (SDG) to 'Zero Hunger' and 'Good Health and Well Being' respectively. NMMC along with TERI's Nutrition Security division has proposed to work on issues related to Malnutrition and improved health through Food fortification which is based on the above mentioned SDGs.

Malnourishment is not confined to the under-nourished children of rural areas but is also prevalent in urban areas. School children are attracted to unhealthy and fast foods such as vada pavs, pizzas and so on, and thus daily intake of the required protein, carbohydrates, vitamins and fats is not consumed by them. India is the third-most obese country in the world. Also, according to WHO, by 2030 India will have 101.2 million diabetic persons, the

[61] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4350886/

highest number in the world[62]. The major reasons for this type of malnourishment in urban areas are sedentary lifestyles, imbalanced intake of nutrition, low physical activity and an ever increasing preference for junk food. Hence, School Education and Sports Department, GoM, issued a GR in May 2017 regarding Ban on High in fat, salt and sugar (HFSS) Food in school canteens.

The complications of childhood obesity affect the whole body. It not only has long term detrimental impacts on the body with the onset of lifestyle disorders but can also contribute to psychosocial problems by causing depression and eating disorders and sleep intolerance and so on[63]. Teenagers need to be cautious in making their food choices to reduce the risk of life-style health disorders in their adulthood. Hence, it is important to motivate the urban youth to adopt a healthy lifestyle. Consumption of whole-some meals and incorporation of various nutritious alternatives instead of 'empty calories' in the diet, along with an increased awareness regarding nutritional content in the daily diets can help stagnate the increasing trend of diabetes, obesity and cardio-vascular diseases among young children.

For this purpose, TERI has developed a health and nutrition program for urban adolescents and youth called Canteen for Teens (CfT). The program could be implemented in at least five Municipal Corporation schools under the jurisdiction of NMMC in the first phase whereby students would be trained to take charge of their nutritional needs, through

- workshops,
- hands on training sessions,
- guest lectures,
- Competitions and so on.

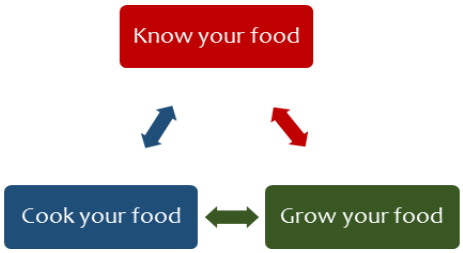


Figure No. 44: TERI's Approach for Canteen for Teen program

Along with students, parents, guardians, canteen staff, teachers and school authorities would also be the stakeholders in this program. Activities would be aimed at capacity building of stakeholders to make conscious decisions with respect to food choices and to incorporate habits and dietary measures that would help in prevention of lifestyle disorders such as diabetes, obesity and so on, through three main components- 'Know your food, Grow your food, Cook your food.'

[62] https://thewire.in/wp-content/uploads/2016/06/REFERENCE-1-DIABETES-INDIA-PREVALENCE.pdf
[63] https://www.sciencedaily.com/releases/2018/11/181112095951.htm

Annexure 1: Calculation of indices

Approach

The information on environmental parameters is often too complex and non-comprehendible to non-environmental professionals. The problem is further complicated as environment covers broad spectrum of areas from air quality to biomedical waste management. The goal of assessing status of environment is planning for sustainable development by ensuring that quality of life of the people is maintained and, if possible, improved while maintaining quality of environment.

The findings of present environmental assessment are discussed in details in the earlier sections and same have been used in this section for computations of indicators. The basis has been maintained same to assess the change in environmental status in NMMC area for the current year.

Methodology

Three indicators have been used in the present assessment:

Environmental Quality Index (EQI);

Urban Infrastructure Index (UII); and

Quality of Life Index (QOLI).

For computation of EQI, ambient air quality (in residential areas & traffic junctions), noise levels in residential areas & traffic junctions), quality of drinking water, quality of surface water, quality of ground water, adequacy of sewage treatment, adequacy of solid waste treatment, and adequacy of biomedical waste treatment are used as parameters. While air quality, noise levels and drinking water quality affects human health both in short term as also in long-term, impact of changes in other parameters are comparatively less important in short-term. Hence, while computing EQI following procedure has been used:

Out of total score of 100, scores have been assigned to individual parameter based on importance. This is termed as Parameter Importance Unit (PIU).

For assessing status of individual parameter, a scale has been developed by assigning zero score to totally un-acceptable parameter measurement and 1 score to desired parameter measurement. This is termed as Parameter Environmental Quality (PEQ). For various measurements of parameter in NMMC, PEQ has been estimated based on data collected for ESR, and values have been averaged to estimate overall PEQ for NMMC area.

Environmental Quality Index (EQI) for an individual parameter has been worked out by multiplying PEQ and PIU.

Values of EQI for all parameters have been added to compute EQI.

Using this method, if values of all parameters are as desired ones the value of EQI will be 100.

For assessing UII, population density, water supply system, sewerage system and storm water collection system, solid waste collection system, slum development, health facility, educational facility, public transport, employment opportunity, parks & gardens, roads network, entertainment facilities, and public grievance redressal mechanism have been used as parameters. As assessment of infrastructure facility is more a subjective judgment than quantitative evaluation, a seven-point scale has been used for evaluation of UII for individual parameters as follows:

Very Poor: 0.0

Poor: 0.20

Satisfactory: 0.40

Good: 0.60

Very good: 0.80

Excellent: 0.90

Outstanding: 1.00

Values of UII for individual parameters have then been converted into percentage for easy comprehension. Quality of Life Index has been computed as average of EQI and UII.

Estimation of Environmental Quality Index

The importance assigned to various parameters selected for computing EQI and scale used for assessing the present status is presented in Table No. 52. PEQ for individual parameters have been computed based on data collected for ESR. Overall EQI is summarised and computed for various nodes of NMMC and it has been found out that present EQI in NMMC area is 77.96%.The detailed parameters for EQI is tabulated in Table No. 52.

Estimation of Urban Infrastructure Index

In the case of urban infrastructure, mere numbers may be misleading (e.g. average per capita water supply may be satisfactory but due to uneven distribution satisfaction level may be low). Hence, for computing UII subjective assessment has been used.

It has been found out that present UII in NMMC area is 82.65 %.

Estimation of QOL

Quality of environment and availability of infrastructure facilities together decide quality of life. As the impact of these considerations is synergistic, equal importance needs to be given to both. Hence, QOL has been computed as average of EQI and UII. Present QOL Index for NMMC area has been worked out as 80.31%.

Table No. 52: Estimation of Environmental Quality Index

Sr. No.	Parameter	Environmental Quality Index, %				
		Max	Average 2017-18	Average 2018-19	Variat -ion	Remarks
A.	Ambient Air Quality					
A.1	Air Quality Index-Residential Area (RSPM)	10	7.64	7.54	-0.10	Due to increase in vehicular population in residential area
A.2	Air Quality Index-Traffic Junctions (RSPM)	5	3.26	3.36	+0.10	Due to completion of construction of roads in MIDC area.
B.	Ambient Noise Levels					
B.1	Noise Level: Residential Area	10	3.95	4.14	+0.19	Due to increased public awareness among the people.
B.2	Noise Level: Traffic Junctions	5	1.64	1.81	+0.17	Completion of road construction activities significantly reduced traffic congestion resulting in reduction of noise levels at traffic junctions.
C.	Ambient (Surface/Ground) Water Quality					
C.1	Surface (Drains) Water Quality, BOD mg/l	3	2.07	2.33	+0.26	Due to decrease in BOD level in some nallahs.
C.2	Surface (Lake) Water Quality, BOD mg/l	3	2.40	2.25	-0.15	Due to contamination of lake water because of washing clothes.
C.3	Ground (Well) Water Quality, BOD mg/l	3	2.91	2.96	+0.05	Due to periodical cleaning & disinfection of wells.
C.4	Efficiency of Sewage Treatment Plants	6	5.85	5.85	0.00	-
D.	Solid Waste Management					
D.1	Solid Waste Collected, percentage	3	2.94	3.00	+0.06	Micro planning in door to door garbage collection and change of compactor to 5T, 8T and 10T
D.2	Solid Waste Segregation at Household Level, percentage	2	1.64	1.68	+0.04	Due to proper awareness and monitoring of segregation of wet & dry garbage at household level.
D.3	Solid Waste Segregation at Disposal Site, percentage	2	2.00	2.00	+0.00	
D.4	Solid Waste Recycle at Household Level, percentage	2	1.60	1.60	0.00	
D.5	Solid Waste Recycle at	2	2.00	2.00	+0.00	

Sr.	Parameter	Environmental Quality Index, %				
	Disposal Site, percentage					
D.6	Biomedical Waste Collected, percentage	2	2.00	2.00	0.00	
D.7	Road/Public Places Cleanliness	2	2.00	2.00	+0.00	
E.	Protection of Ecosystem					
E.1	Protection of mangroves	10	9.00	9.00	0.00	
E.2	Protection of hills and quarry restoration	10	6.00	6.00	0.00	
F.	Public Health					
F.1	Drinking Water Quality, % samples fit for drinking	5	4.83	4.74	-0.09	Continuous monitoring and disinfection by chlorination needs to be followed regularly
F.2	No. of cases of water borne diseases in node(cholera, Jaundice, Hepatitis)	5	4.67	4.69	+0.02	Due to proper monitoring and organization of health campaigns
F.3	No of cases of malaria in node	5	4.81	4.89	+0.07	Due to proper monitoring and control of breeding places of mosquitoes in NMMC area.
F.4	Cases of TB, percentage population affected	3	2.52	2.52	0.00	-
F.5	Control of Street Dogs	2	1.60	1.60	0.00	
	Total	**100**	**77.33**	**77.96**	**+0.63**	

Annexure 2: Category wise no of vehicles registered in Navi Mumbai RTO

SN	Category	Type of Vehicle	Financial Year												
Newly Registered during the year			06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
1	2-Wheelers	Motor Cycles	14262	12716	11345	5235	16361	15188	17395	16525	17953	24354	22535	22175	21909
2		Scooters	930	163	177	7547	271	81	-	0	0	0	0	0	0
3		Mopeds	0	0	0	0	0	0	-	0	0	0	0	0	21
4	4-Wheelers	Cars	8082	11165	9586	10665	13042	13184	11808	8298	10841	10709	10345	10180	8321
5		Jeeps	342	217	162	160	222	104	-	0	0	0	0	0	0
6		Station Wagons	196	0	0	0	0	0	-	0	0	0	0	0	0
7A	Taxi/Autorickshaw	Taxi meter fitted	0	0	0	0	0	187	-	-	0	0	3155	1288	1618
7B		Taxi Tourist Cabs	1010	1261	731	283	630	548	851	439	917	1966		0	0
8		Auto-Rickshaws	516	457	227	606	444	493	628	1663	3487	2445	1993	4695	7241
9	Buses	Stage carriages	0	31	33	49	116	11	4	1	43	44	109	8	20
10		Contract carriages	131	346	337	209	314	251	-	35	248	334	164	180	154
11		School Buses	0	14	30	23	35	136	180	99	96	143	32	84	36
12		Private Service Vehicles	6	32	39	21	43	32	171	5	14	11	10	16	16

SN	Category	Type of Vehicle	Financial Year												
Newly Registered during the year			06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
13		Ambulances	4	41	24	35	39	28	10	16	37	18	18	20	14
14		Arti.& Muli. Vehicles.	43	0	0	0	2	0	30	-	0	0		0	0
15	Other Heavy Vehicles	Trucks & Lorries	1316	2297	939	934	1717	1067	901	725	1655	2609	1057	802	1119
16		Tankers	204	445	186	257	168	220	249	155	226	267	283	403	442
17		Delivery Van (4 wheelers)	1144	667	147	256	309	643	512	213	302	284	197	655	901
18		Delivery Van (3 wheelers)	2167	1501	978	1095	1237	1462	1565	1019	1602	1866	1129	788	749
19		Tractors	11	0	0	0	0	0	-	0	0	0	0	0	2
20		Trailers	347	778	428	460	694	381	438	230	351	364	344	434	343
21		Others	19	12	11	10	20	57	7	15	25	9	46	173	139