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INTEGRATED SEWAGE TREATMENT AND COASTAL MANAGEMENT IN MUMBAI METROPOLITAN REGION

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Abstract
Urbanization in Mumbai Metropolitan Region has resulted in the growth of population, industrial and, commercial units. Municipal corporations are supplying drinking water to population and all other units. Water is used for different purposes and activities. Water related activities generate sewage in metropolitan region. Municipal Corporation of Greater Mumbai generate highest where as the Mira Bhayander Municipal Corporation generates lowest sewage. All the municipal corporations do not treat entire sewage. The sewage is discharged in rivers and sea. It has severe effect on the health of people and marine resources. The least square regression shows the positive correlation of sewage with population, industrial units and health care institutions. The sewage generation will rise in future because of growth of urbanization and number of units. Therefore Municipal Corporation must increase the sewage treatment capacity and do the budgetary provisions through issue of debt instruments. Environment education, behavioral change among people will help to reduce the sewage generation. Compulsory sewage treatment of Municipal Corporations will improve the health and environment across the region.
Keywords: Infrastructure, Treatment, Health

1. INTRODUCTION

Safe water is required for drinking, hygiene and providing food; and adequate water to produce energy and support economic activities such as industry and transportation. Water is natural environment ensures the provision of a multitude of ecosystem services to meet basic human needs and support economic and cultural activities (Connor R. and Hannah S. 2012). The Mumbai Metropolitan Region is stipulated to population growth, urbanization and rapid industrialization. All factors are putting pressure on existing water resources. Drinking water is used for domestic, industrial, commercial and institutional purposes. People across region are depending on marine food as their major source of proteins. Moreover coast provides numerous opportunities for recreation making them important areas for the development of tourist facilities and other commercial activities. At metropolitan shoreline, many aquatic organisms' salt marshes, fresh water marches and sea grasses have a natural place. Near the shoreline, the primary producers use the energy of the sun to synthesize organic matter out of inorganic carbon, water and nutrients. It is the natural growth of the primary producers. The phytoplankton is

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consumed by zooplankton which in turn is eaten by fish and animals which live at the bottom of water bodies near shoreline. Water plants can be eaten by fish or sea urchins. All dead organic matter or detritus is finally mineralized by bacteria making the inorganic nutrients available again to the plants. It is a natural food cycle exists at shoreline.

In the metropolitan region, domestic and industrial sewage is dumped untreated into rivers and sea where it pollutes the usable water and marine resources. Waste water influences physical environment through increasing turbidity. It further affects the biodiversity and pollutes the physical environment of the metropolitan region. A certain amount of pollutants such as nitrates and phosphates can result in smoothening of sea grasses and coral reefs. They reduce the essential supply required for the accretion of coastal wetlands. It results in the decline of these critically important and sensitive habitants near coastline. There is impact of sewage in sea grass communities one of the major risks is the decreasing amount of light that reaches the plants. The flow of the untreated sewage at different places has completely destroyed the fish and the growth of epiphytic algae on the leaves of the sea grasses. At coast, the sea grass and phytoplankton are stimulated by the input of nutrients. But at metropolitan shoreline, the sea grass meadows deteriorated and disappeared with serious environmental consequences. The untreated sewage has impact on coral reefs and nursery areas for fish and shellfish species.

The untreated sewage has severe socio-economic impact in region. The sewage has caused of sharp drops in fish production and various species at coast of metropolitan region. Fishermen have to go far in the Arabian Sea and in deep water for fishing. It further affected on their number of trips, fish cached and income. Most of the fishermen have lost their livelihood in region. Waste water is harmful for the human health. The bacteria, viruses and parasites that are present in human excreta easily enter in the environment. They might remain for some time in water or soil. By drinking contaminated water or eating food with untreated water have severe health consequences. It is well known that water pollution increases water related diseases which cause human morbidity and death. The economic losses due to water washed and water borne diseases are much higher among poor people. The direct cost such as loss of income, medical cost, transport is very high. The indirect cost such as detain in hospital, stand in a long queue, visits of relatives etc. are also higher for poor people. Therefore the sewage disposal has severe impact on health of people and environment.

In metropolitan region, population pressure has put enormous pressure on fragile coastal ecosystems. It has threatened the sustainable use of its precious resources. Coastal and marine habitats are altered or destroyed natural resources across coast. The natural resources at coastline are over exploited and

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pollution is now widespread phenomena. Most of mangrove forest cover has been destroyed to establish residential colonies. The waste water is also destroying the natural protection of mangrove in the region. In Metropolitan region, the untreated sewage is violating the discharge standards. It is contaminating the ground and surface water resources. There are no conventional technologies to reduce the BOD (Biochemical Oxygen Demand) to the permissible standards. Most of the sewage treatment projects of municipal corporations do not have budget or they are facing the problem of environment clearance from ministry. Therefore there is need to evolve an alternative sanitation system that would be sustainable from socio-economic – and environmental perspectives (Dhinadhayalan M. and A. K. Nema 2012). Water pollution will continue to increase in the next future because of population growth. There is need to develop technologies for their wastewater treatment (Coulibaly L. et.al 2008). There is further need to understand the negative environmental impacts posed by the untreated or inadequately treated wastewater. Waste water is entering the nearby ecosystems especially on the lives that depend on the ecosystem. The sustenance survival and perspective of such microbial pathogens especially in conventional wastewater treatment facilitates is in increasingly becoming of interest (Okoh A.L. et.al 2007). It is well understood the impact of sewage on marine resources and human health. In order to overcome with these effects, the sewage treatment facilities are required to ensure the effective collection and treatment to agreed standards of sewage. It includes sources of discharges including wastewater from industrial, commercial and household. The waste water management is considered as one of the solution to water scarcity and marine resource development. But all the aspects in region are ignored and the sewage is continued to discharge in sea and rivers.

2. DEFINITION

Sewage or waste water is defined by different authors and organizations in literature.

According to Farahani, H.A. (2011) “sewage” includes domestic, municipal or industrial liquid waste products disposed of usually via a pipe or sewer or similar structure, sometimes in a cesspool emptier. The physical infrastructure including pipes, pumps, screens, channels etc. used to convey sewage from its origin to the point of eventual treatment or disposal is termed sewerage.

In simple word sewage can be defined as follows, “Sewage consists of a mixture of domestic wastewater effluents from commercial and industrial establishments and urban runoff”.

The domestic waste water is produced in areas within house tap connections and connections to sewer infrastructure. Domestic waste water is the water that has been used by a community and which contains all the materials added to the water during its use. It is thus composed of human wastes (feces

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and urine) together with the water used for flushing toilets. It is also defined as the water resulting from personnel washing, laundry, food preparation and the cleaning of kitchen utensils. Domestic waste water is collected in underground pipes which are called sewers. The flow in sewers is normally by gravity with pumped mains only being used when unavoidable. The sewage from the commercial units is also collected from the underground pipes. Industrial waste water composition depends on the type of industry and whether on site pollution measures have been taken. If toxic compounds are present industrial waste water discharged into a municipal sewer system. It can have a negative impact on the performance of waste water treatment plant.

3. DATA AND ECONOMETRIC MODEL

In order to calculate the water demand, we have referred the city development plan of Mumbai, Thane, Kalyan-Dombivali, Mira-Bhayander, Bhiwandi-Nizampur and Navi Mumbai Municipal Corporation. We have also referred the sanitation and Environment Status Report (ESR) of each municipal corporation. The water supply of each municipal corporation is used as basic indicator to calculate the sewage. We have developed method to calculate the total sewage from the water supply to each municipal corporation. It is explained through following formula.

$$TS = TW * \frac{SW}{100} \quad (1)$$

Where

TS: Total sewage

TW: Total water supply

SW: Proportion of sewage

Alternatively

TS = PCWS (P+I+R+G+T+H+E+P)*0.8 (2)

Total Sewage (TS) is equal to the per unit water supply available to different units in Metropolitan region multiply by 0.08. We have considered that the eight percent sewage generation from water supply to each unit. Such Per Capita Water Supply (PCWS) is considered for population (P), industrial units (I), restaurant (R.), garages (G), theaters (T), hospitals (H), educational institutions (E), parks and gardens(P) etc. The per capita water supply is proportional to the sewage generated by these units. The

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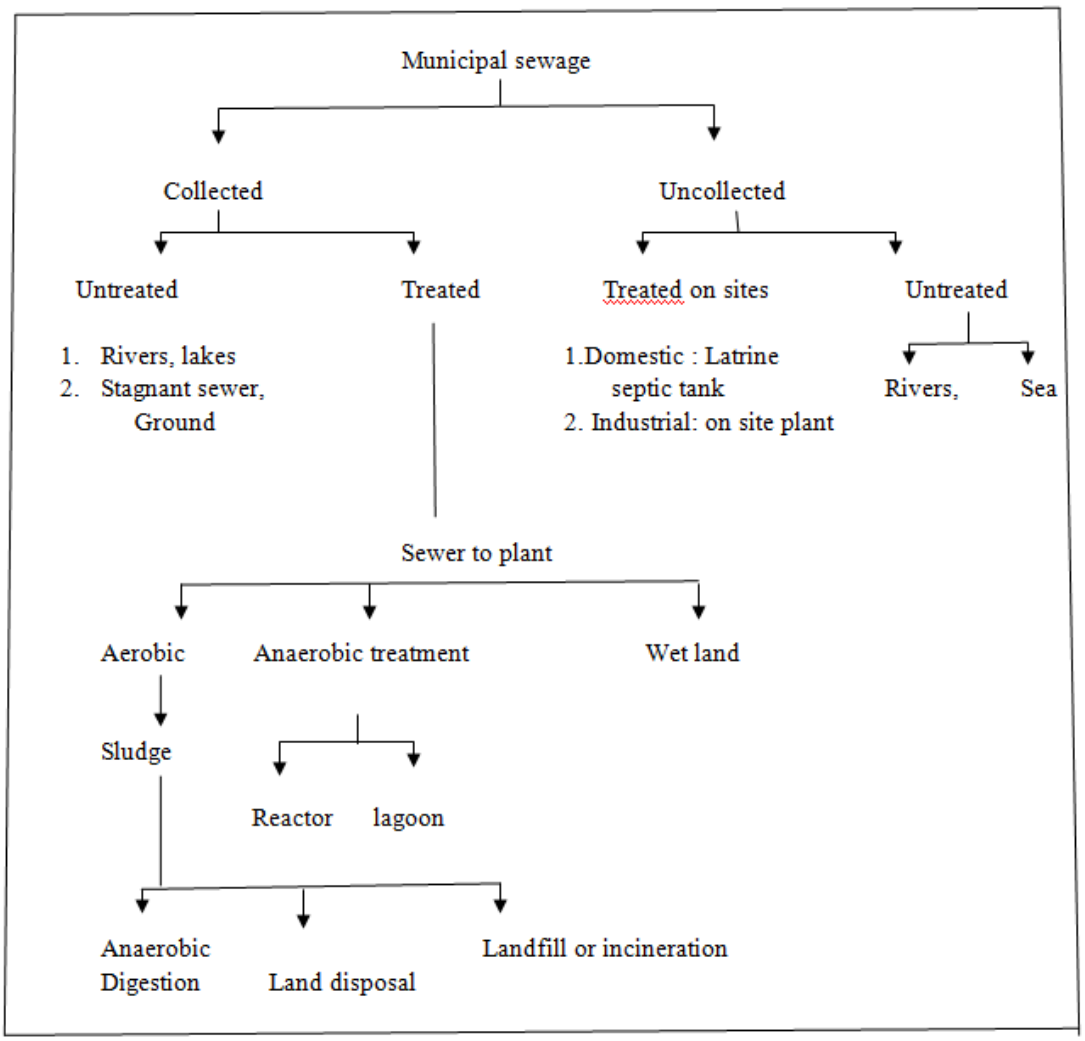
number of units and water supply available to these units varies in each municipal corporation. The per capital availability of water is more useful to calculate the sewage in each municipal corporation.

Municipal sewage treatment

Water is a basic necessity of human being. Water is used extensively for different activities. Used water flows into different directions whereas some proportion of water gets evaporate. The waste water need to collect through particular system of pipelines. In the following flow chat, the collected and uncollected sewage generation to disposal system is explained in detail. Municipal Corporation should have the sewage treatment system.

FLOWCHART 1 SEWAGE TREATMENT METHODS



The municipal waste water is mainly divided as the collected and uncollected sewage. The uncollected sewage is not treated and it is discharge to the rivers and sea. Sometimes, the uncollected sewage

treated at the domestic level but it is very expensive method. It is treated at latrine and septic tank. The industrial waste water is treated on site plants. But again it depends on type of industrial units. Each municipal corporation has the civic responsibility to collect sewage and treat through treatment plants. Municipal Corporation cannot deny of sewage treatment. Therefore all municipal corporations have to collect the sewage in their respective area and treat it before it discharge in the drainage. With increasing urban population, changing lifestyles and industrialization, the waste water is increasing over the years. Hence, it requires treatment before it can be used for different purpose. Since wastewater treatment is an expensive process, many of the municipal corporations are not able to treat their wastewater at appropriate levels and continued to discharge in the sea water. It has long term effects on soil, groundwater and human health. However, many of the water scarce cities are able to treat their wastewater to appropriate levels and recycle in it industries, residential areas, urban gardens and sports lawns. While the lack of wastewater treatment to appropriate levels before use is a major problem, the high cost of wastewater recycling is the major problem (Gayathri Devi M. et.al 2008).

In Mumbai metropolitan region, due to lack of financial resources, the sewage is collected but it is further discharge to the rivers and sea. It is left to discharge without any kind of process. Such untreated sewage creates the pollution in the environment. The municipal corporations are treating the sewage but their capacity is very low. The sewer plants are located in the different sites of each corporation area. The aerobic, anaerobic and wet lands are the major three types. Such sewer plant helps to treat the sewage of corporation in their area. The anaerobic sewer treatment plants are further classified as reactor and lagoon. The sludge is a part of the aerobic sewage treatment but it is further classified into three parts. It is anaerobic digestion, land disposal and landfill or incineration. Aerobic bacteria are carrying out digestion of sludge. Sludge is a semisolid part of sewage. It is further digested by anaerobic bacteria. The sludge can be disposed in land. If the land disposal of sludge creates soil pollution then it is incinerated. At the time of incineration, it is taken care that it should not create air pollution. The anaerobic bacteria are carrying out digestion. Reactor carries out the process of sewage treatment. A lagoon is a sewage treatment method that utilizes a septic tank for primary treatment with the effluent from the tank being discharged into a lagoon. In the lagoon sunlight, temperature and wind provide the final treatment. All the above types help to treat the sewage of Municipal Corporation. The treated water can be used for garden, flushing toilets and agriculture etc.

Sewage generation in Mumbai metropolitan region

In Mumbai metropolitan region growth of population, industrialization is higher. The water use for different purposes is also higher. The waste water is also higher in the Municipal Corporations.

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TABLE 1 - SEWAGE GENERATION IN METROPOLITAN REGION (2012)

Municipal corporation	Sewage (MLD)	Percent
MCGM	2584.9	73.77
TMC	289.6	8.26
NMMC	182.4	5.21
KDMC	204	5.82
MBMC	72.8	2.08
UMC	89.6	2.56
BNMC	80.8	2.31
Total	3503.2	100.00

Source: Computed from data

Table-1shows that Municipal Corporation of Greater Mumbai is generating 2584.9 MLD sewage. It is 74 percent of the total sewage in metropolitan region. Such sewage generation is higher because of high density of population, commercial and industrial units. The water use is higher by the various units and therefore the sewage generation is also higher. The sewage in the Thane municipal corporation is 289.6 MLD which is 8.26 percent of the total sewage in the metropolitan region. In Thane district, it is the only municipal corporation which generates the highest sewage. In Navi Mumbai, the sewage generation is 182.4 MLD. It is 5.21 percent of the total sewage in metropolitan region. In this municipal corporation, the sewage generation is rising fast because growth of population. It is a planned and modern city in this region. In Kalyan Dombivali Municipal Corporation, the sewage generation is 204 MLD. It is 5.82 percent of the total sewage in metropolitan region. It is second highest in Thane district and after Thane Municipal Corporation. The Mira Bhayander municipal corporation generates 72.08 MLD sewage which is 2.08 percent of the total sewage in metropolitan region. It is new Municipal Corporation and it has physical limitation to grow. But still population is growing in this municipal corporation. In the Ulhasnagar municipal corporation, the sewage generation is 89.6 MLD which is 2.56 percent of total sewage in Mumbai metropolitan region. In the Bhiwandi –Nizampur Municipal Corporation, the sewage generation is 80.8 MLD. It is 2.31 percent of the total sewage in Mumbai metropolitan region. The total sewage generated by the seven municipal corporations is 3503.2 MLD in Mumbai metropolitan region. The maximum contribution is of sewage generation by Brihanmumbai Municipal Corporation. It is important to understand the sewage contribution by the area and types in MCGM.

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TABLE 2 - SEWAGE IN BRIHANMUMBAI MUNICIPAL CORPORATION ACCORDING TO ZONES

Zones	Sewage (MLD)	Percentage
Zone1	392.77	15.20
Zone 2	498.71	19.30
Zone 3	556.07	21.52
Zone 4	513.69	19.88
Zone 5	295.60	11.44
Zone 6	326.33	12.62
Total	2583.17	100.00

Source: Computed from data

The highest sewage generation is observed in zone 3 which is 556.07 MLD (21.52 percent). It is highest due to the population, industrial units, theaters and commercial shops and malls. The water use in ward H and K is high and such area consists of Santrcruz, Mahim, Dharavi, Vile Parle and Andheri. Therefore the sewage generation is also high. The sewage generation in zone 5 is 295.60 MLD. It is 11.44 percent of total sewage. Such zone comprises as the ward L and M. Such sewage generation is low due to low density of population, low industrial units and more slums. Such areas are Kurla, Ghatkopar, Vikroli and Chembur. The sewage generation varies in different zones and area in Mumbai and Municipal Corporations of Thane district. It is difficult to explain each ward and zone with sewage generation. Therefore, the types of sewage generation are important for understanding total sewage in Brihanmumbai Municipal Corporation and Thane district.

TABLE 3 - SEWAGE GENERATION ACCORDING TO TYPES (MLD)

Unit	Mumbai city	Percent	Thane district	Percent
Population	2256.34	87.32	819.92	71.36
Large & small Industry	193.54	7.49	296.32	25.79
Hotels, restaurants & shops	66.15	2.56	5.74	0.50
Garages	9.04	0.35	10.34	0.90
Theaters & malls	0.77	0.03	3.33	0.29
Public and private hospitals	6.71	0.20	2.29	0.20
Fire station & hydrants	36.43	1.41	6.43	0.56
Educational institutions	13.95	0.54	4.94	0.13
Parks gardens	0.25	0.01	3.68	0.32
Total	2583.18	100.00	1149	100.00

Source: Computed from data

The population in Brihanmumbai Municipal Corporation generates 2256.34MLD sewage. It is 87.32 percent of the total sewage. Population requires water for drinking, bath, washing cloth, floor etc. The use of water creates more sewage in corporation area. Such water is put in the drainage pipeline. The industries in the Brihanmumbai municipal corporation area generate 193.54 MLD sewage. The large and small industrial units require water for different purposes. The small chemical, automobile and engineering companies use water in production process and create maximum sewage in the city. But

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such sewage is 8 percent of the total sewage in city. The hotels, restaurant and shops also use water for drinking, cooking, washing, cleaning etc. Most of the recreation activities require huge water for different purposes. The people in the respective area are visiting to recreation facilities also use water for different purposes. Therefore the sewage generation is 66.15 percent. It is 2.56 percent of the total sewage in BMC. Due to more vehicles in the city, the garages are using water for cleaning and repairing purposes. There is no restriction on the use of drinking water. Such garages in the city would be generating 9.04 MLD sewage. It is only 0.35 percent of the total sewage. Theaters and malls are the modem entertainment and recreation facilities. The water use for different purposes is high in such facilities. The sewage generation is 0.77 percent of the total sewage. The public and private hospitals use water for different purposes. The use of water for various operations, cleaning, and patients is very high. The waste water generation is 6.71MLD which is 0.20 percent. Fire hydrants and stations also use the water in the city. There are no regular fire incidences in city but water is used for different purposes. Sewage generation is 6.63MLD which is 1.41 percent of the total sewage. There are many educational institutions in city. They use water for drinking, cleaning and toilet purpose. The sewage in the Mumbai city by educational institutions is 13.95MLD which is 0.54 percent of the total sewage. The park and gardens contribute only 0.25MLD sewage in the city. It is difficult to observe the sewage by gardens and parks in the city.

In Thane district, the populations in all six municipal corporations contribute 819.92MLD sewage. It is 71.36 percent of the total sewage. Population requires water for different purposes and the sewage is generated. In the Municipal Corporations, there are industrial units and estates. Such industrial units generate 296.32MLD sewage. The hotels, restaurant generate the sewage which is 5.74 MLD. It is 0.50 percent of total sewage generation. In the Thane district, garages generate the sewage which is 10.34 percent of the sewage. The theater and malls generate 3.33MLD sewage which is 0.29 percent. Fire hydrants and hydrants generate 6.43MLD sewage. It is 0.56 percent of the total sewage in municipal corporations of thane district. Educational institutions have grown significantly in district. They generate 4.94MLD sewage in all municipal corporations. It is 0.13 percent of total sewage in Thane district. Parks and gardens generate 3.68 percent sewage. It is 0.32 percent of total sewage in Municipal corporations of Thane district. Total sewage generated by all municipal corporations in Thane district is 1149 MLD. It is comparatively low with Brihanmumbai Municipal Corporation.

Existing sewage system in municipal corporations of metropolitan region

Mumbai city has old network of sewage system. City has 49 pumping stations, 7 waste water treatment facilities and 1400 k.m of sewer lines. The responsibilities pertaining to sewage disposal is given to

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three departments. The sewage operation department work for the sewage transportation in city. Such department maintains and manages the entire sewage disposal infrastructure. The second department that is sewage project department, which executes various sewage related projects in city. It is responsible are laying new sewer lines and upgrading and replacement of the ageing sewers. They are responsible for different tenders, structures and engineering related tasks. The third department is sewage disposal project. It looks at the disposal of the sewage from the different areas. The MCGM has provided STP's at different locations to treat sewage. The Bhandup (180MLD), Ghatkopar (138 MLD), Malad (240 MLD), Colaba (41 MLD) Worli (757 MLD), Bandra (797MLD) and Varsova (131 MLD) has the sewage treatment plants in the city. The treated waste water quality of sewage treatment plan is explained as follow. In order to control the water pollution of rivers and sea, the BMC staff regularly collect samples at Worli sea face, Shivaji park, Malbar hill, Haji Ali, Gate way of India, Nariman Point, Mithi river, Eleohanta caves, Madh, Manori, Gorai Beach and Juhu. In the city, Mithi River is a major River. This river is confluence of tail water discharges of Pawai and Vihar lakes. Mithi River originates at Pawai and meets Arabian Sea. At Mahim, it is flowing through a residential and industrial complex of Pawai, Sakinaka, Kurla and Mahim over a distance of about 15kms. Most of the sewage water is discharge in this river and it is of households, industrial and commercial unit waste water (MCGM 1995).

In Thane Municipal Corporation area, sewage is generated about 289.6 MLD. From the total sewage only 54 MLD is treated in the sewage treatment plant (STP) located at Kopari. Rest of the sewage goes through septic tank and soak pit. In the corporation area, the total length of sewer line is 69.2 k.m. There are 8 pumping stations. Total sewage treatment plant's capacity is 54 MLD. The method of treatment is activated sludge method. The mode of sewage disposal is Thane creek. There are total eight pumping stations in the Thane city. The pumping station at Kopari has a capacity of 17.09 MLD and pumping stations at Naupada has a capacity of 7.85MLD. The flow of the Cadbury pumping station is having capacity of 15.87 MLD. Each pumping station has different capacity and location. Currently, there are 20 sewage treatment plants operating in private residential complexes, multiplexes and shopping complexes. These complexes are reusing the treated sewage in their own premises. Therefore the water demand in such complexes is low (TMC 2006, ESR2010a). In Bhivandi Nizampur Municipal Corporation (BNMC), the sewage generation is 88MLD but the sewage treatment capacity is very low. In BNMC, out of five zones, there are four and five zones partially with underground drainage system. Area underground drainage network is 45 sq kilo-meter in Municipal Corporation. Population served with underground drainage is 2 to 2.5 lakh. There are 3 pumping stations and the existing capacity of sewage treatment plant is only 17MLD. The proposed ETP phase one is 1MLD. There are 34882 individual toilet seats and 6338 public and community toilet seats. Out of these 11440 seats are

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connected to underground drainage and 29780 seats are connected to septic tank. The STP has capacity to treat 17.5MLD waste water. In zone 3 and 4 do not have underground sewage collection system. Underground sewerage system of zone 5 is spread in some parts of zone 1 and zone 2(CSP (2012a).

Navi Mumbai Municipal Corporation (NMMC) has a well planned system for sewerage. The total length of sewerage is 308296 k.m in corporation area. The maximum developed area in NMMC is covered by underground drainage system. Some part is remained unconnected by sewage system. There are 8 sewage treatment plants in NMMC area. They are located at CBD Belapur, Nerul, Sanpada, Vashi, Koparkhairne and Airoli. The raw sewage generated in NMMC area is treated at Vashi, Nerul, and Airoli. Balance is being let out without treatment. NMMC has also provided underground sewerage system in almost all GES area and villages. NMMC is identified village area where underground sewerage system can be provided. At present, work of laying sewerage system is under progress at all nodes of NMMC. There are 366 public toilets in NMMC area with total seats of 4331.NMMC has also provided 11 mobile toilets on pay and use basis. They are more visible in different parts of slums in corporation area. The work of looking after toilets facility has been given to seven social working organizations on operate basis. There are 8 sewage treatment plants located at CBD Belapur, Nerul, Sanpada, Vashi and Airoli. The treatment plant at Nerul, Vashi and Airoli are reconstructed based on cyclic activated sludge process. The treatment plant at Belapur, Sanpada, and Koparkhairane are under construction based on cyclic activated sludge process. It will improve the treated sewage quality and standards. Samples at inlet and outlet are regularly collected and analyzed to assess the efficiency of treatment plants. Although, NMMC is trying its best to treat sewage to highest standards on its own but the quality of creek water is inferior due to discharge of huge treated sewer by neighboring cities. Such standards are acceptable as per Maharashtra Pollution Control Board. Therefore there is necessary to adopt the long term policy to arrest the ingress of tidal water in NMMC area (NNMC 2006, ESR2010b).

The sewage generated in Mira Bhayander Municipal Corporation (MBMC) is 72.8MLD. But only 11 MLD sewage is treated in corporation area. The sewage system is completely inadequate in Municipal corporation area. Mira Bhayander Municipal Corporation is one of the new municipal corporations in metropolitan region. It came in exist in 2002 therefore the adequate sewage system is not developed. The population of the corporation has increased between 1991 to 2001. It is 196.68 percent. Population has put tremendous pressure on the existing sewage system. At the same time, this corporation is surrounded by water from three sides. Therefore most of the sewage is left in the sea without treatment. Till today only 15 percent of sewage system is working in city. Total 85 percent of the sewage water is

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left in open drainage without treatment. It leads to mosquitoes and pollution in the corporation area (CSP 2012b, NIUB 2008a).

In Ulhasnagar Municipal Corporation (UMC), the sewage system is old. In 1994, Maharashtra Jeevan Pradhikaran (MJP) constructed the underground drainage system for the Ulhasnagar city. It is further transformed by UMC. In Ulhasnagar city, underground sewage system was completed under the World Bank aided stage 1 project. It is developed for the projected population of 366000 for the year 1991. The scheme as above was operated and maintained by Ulhasnagar Municipal Corporation through private contractors. The sewage collection system is 150 mm diameter to 900 mm diameter RCC line. Total length is 112 k.m and there are two pumping stations. The rising mains are 900 mm diameter that is 2.5 kilometer and 400 mm diameter to 1.2 k.m. The sewage treatment plant is 28 MLD. The sewage network varies from 150mm pipe diameter to 1000 mm diameter. But such sewage system is inadequate for growing city (UMC 2006). In Kalyan-Dombivali Municipal Corporation (KDMC), the existing sewage collection system is inadequate. The coverage is only 18.38 percent. Areas presently not covered by the sewer scheme are equipped with septic tank and soak pit systems of sewage disposal. There are only 2 sewerage treatment plants and they have 30 MLD treatment capacity (KDMC 2010, NIUB 2008b).

Present issues in sewage system

In Mumbai city, approximately 2600 million liters daily sewage is generated. The civic body is primarily able to treat only 1600 MLD, meeting the standard of the Maharashtra Pollution Control Board. After the treatment, the water is released into Arabian Sea. In the city, the quantity of sewage and the STP'S provided by MCGM are inadequate and under capacity utilized. At present, 60 percent of the population lives in slums. There is no particular fixed sewage system to such population. Coastal area, creeks, river water quality is deteriorated because of non- availability of sanitation, proper drainage and collection system. The authority is not providing drainage systems to areas which are developed in an unorganized manner. Therefore maximum slum population in city is neglected from sewerage. Mithi River is treated like a drain by the citizens and industrial units. They discharge raw sewage, industrial waste and garbage which is unchecked by municipal corporation. Beside this, there are illegal activities such as washing of oily drums, discharge of unauthorized hazardous waste also carried out along the bank of river. The organic waste, sludge and garbage dumping has reduced the water carrying capacity of the Mithi River. Now the widening of river bank work is undertaken but the sewage treatment is not discussed. The sewage with industrial waste is a threat to marine life in river and at sea. The river is showing the sign of total loss of life support system to city. In TMC, major portion of the sewage

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generated in the city flows through open drainage causing unhygienic conditions. The present STP capacity is insignificant with 15 percent of the sewage generated being treated. The treatment facility for sewage is under augmentation as also the sewage network. In UMC, the heavy floods in July 2005 washed out the sewer mains laid along open drain. The heavy floods also damaged the pumping stations. At present, the sewer mains are not connected with collection mains and thus sewer flowing though the collection mains directly outflows into the open drainage. This open drainage joined the Ulhas River. It carries the sewage and affected the river water quality. Such practice of sewage disposal is not sustainable. The domestic sewage is not collected at different origin. The direct discharge of sewage into inland water destroys the aquatic flora and fauna. The sewage treatment plant of 28 MLD is under corporation rule. Its operating expenses are collected under the property tax. Due to flooding and damage, the sewage carrying capacity has declined and it is observed as only 8MLD. It is only 29 percent of the actual design capacity. Therefore there is need to reconstruct the damaged main lines so that the STP is utilized to its full capacity designated to cater the present and future population. The overall status of sanitation at present in Ulhasnagar is very poor. Total untreated sewage water is 88mld. The treated waste water is only 7 to 10mld. The existing numbers of sewage treatment plant is only one with capacity of 28mld. There is no proposed treatment plant in this municipal corporation. The sewage collection network is 150 to 1000 mm diameter RR sewer line length is 120 km. The sewage pumping stations are only two and they are located at Shanti and Nehru Nagar. Underground drainage system is old and chock regularly. Due to this reason, the pipes may breakdown in near future and it can cause total shutdown of the sewage treatment plant. At present, the main sewer lines along the open drainage lines are used for untreated sewage. Therefore the old drainage lines must be replaced by new lines. They must be regularly maintained and checked. At present only 8MLD on an average of sewage is treated in the STP. Looking at the present and future sewage generation, it is required to increase the STP capacity in corporation area. It will cater the future demand of population. At present, the untreated sewage is discharged in to the water bodies or open drainage. It further meets to Ulhas River. Ulhas River is important river for irrigation, fishing, drinking water etc. But untreated sewage at corporation level is affecting the fisherman, farmers and downstream villages.

In KDMC, the sewage treatment capacity is only 18.38 percent as compare to the normative standard of 85 percent. The sewage is discharged in river without any kind of treatment. The sewage system developed in corporation area is old and hydraulically inadequate. Most of the time, it is choking due to silt deposition. It is a major factor of reduction of the hydraulic capacity of sewers. The present sewage treatment facility is not conventional to a significant extent. The sewage system is not upgraded and ensured a higher degree of sewer treatment.

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Regression result

We have used the Ordinary Least Square (OLS) regression (Greene, William H.2003) method to examine the possible correlation with the sewage in MMRDA region. The sewage generated by the different units is different. The positive correlation with variables may help for policy implication.

$$\sum Y_{it} = \beta + \beta_1 pop + \beta_2 iu + \beta_3 rest + \beta_4 gar + \beta_5 thea + \beta_6 hos + \beta_7 edu + \beta_8 par + \varepsilon$$

(3)

Where

Yit=Total sewage by ith unit at time t

Pop: Population in corporation

Iu: Industrial units

Res: Restaurants and hotels

Gar: Number of garages in each corporation

Thea : Number of theaters

Hos: Health care institutions

Edui : Educational institutions

Par: Parks and gardens in the city

We have regress the total sewage generated in the municipal corporation as a function of population, industrial units, restaurants, garages theaters, health care institutions, educational institutions and parks and gardens. We have used the independent regression for the Brihanmumbai Municipal Corporation and Municipal Corporations of Thane district. The results are presented in the following table.

TABLE 4 - REGRESSION RESULT FOR MCGM

Variables	Co-efficient	T test
Large and small industries	7.00*(0.00)	9.85
Constant	-396.10(1.16)	-39.40
R square =1.00 Adjusted R square=1.00 Root MSE =0.71		

*Significant at 1 percent

* Figures in parenthesis are standard error

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Sewage in Mumbai city is positively co-related to the small and large industries. In Mumbai city, there are many small and large units located at different sites and they are generating sewage. The water is used for industrial input process and final products. Such sewage is thrown in municipal sewage line. Industries are generating more sewage as compare to the population or commercial units. All other variables have multicollinearity problem with total sewage. Therefore the variables are insignificant.

TABLE 5 - REGRESSION RESULTS FOR MUNICIPAL CORPORATIONS IN THANE DISTRICT

Variables	Co-efficient	T test
Population	1.00*(0.00)	9094.99
Health care institutions	27.29*(1.29)	21.05
Constant	-0.00(684)	-83.46
R square =1.00 Adjusted R square=1.00 Root MSE =0.21		

*Significant at 1 percent

* Figures in parenthesis are standard error

In thane district, the sewage is positively co-related to the population. The population use water for different purposes. It is used for cooking, bath, flushing, cleaning etc. All the activities create more waste water. The waste water is left in the sewage system. Sewage generation is positively co-related to the health care institutions. It is because many health care institutions use more water for operations, cleaning, hygiene etc. In such process more waste water is generated. It is statistically significant and positively co-relate with total sewage. There are number of important variables but they are insignificant in regression.

Future estimation of sewage in municipal corporations

In all the municipal corporations, urbanization is rising fast. It has resulted in growth of population, commercial units, industrial units, hotels, malls etc. All factors require more water for different purposes. But the required water supply will generate more sewage in each municipal corporation. The sewage treatment capacity must rise with the growth of the unit in corporation area. But sewage treatment facilities are completely inadequate. We have estimated the sewage generation based on the units in each municipal corporation. Total sewage treatment deficit is calculated as follows

$$\sum_{t=1}^{n} STD = \sum_{t=1}^{n} TWS - \sum_{t=1}^{n} TST \qquad (4)$$

Where

$\sum_{t=1}^{n} STD$: Total sewage deficit at time t in nth Municipal Corporation

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$\sum_{t=1}^{n} TWS$: Total water supply at time t in nth Municipal Corporation

$\sum_{t=1}^{n} TST$: Total sewage treatment capacity of particular Municipal Corporation at time t.

We have calculated the total water demand in each municipal corporation based on the growth of units and required water supply. Such water supply is reduced from the future growth of the sewage treatment projects of each municipal corporation. We have minus the total water supply from total sewage treatment capacity. In such process, we get the sewage treatment deficit. Such deficit is further calculated up to 2031 for each municipal corporation. For Brihanmumbai Municipal Corporation, the sewage treatment deficit is shown in the following figure.

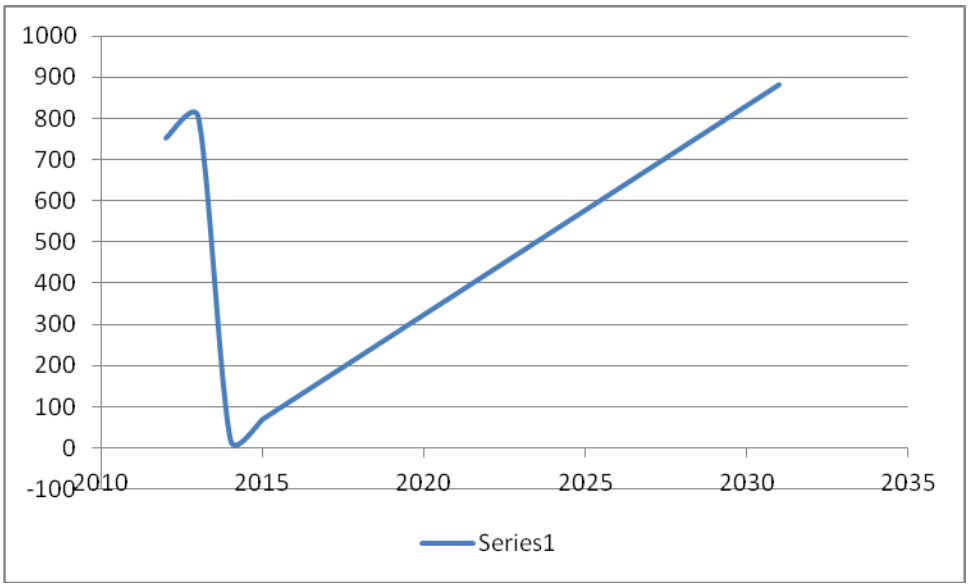

FIGURE 1 - SEWAGE TREATMENT DEFICIT IN MCGM (MLD)

In Brihanmumbai Municipal Corporation, the sewage treatment capacity is high. The largest waste water improvement initiatives in the world are planned in city. If such plans get execute on time then the whole waste water in the municipal corporation will be treated in the sewage treatment plants. The above figure shows that the in the year 2014, whole waste water will get treated in treatment plant. For achieving this target, the civic body has planned to upgrade two waste water treatment plants in Bandra and Malad. But both projects have not received land and environment clearance from MoEF. Either the land is under mangrove cover or it is used by the other agency. Such problems create delay in execution of treatment plants. At present, only 1600 MLD sewage is treated in plants, other is released in the Arabian Sea. If the sewage treatment projects get delayed then the sewage will also rise in future.

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It will further create deficit in sewage treatment. In the year 2030, the situation will be same as it is observed today. But more sewage treatment projects are expected in corporation area. We have also calculated the deficit of the sewage in municipal corporations of Thane district.

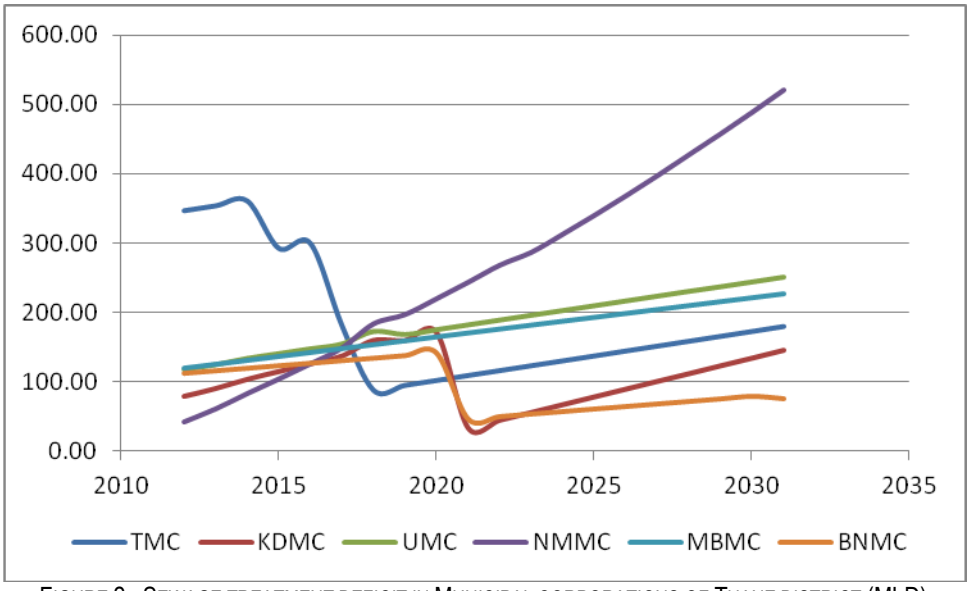

FIGURE 2 - SEWAGE TREATMENT DEFICIT IN MUNICIPAL CORPORATIONS OF THANE DISTRICT (MLD)

The above figure shows that the sewage treatment is inadequate in each municipal corporation of Thane district. In Thane Municipal Corporation, the sewage treatment plants are announced and they will start operating after 2015. In TMC, there are three proposed STP's in the city. The Phase 1 is located at Kopari area, the capacity is 120 MLD. The second phase is of Kalwa which has capacity of 100MLD. The phase three is at Mumbra which has capacity of 32 MLD. All projects were expected to complete in 2012. TMC will treat sewage but the deficit of sewage treatment will be more than 100MLD in the year 2020. The sewage treatment deficit will further rise after 2020. It is because population and other units will rise and demand and supply of water will rise. It will further lead to the sewage generation in city. In Navi Mumbai, now the sewage treatment is almost full. But we have not observed the future projects of sewage treatment. They may not have announced now but Municipal Corporation has a plan of hundred percent sewage treatments. But if the plan is not executed then sewage will rise above 500MLD in 2030. In the long term, sewage projects will get announced in NMMC. In KDMC and BNMC, the projects are announced and the work of sewage treatment plant is going on. But both municipal corporations cannot treat complete sewage. In BNMC, total 18.6 k.m underground drainage line and new STP of 13 MLD and ETP of 1 MLD for slaughter house are in progress. Considering the future requirement of 2041 under phase 2, 158 MLD STP and sewage network with 3 pumping station is proposed. The margin of 100MLD will remain exist till 2031. In MBMC and UMC, the projects are not

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announced. Therefore the sewage will continuously rise in the corporation area. In the long term, the sewage treatment plants are expected to improve health and environment.

4. POLICY IMPLICATION AND CONCLUSIONS

We have observed that the sewage in each municipal corporation is either not completely collected or it is not entirely treated. The untreated sewage is released in the sea or river. Municipal Corporations do not have budget to execute the sewage treatment plants or they do not get the environment clearance for projects. Such untreated water creates various health hazards and pollute the marine resources. Currently, there is growing awareness of the impact of sewage contamination on rivers and lakes. Therefore, wastewater treatment, water and wastewater fees and environmental education according to water saving is now receiving greater attention from a lot of international organizations and government regulatory bodies (Abdel Halim, W. et.al. 2008). The wastewater infrastructure in Municipal corporations is inadequate. Therefore they are unable to keep peace with the demands of rising population. Experience has shown that substantial investments done in the right manner can provide the required returns. However finding a solution will require not only investment but also carefully integrated municipal water and waste water planning that addresses the entire water chain drinking water supply – production and treatment of waste water ecosystem management and urban planning. A waste water becomes a key resource in the coming years, the question will not be whether to recycle wastewater but whether an option exists not to recycle. Under such a scenario, there is a need for all the stakeholders to work towards developing mechanisms to make recycling not just safe but economically efficient with the right but economically efficient with the right institutional mechanisms in place (Gayathri Devi M. et.al 2007). Most of the sewage treatments plants are unfeasible. This is mainly because municipal corporation budget is small. There are technical, financial, and social limitations of sewage treatment projects. It is definitely more rational to develop and incorporate a cost effective, energy efficient and technically simple sewage treatment system while adhering to the needs of discharge regulations (Tendulkar M. et.al 2005). Sewage treatment has two essential roles. Firstly it need to protect public health and second is to protect the environment trends. Most of the projects are focusing on the health of the people. Now the time has come to concern about the environment. The developed nation emphasizes sewage treatment more for the environmental protection. Therefore the reliable and inexpensive methods of wastewater treatment are of importance for solving human diseases and environmental problem as well as for sustainable long term space life support. At present lack of effective and affordable mean of sewage disposal is widespread and it is destroying of marine habitats such as coral reefs (Neason M. et.al 2001). Wastewater is everyone's concern in the home and at work.

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Environmental education will help to change the behavior of people. There is need to educate people to reduce wastewater discharge and also see the opportunities of managing waste water. There is direct link between waste water, health and ecosystem. The potential benefits of waste water reuse in contributing to development and improve well being of human being is high. Educations, awareness, advocacy at multiple levels, professional skills, inter sectoral collaboration and financial planning will generate good results. In each municipal corporation, supply of safe drinking water and reducing the unregulated discharge of wastewater are among the most important factors influencing health. Unmanaged wastewater is a vector of disease causing child and adult mortality and it reduces labor productivity. In present era, waste water is grossly undervalued, ignored and left to drain away. Waste water can be a potential resource only the smart and sustained investment is required in waste water management. It will generate multiple incentives to society, economy and environment.

Sewage treatment related investment will generate social, economical and environmental dividends for exceeding original investments for years to come. Waste water treatment plants have high capital cost in addition to operation and maintenance cost. Restricted local budgets, lack of local expertise and lack of funding are resulting in inadequate operation of wastewater treatment plants in Municipal Corporations (Massoud M. A. et. al.2008). The bond financing on the private capital markets has become much more important source. The private sector participation in water supply and sewerage systems is one instructive for municipal corporations. Private companies have managerial efficiency and they take effective decisions (McCullough, J.S et.al 1993). All municipal corporations should make compulsory to treat sewage in their respective area. All policies will help to manage the coast line in region. Such solutions to waste water will defiantly convert the problem into different opportunities.

NOTES

1. The term sewage is used in interchange as waste water. Both terms are referred as synonyms.
2. Brihanmumbai Municipal Corporation (BMC) is also referred as Municipal Corporation of Greater Mumbai (MCGM).
3. Metropolitan region has considered the Greater Mumbai, Thane, Navi-Mumbai, Kalyan-Dombivali, Mira-Bhaynder, Ulhasnagar and Bhiwandi-Nizampur Municipal Corporation.

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