

# Design of Sewage Treatment Plant for Vasai-Virar Region

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**Abstract** – The population growth in India is immense. Accordingly, the water supply amount is enormous which, in return generates large amounts of wastewater. One such region is the Vasai Virar region whose population growth according to calculations will sky rocket. But the amount of sewage treatment plants present is only one for a particular area. So, to combat this we decided to construct another Sewage treatment plant per another area. The Vasai Virar City Municipal Corporation [VCCMC] plan was to construct total seven sewage treatment plants in for the total region, but as mentioned only one has been constructed. In this paper we will discuss the population growth of the region, design parameters, the method selection for design, introduction, etc.

**Keywords-Sewage**

## I- INTRODUCTION

**S**ewage treatment also called as wastewater treatment is the process of removal impurities from wastewater before they reach natural bodies such as rivers, lakes, oceans and the place where process of sewage treatment is done is called as sewage treatment plant.

Since pure water is not found in nature, any distinction between clean water and polluted water depends on the type and concentration of impurities found in the water as well as on its intended use. In broad terms, water is said to be polluted when it contains enough impurities to make it unfit for a particular use, such as drinking.

Although water quality is affected by natural conditions, the word *pollution* usually implies human activity as the source of contamination. Water pollution, therefore, is caused primarily by the drainage of contaminated wastewater into surface water or groundwater, and wastewater treatment is a major element of water pollution control.

Sewage treatment includes physical, chemical and biological process to remove these contaminants and produced environmentally safer treated waste water. In most of cases sewage contain waste mostly coming from domestic areas. This type waste contains mostly water and very few quantities of other contaminants. Treatment of domestic waste water require less efforts as compare to industrial waste or any other kind of waste. When small amounts of sewage are discharged into a flowing body of water, a natural process of stream self-purification occurs. Densely populated countries generate such large quantities of sewage, however, that dilution alone does not prevent pollution. This makes it necessary to treat or purify wastewater to some degree before disposal.

In this treatment sewage water travel towards sewage treatment plant via piping and in flow aided by gravity or pumps whichever is necessary and further treatment is carried out.

## II- PRESENT SCENARIO IN VASAI-VIRAR REGION

Vasai-Virar is a city located in Palghar district of Maharashtra state in western India. Comprising the most populated part of Palghar district and is also a part of Mumbai Metropolitan

Region (MMR). It is located in Palghar district, 50+ km north of Mumbai. Vasai-Virar City Municipal Corporation (VCCMC) covers the tehsil. Vasai-Virar city is separated several small towns. Vasai-Virar city is currently governed by the Vasai-Virar City Municipal Corporation [for urban area] and Panchayat [for rural area]. With a growing population of more than 1.2 million residents Vasai -Virar is the fifth largest city in Maharashtra. Spread over 383 sq. km of massive land, including forest cover and hilly terrain, it is governed by the Vasai - Virar City Municipal Corporation (VVMC). With office premises shifting from south Mumbai to the city's western suburb and rehabilitation of slums going on full swing, the Vasai-Virar region in Thane district has emerged as a preferred destination for affordable housing.

Massive land bank has attracted many national level developers to the region with mega construction plans in coming futures. "Vasai - Virar sub region has witnessed the fastest growth of real estate as well as ancillary development over the last two decades. The region's population has been increasing rapidly in this region owing to continuously improving connectivity, affordability of real estate prices and improved infrastructure. Over and above, the development approval process has been very quick, prompt and hassle free in this area, helping fast delivery of projects," said Joy Sanyal, National Director, Jones Lang LaSalle. If this growth stays continue population of this region may reach up to 40 lakhs in upcoming 2 decades. Due to rapid increase in population sanitation will become one the biggest problem.

### III- GOVERNMENT APPROACH TOWARDS VASAI-VIRAR REGION –

In recent years Government of Maharashtra trying to reduce the burden from Mumbai city. One of the ways achieve this is to develop the nearby areas like Vasai-Virar and Navi Mumbai.

According to the article "Vasai-Virar: A new emerging city" posted by Clean India Journal – "Vasai-Virar boasts of the youngest municipal corporation in the region. Since its inception the corporation has implemented initiative to manage its increasing population and provide them with the clean city. With the state of art project like sewage treatment plant and bio tech plant the region is developing at much higher rate."

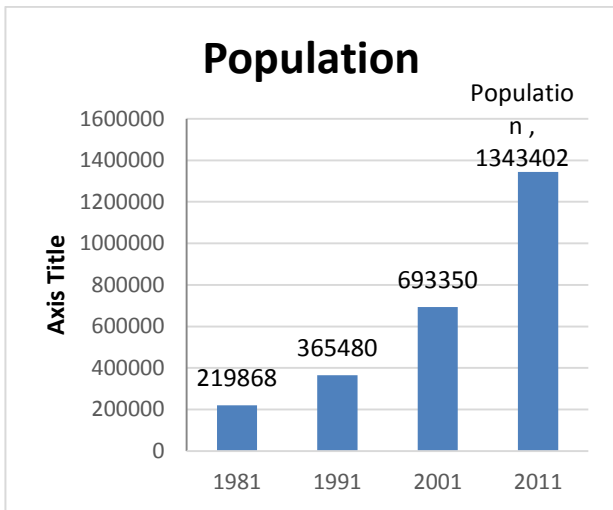
The region is receiving grant of 557 crores from central government under the underground sewerage scheme to build seven sewage treatment plants. The STPs will be

built in different phases with two plants being planned at Chikhaldongri (13 MLD) and Bolinj (30 MLD) capacity both at Virar (w). The plans have already received permission from all the commissions. Out of seven plants 1 has been build and started working.

### IV- NECESSITY OF SEWAGE TREATMENT IN VASAI-VIRAR REGION

- 1) **No treatment facility available:** - Since Vasai Virar is growing city no proper sewage treatment facility is available. Sewage is directly dumped into the nalas without any treatment.
- 2) **Heavy rainfall in recent years:** - In recent years, the rainfall faced in the region of vasai-virar has increased drastically. The increase in rainfall has resulted into waterlogging on roads and all the areas of the cities.
- 3) **Supply wastage ratio:** - As the population increases in the region the demand of water also increases resulting into waste generation to a greater extend. It can be said that the water supply is directly proportional to the waste generation. This generation of waste affects the environment. The water from the dams and rivers overflow due to heavy rains and this increase in water produces waste.
- 4) **Improper Maintenance of sewer line:** - The improper Maintenance of sewer lines results into water losses which in return gives rise to waste generation.
- 5) **Sudden rise in population:** - Population is considered as the one of the biggest crises. Vasai-Virar city is the most populated city in Palghar district. It is one of the fastest developing cities in Maharashtra. As this growth stays continue it is estimated to that the population may reach up to 40 lakhs in upcoming 2 decades.

Sr. No.	Year	Population	Incremental Increase	Incremental Increase [%]
1	1981	219868	-	
2	1991	365480	146512	66.22
3	2001	693350	327876	89.70
4	2011	1343402	650052	93.75



**Reasons For Sudden Rise In Population In Vasai-Virar City: -**

- 1) To control the population growth in Mumbai the state government decided to develop the nearby regions like Vasai-Virar, Navi Mumbai etc. This population growth helps in both housing and working sectors.
- 2) The housing facilities and ammonites were lucrative to the population in both economic and area prospective.
- 3) Sudden migration from other areas due to job opportunities.
- 4) Low cost housing made available by both public and private sectors.

**V- PROPOSED WORK**

There are three types of wastewater or sewage: domestic sewage, industrial sewage, and storm sewage. Since the Vasai-Virar is household area it mostly creates domestic waste. Domestic sewage carries used water from houses and apartments; it is also called sanitary sewage. Various studies shown that domestic sewage has slightly more than 99 % water by weight. The rest less than 1 % contains wide variety of dissolved and suspended impurities. Although the amount of impurities is a very small fraction but it can still create significant technical problem during disposal.

**A. General Information On Treatment Of Sewage: -**

The treatment of sewage consist many complex processes Treatment process are often classified are as follows; -

- 1) Primary treatment
- 2) Secondary treatment
- 3) Tertiary treatment

**1) Primary Treatment: -** Primary treatment removes material that will either float or readily settle out by gravity. It includes the physical processes of screening, commination, grit removal, and sedimentation. Screens are made of long, closely spaced, narrow metal bars. They block floating debris such as wood, rags, and other bulky objects that could clog pipes or pumps. In modern plants the screens are cleaned mechanically, and the material is promptly disposed of by burial on the plant grounds. A comminutor may be used to grind and shred debris that passes through the screens. The shredded material is removed later by sedimentation or flotation processes.

**2) Secondary treatment: -** Secondary treatment removes the soluble organic matter that escapes primary treatment. It also removes more of the suspended solids. Removal is usually accomplished by biological processes in which microbes consume the organic impurities as food, converting them into carbon dioxide, water, and energy for their own growth and reproduction. The sewage treatment plant provides a suitable environment, albeit of steel and concrete, for this natural biological process. Removal of soluble organic matter at the treatment plant helps to protect the dissolved oxygen balance of a receiving stream, river, or lake.

**3) Tertiary treatment: -** The purpose of tertiary treatment is to provide a final treatment stage to further improve the effluent quality before it is discharged to the receiving environment. More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process. It is also called "effluent polishing". This process is proved to be expensive. Sometimes it is doubled the cost of secondary treatment. It is only used in special conditions.

Sr. No.	Level of treatment	Removal of Suspended Solids [%]	Removal of BOD [%]
1	Primary Treatment	60	35
2	Secondary Treatment	85	85
3	Tertiary Treatment	99	99

**B. ANALYSIS OF SEWAGE: -**

The analysis of sewage test sample is to determine the nature and concentration of physical, chemical and biological parameters. The information is required for planning, designing, operation and maintenance of treatment of sewage.

- 1) Physical analysis
- 2) Chemical analysis
- 3) Biological analysis

**1) Physical analysis: -**

- a. **Colour:** - The colour of sewage can normally be detected by the naked eye, and it indicates the freshness of sewage.
- b. **Odour:** - Fresh sewage is practically odourless. But, however in 3- 4 hours, it becomes stale with all oxygen present in sewage being practically exhausted.
- c. **Temperature [20<sup>0</sup>]:** - The temperature has an effect on the biological activity of bacteria present in sewage, and it also affects the solubility of gases in sewage.
- d. **Turbidity:** - Sewage is normally turbid. The turbidity increases as sewage becomes stronger.

**2) Chemical analysis: -**

- a. **pH:** - As per IS: 3025(part 11) – Reaffirmed 2002, In chemistry, PH (potential of hydrogen) is a numeric scale used to specify the acidity or basicity of aqueous solution.
- b. **BOD:** - The amount of oxygen required for biochemical oxidation of the decomposable matter at specified temperature within the specified time under aerobic conditions is called as biological oxygen demand.
- c. **COD:** - The amount oxygen consumed for chemical oxidation of organic matter with potassium permanganate or potassium dichromate in an acidic solution is called chemical oxygen demand.
- d. **Total solids:** - (As per IS:10500-1991) The total solids are quantity of suspended, dissolved and colloidal solids in the sewage and the nature may be organic or inorganic. The total solids are the important indicator of strength of sewage.
- e. **Total suspended solids:** - As per IS:3025 (part 16 & 17), total suspended solids are dry wet of particles trapped by a filter.
- f. **Hardness:** - As per IS:3025 (part21) - reaffirmed 2002, hard waters are generally considered to be those water that require considerable amounts of soap to produce foam and that also produced scale

in water pipes, heaters, boilers and other units in which the temperature of water is increased.

- g. **Chlorides:** - Chlorides are stable and hence not a measure of degree of treatment. The normal chloride concentration in sewage is 120mg/lit.

**3) Biological Analysis: -**

The total and fecal coliform bacteria test are a primary indicator of "potability", suitability for consumption, of drinking water. It measures the concentration of total coliform bacteria associated with the possible presence of disease-causing organisms.

Following are the approved test: -

- a. **Most Probable Number [MPN]:** - The most probable number [MPN] is a statistical method used to estimate the viable numbers of bacteria in a sample by inoculating broth in 10-fold dilutions and is based on the principle of extinction dilution. It is often used in estimating bacterial cells in water and food.
- b. **Membrane Filter:** - The membrane filtration procedure is used for samples that are low in turbidity and have low bacteria counts. The sample is poured through a membrane filter. The bacteria in the sample stays on the membrane filter. The membrane filter is moved to a petri dish that contains a nutritional broth or agar.
- c. **MMO-MUG test:** - *MMO-MUG* is a presence-absence test that is used to simultaneously detect total coliform bacteria and *Escherichia coli* (*E. coli*). *MMO-MUG* is a direct test of water sample and offers the advantages of simultaneous determination of both.
- d. **Multiple Tube Fermentation:** - The multiple-tube fermentation technique is a three-stage procedure in which the results are statistically expressed in terms of the Most Probable Number (MPN). 1 Presumptive Stage: A series of lauryl tryptose broth primary fermentation tubes are inoculated with graduated quantities of the sample to be tested.

**C. POPULATION FORECASTING: -**

- We used Incremental increase method to predict future population of the Vasai-Virar region. This method is improvement over the methods like Arithmetical increase method and Geometrical Increase Method. The average increase in the population is determined by the arithmetical method

and to this is added the average of the net incremental increase once for each future decade.

- Growth rate is assumed to be progressively increasing or decreasing, depending upon whether the average of the incremental increases in the past is positive or negative. The population for a future decade is worked out by adding the mean arithmetic increase to the last known population as in the arithmetic increase method and to this is added the average of incremental increases, once for first decade, twice for second and so on.

$$P_n = P_0 + n \cdot \bar{X} + \frac{n(n+1)}{2} \cdot \bar{Y}$$

Where,

$P_n$  = Future population

$P_0$  = Current year population

$n$  = Number of decades

$\bar{X}$  = Avg. of increase in population

$\bar{Y}$  = Avg. of incremental increase

- Wherever possible, sewage treatment plants should be designed for the flows expected to be received during the next 20 years, under normal growth conditions. Therefore, population forecasting should be done for at least two decades. In certain cases, where it can be shown that staging of construction will be economically advantageous, lesser design periods may be used.

#### D. PEAK DISCHARGE CALCULATION: -

Any sewage treatment plant should be designed for peak flow. Generally, the peak discharge considered as 2 to 3.5 times of actual discharge.

#### E. SELECTION OF APPROPRIATE UNITS:

- The first step in modern wastewater treatment, primary treatment removes solids that are suspended in the wastewater. First the waste is passes through screens both coarse and fine to removes larger object like floating debris like wood, rags, gravels, and other object which may clog the pumps or pipes. Fine grit particles are removed in Grit Chamber.
- Pumping stations are built when sewage must be raised from a low point to a point of higher elevation or where the topography prevents downhill gravity flow. Special nonclogging pumps are available to handle raw sewage. They are installed in structures called lift stations. There are

two basic types of lift stations: dry well and wet well. A wet-well installation has only one chamber or tank to receive and hold the sewage until it is pumped out. Specially designed submersible pumps and motors can be located at the bottom of the chamber, completely below the water level. Dry-well installations have two separate chambers, one to receive the wastewater and one to enclose and protect the pumps and controls. The protective dry chamber allows easy access for inspection and maintenance. All sewage lift stations, whether of the wet-well or dry-well type, should include at least two pumps. One pump can operate while the other is removed for repair.

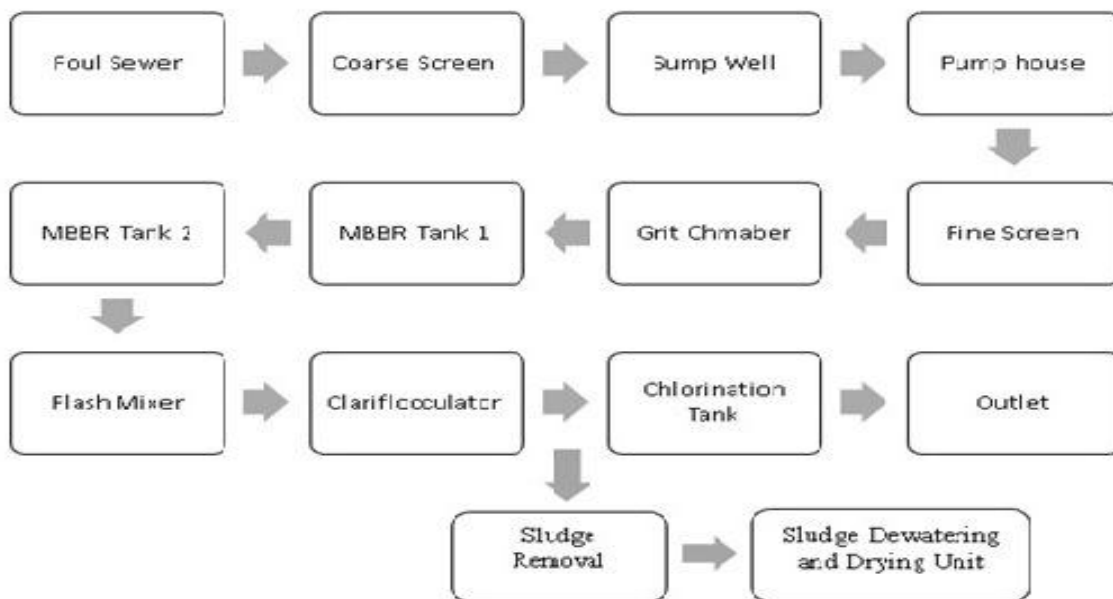
- The second step in sewage treatment is to remove biological content from sewage.
  - Trickling Filter:** - In this process the waste water dispended upon `a bed of media such as rocks stones, plastic or salts. Modern filters use a type of rockwool. The effluent flows through the material at slow enough rates to allow microbial growth on the surface of the media creating a layer of film. The spacing of the media allows air to circulate throughout the trickling system. Once microbial growth takes place additional wastewater flow has contact with microorganisms; this contact ensures that the organic matter in the primary treatment effluent is broken down. Despite being cheap in construction it can occupy a larger area and require high maintenance.
  - Moving Bed Bio Reactor [MBBR]:** - A moving bed biofilm reactor is a biological process, meaning it is natural process that uses biofilm to remove waste from sewage. Microorganisms attached to media in the water consume unwanted waste, leaving cleaner water. This become a popular due to some benefits it offers. This process provides safe and environmentally sustainable means of removing organic substances, reducing BOD as well as achieving nitrification and denitrification. MBBR is the best solution for space constraints. It is as easy to use unit and require less maintenance. It works finely with low hydraulic retention time.
  - Oxidation Pond:** - Oxidation ponds are large and shallow; a typical depth would range from 1-2.5m. The ponds are composed of microorganisms, which feed on the organic matter received from primary effluent. Algae are a key feature in the oxidation

pond system. The only problems with this system that it is a slow process and require sunlight. In rainy season this process is not that effective as compare to other process.

- d. **Upflow Anaerobic Sludge Blanket Reactor [UASB]:** - The Upflow Anaerobic Sludge Blanket Reactor [UASB] is a single tank process. Wastewater enters the reactor from the bottom, and flows upward. A suspended sludge blanket filters and treats the wastewater as the wastewater flows through it. The UASB is a Centralized Treatment technology that must be operated and maintained by professionals. A skilled operator is required to monitor the reactor and repair parts, e.g., pumps, in case of problems. Desludging is infrequent and only excess sludge is removed every 2 to 3 years. This process requires long start-up time to work at full capacity and a constant source of electricity which is expensive and difficult in the areas where power cut frequently occur.
- e. **Sequencing Batch Reactor [SBR]:** - Sequencing batch reactors (SBR) or sequential batch reactors are a type of activated sludge process for the treatment of wastewater. Oxygen is bubbled through the mixture of wastewater and activated sludge to reduce the organic matter (measured as biochemical oxygen demand (BOD) and chemical oxygen demand (COD)). Due to compact tank construction less, land required. This treatment can efficiently remove BOD, COD, TSS, N, P. In this biogas is

released at high amount i.e. proper operation, skilled labour and high maintenance is required. Also, this process requires constant supply of electricity.

- After second step purification remaining effluent still contains some dissolved and suspended solids which need to be removed. To remove these solids clariflocculators are used. In large waste **water treatment** plants, the *flocculator* and the *clarifier* are combined together to achieve economy in construction. The combined unit of flocculator and clarifier is known as Clariflocculator in wastewater treatment process. Clariflocculator shall have two concentric tanks with inner tank serving as flocculation basin and outer tank serving as clarifier. For the better formation of floc flash mixer are also used.
- For all levels of wastewater treatment, the last step prior to discharge of the sewage effluent into a body of surface water is disinfection, which destroys any remaining pathogens in the effluent and protects public health. Disinfection is usually accomplished by mixing the effluent with chlorine gas or with liquid solutions of hypochlorite chemicals in a contact tank for at least 15 minutes. Because chlorine residuals in the effluent may have adverse effects on aquatic life, an additional chemical may be added to dechlorinate the effluent. Therefore, chlorination tank is constructed at the end of any treatment plant.



## VI-CONCLUSION

This report reviews the necessity for establishing another Sewage treatment plant in the Vasai Virar region. It also sheds light on the vast population growth to be experienced by the region. It helped determine the actual methods to be used for the design of the STP. The reports also plot the wastewater treatment procedures in India and the various other environmental aspects. The main intention of this report is to make contribution towards solving the problems posed by contaminated water. Different methods for treatment of water with their conditions are also discussed in this report.

## VII- SCOPE

- The future scope of Sewage treatment plant for Vasai-Virar region is that the treated water can be used for gardening, green belt, farming and the rest part of water can be used for road washing.
- The manual intends to give planners of such projects a helping hand to realize their plans and it point out the problems and risk inherent in these activities.

Following are the selected units for 1 STP with their calculated dimensions: -

Sr. No.	Unit	Dimensions
<b>1]</b>	<b>Foul Sewer: -</b>	
	Diameter	2 m
	Length	30 m
<b>2]</b>	<b>Coarse Screen: -</b>	
	Width	5 m
	Height [Inclined]	4.5
	Channel length	13.5 m
<b>3]</b>	<b>Sump Well: -</b>	
	Diameter	20 m
	Depth [Eff.]	10 m
	Depth [Total]	18.5 m
<b>4]</b>	<b>Pump: -</b>	
	Power of each pump	350 HP
	Number of units	4
<b>5]</b>	<b>Fine Screen: -</b>	
	Width	3 m
	Height [Inclined]	1.45 m
	Channel Length	4 m
<b>6]</b>	<b>Grit Chamber: -</b>	
	Length	11 m
	Width	7 m
	Depth	1.5 m
<b>7]</b>	<b>MBBR Tank: -</b>	
	Number of tanks	2 No's
	Diameter	45 m
	Depth	6 m
<b>8]</b>	<b>Flash Mixer: -</b>	
	Diameter	5.5 m

	Depth	3.5 m
<b>9]</b>	<b>Clariflocculator: -</b>	
	<b>Flocculator: -</b>	
	Diameter	32 m
	Depth	3.5 m
	<b>Clarifier: -</b>	
	Diameter	70 m
	Depth	6.5 m
<b>10]</b>	<b>Chlorination Tank: -</b>	
	Diameter	24 m
	Depth	4.5 m

Note: - Unit Number 1 to 4 are designed for 40 years period and the remaining units are designed for 20 years period.

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