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# Planning of Sewage Treatment Plant (STP) and Sewer Network with Operations- Maintenance, Service Problems

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**ABSTRACT:** This abstract provides a case study on the planning of a Sewage Treatment Plant (STP) and sewer network, with a focus on operations, maintenance, and service challenges in the context of addressing water scarcity through efficient wastewater management and reuse. The study examines in detail the Detailed Project Report for the Underground Sewerage Scheme in the Vasai-Virar City Municipal Corporation, from its inception to its completion and effluent disposal. Relevant municipal departments and consultants provide information. Existing STPs and wastewater systems are evaluated using a mixed-methods approach, including qualitative interviews with experts and stakeholders and quantitative surveys. Utilizing Schedule of Basic Rates (SBD) and price indices, the decade-long cost variations in Vasai-Virar City are analyzed. The findings highlight the necessity of budget planning to account for cost escalation due to inflation, and ultimately contribute to the sustainable development of STPs and wastewater networks in the context of changing environmental and economic factors.

**KEYWORDS:** Sewage Treatment Plant (STP), Sewer Network, Operation and Maintenance Protocols, Sewer Infrastructure etc.

## I. INTRODUCTION

Water scarcity can be tackled by enhancing consumption efficiency and seeking sustainable alternative sources. There are various techniques available, including efficient and effective wastewater management and reuse to augment fresh water and maintain the environment clean. Reusing wastewater can be a solution for releasing freshwater for domestic use while also improving the quality of river waters used for drinking water abstraction (by reducing disposal of effluent into rivers)(Garcia & Pargament, 2015).

Aspects of wastewater management are evaluated from an integrated perspective since effective wastewater management needs a comprehensive understanding of the complete wastewater system, from the point of wastewater generation to the final disposal plans. The generation, collection, treatment (including sludge treatment), disposal, and reuse components of an integrated wastewater management system are all operational. A thorough, objective analysis of wastewater management strategies is necessary for making an informed selection(Kansakar & Polprasert, 1983).

### 1.1 Sewage Treatment Plant (STP)

Sewage Treatment Plant (STP) is the purification as well as reuse of sewage water for gardening, agriculture, along with other purposes. Treated Sewage water is purified and maintained as per the Pollution control board norms. STP are mandatory in most of the industries, housing colonies, apartments etc. STP are equipped with high Precision component with advance technology(WATERPU, 2023).

Many are confused between STP & ETP. While Effluent Treatment Plant (ETP) is, a mechanism or procedure used to purify effluent before its release or reuse in the environment. STP is the method of removing contaminants from wastewater as well as household / industrial sewage, both runoffs (effluents).(WATERPU, 2023).

## Areas in a STP Plant

### Primary treatment

In Primary treatment, wastewater is fed through a screen to remove any large suspended particles. Following this, the water enters a Grit chamber where grit is extracted. Sand, gravel, eggshells, bone fragments, seeds, and other materials comprise grit. To reduce heavy deposits in aeration tanks, digester, channels, and conduits, grit removal is required. The subsequent phase involves primary settling containers. The particulates descend to the bottom of these typically enormous containers due to gravity and are evacuated as sediment. The oil floats to the surface, where it is scraped off. 50-60% of the dispersed particulates are removed and the five-day biological oxygen demand is reduced (Envisol, 2023).

### Secondary treatment

The secondary stage of effluent remediation is secondary treatment. Primary treatment involves the removal of suspended substances, colloidal particles, oil, and grease. The effluent then undergoes a second biological treatment to remove any organic matter.

Native and aquatic microorganisms such as bacteria and protozoa perform this treatment by consuming biodegradable soluble contaminants such as sugar, oil, detergent, and food refuse. These processes are temperature-sensitive, and as the temperature rises, the rate of biological reactions increases.

Secondary treatment is comprised of two distinct processes:

**Aerobic Treatment** – Aerobic wastewater treatment is a biological process that utilises oxygen to decompose organic matter and eliminate other pollutants, such as nitrogen and phosphorus. Generally, aerobic treatment is utilised in effluent treatment.

**Anaerobic Treatment** – Anaerobic remediation is a procedure in which microorganisms decompose effluent or other materials in the absence of dissolved oxygen. However, anaerobic bacteria can and will use oxygen that is present in the systems introduced oxides, or they can obtain oxygen from organic matter within the effluent.

### Tertiary treatment

Tertiary treatment, also known as advanced treatment, is the third stage of effluent purification. Tertiary treatment eliminates the water's nitrogen and phosphorus loads. It contains filtration, ion exchange, activated carbon adsorption, electro dialysis, nitrification, and denitrification. (Envisol, 2023)

Options for tertiary treatment depend on the characteristics of the effluent after secondary treatment and the type of water required at the conclusion of treatment. For instance, if potable water is required, filtration and disinfection are employed to treat effluent.

### STP and IPS

The Contractors who were awarded the Construction Contract currently perform operation and Maintenance (O&M) of the preponderance of extant Sewage Treatment Plants (STPs) and Intermediate Pumping Stations (IPSs). Typically, the contractor is responsible for operating and maintaining the STP/IPSs for an initial period of 5 years, and at the conclusion of the 5th year, the Contractor is required to give over the STP/IPSs operation either to PMC or to a newly selected Contractor to operate the plant for future operations. This arrangement is typical for PMC, even in India (private sector participation), and the Contractors operate the 9 extant STPs in PMC. (Operation, 2017).

### Municipal Waste Water

Wastewater is water that was contaminated by either synthetic or natural microbial compounds because of human beings, commercial, or industrial operations. The characteristics of discharges of wastewater would vary considerably based on the population, number of industries, and degree of separation between atmospheric water and sanitary fluids, and ground water levels of the municipality.

Domestic wastewater consists of effluent from the kitchen, lavatory, and laundry, in addition to any other waste data that people may inadvertently or deliberately discharge down the toilet.

The mineral and organic elements of wastewater range from coarser sediment to fine suspended matter to nanocrystals to soluble materials. In general, wastewater consists of 99.9 percent water and a handful of contaminants that are both detrimental to water supplies and possibly valuable assets. The concentration and volume of domestic effluent would



vary considerably based on a municipality's population, topography, degree of isolation among rainwater and sanitation fluids, and ground water levels.

Consequently, random point selection and evaluation methods are prone to error, and it is advised to use conventional or typical results for a given population with no control. Human excreta, lavatory waste (toilet paper, contraceptives, sanitary towels, sanitary napkins, cloth diapers, and cigarette remains), food, and laundry are examples of household effluent (Sikosana et al., 2019).

### Statement of the Problem

The study is to review the process of the Detailed Project Report on Under Ground Sewerage Scheme for Vasai Virar City Municipal Corporation (VVMC) starting from generation until ultimate wastewater disposal schemes, while considering sustainable and comprehensive solutions along the process. The necessary data will be collected from VVMC's Project department, Sewage department, Project consultant that are mandated to govern Sewerage scheme and the appointed contracting agency for existing 30 MLD Sewage Treatment Plant and sewerage network in the city.

## II. LITERATURE REVIEW

Priyanka T. and Ruksana T. (2019) stated that the design the characteristic of a sustainable sewerage treatment system is that required to meet the requirements of water reclamation, recycling, and reuse in order to meet the water demands of future populations. According to them, the most difficult aspects of the process are the evaluation and choice of viable treatment methods and technologies based on various parameters (P, Ruksana T, 2017)

The sewage system plays an important role in the water resources cycle. To maintain proper hydraulic management and prevent environmental contamination of the sewer network, the various causes and types of their malfunction should be detected. Gabriella Balacco et al. (2020) the most prevalent cause for action in Southern Italian drainage systems was pipe obstruction with exfiltration, then manhole occlusions, according to an investigation. The majority of the causes of pipe repair have nothing to do to the pipe's ages or substance., but rather the installation method or social habits involving incorrect sewage system use (Totaro & Piccinni, 2020).

A sewage treatment plant was required for excess sewage generated by a developing municipality in Andhra Pradesh. In said case M. Bhargavi et al. (2018) conducted an investigation to design a treatment plant for sewage for Vizianagaram, considering thirty years of population growth projection, different requirements, and permitted quantities of wastewater treatment into consideration; with plans to utilize processed sewerage water for water supply, suppression of fires, as well as public-commercial lavatory cleansing, as well as treated sludge to nourish soil fertility (Ananta et al., 2018).

Miguel E.M. Udaeta (2019) assesses the potential for electricity generation from effluent purification in the State of So Paulo (SP). This case study is based on a sewage treatment plant (STP) with expertise in the production of biogas from a wastewater treatment plant (WWTP). The fundamental premise is that the generation of electricity in STPs is advantageous for companies in the Brazilian sanitation sector, resulting in reduced treatment costs. (Udaeta et al., 2019). Sifat Rezwan (2019) demonstrates an efficient IoT method for monitoring the status of a Sewage Treatment Plant (STP) using a small collection of critical sensors connected to Arduino microcontroller boards communicating via Wi-Fi networking technology. STP facilities are essential for maintaining environmental safety. This method employs three critical sensors to measure the status of a sewerage treatment plant and transmits the data to a local cloud server in real time. (Rezwan et al., 2019).

### 2.1 Research gap

- According to a study conducted by the American Society of Civil Engineers (ASCE), a maintenance plan should develop a strategy based on the following factors: problem frequency and location, age, construction material, pipe diameter, and subsurface condition.
- The future of wastewater maintenance is exceedingly bleak because corrosion control measures for sewers have not been implemented. Therefore, preventative measures are required to control sewer corrosion.
- Sewer networks will require aggressive maintenance in the near future.
- Innovative maintenance technologies have a small market share due to their high cost, lack of funding, as well as technical limitations.



- The problem of sewer corrosion is not currently receiving sufficient attention. Unlike in developed nations, measures for mitigating corrosion in sewer networks are not governed by official manuals or standards, as well as there have been very few instances of corrosion as well as odour control in sewer systems.
- Sewer rehabilitation is primarily determined by internal costs; social as well as environmental costs are typically disregarded.
- Construction as well as design organizations have not yet mastered new trenchless technologies such as slide lining, trenchless grouting, as well as pipe breaching.

### III. METHODOLOGY

This research aims to develop a comprehensive understanding of the planning, design, and implementation of a sewage treatment plant (STP) and sewer network, with a specific focus on addressing operations, maintenance, and service problems. The research will adopt a mixed-methods approach, combining both qualitative and quantitative techniques to gather and analyze data. The study will begin with a comprehensive literature review to gain insights into existing methodologies and best practices related to the planning and management of STPs and sewer networks, serving as the foundation for the research. Data collection will involve two primary methods:

a) Qualitative Method: In-depth interviews will be conducted with experts, policymakers, and stakeholders involved in the planning, construction, operation, and maintenance of sewage treatment plants and sewer networks to gain valuable insights into the challenges faced and potential solutions.

b) Quantitative Method: Surveys will be administered to residents, local authorities, and STP operators to gather quantitative data on the efficiency, service quality, and maintenance practices of existing STPs and sewer systems. The data will be analyzed using thematic analysis for qualitative data and statistical techniques for quantitative data, to identify recurring themes, patterns, and correlations. The research will utilize a case study approach, focusing on Vasai-Virar City, to illustrate and validate the findings. Ultimately, this methodology aims to contribute valuable insights and recommendations to enhance the efficiency and sustainability of sewage treatment plants and sewer networks.



Fig. no 1 flowchart

#### Case study

Corporation had planned seven major STP in urban areas. Out of 7 STP's zone, no. 2 (STP-2) with capacity of 30 MLD has commissioned in Aug-2017 and remaining 6 STP's are under planning stage.

For STP-2 sewer collection, network RCC pipeline was laid using open cut method, during execution work major issues were faced due to those slushy and collapsible strata. Hence resulting delayed work and excess road restoration work.

### Vasai Virar

The Vasai-Virar City Municipal Corporation (VCCMC) administers regions and villages in the most populous portion of Palghar district in Maharashtra, India's Vasai-Virar taluka. It is the fifth-biggest metropolis in Maharashtra, based to the census conducted in 2011, with an estimated population of over 1.3 million. The township is situated 50 kilometers north of Mumbai, on the north branch of Vasai Creek. It was established on 3 July 2010 when 4 city councils and 53-gram panchayats were merged.



Vasai-Virar has four stations on the Western Railway line of the Mumbai suburban railway: Naigaon, Vasai Road (Junction), NalaSopara, and Virar.

### Location



Vasai-Virar City is the only city in the Palghar district with a population of more than 12 lakhs as well as a municipal corporation. It is in the north of Mumbai. The city of Vasai-Virar covers 311 square kilometers. In addition, total vegetative cover is approximately 43.93 percent.

Due to the prevalence of Vasai Creek, Greater Mumbai and Mira-Bhayandar City are geographically distinct from Vasai-Virar City. The region is well connected to Mumbai via the Western Railway and the Mumbai-Ahmedabad National Highway. The Vasai-Diva Railway line connects Navi Mumbai, Thane, Bhiwandi, Kalyan, and Panvel to the metropolis. Due to its proximity to Mumbai, Vasai Virar City has significant development potential.

Geographically speaking, the city is situated within the Deccan volcanic landscape. The development area lies within the jurisdiction of the Vasai Virar City Municipal Corporation (VCCMC). The Vasai Virar neighborhood is situated in the Palghar, Gujarat region.



**Accessibility**

The railway stations in Virar, Nallasopara, Vasai Road, as well as Naigaon are connected to the national highway and the coastal villages via east-west highways. The Vasai-Agashi highway, which runs parallel to the coast from north to south, effectively connects all coastal municipalities.

The commuter railway, whose terminus is in Virar, provided a catalyst for growth. This Virar Railway Station also serves as the terminal for transit trains destined for Gujarat. The Vasai to Diva railway connects Western Railway to Centre and Konkan Trains.

**IV. RESULTS AND DISCUSSION**

**Table 1 Recap sheet for STP-1 Chikhaldongari, Virar**

	Components	Cost Put to Approved Tender (2013)	Revised cost with Variation -2021 (SBD Method- WPI & CPI Index) (Feb 2018 and Feb 2021)	% Change with SBD Method- 2021	Revised cost with Variation - 2023 (SBD Method- WPI & CPI Index) (Feb 2018 and Feb 2023)	% Change with SBD Method- 2023
1	Sewer network (length= 17852 m) (Full RCC)	203690273.00	228825652.7	12.34	234180173	14.968756
	Road Restoration Work	66671573	74898845.11	12.34	76651478.08	14.968756
2	Sewage Treatment Plant (26.5 MLD)	297317107	334006038	12.34	341821779.3	14.968756
3	Wet Well + Pumping (Civil + E&M)	43045275	45774345.44	6.34	47728909.99	10.880718
4	Miscellaneous	81518577	91577969.4	12.34	93720893.89	14.968756
5	O&M (for 15 years + Asset Replacement)	305566932.7	386053262.8	26.34	433692235.4	41.930356
	Estimate Cost	99,78,09,738	1161136113	13.67333333	1227795470	18.78101633
	Estimate in Cr	99.78	116.1136113		122.779547	

Note: Amount is in rupees.

Using the SBD (Schedule of Basic Rates) method with the WPI (Wholesale Price Index) and CPI (Consumer Price Index) indices, the supplied data illustrates cost variations for various project components over time. The project includes a wastewater network, road restoration, a sewage treatment plant, a damp well with pumping, extraneous items, and operation and maintenance (O&M) expenses.

From 2013 to 2023, the costs of all components have increased due to inflation and other factors. Notably, the O&M cost has increased by 41.93 percent due to the long-term character of the operation and the replacement of assets. Using the SBD method, the total estimated cost has risen from 99.78 crore in 2013 to 122.78 crore in 2023, an increase of 18.78%. This cost escalation must be factored into budget planning and project management in order to ensure adequate funding and successful project execution.



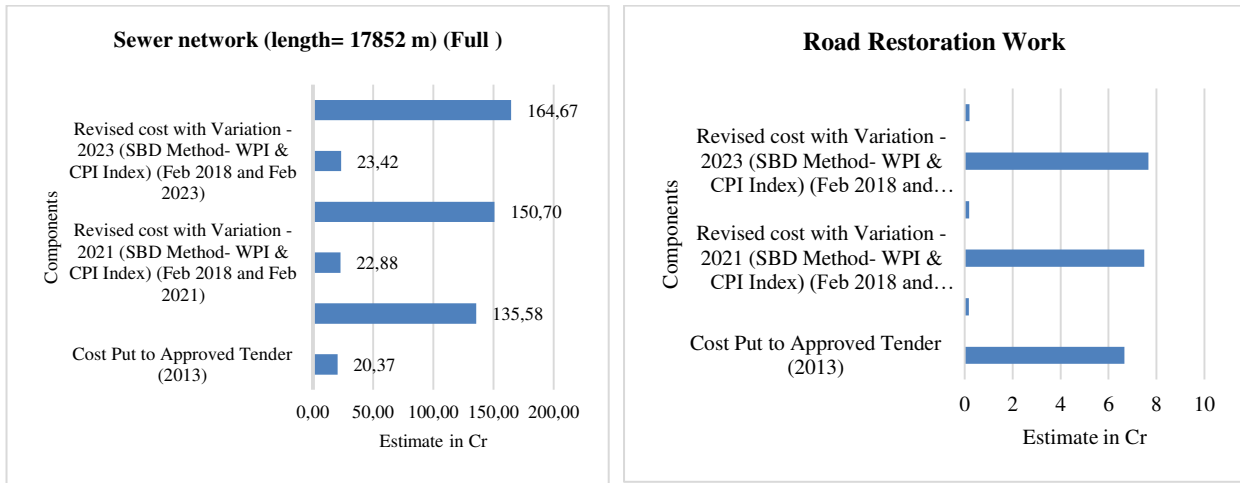
**Table 2 Estimate for STP-1 Chikhal dongari, Virar**

	Components	Cost Put to Tender – (SOR 2018 & Budgetary)	Revised cost with Variation -2021 (SBD Method- WPI & CPI Index) (Feb 2018 and Feb 2021)	% Change with SBD Method- 2021	Revised cost with Variation -2023 (SBD Method- WPI & CPI Index) (Feb 2018 and Feb 2023)	% Change with SBD Method- 2023
1	Sewer network (length= 17852 m) (Full HDD)	1355831266	1507006452	11.15%	1646657072	21.45
	Road Restoration Work	1653194	1837525.13	11.15%	2007804.11	21.45
2	Sewage Treatment Plant (26.5 MLD)	2471211828	2746751947	11.15%	3001286765	21.45
3	Wet Well + Pumping (Civil + E&M)	164116824	172437547	5.07%	181234209	10.43
4	Miscellaneous	344428607	382832396	11.15%	380352510	10.43
5	O&M (for 15 years + Asset Replacement)	2551790209	3083328109	20.83%	3212959052	25.91
	Estimate Cost	6889031928	7894193977	11.75%	8424497413	18.52
	Estimate in Cr	688.9	789.42	11.75%	842.449741	

Note: Amount is in rupees.

The revised cost of a sewerage project using the SBD method in 2021 and 2023. The total cost of the undertaking increased by 11.75 percent in 2021 and 18.50 percent in 2023 due to India's soaring inflation. In 2023, the effluent treatment plant and sewer network saw the greatest cost increases, both rising by 21.45%. The price of road restoration and damp well + pumping increased by 11.15 percent, while the price of miscellaneous items rose by 10.4 percent. The estimated cost of the project in 2021 was 688.9 crores, rising to 774.42 crores in 2023, and it is anticipated that the cost will continue to rise in the future due to inflation.



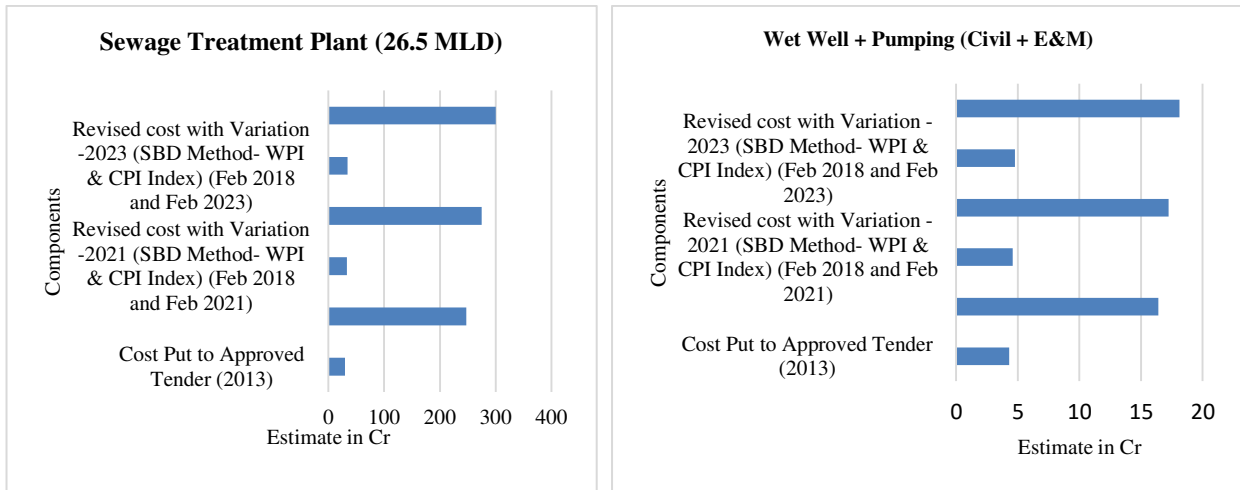


**Graph 1 Sewer network (length= 17852 m) (Full)**

The estimated cost of the sewer network project has increased from 20.37 crore in 2013 to 23.42 crore in 2023, as calculated by the SBD Method utilising the WPI and CPI Index to account for inflation and changes in construction costs.

**Graph 2 Road Restoration Work**

The cost of road restoration work has steadily increased over the years, reflecting the impact of inflation and economic changes, with a notable rise from 2013 to 2023, especially in the RCC (Reinforced Cement Concrete) category.

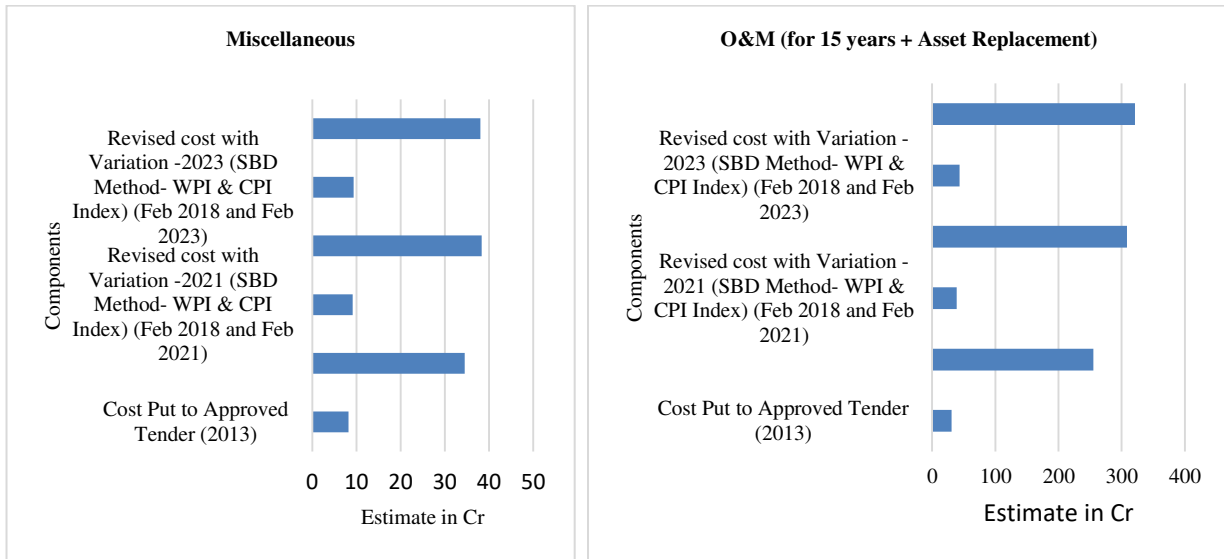


**Graph 3 Sewage Treatment Plant (26.5 MLD)**

The cost of the Sewage Treatment Plant increased substantially from its initial estimate in 2013 due to multiple revisions prompted by inflation indices and methodological modifications, ultimately attaining a higher value by 2023.

**Graph 4 Wet Well + Pumping (Civil + E&M)**

The cost estimate for the Wet Well + Pumping project experienced significant increases over the years due to variations and inflation, with the 2023 revised cost being the highest, indicating potential budget challenges.



**Graph 5 Miscellaneous**

The miscellaneous costs for the approved tender in 2013 have seen revisions, incorporating variations in cost using the SBD method based on WPI and CPI indices, with significant increases by 2023 for both RCC and HDD categories.

**Graph 6 O&M (for 15 years + Asset replacement)**

The cost estimate for O&M (Operations and Maintenance) with a 15-year duration and asset replacement, initially approved in 2013, has undergone revisions in 2021 and 2023 using the SBD method with WPI and CPI indices, resulting in increased costs for both RCC and HDD components.

**V. CONCLUSION**

In conclusion, when evaluating the cost of sewer pipe laying, the HDD method for HDPE pipelines proves to be more expensive than the RCC sewer pipeline using the open cut method. However, the benefits of opting for HDPE sewer lines with the HDD method outweigh the initial cost differences. The advantages include timesaving processes, reduced expenses for road restoration, and a longer life expectancy for HDPE pipelines.

Moreover, the socio-economic costs are lower with the HDPE sewer line, contributing to a more sustainable environment. When examining the cost variations for different project components between 2013, 2021, and 2023, it is evident that inflation has led to an overall increase in expenses. In 2021, most components saw a rise of 12.34%, which slightly increased further in 2023. Particularly, Operations & Maintenance costs experienced a significant increase of 26.34% in 2021 and a staggering 41.93% surge in 2023.

The total estimated project cost in 2023 amounts to 122.78 crores, reflecting an 18.78% increase from the 2013 costs. The project estimate witnessed a rise from 688.9 Cr in 2013 to 842.45 Cr in 2023, which is an 18.52% overall increase. In summary, the comparison of costs between the different project components over time shows a general upward trend due to inflation. Despite the increased expenses, the advantages of the HDPE sewer line with the HDD method make it a viable choice, especially in the context of the rising overall project costs.

**VI. FUTURE SCOPE**

The future scope of planning sewage treatment plants (STPs) and sewer networks, with a focus on operations, maintenance, and addressing service problems, as demonstrated by this case study, highlights the continued significance of considering innovative methods such as the Horizontal Directional Drilling (HDD) method for High-Density Polyethylene (HDPE) pipelines. Despite the fact that this method may initially appear to be more expensive

than traditional RCC sewer pipelines using the open-cut method, its long-term benefits in terms of time efficiency, reduced costs associated with road restoration, and the longer lifetime of HDPE pipelines make it a compelling option.

Moreover, the environmental and socioeconomic benefits of HDPE sewer lines, such as reduced socioeconomic costs and improved sustainability, are becoming increasingly important. The analysis of price fluctuations over time reveals the effects of inflation, with prices increasing consistently. The estimated total project cost in 2023 is 18.78% higher than in 2013, indicating a continuing upward trend in project expenditures. However, despite these rising costs, the demonstrated benefits of the HDPE sewer line with the HDD method make it a practical and sustainable option in the face of rising overall project costs. Future sewage infrastructure planning and development will likely place a greater emphasis on the use of such innovative strategies as urban areas continue to grow and environmental concerns persist.

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