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Upgradation of Sewage Treatment Facility of Pune and Pimpri-Chinchwad City: A Step Towards Sustainable Development

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Abstract: About 80 percent of the water supplied to consumers in Indian cities gets converted into sewage. The metros, major cities and towns together generate about 20,000 million litres of wastewater (sewage) per day. About 50 to 70 percent of the pollution load of rivers and streams is from domestic sewage. Sources of fresh water are getting exhausted and development of new water resources is cost intensive and time consuming. Since water stored in dams and lakes is the main source of water for urban population, it is to be conserved, collected after its use and treated before it is discharged into the nearby water bodies. Sustainable development is necessity of the present world for every industry. Wastewater treatment industry is not an exceptional for this; in fact it is primary need for conservation of natural water sources. To prevent the degradation and to maintain the quality of water in the rivers, the sewage generated from cities is to be treated before its disposal into the nearby river. The treated sewage can be used for secondary purposes like gardening, agriculture, industrial reuse and recreational fields. The paper discusses the integrated approach in decentralised planning, designing and execution of new sewage treatment plants of Pune and Pimpri-Chinchwad Municipal Corporation for sewage treatment and disposal.

Key words: Master Plan 2025, activated sludge process (ASP), biochemical oxygen demand (BOD), suspended solids, fluidized aerobic bioreactor (FAB) technology, sequential batch reactor (SBR).

Introduction

The Pune city, with 18° 31′ N latitude and 73° 51′ E longitude, is situated on the western margin of the Deccan Plateau at the confluence of Mutha and Mula rivers. Pune is second largest city of Maharashtra state and lies on the leeward side of the Western Ghats, at a height of about 560 Mts above mean sea level**.** The mean daily maximum and the minimum temperatures for the hottest month i.e. May are 38°C and 23°C respectively. The same for the coldest month of December are 30°C and 12°C respectively. The annual rainfall is about 70 cm. The total storage of 28 TMC in Panshet, Varasgaon, Temghar, Khadakwasala and some other small dams within Mutha river catchment is the source of water to Pune city. This total storage capacity also includes the agricultural requirements. Mula and Mutha are the two major rivers, which converge and pass through Pune city. A large population is dependent on Mula-Mutha river water flow down to Pune city and these rivers finally discharge into Ujani dam. As per census of 2001 the city population is 25,40,069 souls. The forecasted population of Pune city for the year 2011 and 2025 are 43,00,000 and 65,00,000 respectively. At present the annual water requirement of Pune city is about 9.5 TMC.

Pimpri-Chinchwad is an industrial city at 10 km distance from Pune city. As per census record the population in year 2001 was 10,54,000. Projected

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population of Pimpri-Chinchwad city for year 2011 and 2025 is 15,00,000 and 235,00,000 respectively. The source of water to Pimpri-Chinchwad city is Pawana dam which has a capacity of 10.5 TMC and is about 36 km on West-North side. Water from dam is released into Pawana river. Intake well of Pimpri-Chinchwad Municipal Corporation (PCMC) water supply project is located on pawana river at Rawet village from where 328 MLD water is picked up.

On an average, Pune Municipal Corporation (PMC) and Pimpri-Chinchwad Municipal Corporation (PCMC) are supplying water at the rate of about 200 litres per head per day to its citizens. The Pune city generates around 451 MLD of sewage. Municipal authorities abide by the norms of state pollution control board for disposal of treated sewage into the rivers. Up to year 1997, in old Pune city limit Dr Naidu sewage treatment plant with full-fledged primary and secondary treatment facility was treating 90 MLD sewage and old Bhairoba sewage plant with primary treatment facility was treating 32 MLD sewage (Table 1). Due to merger of 23 villages from the outskirts in year 1997, the area under jurisdiction of PMC has gone up to 243 sq kms. PMC anticipated sudden load on municipal services like water supply and sanitation due to merger of nearby villages and initiated formulation of the Master Plan of these services up to year 2025. The approximate total budget of Master Plan 2025 for sewerage and sewage treatment is 523 crores. This master plan is being executed in three phases. Phase I was completed in year 2005 and Phase II at a later date. Early execution of Phase III is in thought process and is likely to be completed by 2015 instead of earlier plan of 2025. At present, 68% (305 MLD) of the total sewage is treated before discharge into the rivers and remaining 32% (145 MLD) untreated sewage reaching the rivers through drains and nallas due to inadequate collection and conveyance system.

Till 1985, PCMC was having one sewage treatment of 16 MLD capacity at Chikhali. At present Pimpri-Chinchwad city generates sewage about 287 MLD. With increase in the size of city and amount of sewage generated PCMC has gone for large scale augmentation of its sewage treatment plant capacity. From the year 1997 to 2008, PCMC has constructed and commissioned six new sewage treatment plants (Table 2). Out of total 287 MLD of sewage generated about 207 MLD (72%) sewage is being treated and treated sewage is being discharged in Pawna river. Remaining about 80 MLD (28%) is reaching nearby drains and finally Pawana and Mula rivers without proper collection and treatment.

This is leading to an adverse impact on the environment in the surrounding areas through Mula-Mutha and Pawana rivers flow. A large number of housing schemes in the outer areas of PMC and PCMC still depend on the on site sanitation in the form of septic tanks. Massive programme to augment the sewage treatment capacity was undertaken around year 1999 and it is one of the most important aspects to reduce Mula-Mutha, Pawana river pollution and make the city clean and healthy in every possible way. Pune and Pimpri-Chinchwad Municipal Corporation under this master plan will treat 100% of its sewage generated by the end of 2015.

Obligatory Condition of State Irrigation Dept and Pollution Control Board Norms (20/30)

Originally, Kamshet and Warasgaon dams within the Mutha rivers basin were constructed for agricultural water requirements. In 1960 the water supplied to Pune city was 5% of cumulative storage capacity of these dams and now the demand has gone up to 25%. The water to Pune city is supplied at the cost of partial cut down of agricultural requirements. The right bank canal of Khadakwasla dam passes through Pune city and at Hadapsar the shortest distance between Mula-Mutha river and canal is hardly 1-1.5 kms. All these old and newly constructed sewage treatment plants of PMC and PCMC are located on or near the banks of Mula-Mutha, Pawana rivers flowing through Pune and Pimpri-Chinchwad city (Figure 1). In developing countries and especially in the areas of water scarcity greater compatibility between water, wastewater and agriculture is necessary for the sustainability. There are several villages and towns (riparian) on the downstream who are dependent on the river flow for their agricultural and drinking water requirements. In view of their dependency and as a matter of long-term policy, the Irrigation Department of government of Maharashtra in year 1997 has laid down a condition to PMC while granting the increased demand of water to Pune city to 11.5 TMC, that the Pune Municipal Corporation at its own cost will pump 6.5 TMC mixture of Mula-Mutha river flow and treated sewage from suitable downstream point of Pune city and deliver into Khadakwasla right bank irrigation canal at Sadesatranali ($17^1/_2$ nali) near Hadapsar for agricultural reuse.

To prevent the degradation of river water and to maintain clean river water, the Maharashtra state pollution control board has norms for disposal of treated sewage effluents into the rivers. Part of the mixture of

Table 1: Details of various sewage treatment plants of Pune Municipal Corporation, Pune

Sr. No	Description	*Master Plan 2025*									*Old STP's till Year 1997*	
						Under Construction			*Future Plants*			
		Bopodi	*Tanajiwadi*	*Erandwane*	*Bhairoba*	*Vitthalwadi*	*Existing premises of Dr. Naidu Hospital*	*Baner*	*Kharadi*	*Mundhawa*	*Dr.Naidu Hospital*	*Bhairoba Nala*
1	Plant Capacity	18 MLD	17 MLD	50 MLD	130 MLD	32 MLD	115 MLD	30 MLD	40 MLD	45 MLD	90 MLD	32 MLD
2	Treatment Process	Extended Aeration	Bio Tower and Diffused Aeration	Modified Activated Sludge Process	Activated Sludge Process	Sequential Bio-Reactor	Activated Sludge Process	Sequential Bio-Reactor	Sequential Bio-Reactor	Sequential Bio-Reactor	Carrousel Process (AST)	-
3	Year of Commissioning	May 2003	April 2004	December 2004	July 2003	Expected by March 2010	May 2010	December 2009	2011	Dec 2010	1988	1928
4	Plant Area	1.5 Hectare	0.72 Hectare	0.8 Hectare	8 Hectare						4.26 Hectare	-
5	Population	1,25,150	1,29,000	3,46,000	7,41,000						-	-
6	Project Cost in Crores	5.69	6.75	11.12	37.54	12	40	30			2	-
7	Power Consumption per Day	2300 kWh	4050 kWh	11000 kWh	24000 kWh						15700 kWh	-
8	Design Parameters	BOD: 250, < 20 mg/l; COD:350 mg/l; TSS: 300, < 30 mg/l; pH : 6 to 8 ; Oil and grease: 30, < 10 mg/l; Residual Chlorine < 0.5 ppm										
9	Energy Consumption kWh/Person/year	6.71	11.45	11.66	11.82							
10	Land Utilization m^2/Person	0.12	0.055	0.023	0.083							
11	Operation & Maintenance cost per year in Lakhs	81.42	118	240	381.8		-	-	-		O&M by PMC	
12	Tertiary Treatment/ Chlorine Contact Tank	Applied dose of chlorine in all STPs is in the range of 3 to 5 ppm								3 to 5 ppm	-	
13	Disposal of Treated Sewage	Treated sewage is discharged into the Mula-Mutha river									Reuse for	Irrigation till 1980

Table 2: Details of various sewage treatment plants of Pimpri Chinchwad Municipal Corporation, Pune

Sr. No	Description	New Plants									Future Plants			Old Plant
				Kasarwadi				Under construction						
		Chikhali (New)	Chinchwad	Phase I	Phase II	Sangavi	Pimple Nilakh	Chinchwad Phase II	Rawet	Khasarwadi Phase III	Charholi	Akurdi	Sangavi	Chikhal (Old)
1	Plant Capacity	16 MLD	30 MLD	40 MLD	40 MLD	15 MLD	20 MLD	30 MLD	20 MLD	40 MLD	21 MLD	30 MLD	20 MLD	16 MLD
2	Treatment Process	ASP	ASP	ASP	ASP	FAB	Bio-tower aeration	SBR	SBR	SBR	SBR	SBR	SBR	Extender Aeration
3	Year of Commissioning	Dec 1999	June 2000	Sept 1999	Aug 2003	Dec 2001	Dec 2008	April 2009	Nov 2009	March 2010	2010	2010	2010	Sep. 1987
4	Plant Area	1.5 Hectare	1.75 Hectare	3 Hectare	2 Hectare	0.37 Hectare	0.8 Hectare							1.5 Hectare
5	Population	110000	170000	225000	220000	120000	105000							102000
6	Project Cost in Crores	4.1	7.25	16.11	6.82	5.25	12	16	12					48.65 Lakhs
7	Power Consumption per Day	2150 kWh	3200 kWh	4400 kWh	4300 kWh	2400 kWh	4000 kWh							4300 kWh
8	Design Parameters	BOD: 250, < 20 mg/l; COD:350 mg/l; TSS: 300, < 30 mg/l; pH : 6 to 8 ; Oil and grease: 30, < 10 mg/l; Residual Chlorine < 0.5 ppm												
9	Energy Consumption kWh/Person/year	7.13	6.87	7.12	7.13	7.3	13.90							15.38
10	Land Utilization m^2/Person	0.166	0.11	0.141	0.094	0.046	0.055							0.166
11	Operation & Maintenance cost per year in Lakhs	81.53	54.95	246	246	51.14	138.82				PMC			81.53
12	Tertiary Treatment/ Chlorine Contact Tank	Applied dose of chlorine in all STPs is in the range of 3 to 5 ppm								3 to 5 ppm	-			
13	Disposal of Treated Sewage	Treated sewage is discharged into the Pawana river and that from Charoli STP will be discharged in Indrayani River												

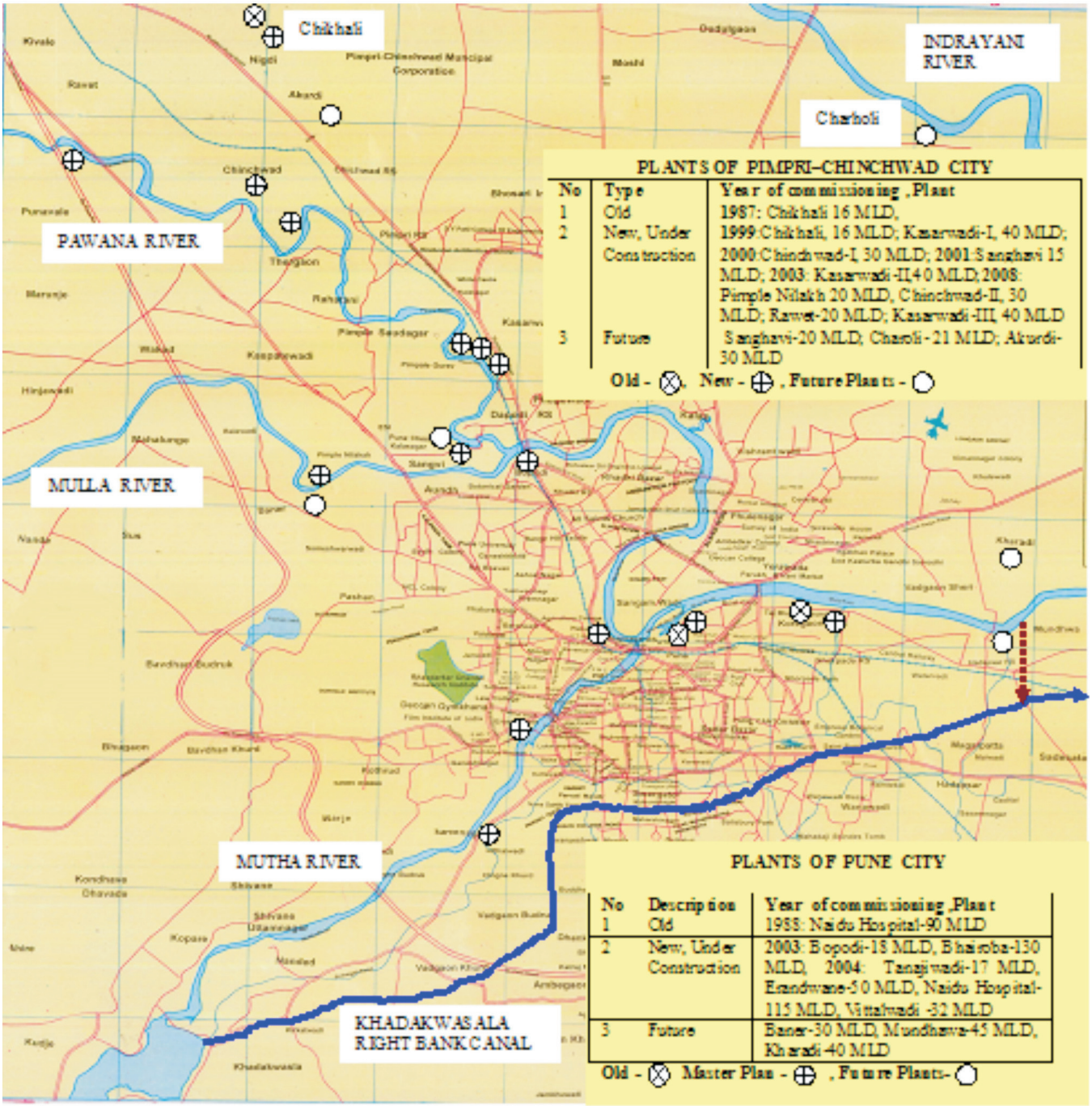

Figure 1: Location of various sewage treatment plants under PMC and PCMC.

Mula-Mutha river flow and treated sewage is proposed to pump back to Khadakwasla right bank canal for agricultural reuse. These rivers finally discharge into Ujani dam from where the raw water is picked up for drinking needs of Solapur city. Therefore, the city sewage generated is being treated to river standard (20/30) i.e. BOD < 20 mg/l, TSS < 30 mg/l and is being discharged into these rivers.

Decentralisation Approach in Sewage Treatment Planning

A small town can be effectively and economically served by using a single network of sewers, a single treatment plant and a single disposal system. But when the town grows into a city and then into a mega city, it becomes difficult to collect the sewage at a single sewage treatment

plant, and operate and maintain a single STP. In terms of capital cost, wastewater collection is more expensive than its treatment. Therefore, the decentralisation of treatment facility to avoid the need for a long collection system becomes an effective and economical solution for the treatment and disposal of sewage. Also, to minimize land requirement the sewage collection system must be decentralized as much as possible consistent with the topography of the area and its population deposition. Nearly 7-8 drainage districts of PMC and 3-4 drainage districts of PCMC are catering to different areas. The availability of land for construction of new STPs at their outlets at different locations on or near the Mula-Mutha, Pawana rivers has favoured the decentralization of sewage treatment plants under Master Plan 2025 (Figure 1). The future plants under Master Plan 2025 are going to serve another 2-3 drainage areas both in PMC and PCMC.

Master Plan 2025 of Pune City for Sewage Treatment

The area under PMC jurisdiction is around 243 sq. kms. For the treatment of sewage generated and to prevent the pollution of the rivers, Pune Municipal Corporation has constructed four new state-of-the-art sewage treatment plants in addition to existing old sewage treatment plants. These newly constructed sewage treatment plants are at Bopodi (18 MLD), Tanajiwadi (17 MLD), Erandwane (50 MLD), and Bhairoba (130 MLD). Bopodi and Bhairoba STPs have been commissioned in January 2003, where as the STPs at Tanajiwadi and Erandawane have been commissioned in the year 2004. The execution of these plants in totality under phase I of master plan of sewerage project was completed in year 2005 (Table 1). Total 451 MLD of sewage is generated in Pune Municipal Corporation limit, out of which 305 MLD is treated in these newly constructed four sewage treatment plants and Dr Naidu Hospital sewage treatment plant and the treated sewage is discharged into Mula-Mutha rivers. For the remaining 177 MLD sewage generated, three new sewage treatment plants were proposed and are under construction to upgrade the sewage treatment facility, one is at Vitthalwadi (32 MLD), Baner (30 MLD) and another at existing premises of Dr Naidu sewage treatment plant (115 MLD) and are likely to be commissioned at a later date. The future plants for Mundhawa (45 MLD) and Kharadi (40 MLD) are under consideration.

Upgradation of Sewage Treatment Facility of Pimpri-Chinchwad City

Pimpri-Chinchwad is an industrial city just at 10 km from Pune city. As per census record the population in year 2001 was 10,54,000. Originally, till 1998 it was having one old sewage treatment plant of 16 MLD capacity at Chikhali. With the increase in size of city and amount of sewage generated Pimpri-Chinchwad Municipal Corporation has gone for augmentation of sewage treatment facility. Pimpri-Chinchwad city generates sewage about 287 MLD and out of that 207 MLD (72%) sewage is being treated. The new plants are Chikhali 16 MLD (1999), Kasarwadi Phase-I 40 MLD (1999), Chinchwad 30 MLD (2000), Chinchwad Phase-II 30 MLD (April 2009), Kasarwadi Phase-II 40 MLD (2003), Sangavi 15 MLD (2001) and Pimple Nilakh 20 MLD (2008). Remaining about 80 MLD (28%) is reaching nearby drains and finally Pawana and Mula rivers without proper collection and treatment. Two new plants are under construction—Rawet 20 MLD and Kasarwadi Phase-III 30 MLD—and will be commissioned at a later date. The future plants are Charholi (21 MLD), Sangvi 20 MLD and Akurdi (30 MLD).

Sewage Treatment Process: An Overview

In general, sewage contains large debris, paper, rags, grit, egg shells, oil and grease, dissolved and suspended organic solids and microorganisms. This sewage can be treated by biological methods. Most of the sewage treatment plants constructed in last five decades in India are activated sludge treatment plant process or its modifications. These newly constructed sewage treatment plants of PMC and PCMC are either activated sludge treatment process, its modifications or combined with the other processes, fluidized aerobic bioreactor (FAB) technology and sequential batch reactor (SBR). In general the treatment given is preliminary, secondary and tertiary. Use of polyelectrolyte and centrifuging of biological sludge produced by the mechanical device, chlorination of treated sewage before disposal in chlorine contact tank (CCT) is practiced in all plants. Sludge thickening and anaerobic digestion of biological sludge for methane generation and energy recovery is an added feature of 130 MLD Bhairoba sewage treatment plant (PMC). These newly constructed sewage treatment plants (STPs) are designed to treat sewage having BOD value of 250 mg/l. The process adopted, area and power requirement, and mode of disposal of treated sewage of various sewage treatment plants are as given in Tables 1 and 2.

Land Utilisation and Power Consumption

(a) **Land utilization:** Availability of a suitable land in cities is a major constraint for the construction

of sewage treatment plants. To minimize land requirement the sewage collection system must be decentralized as much as possible consistent with the topography of the area and its population disposition. The per person land required (m^2/person) in warm climates for conventional activated sludge treatment process and extended aeration is to be within the range of 0.20–0.25 and 0.15–0.20 m^2/person. The land utilised at various STPs is as mentioned in Tables 1 and 2. The 50 MLD sewage treatment plant at Erandwane (PMC) is an activated sludge process with diffused aeration. The total plant is planned and constructed in a very small area of 0.8 hectare.

(b) Energy consumption: The continual increased demand of energy of urban population is alarming and has always been a problem of developing countries like India. While designing the sewage treatment plant two aspects of power are to be kept in mind: (1) minimum power/energy requirements and (2) effect of its dependability on the process. As far as possible the least energy intensive processes capable of meeting effluent quality requirements should be selected. This requires judicious selection of equipment and processes. Generally, aerobic digestion needs more power than anaerobic digestion. A more energy intensive process is selected only for very high BOD removal efficiency as a need for nitrification or as a need for reliability in operation. Combining two processes having different requirements and power can be able to optimize the overall cost. As far as possible benefits of natural land contours must be used to avoid pumping. The adoption of advanced resources recovery process such as sludge digestion for methane gas and power generation is an added advantage.

For conventional activated sludge process and extended aeration, the process power required in kWh/person-year is in the range of 12-15 and 16-19 kWh/person-year respectively. The power requirement of STPs of PMC and PCMC is as given in Tables 1 and 2.

Performance of Sewage Treatment Plants

The performance of the old and new sewage treatment plants of Pune and Pimpri-Chinchwad is monitored daily and performance parameters of some new plants are presented in Tables 3 and 4. The design parameters limit for BOD, TSS, Oil and grease, and residual chlorine are <20 mg/l, <30 mg/l, <10 mg/l and <1 mg/l respectively. The MLSS, MLVSS, SVI values of aeration tanks of Pune and Pimpri-Chinchwad sewage treatment plants are in the range of 3000-3510 mg/l, 2480-2750 mg/l and 115-120 ml/gm respectively. SVI value of aerated liquor of Bopodi STP is about 45 ml/gm (much lesser than 80 to 100 ml/gm, which is normally expected for extended aeration process), indicating its good settling ability. The BOD values of effluent at all plants consistently are in the range of 10-16 mg/l, whereas total suspended solid values are in a range of 15-18 mg/l. The oil and grease amount is not detectable in effluent from STPs. The residual chlorine at the outlet of CCT is less than 0.5 mg/l. The typical performance parameter values of different sewage treatment plants are given in Tables 3 and 4.

Operation & Maintenance and Cleanliness in the Areas of STPs

The bi-annual operation and maintenance (O&M) contract of these STPs is being awarded to private agencies. The operation and maintenance contract includes monitoring the performance of STP, major and minor breakdown services, security, maintenance of hygienicity and cleanliness within the STP premises. The total expenses per year towards operation and maintenance (O&M) contract, chlorine and electricity, polyelectrolyte, laboratory chemicals, oil and grease charges at various STPs is given in Tables 1 and 2. The cleanliness in the premises is noticeable in the sense that utmost care is taken in removing and disposal of the debris, solid waste separated at different stages and garden waste. These sewage treatment premises are absolutely free from foul smell and odour. The absence of foul smell in the premises of STPs is the indication of their excellent performance.

Discussion

The availability of suitable sites along the Mula-Mutha and Pawana rivers and near the outlets of drainage districts for construction of new and proposed STPs has favoured the decentralization of sewerage and sewage treatment under Master Plan 2025. At present about 70% of total sewage generated by Pune and Pimpri-Chinchwad city is being treated in the treatment plants. Some treatment plants are receiving the raw sewage of lesser BOD value than designed value of 250 mg/l, may be due to improved living standard or high usage of water. The continuous operation and maintenance of coarse and fine screens, and grit chamber are removing almost all large and small debris and grit from sewage. The suspended solids removal efficiency of primary clarifiers of all plants is around 50-60%. The MLSS, MLVSS, SVI values of

Table 3: Quality of raw and treated sewage (PMC plants)

Sr No	Parameter	Bopodi		Tanajiwadi		Erandwane		Bhairoba		MPCB Norms
		Raw sewage	Treated sewage	Raw sewage	Treated sewage	Raw sewage	Treated sewage	Raw sewage	Treated sewage	
1	BOD	145	16	180	12	175	14	110	12	< 20 mg/l
2	COD	296	32	235	28	252	20	238	32	< 250 mg/l
3	TSS	138	17	140	15	150	10	114	18	< 30 mg/l
4	pH	6.9	-	6.8	7.1	6.8	7.2	6.9	7.3	6-8
5	Residual chlorine	-	< 0.5	-	< 0.5	-	< 0.5	-	< 0.5	< 0.5 mg/l
6	Oil and grease	ND	ND	3.0	ND	2.5	ND	2.5	ND	-

Note: All values except pH are in mg/l

Table 4: Quality of raw and treated sewage (PCMC plants)

Sr No	Parameter	Chikhali New		Chinchwad		Kasarwadi Phase I		Sangavi		MPCB Norms
		Raw sewage	Treated sewage	Raw sewage	Treated sewage	Raw sewage	Treated sewage	Raw sewage	Treated sewage	
1	BOD	221	10	222	13	223	11	200	12	< 20 mg/l
2	COD	300	48	290	44	312	28	350	50	< 250 mg/l
3	TSS	130	28	180	18	130	7	200	20	< 30 mg/l
4	pH	7.0	7.2	7.1	7.1	7.0	7.5	7.05	7.09	6-8
5	Residual chlorine	-	< 0.5	-	< 0.5	-	< 0.5	-	< 0.5	< 0.5 mg/l
6	Oil and grease	2.5	ND	4.0	ND	3.5	ND	3.0	ND	-

Note: All values except pH are in mg/l

aeration tanks of all plants are in the range of 3000-3510 mg/l, 2480-2750 mg/l and 115-120 ml/gm respectively. The SVI value of aerated liquor indicates its good settling ability. The processes are completely stable and consistent in their performance parameters. The values of BOD and TSS of treated sewage over a period of three months are in the range of 10-16 and 15-18 mg/l respectively. The BOD and TSS removal efficiency is above 90% and 85 to 90% respectively. The sludge produced in secondary clarifiers is completely stabilized. The waste centrifuged sludge has no odour and is fit to use as organic manure. The effluent quality parameters like BOD and SS are well within the limits laid down by Maharashtra Pollution Control Board (MPCB) norms and permits the disposal of treated sewage in Mula-Mutha and Pawana rivers. The satisfactory performance of new STPs is reducing the pollution load on rivers where treated sewage is discharged safely.

Summary

Day by day the water resources are getting exhausted. Reclamation and reuse of sewage/wastewater is not an option. It is a grim necessity. Proven technologies for the treatment of sewage wastewater are activated sludge treatment process and its modifications, or its combination with Bio-towers. The BOD removal efficiency of the treatment processes adopted in STPs of PMC and PCMC is above 90%. Close operational control and maintenance is certainly ensuring the desired efficiency of the STPs. The effluent from these sewage treatment plants is meeting the limits of State Pollution Control Board. The quality of effluent from STP has a near-sparkling appearance and can be reused for secondary purposes like gardening, agriculture and industrial reuse or even for recreational purpose in rowing channel. By 2015, the remaining 30-35% uncollected sewage reaching the rivers will get reduced. There will be a gradual and total improvement in quality of Mula-Mutha river water as PMC and PCMC are aiming for 100% treatment of generated sewage. Due to reduction in pollution load on river water, there is a reappearance of flora and fauna and fish in the river water. The improvement in river water quality and its environment will secure the dependency and right of riparian (downstream population).

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