SEWAGE POLLUTION CONTROL

Performance Evaluation of Sewage Treatment Plants in India

Discharge of untreated sewage is single most important cause for pollution of surface and ground water because there is a large gap between generation and treatment of domestic wastewater in India. Central Pollution Control Board in association with a consultant carried out a study for performance evaluation of the STPs in India. The study includes individual plant visit, discussion with operating staff, evaluating technological and management aspects to find out the major causes for poor performance. The summary findings of the study are given as below.

1. In all 84 Sewage Treatment Plants (STP) were studied during the study. State wise and technology wise number of STPs visited given below:

State	Number of STPs visited
Bihar	4
Delhi	30
Goa	1
Haryana	6
Maharashtra	11
Tamil Nadu	5
U.P.	17
Uttranchal	2
West Bengal	8
Total	**84**

Technology wise STPs	Number of STPs visited
Activated Sludge Process (ASP) (conventional)	36
Activated Sludge Process (ASP) (extended aeration)	3
Fluidized Aerobic Bed (FAB) (Denseg)	3
Fluidized Aerobic Bed (FAB)	3
Trickling Filters	2
SAF	1
UASB + Aerated Lagoons	2
UASB	1
Aerated Lagoons	6
SBR	1
Waste Stabilization Ponds	12
UASB + Polishing Ponds	12
Micro STPs	2
Total	**84**

2. The STPs performance is dismal, as overall performance of 46 STPs has been found Poor or Very Poor. Performance of only 8 STPs has been rated Good while that of 30 other has been rated Satisfactory.

Performance rating	**Number of STPs in the rating**
Good	8
Satisfactory	30
Poor	28
Very Poor	18
Total	**84**

3. Capacity utilization of the STPs observed is inadequate in general. In formation on capacity utilization was collected from 55 STPs. Ten STPs were found highly under-loaded (treating less than 50% design flow) and one STP was found highly over-loaded (treating more than 150% design flow). Five STPs were found under-loaded (treating 50 to 90% design flow) and five STPs were found over-loaded (treating 110 to 150% design flow). Thus out of 55 STPs only 18 STPs (i.e 33%) were operating at normal flow (90 to 110% design flow) whereas rest 37 (i.e.67%) were either under-loaded or over-loaded.
4. Sludge removal / treatment / handling appeares to be the most neglected area in STPs operation. In 43 STPs based on ASP technology or other high rate aeration systems, sludge-handling facilities were found mostly out of order in 16 cases and partly out of order in one case. Similarly, in 28 STPs based on Waste Stabilization Pond or where Ponds have been employed in treatment schemes, cleaning of accumulated sludge was not done in 24 cases.
5. Utilization of biogas generated from UASB reactors or digesters is also not adequate in most of the cases. It was observed that there was no gas generation and utilization in 13 plants in spite of having anaerobic reactors/digesters. In 14 STPs the gas generated is being flared and not being utilized. In 8 STPs the gas generated is only partly utilized mostly flared. Only in 12 STPs the gas generated was being utilized as domestic fuel (5 STPs) or as fuel for gas engine (4 STPs) or duel fuel generator, DFG (3 STPs)
6. Alternate power supply facility is not available in most of the cases. Out of 84 STPs, only 13 STPs were having operational alternate power supply facility, 12 having DFG and 1 having DG Set. Six other STPs were also having alternate power supply facility but were not able to utilize this due to funds constraints.

7. Fund shortage is an important factor in poor operation and maintenance of STPs and has been reported in 26 cases. The problem of fund shortage is mostly reported from States of Bihar, Haryana, U.P., and West Bengal. This trend shows the root of problem lies in less priority being given to sewage treatment.
8. In case of 42 STPs the testing is reportedly done at common departmental laboratories. In case of another 16 STPs the testing is done through contract with some laboratory. In all these cases, day-to-day testing is normally not done that could enable proper control on plants' performance. Samples are collected and analyzed by departmental/external labs once in a month or week.
9. In majority of the cases, operation of the STPs is looked after by contractors. These contractors generally depute unqualified or less qualified staff at site, which is also an important factor responsible for poor operation of STPs. This indicates that terms and condition of operation contracts are not adequately framed to check this situation.

Status of Water supply, Sewage Collection/Treatment/ Disposal and Municipal Solid Waste Collection/Processing/Disposal in Class-I & II cities

The status of water supply and sanitation is an important indicator of environmental quality in terms of pollution load and related issues. Domestic sewage is responsible for about eighty percent of water pollution in India. Most of the cities are not having sewage treatment and municipal solid waste processing facilities. The information on these aspects are very important for highlighting need of urgent planning and action in these areas. The Central Pollution Control Board (CPCB) has earlier brought out reports on the status of water supply and wastewater generation, collection, treatment and disposal in Class -I & II cities in 1978-79, 1989-90 and 1999-2000. CPCB has initiated the collection of information on water supply, sewage collection/treatment/disposal and municipal solid waste Collection /transportation /disposal through questionnaire survey from Class-I & II cities. So far information from 176 Class-I cities & 201 Class–II cities has been received. The concerned authorities are being persuaded to send the information at earliest.

Performance Status of Sewage Treatment Plants in Delhi

There are 30 STPs located at 17 locations in Delhi. Central Pollution Control Board carried out inspection of all the thirty STPs during November-December 2006 in Delhi for performance evaluation. The study has been carried out with following objectives:

- To assess the existing sewage treatment capacity in Delhi and its utilization

- To evaluate the performance of sewage treatment plants with respect to reduction in BOD, COD, TSS and Coliforms
- To assess the problems in each sewage treatment plant

Status of sewage Treatment Plants in Delhi (Nov- Dec, 2006)

Name of the STP site / Design capacity of units (mgd)	**Design capacity (MLD)**	**Actual flow (MLD)**	**Type of STP**
Coronation Pillar STPs (10) MGD Unit (10) MGD Unit (20) MGD Unit	 45.46 45.46 90.92	 40.87 63.46 56.55	Two stage trickling filter Activated sludge process Activated sludge process
Delhi Gate (2.2)	10.00	10.00	High rate bio filter (Densadeg)
Ghitorni (5)	22.73	Not in operation	Activated sludge process***
Keshopur STPs (12) MGD Unit (20) MGD Unit (40) MGD Unit	 54.55 90.92 181.84	Not in operation* 95.10 106.46	Activated sludge process Activated sludge process Activated sludge process
Kondli STPs (10-Phase-I) (25 -Phase-II) (10-Phase-III)	 45.46 113.65 45.46	 56.55 57.96 28.36	Activated sludge process Activated sludge process Activated sludge process
Mehrauli STP (5)	22.73	4.95	Activated Sludge Process
Najafgarh STP (5)	22.73	2.27	Activated sludge process
Nilothi STP (40)	181.84	15.0	Activated sludge process
Narela STP (10)	45.46	2.50	Activated sludge process
Okhla STP's (12) MGD Unit (16) MGD Unit (30) MGD Unit (37) MGD Unit (45) MGD Unit	 54.55 72.73 136.38 168.20 204.57	 39.09 40.91 136.98 159.11 181.84	Activated sludge process Activated sludge process Activated sludge process Activated sludge process Activated sludge

Name of the STP site / Design capacity of units (mgd)	Design capacity (MLD)	Actual flow (MLD)	Type of STP
			process
Papankalan STP (20)	90.92	37.73	Activated sludge process
Rithala STP's (40) Old (40) New	 181.84 181.84	 46.28 185.07	Activated sludge process Activated sludge process**
Rohini STP (15)	68.19	Not in operation	Activated sludge process
Dr. Sen N.H. STP (2.2)	10.0	10.0	High rate bio filter (Densadeg)
Timarpur /Nehru Vihar (6)	27.27	4.79	Series of oxidation ponds
Yamuna Vihar STP's Ph-I (10) Ph-II (10)	 45.46 45.46	 27.27 14.77	Activated sludge process Activated sludge process
Vasant Kunj STP's (2.2) MGD Unit (3.0) MGD Unit	 10.00 13.63	 3.18 4.36	Activated sludge process*** Activated sludge process***
Total 30	**2330**	**1478**	

* 12 mgd STP not in full operation, 46.55 MLD flow reaching STP is passed through PST

** ASP followed by bio filters

*** ASP extended aeration modification

The total design capacity of the 30 STPs is 2330 mld. The actual treatment of sewage being undertaken during November-December 2006 was only 1478 mld which is about 63% of the total installed treatment capacity. Out of 30 STPs, 20 are running under capacity, 5 are running over capacity and 3 have been found non functional while 2 were running to their capacity. Twenty six STPs are based on activated sludge process (ASP), three among these employing extended aeration modification of ASP. Two STPs are based on high rate bio-filters technology and one each on two stage trickling filters and series of oxidation pond technology, respectively.

Grab samples were collected from the inlet and outlet and also at intermediate stages of treatment and were analyzed for pH, TSS, TDS, COD, BOD, Faecal Coliform and Total Coliform. The inlet and outlet of each STPs were also analysed for TKN, NH3-N, and Phosphate. Out of thirty STP's, three STP's (Ghitorni, Rohini and Keshopur -I) have not been found in operation at the time of

inspection/monitoring. The influent and effluent quality of respective STP are also presented below:

Influent and Effluent Quality of Wastewater at STP in Delhi (Nov-Dec, 2006)

Sl. No.	Name of STP & Capacity (mgd)	Design Capacity, MLD	Actual flow, MLD	Performance Evaluation of STPs (24 Hour composite sampling of three hourly samples)									
				Influent Quality					Effluent Quality				
				pH	TSS	COD	BOD	Cond.	pH	TSS	COD	BOD	Cond.
1	Cor. Pillar (10)	45.46	40.87	7.2	179	317	112	908	7.4	35	61	18	1090
2 & 3	Cor. Pillar (20+10)	136.38	120.01	6.44	342	172	48	1700	6.9	93	48	15	1730
4	Keshopur (12)	54.55	46.55	-	-	-	-	-	-	-	-	-	-
5	Keshopur (20)	90.92	95.1	7.3	404	560	282	1390	7.6	78	149	45	1390
6	Keshopur (40)	181.84	106.46	7.3	404	560	282	1390	7.8	21	55	10	1520
7	Okhla (12)	54.55	39.09	7.3	498	517	204	1440	7.8	21	54	10	1460
8	Okhla (16)	72.73	40.91	7.4	291	486	207	1510	7.7	83	108	48	1400
9	Okhla (30)	136.38	136.98	7.4	647	551	222	1480	7.6	76	153	45	1470
10	Okhla (37)	168.2	159.11	7.3	480	515	249	1590	7.8	32	62	12	1540
11	Okhla (45)	204.57	181.84	7.3	480	515	249	1590	7.7	27	51	19	1530
12	Narela (10)	45.46	2.5	7.4	426	447	100	1720	8	38	72	8	1720
13	Y. Vihar Ph.-I (10),	45.46	27.27	7.1	391	505	174	1110	7.7	44	84	17	1050
14	Y. Vihar Ph.-II (10)	45.46	14.77	7.2	405	538	199	1020	7.5	39	44	20	1070
15	Timarpur O.P - (6)	27.27	4.79	6.7	412	272	106	1650	7.3	11	26	4	1650
16	Najafgarh (5)	22.73	2.27	7.4	165	205	54	810	7.7	29	38	1	687
17	Nilothi (40)	181.84	15	7.7	432	328	90	2340	7.8	21	26	4	1960
18	Dr. Sen N.H.(2.2)	10	10	7.5	370	585	236	1680	7.4	36	46	16	1660
19	Delhi Gate (2.2)	10	10	7.5	263	605	147	1020	7.3	26	62	20	1030
20	Papankalan (20)	90.92	37.73	7.6	142	275	103	2190	7.9	39	46	10	1580
21	Kondli Ph.-I (10)	45.46	56.55	7.3	363	507	241	1390	7.8	68	140	27	1390
22	Kondli Ph.-II (25)	113.65	57.96	7.3	604	588	261	1550	7.6	45	50	34	1350
23	Kondli Ph.-III (10)	45.46	28.36	7.3	519	615	237	1530	7.8	16	50	14	1220
24	Mehrauli(5)	22.73	4.95	7.8	251	326	126	1090	8.1	12	35	7	1180
25	Rithala {(40 Old)	181.84	46.28	7.2	330	399	205	1260	7.5	75	54	14	1240
26	Rithala (40 New)}	181.84	185.07	7.2	330	399	205	1260	7.3	47	151	55	1230
27	Vasant Kunj (2.2)	10	3.18	7.5	379	460	323	1710	7.8	23	43	7	1450
28	Vasant Kunj (3)	13.63	4.36	7.4	479	565	306	1400	7.9	49	80	20	1470
29	Rohini (15)	68.19	Nil	-	-	-	-	-	-	-	-	-	-
30	Ghitorni (5)	22.73	Nil	-	-	-	-	-	-	-	-	-	-

All values are in mg/l except pH and conductivity (µmhos/cm)

It is revealed from the table that the influent pollution load received at all the STPs in respect of TSS, COD & BOD has been 894, 667 and 302 TPD respectively and their reduction by treatment was 92%, 81% & 87% respectively. Against an estimated 3267 mld of total sewage generation in Delhi, installed treatment capacity was 2330 mld (71%) However, owing to only 63% utilization of the installed treatment capacity, only about 1478 mld (45%) sewage is being treated. In terms of pollution load, out of 480 tonnes/day BOD load generated in Delhi, 264 tonnes/day BOD load (or 55%) is reduced as a result of treatment.

Rithala STP (new) and Okhla STP are collecting gas in gasholders and gas is being utilized through the network. Yamuna Vihar, Rithala (old) and Papankalan STP is flaring off the gas and not utilizing for useful purpose. Whereas, Rithala (new) STP 40 mgd capacity is producing gas of about 7556 Cubic meter per day and generating electricity of about 17,000 KWH/day as energy. All other plants are neither using sludge digester properly nor the gas being collected for beneficial purposes.

Performance studies of STPs in Gujarat & Maharashtra

Gujarat State have 11 sewage treatment plants located in major cities such as Vadodara, Surat, Ahmedabad, Rajkot etc. The STPs namely Pirana and Vasna at Ahmedabad have been monitored and data collection through questionnaire from Nagarpalikas and Municipal Corporations have been undertaken.

Status of STPs in Chennai and Bangalore

An extensive study have been undertaken by Central Pollution Control Board Zonal office Bangalore on performance evaluation of the sewage treatment plants located in Chennai and Bangalore cities. Five STPs located in Chennai and five STPs in Bangalore were monitored. The monitoring indicated that the treated wastewater is not meeting the prescribed standards for discharge into the river in the case of Koyambedu-New and Nespakkam, STP in Chennai and Vrishbhavathi valley STP in Bangalore. The operation and maintenance of various STPs need to be streamlined and upgraded.

Performance of Sewage Treatment Plants in North Region

The project for surveillance of raw sewage and treated effluent quality from sewage treatment plants installed along the river stretch from Allahabad to Tarighat (Gazipur) has been under taken by Central Pollution Control Board as identified by NRCD, Ministry of Environment & forests. Composite samples for round the clock operation are collected on monthly basis from inlet and outlet of

each unit to evaluate the complete performance of STPs. The performance evaluation of each STP monitored by Central Pollution Control Board during 2006 is presented below.

Allahabad STP (60 MLD)

- With reference to designed specifications as also to standard norms, the quality of treated effluent do not conforms in terms of BOD and TSS. The performance of STP has decreased in year 2006 indicating improper maintenance. The Coliform contents are appreciably high as there is no provision for its control/treatment.
- The STP seems to be over designed in terms of organic loading and irregular cleaning of treated effluent holding tank also contaminating final outlet quality.
- The gas generation is much below the designed value and that too is not utilized optimally, resulting in loss of resource. This needs to be attended on priority by the plant management.
- Distribution of sewage to STP & bypass is not regular, sometimes plant gets huge amount of sewage & sometimes very low. Such shock loads are detrimental to the performance of STP.

Mirzapur STP (18 MLD)

- With reference to standard norms the quality of treated effluent do not conform in terms of BOD and TSS. The coliform content are appreciably high as there are no provision for its control / treatment.
- The plant lacks in optimal utilisation of Biogas, which is merely flared.

Dinapur STP, Varanasi (80 MLD)

- Biogas generated is always flared in place of its designed use for genset operation.
- Strict measures for urgent procurement of power back up (Gensets) at main pumping station at Konia must be taken. The plant is regularly not in operation for about six hours daily during power failure. Generators installed for power backup has never been found in operation.
- The aeration and sludge recycling/wastage require a better optimisation necessitated by the observation, wherein, high MLSS and low to “nil” DO has been observed.
- The trickling filters in particular are poorly maintained, as obvious from their “contributing” BOD and TSS, which may be due to excessive growth of microbial film over the gravels leading to endogenous phase with low F/M ratio. Proper attention is immediately required to optimise their performance.

Diesel Locomotive Works (DLW) STP, Varanasi (12 MLD)

- With reference to standard norms, the quality of treated effluent conforms in terms of BOD and TSS, however coliform content are appreciably high as there is no provision for its control/treatment.
- In consideration of designed maximum hydraulic loading of 12 MLD, it has been observed that plant always receives less flow. The pumping of sewage to the plant has also been irregular.
- Input (raw sewage) characteristics are appreciably diluted and are not conducive for proper & sustainable bacterial population thus rendering the treatment process a meaningless exercise.
- Operational parameters need to be regularly analysed by STP Laboratory and the data should be utilized for performance optimisation of the plant.

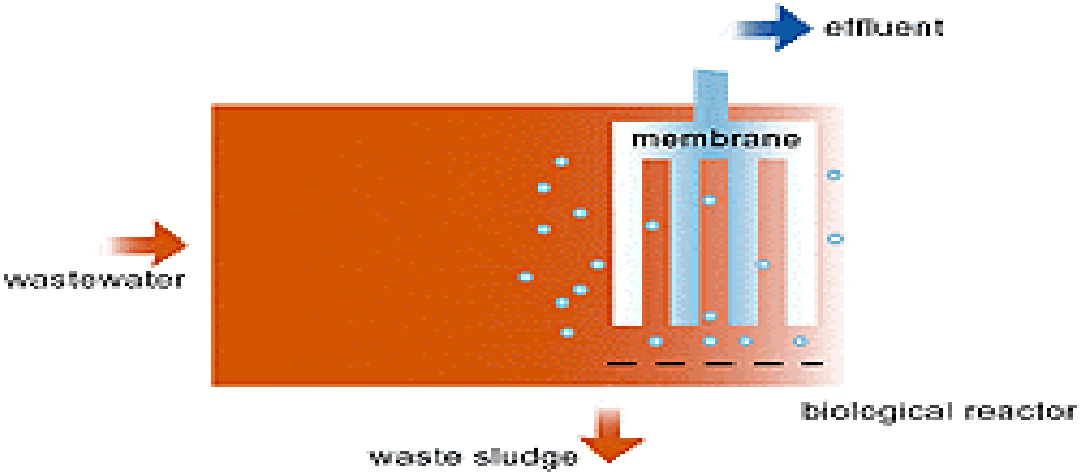
Bhagvanpur STP Varanasi (8 MLD)

- In consideration of designed maximum hydraulic loading of 8 MLD, the plant receives higher flow upto 9 MLD.
- Against designed characteristics for inlet (raw sewage) the plant generally receives appreciably diluted characteristics.
- The withdrawal of treated effluent which is conveyed through irrigation channel & its minors becomes irregular due to improper management resulting in backflow in the main channel itself, thereby overflowing treatment units of the STP thus making the treatment process a meaningless exercise.

Performance Evaluation of STP Based on MBR Technology

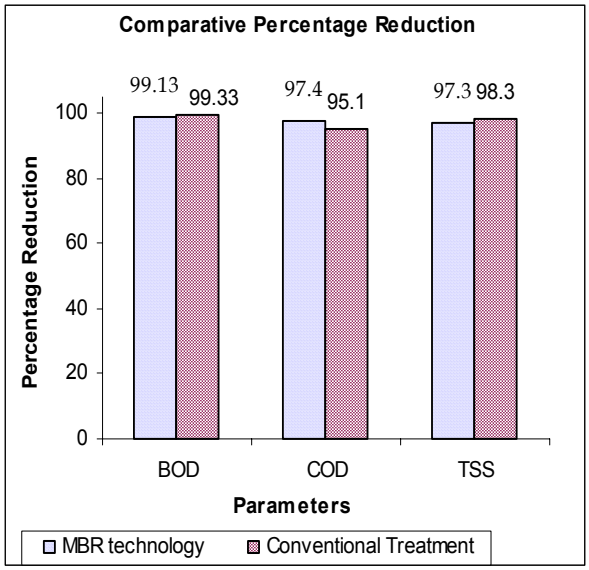
There are several new technological options available for sewage treatment in addition to the conventional treatment system including Membrane Bio Reactor (MBR) and Nanofiltration. In *Membrane Bio Reactor (*MBR) two basic processes of biological oxidation and solids separation are combined in a single reacter, where microorganisms biomass is separated from the treated water by membrane filtration unit. This enables good control on the solids residence time for the microorganisms in the reactor and provides highly clarified effluent. Excess sludge is pumped directly from the reactor (aeration tank) in order to maintain desired sludge age and solids concentration in the reactor. The membrane requires regular cleaning by backwashing, chemical washing or both.

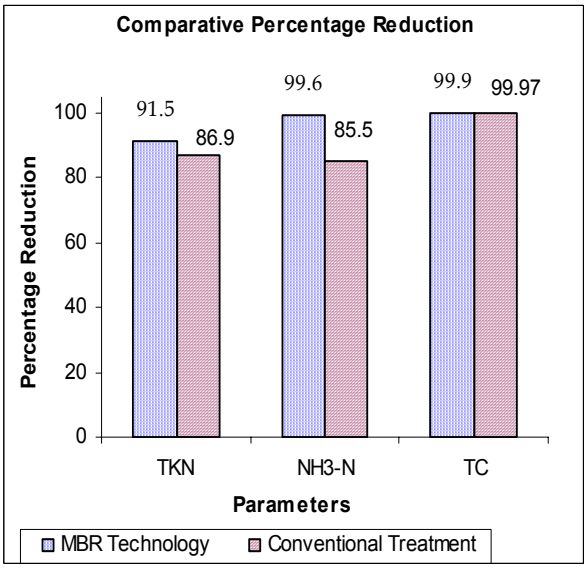
Membrane Bioreactor



Membrane Filters in MBR SYSTEM

The first Sewage Treatment Plant (STP) using MBR technology has been installed at Cubbon Park in Bangalor, Karnataka. The STP was setup at a cost of Rs. 370 lakhs and commissioned during August 2005. The cost of membrane alone is about Rs. 90 lakhs at the said STP. CPCB carried out the study to compare performance of an STP of 1.5 MLD capacity at Cubbon Park STP, Bangalore absed on MBR technology with conventional ASP based STP. During the study samples were collected from both Conventional plant and MBR and the percentage of reduction has been observed.





The MBR technology is a process modification of 'activated sludge process with sludge recycle' in which the solid separation and sludge recycling are achieved by 0.4 micron membrane filter, instead of a clarifier used in the convention process. In contrast to a clarifier, where solids settling and thickening efficiencies are limited by size of the clarifier, the membrane acts as a near-complete barrier for solids, allowing maintaining high 'mixed liquor suspended solids' (MLSS) in aeration tank and resulting in an effluent free from solids. Consequently, when a plant is operated at high MLSS, it operates at very low F/M and provides high organic matter removal efficiency. Thus, the final effluent is treated to a higher degree both in terms of soluble and suspended organic matter.

The biomass active in treatment in an aeration tank is often represented by 'mixed liquor volatile suspended solids' (MLVSS). As the aeration tank MLSS is increased beyond normal range of 3000-4000 mg/L, the MLVSS-to-MLSS ratio tends to decrease. Therefore, even if very high MLSS is attempted and achieved, some of the advantage may be lost due to lowered MLVSS-to-MLSS ratio. Moreover, if aeration capacity of a plant is designed without considering this, it may exceed the actual requirement and unnecessary loss of energy may occur. These points were also proved during performance evaluation of Cubban Park STP. A 0.5 MLVSS-to-MLSS ratio was observed as the plant was being operated at 8000-10000 MLSS, while a 0.8 value of MLVSS-to-MLSS ratio is normal in a conventional system. Dissolved Oxygen levels in aeration tanks were also observed as high as 4.9 mg/l, higher than the normal. Based on the studies, the following inference is deduced:

- MBR plant requires only about half of the space required for conventional STP
- Sludge bulking, sludge rising, etc problems associated with clarifier unit are eliminated
- High quality treated water is generated from MBR plant
- MBR plant generates highly stabilized sludge of low volume
- The main disadvantages of MBR is the high initial cost and regular cleaning of membrane filters at least once in 48 hours.