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PERFORMANCE STUDY ON SEWAGE TREATMENT PLANTS IN DELHI BASED ON ADOPTED ADVANCED TECHNOLOGIES

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ABSTRACT

Delhi has a population of over 13.9 million as of 2018 and it is estimated to increase to 72 million by 2051 at a growth rate of 44%. The Delhi Development Authority estimated the water requirement and wastewater generation by 2051 is 19728 Million Litres per Day (MLD) and 17750 MLD, respectively. The sewage generation in Delhi is about 4000MLD daily. The installed capacity of the Sewage Treatment Plant (STP) is about 2815MLD to treat the entire generated sewage, which is about 70% of total sewage. Delhi Jal Board has adopted advanced technologies to treat sewage to comply with the notified standards as prescribed under the Environment (Protection) Act, 1986. During the year (2017/18/19), 12 numbers of STPs have been studied and sewage water samples have been analysed for desired physicochemical parameters. The results have indicated the consistent good performance of all the sewage treatment plants and met the discharge standards concerning compulsory parameters pH, BOD, COD and TSS. It is important to note that the intake point (untreated sewage) and discharge point (treated sewage) is of the same drain even after proper treatment complying with the desired standards, nullifying the treatment cost. The present study gives an overview of technologies adopted by STPs in Delhi and its management along with performance evaluation, which may help to explore (an idea) in water conservation methods instead of discharging into river Yamuna.

KEY WORDS : Sewage generation, Sewage Treatment Plants, Advanced technologies, Performance evaluation

INTRODUCTION

Rapid urbanization, industrialization and modernization has led environmental consequences of which improper sewage management and groundwater exploitation are major issues especially in metropolitan cities like Delhi. The population growth in Delhi is expected to increase by 72 millionby 2051 at a constant growth rate of 44% (Rajneesh, 2017). National wide, freshwater demand increased and became a vital issue at present and for the future. Thus, it's time to switch over the usage of treated sewage/industrial effluent by adopting emerging technologies for their treatment to meet surplus demand management.

Central Public Health and Environmental Engineering Organization (CPHEEO) estimates that out of total freshwater supply for domestic use, about 70-80% of sewage/wastewater being generated) (CPHEEO Manual, 1993). The per capita wastewater generation by the Class-I cities and Class-II towns representing 72% of the urban population in India, has estimated to be around 98 lit/capita/day (lpcd) while Delhi alone is over 220 lpcd (lit/capita/day)(CPCB, CUPS, 2004).

The National Capital does not have a proper drainage system and sewer lines and facing severe problem of untreated sewage. Only 55% homes in Delhi are linked to a centralized sewerage system and the rest of the 45% of wastes/wastewater goes into the Yamuna river directly (Sharma and Kansal, 2011). Among the challenges faced by urban planners, it became a necessity to ensure ongoing basic human series such as the provision of water and sanitation. The accumulation of human waste is constant and unmanned sewage/wastewater directly contributes to the contamination of locally available freshwater supplies, thus have a degenerative effect on both public and ecosystem health.

Despite being one of the first Indian cities to come up with a City Development Plan way back in 1962, Delhi has been identified as the top-priority city for the work to be done to combat the magnitude of pollution in the river Yamuna 22km stretch through the city (Rustogi and Singh, 2017).

Sewage treatment plants incorporate expulsion of organic load/toxins or contaminants (generated from household sewage plus some small scale industrial wastewaters) producing treated wastewater which is safe to the environment (Rumani, 2014). However, due to improper and inadequate sewage treatment system, the major impact factors effected the environment and the citizens of Delhi are as under:

- Malfunctioning septic systems resulted in contamination of groundwater, river water & soil threatening public health
- Untreated and open drainages have conducive breeding for mosquitoes, flies, rodents, insects and other diseases carrying vectors. Also, led to stinking and foul smell
- Low lying area people are directly exposed to wastewater for bathing, washing clothes and utensils
- Toxic food farming has increased around the Yamuna River leading to various diseases like vomiting, gastroenteritis, diarrhoea, blood infection, dehydration, kidney dysfunction and urinary infection.
- Almost all the surface water sources are contaminated to some extent by organic pollutants and bacterial contamination and make them unfit for human consumption unless disinfected.

Thus proper treatment and management of sewage became a basic necessity to ensure good health and quality of life. This paper depicts – performance of Delhi STPs based on adopted treatment technologies and its impact on river quality of Yamuna.

Concluding with the need for intense attention to conserve water and to revamp the present system by:

- Optimization of the existing system for better performance.
- Augmentation of existing treatment capacity and up-gradation of treatment facilities and

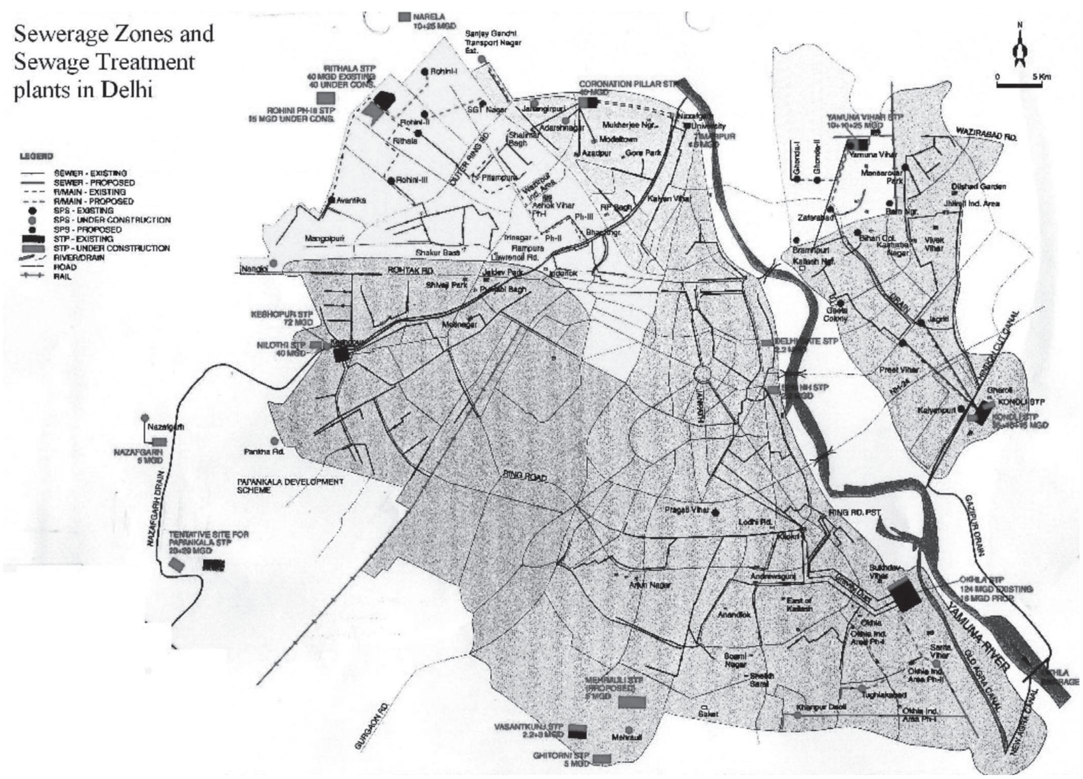

Fig. 1. A location map of sewerage zones, facility including location of sewage treatment plants, and sewage pumping stations

- To look forward to safely completing utilization of treated sewage.

Sewage generation in Delhi

It has been estimated that on an average of 4000MLD of sewage being generated per day of which about 2815MLD of sewage is being channelized to Sewage Treatment Plants (STPs) to treat, however, about 878 MLD of untreated sewage (without any treatment) is directly dumped into the river Yamuna every day.

Delhi is served by a gravity collection sewerage system involving a large network of branch sewers, intercepting sewers, peripheral and trunk sewers of about 7000km length. Delhi is divided into six drainage zones viz. (i) Keshopur Zone, (ii) Rithala-Rohini Zone, (iii) Okhla Zone, (iv) Coronation Pillar Zone, (v) Trans Yamuna (Shahdara) Zone, and (vi) Outer Delhi Zone. The Najafgarh drain basin area, the largest drain basin lies mainly in Zones (i), (ii), (iv) & (vi). As of now 22 drains carrying wastewater (treated and untreated) into river Yamuna/ Agra Canal (Trivedi and Agrawal, 2005).

Sewage treatment in Delhi

Throughout the study, Delhi STPs were visited and found, 40 STPs were commissioned in 17 localities having the total sewage treatment capacity of 2815 MLD. Out of 40 STPs - 34 STPs were found functional and 6 were non-functional. Out of 34 functional STPs - 3 STPs were found non-operational and 31 STPs were found operational. The total sewage treatment capacity for 40 STPs is 2815.47 MLD however, its actual treatment is only 1936.8 MLD leaving a gap of 878.67MLD (68.8%) is shown in Fig. 2.

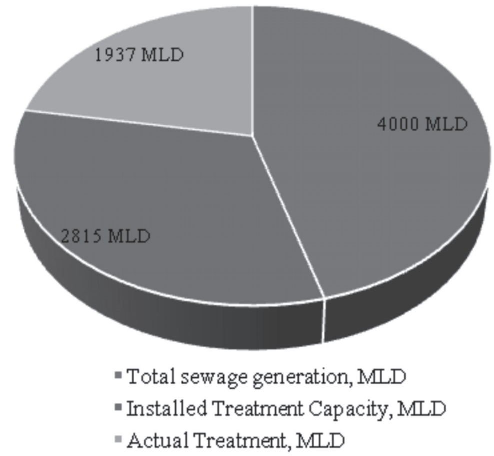

Fig. 2. Sewage generation status of delhi

Existing Standards

CPCB has notified new standards, G.R.S 1265 (E) : Environment (Protection) Amendment Rules, 2017 for discharge of treated effluent of Sewage Treatment Plants is given in Table 1.

Adopted /available Treatment Technologies of Sewage Treatment Plants in Delhi

Typically this generated domestic wastewater is being treated in Sewage Treatment Plants to meet the discharge standards prescribed under section 5 of the Environment (Protection) Act, 1986 before being discharged into river or surface water bodies to protect human health and environment.

For the safe disposal of treated wastewater, the selection of treatment technologies shall be based on varying levels of mechanism, energy input, cost economics, skilled manpower, land requirement etc. Thus choosing an effective treatment is very important to get a good quality of treated water and

Table 1. Existing Standards for treated effluent of sewage treatment plants

S. No.	Industry	Parameters	Standards for New STPs (Design after notification date)*
1		pH	6.5-9.0
2		BOD, mg/L	10
3		COD, mg/l	50
4		TSS, mg/l	10
5	Sewage Treatment Plant	NH_4-N, mg/L	5
6		N-total, mg/L	10
7		Fecal Coliform, MPN/100 mL	<230 MPN/100 mL
8		PO_4-P , mg/L	2

Note: (i) These standards will be applicable for discharge in water resources as well as for land disposal. The standards for Fecal Coliform may not be applied for use of treated sewage in industrial purposes.* Achievements of Standards for existing STPs within 05 years from date of notification.

its break-up is given in Table 2.

Following is the brief description on the adopted technologies for treatment of Sewage

Activated Sludge Process (ASP)

Activated-sludge technique is a conventional sewage-treatment process in which sludge, the amassed microbe's rich deposits of settling tanks and basins, is seeded into the approaching wastewater and the blend agitated for a few hours (4-8 hours) within the sight of adequate air supply. Suspended solids and numerous organic solids are absorbed by the sludge, while the organic matter is oxidized by the microorganisms (Metcalf and Eddy, 1991 & 2003). The measure of air and sludge utilized can be changed to control the level of treatment received and the sludge is then isolated in a settling tank.

For sludge treatment and disposal

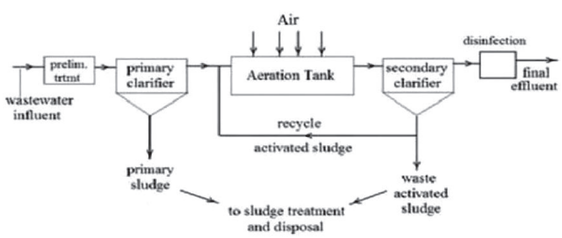

Fig. 3. Schematic flow chart of Activated Sludge Process

Bio-filtration(BIOFOR)

The main components of the treatment process of Densadeg - BIOFOR plant comprise coagulation and flocculation carried out in a specially designed clarisettler, followed by two-stage filtration through a special medial bed where organic degradation is facilitated by external oxygenation (Degremont Ltd, 2013). In this process, the air is passed through a network of diffusers located at the base of the reactor provides oxygen for aerobic biological activity in the media. Exceptionally, high oxygen transfer is achieved in the media due to the up-flow pattern of air bubbles. The biological filtration process is of the submerged bed type. The untreated effluent enters continuously from the bottom of the reactor and is distributed over the entire filter surface area by the nozzle underdrain. Co-current up-flows of air and water allows the finest particles to pass to flow through the Biolite filter support media. Here, Carbonaceous and nitrogenous pollution is eliminated through the high concentration of fixed-film biomass which is retained on the filter media during the filtration cycle.

The Biological filtration can be described as a system of three phases namely

(a) A solid-phase:- the filter material with attached biomass
(b) A liquid phase:- the wastewater that passes through filter material
(c) A gas phase:- the oxygen to assure oxidative process or the gaseous nitrogen at denitrification.

Dosage of alum as a coagulant is rather high at around 60 mg/L and then the sedimentation of flocs is enhanced by the addition of polyelectrolyte. A bulk of the treatment takes place at this primary clarification stage where almost 90% of suspended solids and 70% of BOD are removed. The second stage of upflow filtration is then considered more of polishing treatment. This stage reduces the content

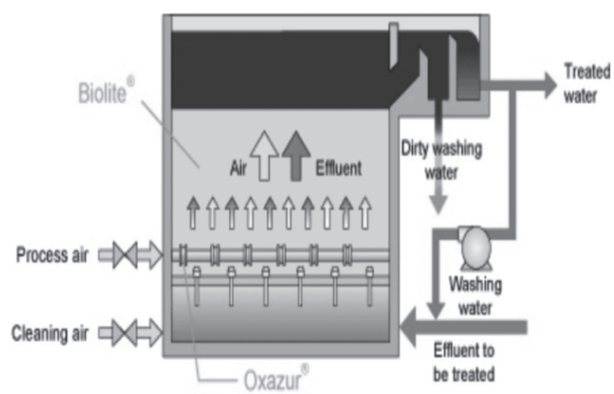

Fig. 4. Depicts the schematic process of Densadeg – BIOFOR Technology

Table 2. Break-up of different treatment technologies used in the different Sewage Treatment Plants in Delhi

S.No.	Technology	No. of STPs
1.	Activated Sludge Process (ASP)	26
2.	Biological Filtration and Oxygenated Reactor (BIO-FOR)	3
3.	Extended Aeration (EA)	2
4.	Sequencing Batch Reactor (SBR)	2
5.	Membrane Bio-Reactor (MBR)	1

of Suspended Solids and the BOD in the effluent to the required levels. The biological filtration is carried out in two identical successive stages.

It will be noticed that there are no primary or secondary clarifiers and conventional aeration reactor. As a result, the entire system is very compact. The special design of the clarisettler enables simultaneous thickening of the sludge and thereby eliminates the need for a separate thickener and thus saves space.

Extended Aeration (EA)

The conventional activated sludge plant has been

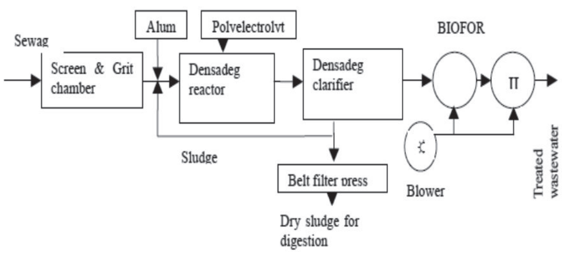

Fig. 5. Flow chart of STP with BIO-FOR Technology

modified to eliminate the primary sedimentation tank or primary clarifier. Extended Aeration aims at providing extensive aeration for biological oxidation with diffused aeration system with longer aeration time (Colmenarejo *et al.*, 2006). Thus it requires a hydraulic retention time of around 24 hours instead of the 6 to 8 hours so that the settleable organic matter will biologically be oxidized along with the dissolved and fine suspended organic matter.

Extended Aeration simplifies the operation of the plant by eliminating the primary clarifier and reducing the need for sludge treatment and disposal with a very minimal flow of waste activated sludge which must be drawn off periodically.Extensive aeration reduces odour-producing substances such as Hydrogen Sulfide (H_2S) and other volatiles.

For large treatment plants, the aeration tank is often built with a serpentine pattern like that shown in the diagram at the right, to obtain the desired plug flow without an excessive length requirement for the tank.

Membrane Bio-Reactor (MBR)

MBR technology is based on the combination of conventional activated sludge treatment together with a process filtration through a membrane with a pore size between 10 nm and 0.4 microns (micro/ ultrafiltration), which allows sludge separation. The individual membranes are housed in units known as modules, cassettes, or racks and a combined series of these modules are referred to as a working membrane unit (Manem and Sanderson, 1996). As the pore size gets smaller or the molecular weight cut-off decreases, the pressure applied to the membrane for separation of water from other material generally increases.

Membrane filtration extends this application further to include the separation of dissolved solids in liquid streams, ranging from salts to microorganisms providing a complete disinfection of treated water. Easy Operation and maintenance work and automated monitoring and control of treatment process. This minimal treatment framework is viable in the expulsion of BOD as well as nitrogen and phosphorus while encouraging successful solids separation.

This technique does not require primary and final sedimentation tanks, and disinfection facilities. It requires relatively less space than conventional biological systems (Sutton, Paul M., Membrane *Bioreactors for Industrial Wastewater Treatment).* Enables dewatering of the excess sludge from the

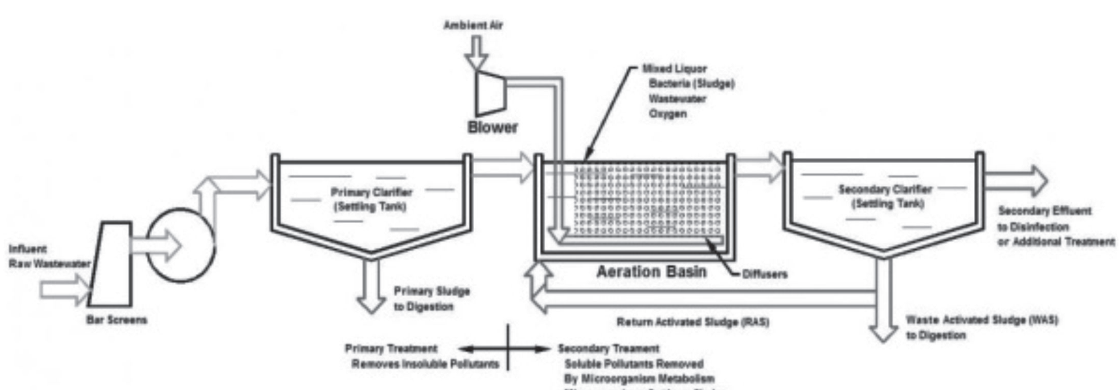

Fig. 6. Flow Chart of Extended Aeration

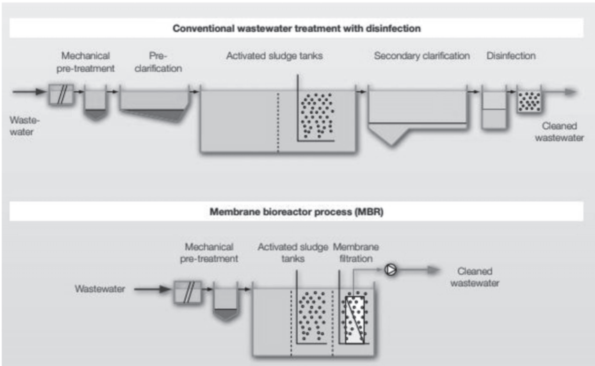

Fig. 6. Flow Chart of Membrane Bio Reactor

reaction tank without thickening.

Sequential Batch Reactor (SBR)

Sequencing batch reactor (SBR) process is a progressive suspended growth (activated sludge) process where each major progress occurs in a common tank in a sequential method. The system is operated in a batch mode sequence. The plant is equipped with 3 basins to ensure continuous treatment and flow is further distributed by using motorized gates at the inlet chamber of the basin.

The SBR system utilizes five basic phases of operation to meet advanced wastewater treatment objectives (Shreya Gupta, 2018). The duration of any particular phase is based on specific waste characteristics and effluent objectives. These phases happen in a single reactor by which it diminishes the impression. The five stages of SBR are as follows:

Mix-FILL: Wastewater fills the tank, mixing with biomass that settles amid the past cycle.

REACT: Air is added to the tank to enable biological growth and felicitate waste diminishment.

SETTLE: Mixing and Aeration quit amid this stage to empower solids to settle.

DRAW: Clarified profluent is discharged.

IDLE: Sludge can be removed amid this stage.

SBRs can be designed and operated to enhance removal of nitrogen, phosphorus, and ammonia,

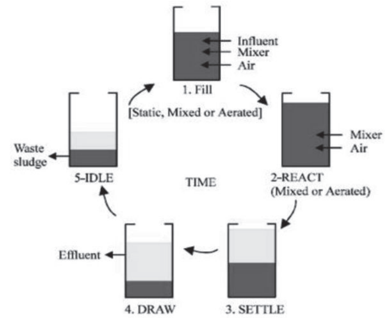

Fig. 7. Flow Chart of Sequential Batch Reactor (SBR)

despite clearing TSS and BOD.

Comparative assessment of various technologies adopted by Delhi STPs, summarized at Table 3.

Status of treated sewage and its utilization

Out of 1936.8 mld of treated sewage, about 1689.8 mld treated sewage is being discharged back to the open drains nullifying the cost incurred in the treatment process and ultimately finds access to the River Yamuna/Agra canal. A detailed account of treated sewage disposal in Delhi is presented in Table 4.

RESULTS

Because of the above studies, the observations made concerning achievability in the reduction of organic and bacteriological pollutants. The primary goal of the sewage treatment plant is to reduce organic loading and the performance efficiency is drawn by comparing the outlet and inlet quality. Study of performance evaluation of STPs consecutively in 3 years (2017-2019) based on ASP – 4nos., BIOFOR-3 nos., MBR-1 no., SBR-2 nos. and EA-2 nos.

Table 3. Comparison for various technologies for sewage treatment plants

S.No.	Assessment Parameter/Technology	ASP*,[a]	MBR*,[c]	SBR*,[a,b]	EA*,[a]	BIO-FOR
1.0	**Performance after Secondary treatment**					
1.1	Effluent BOD (mg/L)	<25	<10	<10	<20	<5
1.2	Effluent SS (mg/L)	<30	<10	<10	<30	<5
1.3	Faecal coliform removal, Log unit	Upto5<6	Upto2<3	Upto3<4	Upto2<3	Upto2<3
1.4	T-N removal Efficiency, %	10-20	50-60	70-80	10-20	70-80
2.0	**Performance after tertiary treatment : Chlorination**					
2.1	Effluent Fecal Coliforms, MPN/100 ml	10	10	10	10	10

Sludge Treatment: * Thickner +Centrifuge; Type : [a] Aerobic; [b] Anaerobic-Aerobic; [c] Anoxic/Anaerobic-Aerobic ASP: Activated Sludge Process MBR: Membrane Bio Reactor EA: Extended Aeration SBR: Sequential Batch Reactor BIO-FOR:Bio filtration:

technologies are showed in Fig: 8 -percentage reduction of TSS, Fig: 9-percentage reduction of COD and Fig: 10 percentage reduction of BOD.

Adopting the referred technologies all most all the STPs of Delhi are meeting the standards for other parameters as prescribed in existing standards namely, pH, Ammonical Nitrogen, Total Nitrogen, Phosphates. However, Fecal coliform norms being achieved after chlorination/UV at tertiary treatment level.

DISCUSSION

All the treatment technologies are based on conventional biological treatments except BIO-FOR technology (chemical treatment – coagulation & flocculation) showing good performance and can meet the discharge standards regarding parameters - pH, BOD, COD and TSS. However, based on the experience of the present study, the operation and maintenance of STP's depend mainly on three factors:

- Regular and proper maintenance
- Uninterrupted power supply
- Skilled Manpower

CONCLUSION

- Increase in population is defined and undefined areas increased the water demand, this further increased wastewater generation.

Table 4. Status of Treated effluent/sewage discharge intothe open drains, Yamuna River & Agra Canal

S. No	Name of the STP	Design capacity (mld)	Treated effluent (mld)	Ultimate disposal
1	Okhla	635.52	626.44	It is claimed by DJB that about 90 mld is being given to NDMC for Horticulture purpose and rest goes in to new Agra Canal through Old Agra Canal at near Jasola Village/Sarita Vihr Bridge
2	Rithala	363.2	272.4	Rohini/Nangloi drain to Supplementary Drain & finally to Yamuna River d/s Wazirabad Barrage
3	Keshopur	326.9	54.5	It is claimed by DJB that whole treated effluent goes to MID, but observed that maximum treated effluent flows to Najafgarh drain to Yamuna river
4	Kondli	317.8	266.1	Shahdara drain to YamunaRiver
5	C. Pillar	136.2	136.2	136.2 mld for irrigation purpose & rest goes to Najafgarh drain to Y. River
6	Nilothi	272	90.8	Najafgarh Drain to Yamuna river
7	Yamuna Vihar	204.3	108.96	Shahdara drain to Yamuna River
8	Pappankalan	181.6	148	Najafgarh Drain to Yamuna river
9	Rohini	68.19	26.3	Supplementary drain to Najafgarh drain to Yamuna river
10	Narela	45.46	13.6	Najafgarh Drain to Yamuna river
11	Timarpur	27.27	0	Najafgarh Drain to Yamuna river
12	Nazafgarh	22.73	11.35	Najafgarh Drain to Yamuna river
13	Vasant Kunj	23.63	21.5	Partly to Sanjay Van to open drain (Kushak drain) to Barapulla drain to Yamuna river
14	Mehrauli	22.73	18.2	Yamuna River through open drains
15	Ghitorni	22.73	1.9	Yamuna River through open drains
16	Delhi gate	78.1	78.1	10 mld utilizing for cooling purposes at Pragati Power Corporation and finally to Yamuna River through open drains
17	Dr. SNH	10	10	10 mld utilizing for cooling purposes at Pragati Power Corporation and finally to Yamuna River through open drains
18	Molarbund	13.6	0.7	Yamuna River through open drains
19	Akshardham	4.54	0.9	0.9 mld is used for Flushing flats, Horticulture & cooling water
20	Chilla	40.86	40.86	Shahdara drain to Yamuna River
21	Kapashera	22.7	10	Yamuna River through open drains
22	Bakkarwala	2.99	0	–
	Total STPs = 34	2815.47	1936.8	

Note: Total treated effluent is 1936.8 mld,out of which 247 mld is reused and rest is finally disposed directly or indirectly into river Yamuna and Agra Canal due to inadequate treatment capacity and improper management of the existing STPs.

- Around 4000 mld of sewage being generated in Delhi, however, the actual treatment is of only 1936.8 mld, which is a huge gap is observed between generation and available treatment.
- About 12 nos. of STPs were under-utilized because of deficiency in the sewage network system. There is a need to augment the treatment capacity of STP's and new STP's should be commissioned closure to sewage generating unsewered areas (unauthorized/regularized colonies).
- Conventional treatment technologies are energy-intensive and require knowledge of the process, skilled manpower for operation & maintenance,

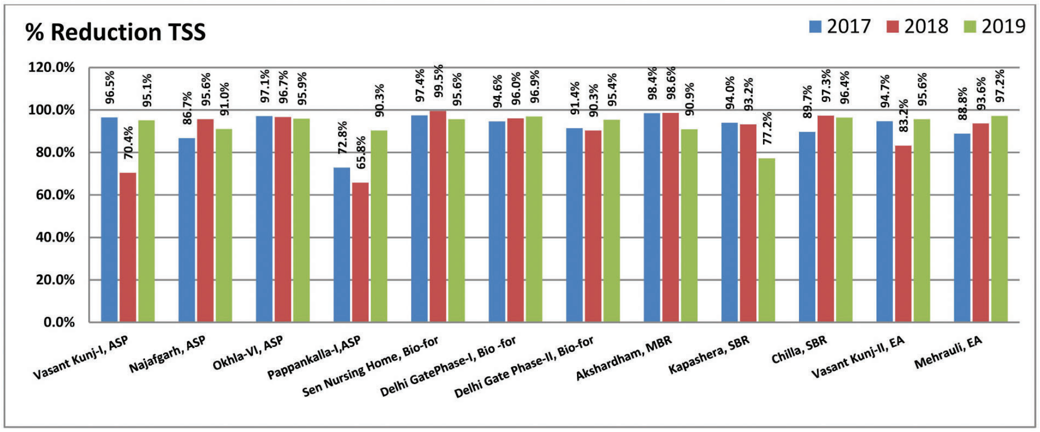

Fig. 8. % reduction efficiency of TSS

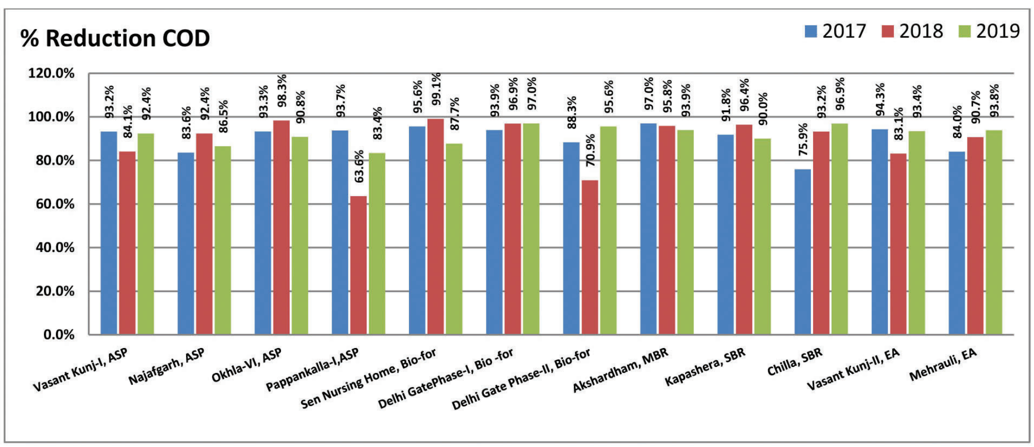

Fig. 9. % reduction efficiency of COD

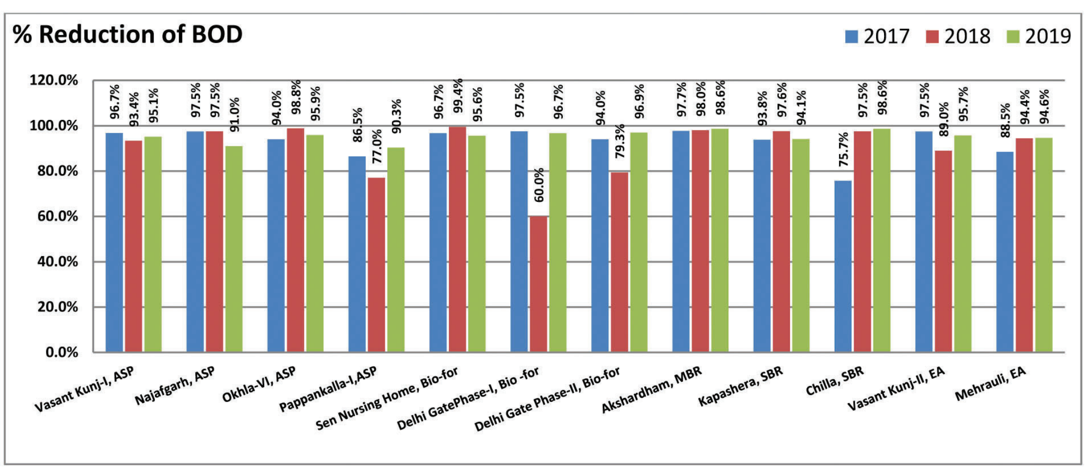

Fig. 10. % reduction efficiency of BOD

for the smooth functioning of the STPs.

- Stormwater drains to be lined separately to recharge the groundwater table. All the drains to be trapped into a sewerage system to treatment plants to minimize the flow of untreated wastewater into river Yamuna.
- Numerous advanced treatments up to tertiary level have emerged, to reuse after treatment and the generated sludge can be used as manure.
- Various water conservation techniques to be adopted to reduce overexploitation of natural water resources and by reusing the treated sewage for agricultural purpose, vehicle washings, industrial purpose, cooling towers, flushing the toilets, horticulture, irrigation, construction purpose, to spray on roads (dust suppression) etc.

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