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A study of effectiveness of treatment technology of wastewater treatment plants in Delhi and NCR regions

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Abstract
This is a study to assess the efficiency of treatment technologies of Wastewater Treatment Plants. The performance of four plants at Haryana and Delhi working on different technologies were evaluated. Wastewater samples were analyzed for various parameters like pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Ammoniacal Nitrogen (TN), Total Phosphorus (TP), Total Coliforms (TC) and Fecal Coliforms (FC). The samples were collected from the inlet unit and outlet unit and then compared. Performance efficiency of technologies such as Up flow anaerobic sludge blanket technology (UASB) with pretreatment by Extended Aeration (EA) and Oxidation pond (OP), Activated Sludge process (ASP) and BIOFOR were studied and compared. Study of performance evaluation of UASB+EA, UASB+OP, ASP and BIOFOR technologies shows that the BOD removal efficiencies were 97.72%, 94.21%, 94.49% and 96.55% while the COD removal efficiencies were 89.85%, 94.53%, 86.9 % and 97.09 %. The results were not significantly varying and the performance of all the plants was at par as the treated effluent was in permissible limits set by the Ministry of Environment, Forest and Climate Change (MOEF). Based on the experience of this study the performance also depends on three major factors which are regular maintenance, skilled manpower and uninterrupted power supply. All the technologies are efficient in reducing the organic load, nutrients and pathogens from the waste water effectively.

Keywords: waste water technology, UASB, BIOFOR, ASP, BOD, COD, TSS, TC, FC

Introduction

Inadequate environmental sanitation in developing countries has led to better understanding of treatment technologies and eventual development of water quality standards [1]. Increasing pollution has led to innovation of modern treatment technologies which are more efficient in removing pollutants from wastewater. Wastewater treatment plants receive waste from residential, industrial and commercial establishments to remove pollutants that can harm natural environment and human health. The main objective of such plants is to produce a treated effluent and a sludge which can be discharged or reuse back into the environment [2].

According to the environmental conditions, characteristics of the incoming waste and organic loading amount there is a selection of treatment technologies for efficient treatment. Technologies like ASP, UASB, and BIOFOR are prominent in treating high organic loads. The activated sludge process (ASP) can remove 96% of suspended solids and is able to high organic handle loads. It uses mass of microorganism to treat wastewater under aerobic condition. The biomass is settled down in the settling chamber remains active and can be sent back to aeration unit to continue biodegradation of organic matter [3]. The BIOFOR (biological filtration oxygenated reactor) process has a high concentration of biofilm and strong retention capacity. In this process, a special aeration head is used to effectively supply oxygen and it is easy to operate and maintain [4]. The main components of the treatment process of Densadeg - BIOFOR plant comprise coagulation and flocculation in a specially designed clarisettler. This is a new advanced technology that is capable of handling high fluctuations and produce high efficiency removal of contaminants. It also requires less manpower. Up flow anaerobic sludge blanket technology also known as UASB reactor is a form of anaerobic digester which works in anaerobic environment Influent to be treated is made to enter from the bottom of the reactor then flows upward through a blanket of biologically activated sludge [5]. A benefit of this technology is that it produces biogas upon anaerobic conversion of organic matter which can be used for various other purposes. This process can be coupled with extended aeration and oxidation pond as pretreatment options. In EA, the waste water goes directly to the aeration unit for treatment. The whole process is under presence of oxygen. One of the natural biological systems used for wastewater treatment is Oxidation pond. There is natural purification of wastewater. By this way 97% to 99% of BOD reduction in waste water is often possible Physiochemical and biological processes are used to remove physiochemical and biological contaminants [6]. In case of waste water, the degree of treatment is considered in terms of removal of pH, TSS, BOD, COD, nitrogen, phosphorous and coli forms, etc. The pH is one of the most significant factors in water quality management. BOD is the amount of oxygen required in this process. This test is applied for finding out the pollution level and performance of waste water treatment plants. The Chemical Oxygen Demand (COD) test is a measure of the oxygen amount that is required during oxidation in the presence of a strong chemical oxidant. It measures organic strength of polluted water. Total suspended solids (TSS) are filterable or non-filterable material that remains as leftover residue on evaporation. It affects water quality greatly in a number of ways. High mineralized water is not suitable for many applications in industries and for purposes such as bathing. TSS analysis is necessary for biological waste water treatment and for the performance assessment.

Phosphorous is present in the form of phosphates in the natural and polluted water. Phosphates in waste water testing have a significant importance. At less concentration, they are being used in water supplies to reduce formation of scale, increasing carrying capacity, avoiding corrosion, removing iron and manganese in smaller quantities. Ammonia concentration above a particular value in waste water is considered toxic for animals like fish. Whereas pathogens in water can enter the body of humans by skin, ingestion, aspiration, and inhalation or by direct contact with any part of body and can cause severe effects and diseases [7]. If treated waste water is to be disposed of, guidelines of CPCB (mainly BOD5<30 mg/l) should be followed. Other specifications are as under:

Table 1: Wastewater Standards for disposal [8]

Characteristics	General Standards	New notified Standards (2017)
PH	5-9	6.5-9
BOD	30mg/l	20 mg/l
COD	250mg/l	-
TSS	100mg/l	<50 mg/l
Coliform	<1000 MPN/100 ml	<1000 MPN/100 ml
Ammonia nitrogen	10mg/l	-
Phosphate	5mg/l	-

Study Area

The waste water treatment plants located at Haryana and Delhi, India. The waste water treatment plant located at Jatal road, District Panipat, Haryana has designed capacity of 10 MLD which is based on UASB followed by extended aeration process. The plant receives 5 MLD sewage from Model town and surrounding domestic colonies. The plant is comprised of Intermediate pumping stations, Screen (Manual & Mechanical), Grit chamber, UASB reactors (2 x 5 MLD), Extended aeration, Clarifier, Sludge pump, Decanter. The waste water treatment plant located at Radaur road, District Yamuna Nagar, Haryana has designed capacity of 25 MLD which is based on UASB followed by oxidation pond process. The plant receives 40MLD sewage from nearby surrounding areas and is comprised of Intermediate pumping stations, Screen (Manual & Mechanical), Grit chamber, UASB reactors (2 x 12.5MLD), Polished ponds, Clarifier, Sludge pump, Sludge drying beds, Decanter. Delhi Gate (New) plant is located near Delhi Secretariat and receives waste water from Delhi Gate Drain. The installed capacity of plant is 68 MLD and actual utilization is 69 MLD. The treatment is based on Densadeg-BIOFOR technology. The main components of the treatment process of Densadeg BIOFOR plant comprise coagulation and flocculation in a specially designed clarisettler, followed by two stage filtrations through a special medial bed where organic degradation is facilitated by external oxygenation. Okhla plant is located at Phase VI Okhla, Delhi Secretariat and receives wastewater from surrounding areas. The installed capacity of plant is 136.2 MLD and actual utilization is 136.2 MLD. The treatment is based on ASP technology and plant is comprised of Intermediate pumping stations, Screen (Manual &Mechanical), Grit chamber, Primary Clarifier, Aeration tank, Secondary Clarifier, Filtration unit, Chlorination tank, Sludge Digestors.

Methods and Materials

Samples were collected from the inlet and outlet of each plant. A total of 8 samples were collected, representing four inlets and seven outlets of the plant. The samples were tested for the following parameters: pH, BOD, COD, TSS, TN, TP, TC and FC. The pH was measured by the electrolytic method (Guide Manual, Water and Waste Water Analysis, CPCB). BOD was tested by titrimetric method (Guide Manual, Water and Waste Water Analysis, CPCB). COD of the samples was measured using closed reflux (titrimetric and colorimetric) method using cod digester for cod analysis (Guide Manual, Water and Waste Water Analysis, CPCB). Total solids are measured by the evaporation and subsequent drying of a known volume of sample in oven at a specific temperature (usually 103-105°C). Stannous chloride method was used for phosphate analysis; intensity of the blue coloured complex was measured at 690nm within 8-10 minutes after appearance of colour (Guide Manual, Water and Waste Water Analysis, CPCB). Nesslerisation method was used for ammonia analysis (Guide Manual, Water and Waste Water Analysis, CPCB). For the analysis of total coliform count, Most Probable Number (MPN) method was used (Guide Manual, Water and Waste Water Analysis, CPCB). Fecal coliform was counted by Thermotolerant method [7].

Results and Discussions

The team inspected wastewater treatment plants in Haryana and Noida on advanced treatment technology along with coliform reduction facilities. All the four plants are designed on different treatment technology. The details of plants are mentioned in Table 2 and figure 1 below:

Table 2: List/Details of plants

Sl. No.	Plant Location	Technology	Capacity Installed (MLD)	Actual Treatment Capacity (MLD)
1.	Delhi Gate Phase II	BIOFAR	68.1	49.94
2.	Okhla Phase VI	ASP	136.2	136.2
3.	Jattal Road, Panipat	UASB+EA	10	6.7
4.	Yamuna Nagar	UASB+OP	25	40

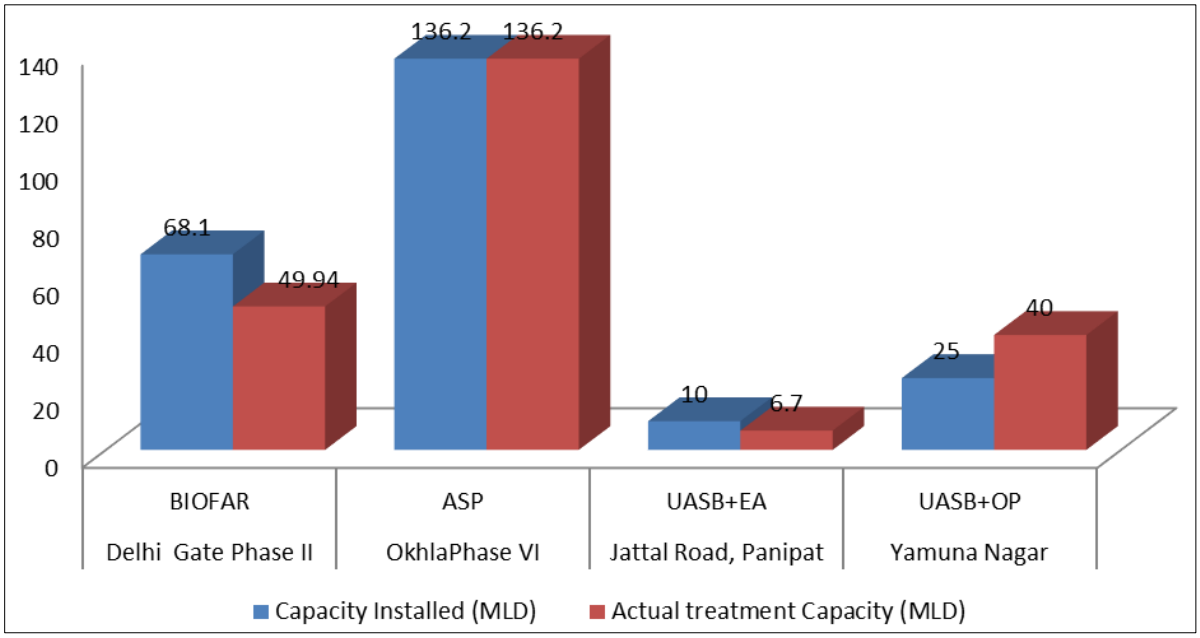

Fig 1: List of waste water plants with actual and installed capacity

In order to assess the performance of above said plants and to efficiency removal of pollutant, in-depth analysis was carried out at inlet and outlet units of treatment plants. CPCB's team collected samples from inlet and outlet units. The samples collected were analyzed for following parameters.

Waste water Treatment plants	Inlet	pH, COD, BOD, SS, NH_4-N, PO^{4-}, Total and Fecal Coliform
	Outlet	pH, COD, BOD, SS, NH_4-N, PO^{4-}, Total and Fecal Coliform

Sampling of plants is carried out at different stages/treatment process of plant with respect to Physio-Chemical Parameters and Bacteriological parameters. The summarized table indicating analytical results of all the four treatment technologies for above said parameters is mentioned in Table 3. This table indicates analytical result of plants for Inlet and Outlet with respect to Physio-Chemical Parameters and Bacteriological parameters analyzed.

Table 3: Analytical result of plants for Inlet and Outlet with respect to Physio-Chemical Parameters and Bacteriological parameters

Sl. No	Plant Location	Source	Parameters							
			pH	TSS	COD	BOD	NH_3-N	PO_4-P	T.C MPN/ 100ml	F.C MPN/ 100ml
1.	Delhi Gate Phase II	Inlet	7.58	256	397	109	39	2.82	70×10^9	49×10^9
		Outlet	7.69	13	52	06	21	0.42	<1.8	<1.8
2.	OkhlaPhase VI	Inlet	6.99	143	172	87	25	3.44	16×10^{10}	16×10^{10}
		Outlet	7.17	13	5	3	19	0.62	20	20
3.	Jattal Road Panipat	Inlet	6.95	336	628	315	20	1.4	35×10^7	24×10^7
		Outlet	7.42	10	11	4	<1	0.14	43×10^4	43×10^4
4.	Yamuna Nagar	Inlet	6.63	210	442	167	20	1.12	14×10^7	7×10^7
		Outlet	7.35	28	67	15	14	0.66	35×10^5	24×10^5
Note:All values are measured in mg/l except pH										

The comparative analysis of aforesaid plants was carried out to find out the removal efficiency for microbial and organic pollutant. Summary of removal efficiency is depicted in Table 4.

Table 4: Removal Efficiency of plants for Organic and Microbial Pollutant

Sl. No.	Plant Location	Treatment Technology	% BOD removal	% COD removal	% TSS removal	% Total Coliform reduction	% Fecal Coliform reduction
1.	Delhi Gate Phase II	BIOFAR	94.49	86.90	94.92	100	100
2.	OkhlaPhase VI	ASP	96.55	97.09	90.90	100	100
3.	Jattal Road Panipat	UASB+EA	98.73	98.24	97.02	99.87	99.82
4.	Yamuna Nagar	UASB+OP	91.01	84.84	86.66	97.56	96.57

In view of above studies and facts, observations are made with respect to achievability in reduction of organic and bacteriological pollutant. The primary goal of wastewater treatment plant is to reduce organic loading [9-10].Performance efficiency is done by comparing the outlet and inlet BOD. It greatly depends on the inlet quality BOD removal efficiency also depends upon the aeration time provided which varies according to the plant size and quantity and composition of incoming waste. Study of performance evaluation of plants based on BIOFAR, ASP, UASB+EA and UASB+OP technologies shows that the BOD removal efficiencies are 94.49%, 96.55%, 98.73% and 91.01% while the COD removal efficiencies are 86.9 %, 97.09 %, 98.24% and 84.84%.

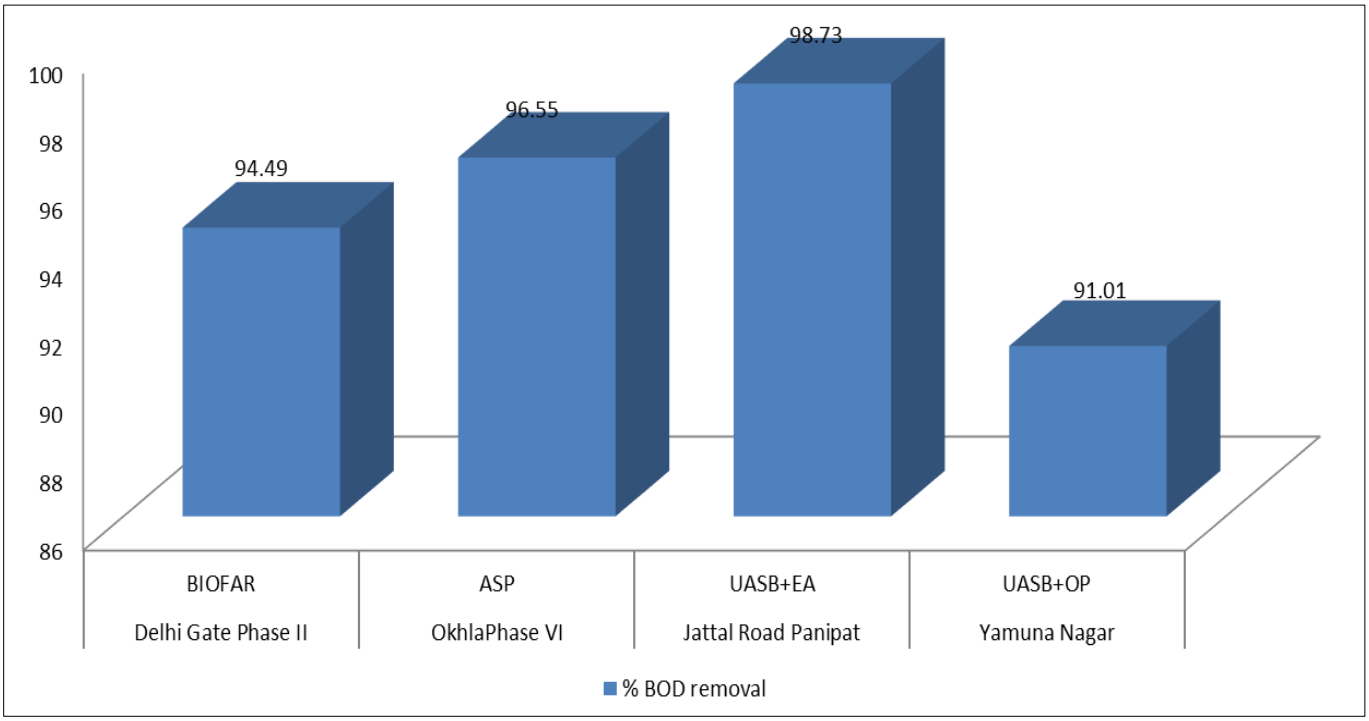

Fig 2: BOD reduction efficiency

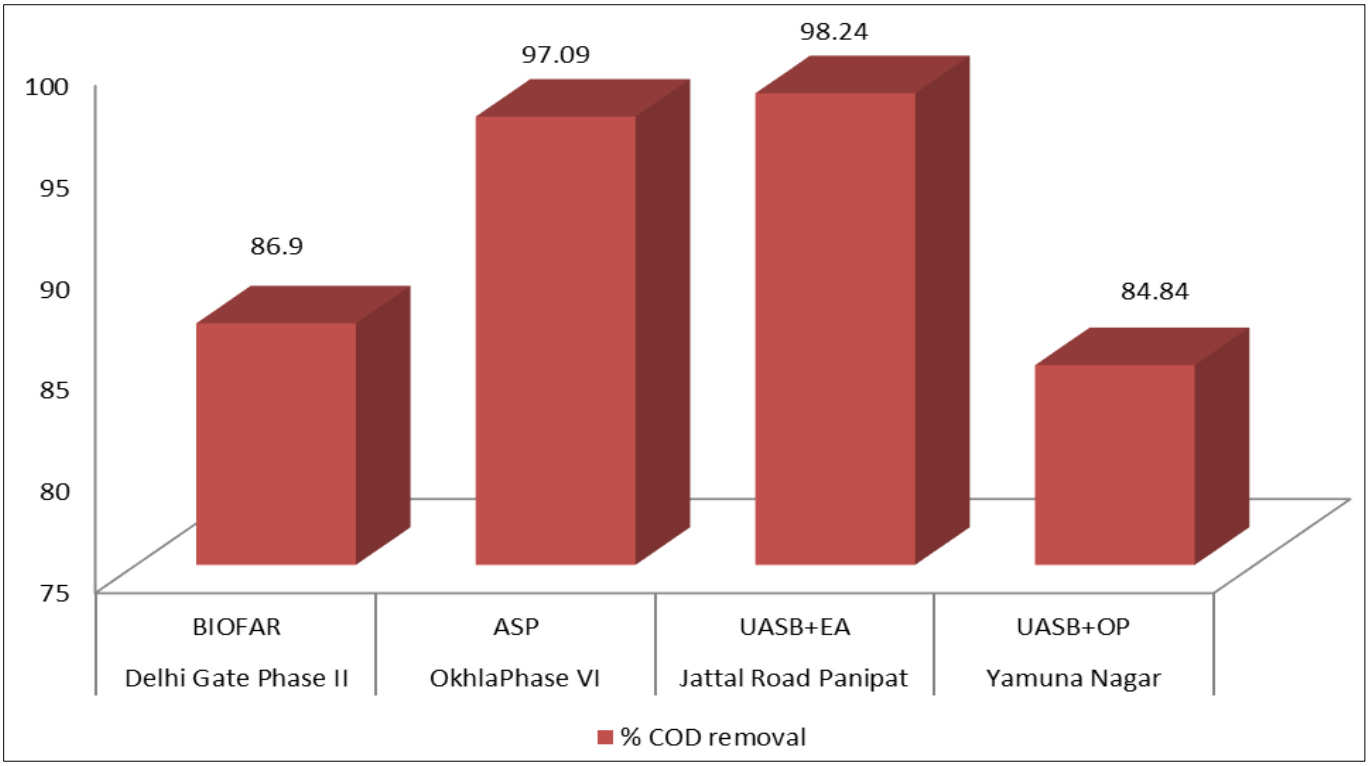

Fig 3: COD reduction efficiency

Study of performance evaluation based on BIOFAR, ASP, UASB+EA, UASB+OP technologies shows that the TSS removal efficiencies are 94.92%, 90.9%, 97.02% and 86.66% The reduced TSS levels at the outlet are attributed to the plant's efficiency of TSS removal through sedimentation of settleable solids. Discharge of effluents with high levels of suspended solids into water bodies lower the quality of water and deplete dissolved oxygen availability for aquatic life.

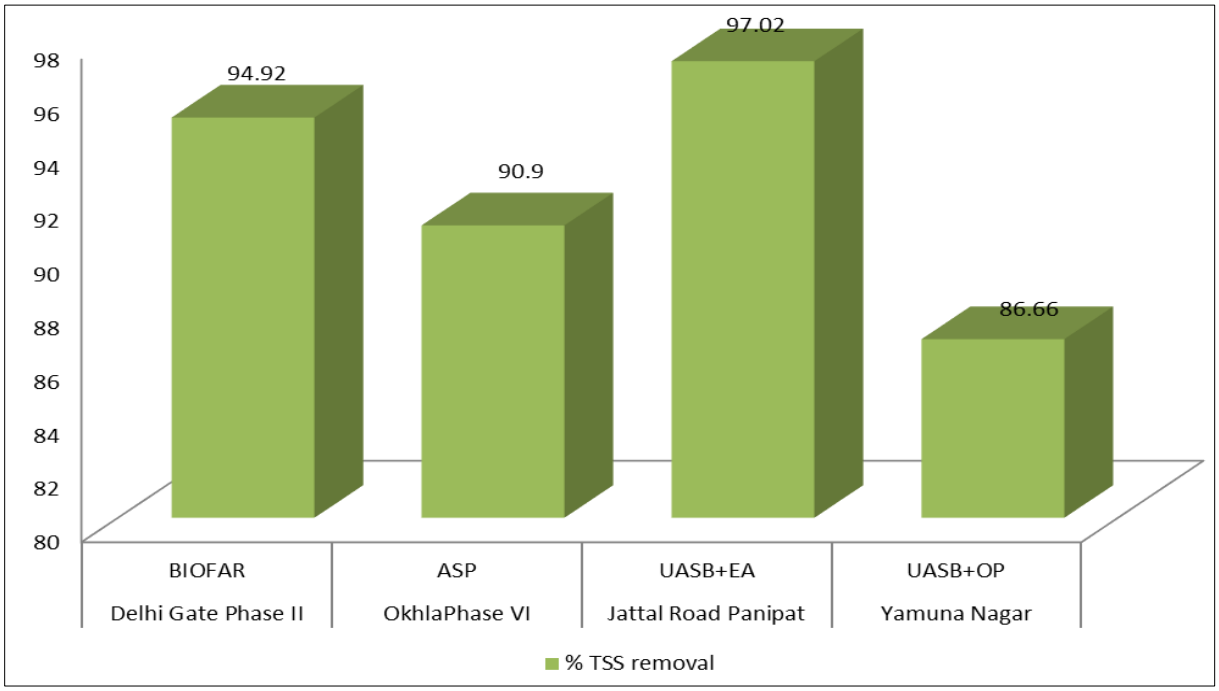

Fig 4: TSS reduction efficiency

Study of performance evaluation based on BIOFAR, ASP, UASB+EA, UASB+OP technologies shows that the TC removal efficiencies are 100%, 100%, 99.87%, 97.56% and FC removal efficiencies are 100%, 100%, 99.82% and 96.57%. Monitoring the biological markers of a particular treated wastewater means to determine the overall quality of treated waste. Since 1920s, TC and FC are the standard microbial indicators of water quality. The types and concentration of these organisms depends on factors such as per capita water supply rate, connection of major sources like hospitals, levels of disease in the community and other constituents of wastewater including toxic chemicals.

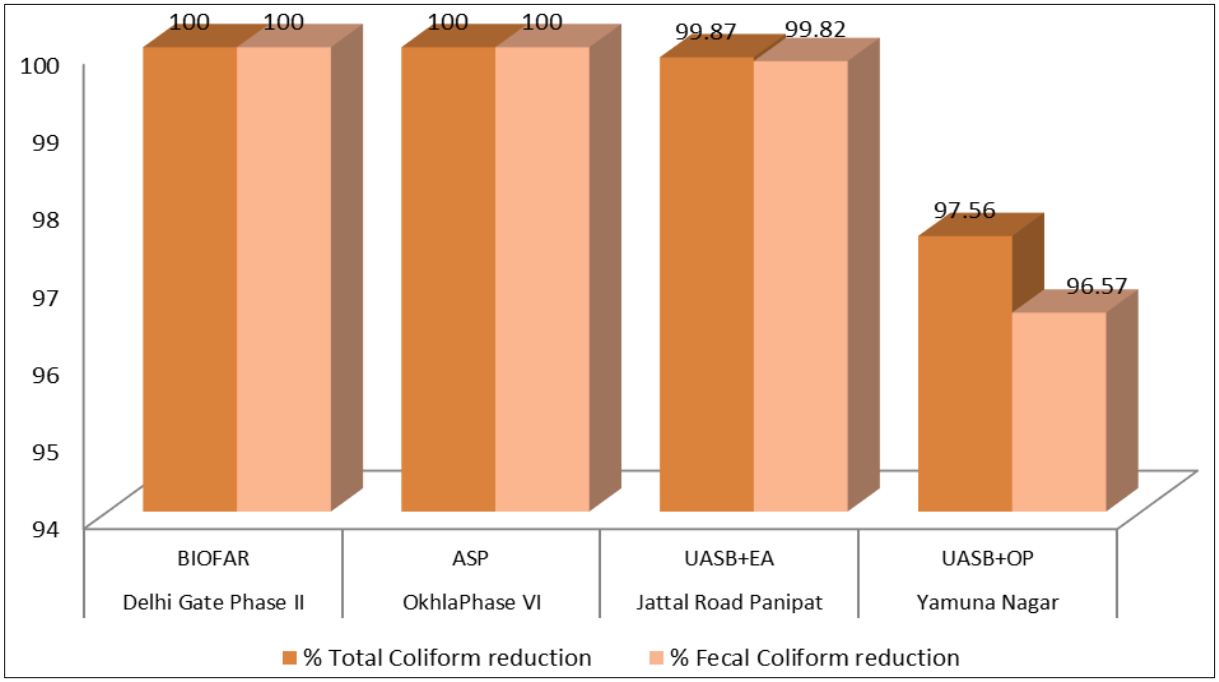

Fig 5: TC and FC reduction efficiency

Based on the experience of present study, the operation and maintenance of waste water treatment plants depends on three factors:

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

In the case of conventional treatment technologies, more energy is required. For proper knowledge of the process and operation, skilled manpower is required for smooth functioning of the plants. Also, maintenance is required at every stage with due diligence.

Conclusion

Treatment of waste water is vital to prevent pollution and protect environment and public health before being discharged to aquatic bodies. In this study, attempt was made to generate a rational basis for comparison of different waste water treatment technologies viz, BIOFAR, UASB, and ASP. The performance of all the technology plant in respect of removal of different monitoring parameters such as BOD, COD, TSS and Coliforms was almost comparable and were not significantly varying. The plants designed on advanced technology are achieving BOD of less than 10mg/l and COD 50 mg/l. The above plants are also achieving Nutrients removal with respect to Phosphate and Ammoniacal Nitrogen removal. Plants having facility of Sand filtration before disinfection have achieved TSS level of less than 10 mg/l and coliform less than 230 MPN/100ml. The treatment plants are disinfecting the treated effluent using Ultra Violet system and have coliform reduction with 99.999% reduction. It shows that all the technologies are relatively efficient in reduction of organic loads and nutrients from waste water. The study depicts that availability of advance technology can reduce organic pollutant, Nutrients and bacteriological contamination significantly at par with the standards.

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