

# Role of UASBs in River Water Quality Conservation in India

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**Abstract.** Appropriate low-cost treatment technologies are a prerequisite for sound management of natural water resources against pollution in developing countries. Among the existing technologies available, UASB is found to be economically viable for India when considering all factors including operation and maintenance cost and treatment efficiency. However, this technology suffers setbacks in meeting the effluent guidelines prescribed by the government of India. Post treatment is supplemental to this process to meet the effluent standards in terms of removal of organic matter, suspended solids, pathogens and nutrients. Recent stringent effluent guidelines notified by the Ministry of Environment, Forests and Climate Change, Government of India has further reduced the limits of BOD by 3 times, COD and TSS by 5 times, NH<sub>4</sub>-N and total Nitrogen by 10 times as compared to the previous guidelines. Fe<sub>cal</sub> Coliforms has been specified as <100MPN/100mL. In this paper, the present scenario of UASB based STPs and their role in river conservation is reviewed against the backdrop of stringent effluent guidelines. The minimum removal rates of BOD, COD and TSS in these plants are around 42 – 44% and the average removal rates are reported to be 66%, 61% and 65% respectively. The enhanced removal of BOD (97%), COD (98%) and TSS has been reported in STPs in conjunction with post treatment facilities such as facultative aerated lagoons, aeration tanks and polishing ponds.

## 1 Introduction

India is the second most populous country in the world with an estimated population of over 1.3 billion during 2017. There are 29 states and 7 Union Territories(UTs) in the country. Central Pollution Control Board (CPCB), is an apex body under the Ministry of Environment, Forest and Climate Change (MOEF & CC), Government of India (GOI) for control and abatement of pollution in India. According to CPCB, the estimated sewage generation in the country during 2015 was 61,948 Million Litres per Day (MLD) against available treatment capacity of 23,277 MLD. There are 816 Sewage Treatment Plants (STPs) in the country out of which 522 are operational, 79 are non-operational, 145 are under construction and 70 are under planning stage. While the existing installed treatment capacity corresponds to around 37.6%, the operational capacity of the STPs is only 30.5%

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of the total sewage generated. The remaining untreated sewage is discharged into nearby water bodies. Domestic sewage is considered responsible for about 80% of the water pollution in India due to inadequate sewage treatment facilities. The National River Conservation Directorate (NRCD) which functions under MOEF & CC provides assistance to various State Governments for implementing the River Action Plans in 29 identified grossly polluted stretches of various rivers of India under the National River Conservation Plan (NRCP). The objective of NRCP is to improve the water quality of these rivers, which are the major fresh water sources in the country, through the implementation of pollution abatement schemes. MOEF & CC in its draft notification released on 24 November 2015 under the Environment (Protection) Act, 1986 has set up new standards for sewage treatment plants along with time frame for implementation as shown in Table 1. Achievement of standards for existing STPs is within 05 years from date of notification.

**Table 1.** Standards for Sewage Treatment Plants.

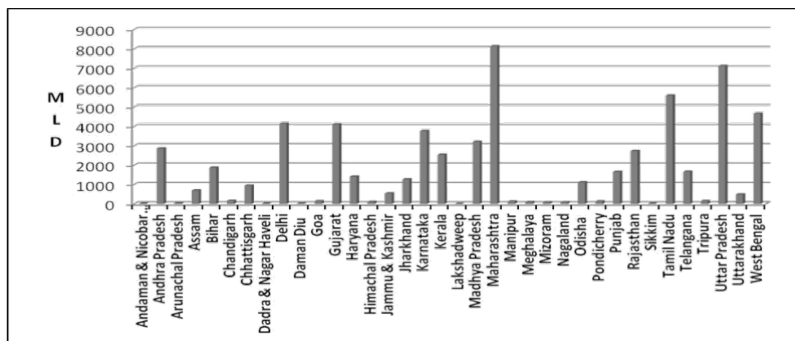
Parameters	Standards for New STPs	Existing general effluent standards
pH	6.5 – 9.0	5.5 – 9.0
BOD	10	30
COD	50	250
TSS	20	100
NH4-N	5	50
N-Total	10	100
Fe <sub>cal</sub> Coliforms (MPN/100mL)	<100	Not specified earlier

Note:

- (i) All values in mg/L except pH and Coliform.
- (ii) These standards will be applicable for discharge in water resources as well as for land disposal. The standards for Fe<sub>cal</sub> Coliform may not be applied for use of treated sewage in industrial purposes.

## 2 Overview of Sewage Generation in India

There are 53 urban agglomerations in India with a population of 1 million or more as of 2011 against 35 in 2001. The rapid rate of growth of urbanization from 10.7% in 1971 to 37.7% in 2011 has put lot of stress on urban infrastructure including potable water supply and safe disposal of wastewater. According to CPCB report on inventorization of STPs in India published in March 2015, the states/UTs generating various amounts of sewage are shown in Fig. 1.



**Fig. 1.** Sewage Generation of Urban Population in 2015 (calculated @ 148 Lpcd) [5].

There are three states which contribute to more than 5000MLD of sewage whereas Lakshadweep is a UT contributing to 10MLD as shown in Table 2. The five states i.e., Maharashtra (13%), Gujarat (7%), Uttar Pradesh (12%), Delhi (7%) and Tamil Nadu (9%) contributed to around 50% of the sewage generated in India whereas 67% of the total sewage treatment capacity is installed in these states/UTs.

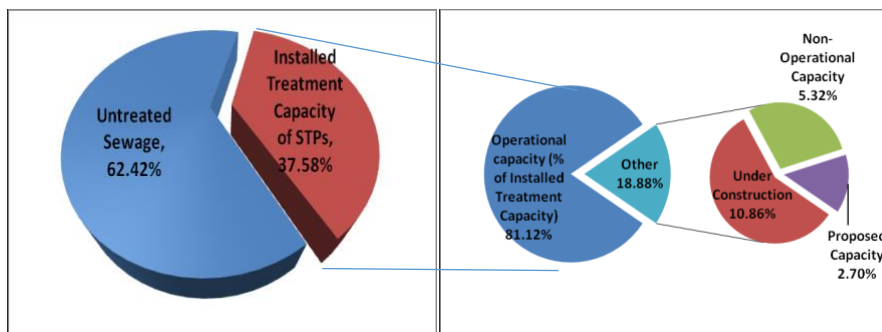
**Table 2.** Sewage Generation Classification.

Sewage Generation, MLD	No. of States/UTs	State/UT
Less than 10	1	Lakshadweep, Andaman & Nicobar Islands, Arunachal Pradesh, Dadra
10 to 50	5	and Nagar Haveli, Daman Diu and Sikkim
50 - 100	3	Meghalaya, Mizoram and Nagaland
100 - 500	7	Chandigarh, Goa, Himachal Pradesh, Manipur, Pondicherry, Tripura and Uttarakhand
500 - 1000	3	Assam, Chhattisgarh and Jammu & Kashmir
1000 - 2000	6	Bihar, Haryana, Jharkhand, Odisha, Punjab and Telangana
2000 - 5000	8	Andhra Pradesh, Delhi, Gujarat, Karnataka, Kerala, Madhya Pradesh, Rajasthan, West Bengal
>5000	3	Maharashtra, Tamil Nadu and Uttar Pradesh
Total		36

The overall BOD load discharged into surface water bodies has been assessed as 14352.7 TPD out of which less than 1% is contributed by industries [6]. The raw sewage characteristics with respect to BOD, COD and TSS are reported to range from 50 – 250mg/L (185.5mg/L), 100 – 700mg/L (481 mg/L) and 100 – 500 mg/L (328mg/L) with average values in parenthesis. Average COD to BOD ratio is found to be around 2.6 [3].

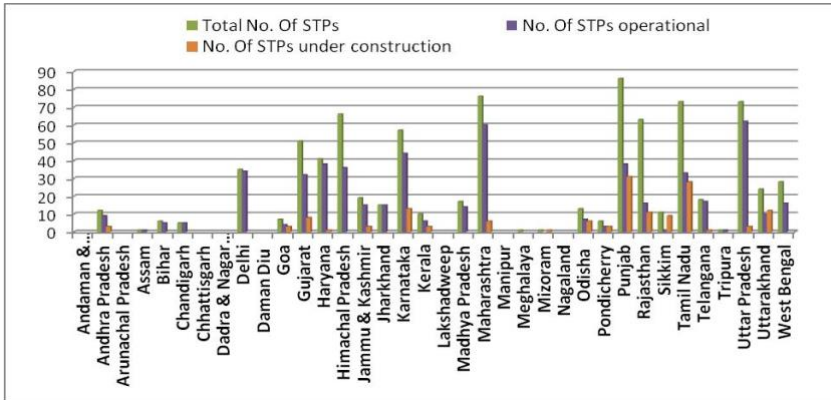
### 2.1 Status of Sewage Treatment in India

During 2015, the installed treatment capacity of STPs was 37.58% of the total sewage generated by Urban Agglomerations out of which 81.12% of the sewage was under operational capacity of installed STPs while 5.32% was non-operational, 10.86% of the sewage would be treated in STPs under construction and 2.70% of the sewage was under proposed capacity as shown in Fig. 2.



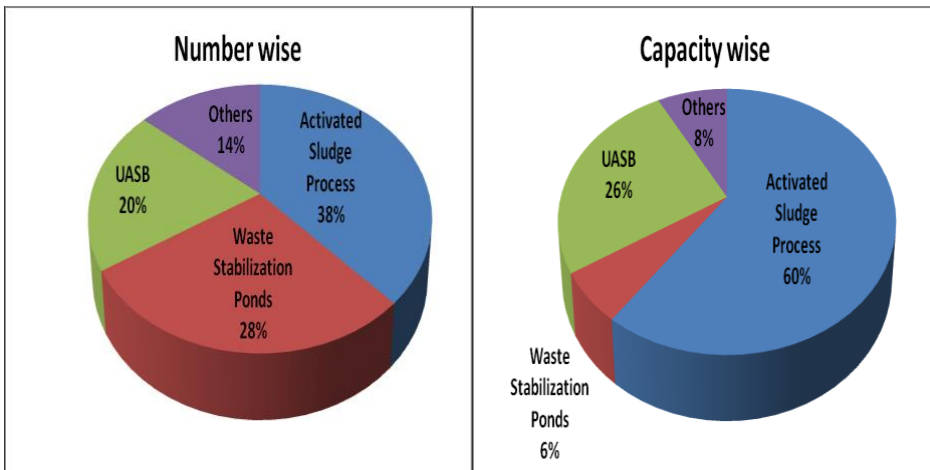
**Fig. 2.** Sewage treatment potential in India.

Out of 816 STPs, 522 were in operation whereas 79 STPs were non-operational and 145 STPs were under construction as shown in Fig. 3. The number of STPs proposed are 70 with treatment capacity of 628.64 MLD.



**Fig. 3.** Status of STPs in India.

There are different technologies which are adopted for the treatment of sewage in India, which includes Activated Sludge Process (ASP), Waste Stabilization Ponds(WSP), Aerated Lagoons (AL), Trickling Filters (TF), Fluidized Aerated Bed (FAB), Upflow Anaerobic Sludge Blanket (UASB), Oxidation Pond (OP) and advanced technologies like Sequencing Batch Reactor (SBR), Membrane bioreactor (MBR) [5]. The STPs prevailing in India are shown in Fig. 4.



**Fig. 4.** Status of different types of sewage treatment technology in India [1].

In recent years, UASB technology has been extensively employed for treatment of domestic sewage in India. It is claimed that 80% of total UASB reactors installed globally for domestic wastewater treatment are in India [10]. 48 UASB based STPs are in operation accounting for around 72% of the plants and remaining are either non-operational or under construction and commissioning phase [5] as shown in Fig. 5.

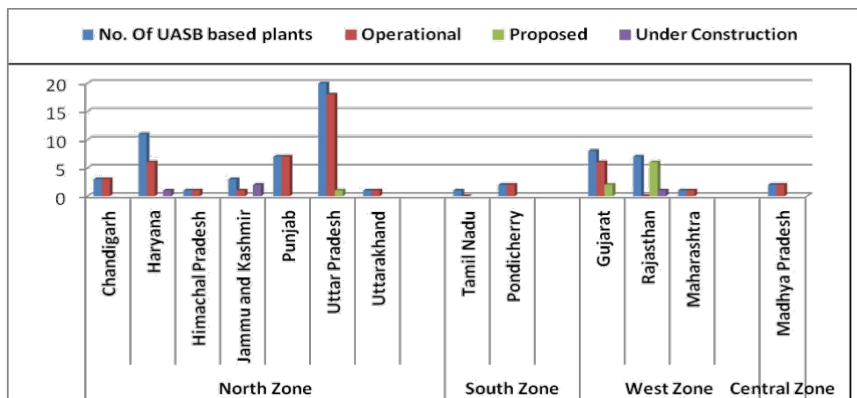


Fig. 5. UASB based STPs in India, Zone-wise [5].

## 2.2 Performance of UASB based STPs in India

The Government of India initiated the Yamuna Action Plan (YAP) in 1993 for conservation of river Yamuna under which 16 UASB STPs were commissioned [10] and 19 UASB plants under Ganga Action Plan-Phase I (GAP-I) [5]. The average BOD, COD and TSS removal efficiency of UASB based plants in India is reported to be 66%, 61% and 65% respectively. The maximum BOD and COD removal efficiency has been found in UASB based STPs in Hyderabad. 97% BOD removal efficiency is reported from 30MLD Nallacheruvu plant with 9hrs HRT in UASB reactor followed by 1 day HRT in facultative aerated lagoons. Similarly, 98% COD reduction is obtained in 339 MLD STP in Amberpet, Hyderabad. The HRT of UASB reactor is 8.88 hrs and that of Aeration tanks and Polishing Ponds are 1day and 12 hrs respectively. Minimum BOD removal efficiency of 44% is reported from 14MLD STP in Jaganpur, Agra with UASB technology followed by Polishing Ponds for post treatment whereas 56MLD STP in Ghaziabad has a minimum COD removal efficiency of 42%. The designed capacity of this plant is 56 MLD whereas actual treatment capacity is 58 MLD [4]. HRT of UASB is 10.7hr and that of Final Polishing Unit is 1.5day [13]. The average TSS removal efficiency of UASB reactors treating sewage is 65%. Maximum removal efficiency is found in 78 MLD STP in Kabt Khedi, Indore, Madhya Pradesh and minimum TSS removal efficiency is of 40 MLD STP in Karnal which is about 42%. UASB alone does not meet discharge standards; therefore, various post-treatments were used in combination with UASB reactor to achieve desired BOD and SS reduction [10]. The best operating full scale UASB reactor has achieved 67, 70 and 75% of removal efficiencies for COD, BOD and TSS in which temperature varies between 17 and 27°C [15].

## 3 State of Art Post-Treatment

The prime objective of installing post-treatment in combination with UASB reactor is to meet the effluent standards set by NRCd for public health, safety, water usage and environmental considerations [13]. There are various types of post-treatment configurations based on different combinations such as UASB + Activated Sludge, UASB + Biofilm Aerobic Reactor System, UASB + Polishing Ponds etc. UASB with ASP is considered most appropriate combination for treatment in warm conditions than the conventional AS system alone [11]. Polishing ponds are very interesting alternative post-treatment option because they require less investment costs and simple design and operation [13]. Utilization

of UASB reactor and polishing ponds can reduce the problems related to odours in plants [2]. Polishing pond technology has been used commonly in many developing countries because the polishing pond effluent can be used for agriculture purposes as it aims at the removal of pathogens present in sewage [7]. UASB/SAB can maintain stable operational conditions without being affected by influent load variations [7]. TF can be adopted as post-treatment for treating UASB effluent for low hydraulic and organic rates under mesophilic conditions in tropical countries [11].

## 4 UASB Operations and Maintenance

The overall efficiency of STPs depends on the operation and maintenance of reactor. The UASB technology should be constructed, operated and maintained by professionals. UASB reactor operation requires various activities which are necessary for better performance of a reactor. Activities like process performance monitoring, collection of data, collection of influent and effluent samples for testing, collection of sludge samples, etc. Operator of the plant is fully responsible for the operation and maintenance of plant and a skilled and experienced operator is required to monitor the reactor and repair the part. Plant operation also includes start-up process and shut down of the plant. UASB plant requires a long start-up period as it takes several months for sludge to form and to adapt to the characteristics of the wastewater. During starting phase, the granulation process accelerates by high organic loading rates in connection with lower organic loading rates [14]. Monitoring of sludge and its profile inside the reactor is one of the major operational activities related to UASB plants [10]. Maintenance of UASB plant includes removal of floating layers inside the gas dome at least once in six months, cleaning and repairing of gutters, V- notch weir plates, baffles and feeding boxes, checking of the level of the overflow weirs yearly, removal of floating scum/material at the top of the water surface of the reactor once a day and cleaning of choked feeding pipes [12]. Consequences of operational failure include deterioration of effluent quality [8] and impose a barrier for energy recovery by blocking the natural passage of gas [9]. Operation and maintenance cost of UASB plants is less than 1% of the capital cost per annum [10].

## 5 Conclusions

It is observed that all UASB based STPs are not capable of producing effluent that follows the discharge standards in terms of BOD, COD and TSS removal. Minimum removal rates of BOD, COD and TSS of 42-44% have been found in some plants despite of having post treatment technologies. This may be because of poor operation and maintenance of STPs such as improper cleaning of screens at inlet and ponds, excess sludge accumulation in reactors and ponds and hiring of persons with less knowledge of plant operations.

The underperformance of UASB based STPs in achieving the regulatory standards set forth by the MOEF & CC has been attributed to some of the following reasons by various researchers and reports:

- Actual Capacity of the plants exceeds the Design Capacity which would affect the HLR and HRT of the reactors.
- Mixing of Industrial Wastewater along with sewage affects the influent characteristics and design flow for which the STPs are designed. In turn, the STPs may be subjected to shock organic and hydraulic loading. The toxic and inhibitory compounds present in industrial wastewater can affect the biological processes.
- Leakage of raising mains/pipelines.

Improper operation and Maintenance involves non-functioning of bar screens, pumps, flow measuring devices, Diesel Generator (DG) sets during power failure, gas collection system etc.

## 6 Recommendations based on Literature, Reports and personal opinion

- The estimation of sewage generation is based on 80% of the fresh water supplied by the Urban Local Bodies (ULBs) / Municipal Corporation (MC). However, the discharge may vary given the individual household supplies through private wells and other sources.
- The performance evaluation of UASB based STPs are made on grab sampling done one time. However, data based on composite sampling would be more realistic. Studies may be carried out under different seasons
- Need for trained and experienced workers to analyse the treatment performance at defined time intervals
- UASBs are vulnerable to shock loads, shock temperature, organic loading rate, hydraulic loading rate etc. Equalization tanks may be installed to overcome such shock loads.
- Operational guidelines should be strictly followed
- Periodic Sludge Profiling of UASB reactor as a Sludge Management tool can enhance UASB performance
- Upgradation of STP facilities and physical improvement of FPU's by adding an aerator and extending retention time or re-evaluation of FPU's by considering alternate technologies such as ASP, TF and RBC. UASB with ASP is considered the most suitable combination as it can achieve 85-95% removal rates
- Consideration of Down Hanging Sponge System (DHS) as a novel technology in post treatment
- Since the STPs vary in both size and effluent quality, a parameter such as Effluent Quality Index (EQI) may be generated to evaluate the STPs on a common platform.

To optimize the performance of STPs, the UASB reactors should be maintained and operated properly. Maximum removal rates are found in some plants which are in combination with post treatment facilities such as facultative aerated lagoons, aeration tanks and polishing ponds. While most of the STPs are evaluated for previous discharge standards, they should be re-evaluated for current standards and necessary measures be taken.

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