COMPARATIVE EVALUATION OF SEWAGE TREATMENT PLANTS: A NOVEL APPROACH

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Abstract— Sewage treatment plants based on different technologies are in practice. Varied claims are being made on their performance efficiency and suitability. In most of the situations, these claims are made on the basis of evaluation of different plants in isolation. A uniform or rational basis for comparison of these plants is yet to evolve. This paper presents a life cycle cost based approach to evaluate the performance of the treatment plants based on UASBR, SBR and MBBR, operating under similar conditions. LCC analysis could be used as a potential tool for comparative evaluation of sewage treatment plants. UASBR has been found to be the most suitable technology for sewage treatment followed by MBBR and SBR.

Index Terms— Life Cycle cost (LCC), MBBR, STP, SBR, UASBR

INTRODUCTION

Different technologies for sewage treatment are in practice and varying claims on comparison of performance have been reported. Various studies have been carried out for comparison of different sewage treatment technologies. Majority of the reported literature comparing the performance of different technologies indicated that removal of different process evaluation parameters was almost comparable and was not significantly varying ([1],[2],[3],[4]).

Life Cycle Cost analysis has evolved as one of the tools for determining the suitability for use of a particular type of wastewater treatment technology. Life Cycle Cost analysis helps to evaluate the cost of a treatment technology over its design period to help determine the most suitable one. This is particularly helpful in areas where selection of wastewater treatment technology may be restricted due to financial constraints [5].

The present study was carried out with a view to propose a rational basis for comparative evaluation of different sewage treatment processes based on different technologies. It was achieved by monitoring and comparing the performance of the STPs, evaluating and comparing the total cost involved in each of the treatment process and applying LCC analysis technique to rationalize the comparative evaluation of STPs

MATERIALS AND METHODS

A. Performance Evaluation

Chandigarh (India) has a well planned underground network of pipes for the disposal of sewage generated in the city. As the city has same social base, quality of sewage generated is almost similar. Three sewage treatment plants based on Upflow Anaerobic Sludge Blanket (UASB), Sequencing Batch Reactor (SBR) and Moving Bed Biofilm Reactor (MBBR) technologies were selected for the study. The treatment plants based on UASB and SBR are located at 3BRD, while as MBBR based plant is located at Diggian, Mohali. The details of the treatment plants are specified in Table 1.

Wastewater samples were collected from three treatment plants on a weekly basis during the period of study. Physical and Chemical analysis of both treated and untreated wastewater was performed in accordance with procedures detailed in Standard Methods [6].

Table 1 Sewage Treatment Plant Technologies

S.No	Location of STP	Capacity	Technology
1	Sewage Treatment Plant, 3 BRD	22.7 MLD	UASBR Based Technology
		45.4 MLD	SBR Based Technology
2	Sewage Treatment Plant, Diggian, Mohali	136 MLD	MBBR Based Technology

B. Life Cycle Cost

For Life Cycle Cost analysis, the cost data for different technologies was collected from the respective treatment plants. This included initial cost comprising of construction cost and equipment setup, land required and its cost, net operation and maintenance cost including electricity charges, replacement works, manpower involved, maintenance works, etc.

The total annual cost is calculated by using the following equation as proposed by Khalil et.al [1]:

$$TAC = (CRF \times IC) + OMC$$

Where,
TAC = Total Annual Cost, CRF = Capital Recovery Factor, IC = Initial Cost (e.g., for Capital, Land), OMC = Operation and Maintenance Cost

The economic life of STP and annual rate of interest have been considered as 30 years and 12 %, respectively

Results and Discussion

A. Performance Evaluation

The performance of the Sewage Treatment Plants was evaluated over a period of 4 months. The various parameters which were monitored included BOD, COD, Total Suspended Solids, Nitrates and Coliform Reduction. The removal efficiencies in respect of the mentioned parameters for each of the treatment plant were calculated and analyzed on a weekly basis.

In the present study, the BOD removal efficiency varied in the order SBR > UASBR > MBBR. The COD removal was in the order MBBR > SBR > UASBR. The TSS removal efficiency followed the order UASBR > MBBR > SBR. The nitrates removal efficiency was in the order MBBR > SBR > UASBR.

Therefore, it is implied that comparison of removal efficiencies of the individual parameters in these reactors may not yield reliable information for decision making

As such, removal efficiency of individual process parameters cannot be considered as the sole basis for selection or comparison of these reactors.

B. Life Cycle Cost Analysis

As mentioned, the performance evaluation is not alone sufficient for the comparison of different sewage treatment technologies. Life cycle cost (LCC) analysis has been largely applied as a tool to evaluate the best cost effective alternative among various alternatives to achieve the lowest long term cost of ownership. Table 2 presents LCC per MLD of the treatment plants studied.

It is observed that the UASB based plant showed least cost required per MLD, which is in accordance with the prevalent studies. Khalil et al. had compared different sewage treatments plants based on ASP, WSP, UASB, MBBR, SBR and MBR on the basis of LCC. It was observed that among UASB, SBR and MBBR, lowest cost requirement was shown by UASB, followed by MBBR and SBR [1]. NGRBA prepared a report comparing treatment costs of various treatment plants including UASB, MBBR and SBR. The results showed that UASB based STP had least cost requirements, followed by SBR and MBBR [7]. The present study indicated the following order in case of life cycle cost for the STPs:

UASB < SBR < MBBR.

The land area in use for SBR and MBBR based treatment plants is almost equal to that prescribed as standard requirements. It is also observed that a certain portion of energy requirements is fulfilled in case of UASB process due to bio gas generation. This is another factor contributing to lower the operation costs for UASB process.

A. *Discussion*

It is observed that on the basis of prevalent conditions and actual area provided, the UASB based treatment plant shows highest cost requirement per MLD as compared to SBR and MBBR based plants. However, it is in contradiction to previous studies which have shown UASB as more cost effective than the other two technologies. Khalil et al. had compared different sewage treatments plants based on ASP, WSP, UASB, MBBR, SBR and MBR on the basis of LCC. It was observed that among UASB, SBR and MBBR, lowest cost requirement was shown by UASB, followed by MBBR and SBR [1]. NGRBA prepared a report comparing treatment costs of various treatment plants including UASB, MBBR and SBR. The results showed that UASB based STP had least cost requirements, followed by SBR and MBBR [7]. CPCB indicated the following order in case of life cycle cost for STPs: UASB < SBR < MBBR [3].

In the present study also, when the standard conditions, especially the land area required for each of the process, were used in the calculation, it was found that the UASB based plant showed least cost required per MLD, which is in accordance with the prevalent studies. The land area in use for SBR and MBBR based treatment plants is almost equal to that prescribed as standard requirements. It is also observed that a certain portion of energy requirements is fulfilled in case of UASB process due to bio gas generation. This is another factor contributing to lower the operation costs for UASB process.

CONCLUSIONS

In this study, attempt was made to generate a rational basis for comparison of STPs based on SBR, UASBR and MBBR. The performance of all the STPs in respect of removal of different monitoring parameters such as BOD, COD and TSS was almost comparable and were not significantly varying. As such, comparison of the treatment efficiencies in respect of the removal efficiencies of routine monitoring parameters may not provide sufficient information which will facilitate their selection or choice.

LCC could be considered as a potential tool for the comparison of the STPs under similar working conditions. In the study area, due to larger land area provided to the UASB reactor, it was found to be having the highest net worth investment cost. Life Cycle Cost analysis based on the standard land area requirement for all the technologies indicated the cost comparison as UASB < MBBR < SBR.

On basis of the results of the study, it can be concluded that UASB is the most suitable technology for sewage treatment for given conditions, followed by MBBR and SBR.

REFERENCES

[1} Khalil, N., Sinha, R., Raghav, A.K. and Mittal, A.K., 2008. UASB Technology for Sewage Treatment in India: Experience, Economic Evaluation and its Potential in other developing Countries, *Twelfth International Water Technology Conference*, Alexandria, Egypt.

[2} Singh, D.D. and John, S., 2013. Study the different parameters of sewage treatment with UASB and SBR technologies. *IOSR Journal of Mechanical and Civil Engineering*, 6(1).

[3] CPCB, 2013. Performance Evaluation of Sewage Treatment Plants under NRCD, Central Pollution Control Board, New Delhi.

[4] Tripathi, M. and Singhal, S.K., 2013. Performance Evaluation of Sewage Treatment Plants In Lucknow City, *Hydro Nepal*, 12(1).

[5] ITRC, 2006. Life Cycle Cost Analysis, *The Interstate Technology & Regulatory Council* - Remediation Process Optimization Team, Washington, DC.

[6] APHA, AWWA, WEF, 1998. Standard Methods for Examination of Water and Wastewater.

[7] NGRBA 2010. Sewage Treatment in Class I towns: Recommendations and Guidelines. *National Ganga River Basin Authority*, New Delhi.

[8] Dhupkar V., 2014. Optimization of Design and Technology for Sewage Treatment,

National Conference on Energy and Environment, University of Pune, Pune.

[9] CPCB, 1998. Status of Sewage Treatment in India, Central Pollution Control Board, New Delhi.

[10] Metcalf and Eddy, 2003. Wastewater Engineering-Treatment and Reuse, *McGraw Hill Education*, Fourth Edition.

[11] Patil, I.P., Wagh, H.D. and Dwivedi, A.K., 2013. Water Recycle and Reuse – A Case Study of NMIMS University Campus, *IJESI*, 2(9).

Table 2 LCC per MLD

S No	Parameter	Unit	SBR	UASBR	MBBR
1	Average Area Required	acres/MLD	0.13	0.26	0.13
2	Capital Cost	crores/MLD	0.7	0.26	0.21
3	Biogas Generation	m^3/d	-	312	-
4	Bio energy Generation*	kWh	-	187	-
5	Annual Power Cost	crores/MLD	0.0312	0.0052	0.019
6	Annual O&M cost (including recurring, chemical, manpower costs, etc.)	crores/MLD	0.6	0.203	0.6
7	Total Annual O&M cost	crores/MLD	0.63	0.208	0.6
8	Average Land cost (per acre)	crores	11	11	11
9	Cost of Land	crores/MLD	1.43	2.86	1.43
10	Unit Capital cost including land	crores/MLD	2.13	3.12	1.64
11	Annual Interest	percent	12	12	12
12	Economic Life	years	30	30	30
13	Capital Recovery Factor (CRF)		0.124	0.124	0.124
14	Total Annual cost	crores/MLD	0.89	0.59	0.8
15	Present Discount Factor		8.06	8.06	8.06
16	**Life Cycle Cost**	**crores/MLD**	**7.17**	**4.75**	**6.44**

*1m^3 CH_4 can generate about 0.6 kWh of electricity [1]