Life Cycle Considerations for selection of Wastewater Treatment Alternatives

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1. Introduction

Water quality-monitoring studies carried out by various agencies regularly identify that the organic and microbial pollutants are the major contaminants of freshwater bodies in India. Domestic wastewater generated from urban areas of the country is the major contributor of these pollutants as less than 25% is treated before disposal. While efforts are on to improve the quality of water bodies by providing sewerage collection and sewage treatment plants for small towns located on riverbanks.

Urbanization is by for the most important social change that has taken place in India in recent times. From a modest base of 25.8 million in 1901, the urban population has grown to 285 million in 2001, signalling an astonishing eleven-fold increase in one century. More than 60% of this urban growth, however, has occurred within the last three decades. Unregulated urbanisation with inadequate infrastructure for water supply and sanitation has led to an alarming deterioration of environmental quality and worsening quality of life in both rural and urban India. Presently more than 85% of an estimated 16,662 MLD of domestic wastewater generated in the country is being discharged into the environment without any treatment. Consequently, a majority of the surface water sources has been contaminated with organic and microbial pollutants. However, pollution due to industrial discharges are controlled, monitored and regulated by the pollution control authorities. Regulations are made more stringent based on the specific site requirements.

The status and growth of wastewater generation, collection and treatment in towns over the years indicates that the wastewater treatment capacity has not taken pace with the increase in wastewater generation. The main constrain in establishment of sewerage collection and sewage treatment plant is the initial capital cost and operation and maintenance cost for sustaining the treatment. With the implementation of the National River Conservation Programme (NRCP) for major rivers in India, about 70% of the capital cost is financed by the Central Government (Ministry of Environment and Forests) to towns situated on the bank of the river for establishment of sewerage collection of network and sewage treatment plant as subsidy. For successful and sustained operation of sewage treatment, the operation and maintenance cost shall be minimum and bearable by the municipality of the town. Similarly in industrial effluent treatment plant also, the operation and maintenance cost shall be minimum and bearable by the industries.

3. Wastewater Treatment alternatives

In this study, different proven technologies for wastewater treatment were considered. The treatment system includes primary treatment with and without chemical addition for removal of suspended solids, secondary treatment using aerobic and anaerobic process for reduction of Biochemical oxygen demand (BOD) and tertiary treatment or polishing treatment for reduction of pathogenic organisms in case of domestic sewage. Based on the characteristics of the wastewater and requirement of treated wastewater quality, the different alternatives are to be selected based on the performance. Different possible treatment configurations for wastewater treatment plant are given below in Table 1:

Table 1 Various wastewater treatment alternatives

Alternative – I	Physio-Chemical Treatment (PCT)+ Activated Sludge Process (ASP) + Chlorination
Alternative – II	Physio-Chemical Treatment (PCT)+ Activated Sludge Process (ASP) + Waste Stabilization Pond (WSP)
Alternative – III	Pre-settler (PS)+ Upflow Anaerobic Sludge Blanket (UASB) Reactor + Activated Sludge Process (ASP) + Chlorination
Alternative – IV	Pre-settler (PS)+ Upflow Anaerobic Sludge Blanket (UASB) Reactor + Activated Sludge Process (ASP) + Waste Stabilization Pond (WSP)
Alternative – V	Upflow Anaerobic Sludge Blanket (UASB) Reactor + Waste Stabilization Pond (WSP)
Alternative – VI	Physio-Chemical Treatment (PCT)+ Anaerobic lagoon (AL) + Activated sludge process + Waste Stabilization Pond (WSP)
Alternative – VII	Anaerobic lagoon (AL) + Waste Stabilization Pond (WSP)

4. Life Cycle Consideration factors

The above alternatives were compared considering life cycle impact and other factors like chemical and energy consumption, quantity of sludge generation, emission of green house gases, capital cost (civil construction and mechanical installation), maintenance cost, and land requirement. For the above various treatment alternatives, the weightage for each factor has been given four scales viz., no, low, medium and high impact and the same are shown in Table 2.

5. Selection of Wastewater Treatment Alternative

For selection of wastewater treatment alternative, the appropriate alternatives are to chosen based on the characteristics of the influent wastewater and requirement of quality of the treated wastewater to be disposed. Within the appropriate alternatives, number of no, low, medium and high factors are to counted and the total impact value is to be calculated by assigning values 0, 1, 2, 3 for no, low, medium and high impact factors respectively. The effective alternative is the one with lowest total impact value.

5.1 Sewage treatment Plant

In the case of sewage treatment, the alternatives I, II, V and VII will be able to meet environmental performance requirements. For the four alternatives, total impact value are to calculated based on the life cycle factors given in Table 2.

Table 2 Life Cycle considerations factors on various wastewater treatment alternatives

Life cycle impact and other factors	Wastewater Treatment Alternatives (I to VII)						
	PCT + ASP+ Chlorination (I)	PCT + ASP+ WSP (II)	PS+ UASB +ASP+ Chlorination (III)	PS+ UASB+ ASP + WSP (IV)	UASB + WSP (V)	PCT + AL+ASP+ WSP (VI)	AL + WSP (VII)
Chemical requirement	High	Medium	Medium	No	No	Medium	No
Energy requirement	High	High	Medium	Medium	Low	High	Low
Green house gas emissions	Medium	Medium	Medium	Medium	Low	High	High
Sludge generation	High	High	Medium	Medium	Low	High	Low
Capital cost	Medium	Medium	High	High	Medium	Medium	Low
Land requirement	Low	Medium	Low	Medium	Medium	High	High
Chemical Hazard/ Risk	High	No	High	No	No	No	No

For Alternative I, High -4; Medium -2; Low-1 and No: 0;
Total impact value =4x3 + 2x2+ 1x1 + 1x0 = 17
For Alternative II, High -2; Medium -4; Low-0 and No: 1
Total impact value =2x3 + 4x2+ 0x1 + 1x0 = 14
For Alternative V, High -0; Medium -2; Low-3 and No: 2
Total impact value =0x3 + 2x2+ 3x1 + 2x0 = 7
For Alternative VII, High -2; Medium -0; Low-3 and No: 2
Total impact value =2x3 + 0x2+ 3x1 + 2x0 = 9

Treatment alternative for sewage treatment plant with lowest total impact value 7 (Alternative V) i.e., UASB followed by wastewater stabilization pond is the best alternative considering the life cycle approach.

5.2 Industrial Wastewater Treatment Plant

In the case of tannery wastewater treatment, the alternatives II, IV and VI will be able to meet environmental performance requirements. In industrial wastewater, it is not mandatory to reduce the pathogens by adopting chlorination or waste stabilization ponds and hence both factors need not taken into account while calculating the total impact factor. For the three alternatives, total impact value are to be calculated based on the life cycle factors given in Table 2 without impact due to land requirement and chemical hazard.

For Alternative II, High -2; Medium -3; Low-0 and No: 0
Total impact value =2x3 + 3x2+ 0x0+0x0 = 12
For Alternative IV, High -1; Medium -3; Low-0 and No:1
Total impact value =1x3 + 3x2+ 0x1 +1x0 =9
For Alternative VI, High -3; Medium -2; Low-0 and No: 0
Total impact value =3x3 + 2x2+ 0x1+0x0 = 13

For tannery wastewater treatment plant, treatment alternative with lowest total impact value 9 (Alternative IV) i.e., UASB followed by activated sludge process is the best alternative considering the life cycle approach.

6. Conclusion

In addition to capital cost, wastewater treatment plant consumes energy, materials in the form of chemicals, emits green house gases and generates solid waste in the form of sludge. A simple methodology has been developed for selection of wastewater treatment alternative incorporating life cycle impact and other factors. For two typical wastewater i.e., sewage and tannery wastewater, it has been established that closed anaerobic system is better compared to open anaerobic and aerobic treatment process. This approach for selection of wastewater alternative can be further improved by giving weightage for each factor and also by adding secondary parameters depending upon the site-specific requirements.

References

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