SUSTAINABILITY OF ACHIEVING HIGH QUALITY NORMS FOR TREATED WASTEWATER

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INTRODUCTION

1. This paper pertains to wastewater treatment projects in the two cities of Delhi and Hyderabad. In case of Delhi, two pilot plants of 10 MLD capacity are considered which were constructed under the Yamuna Action Plan Phase-I. In case of Hyderabad a series of 8 plants (3 plants have been commissioned and 5 are under construction) are considered which have capacities in the range of 0.6 MLD to 10 MLD. This latter set of plants forms part of a comprehensive city-wide lake improvement project underway in Hyderabad. In both the cases these small capacity plants essentially represent decentralised wastewater management (DWWM) approach where they are located in high premium urban areas. With regard to the boundary conditions imposed by their respective locations, there are number of common features of these plants. For instance, because of the nature of the area the first requirement on the systems is that they should not lead to any odour nuisance. Secondly, due to shortage of land, the systems are required to be compact. Thirdly, all these plants are not designed to treat entire flow of wastewater reaching that particular location but to lift only that much quantity which is necessary as per the downstream requirements. Fourth common feature which is the basis of the argument for this paper is that all these plants are designed to produce treated effluent of very high quality specifications. The argument being put forth here is whether such advanced technology options are sustainable in the Indian context given the diverse limitations of resources and availability of skills for operation and maintenance. In case of Delhi, circumstantial coincidence has provided a lease of life to the two plants, while in Hyderabad the planers are revisiting the water quality criteria to make the systems affordable and sustainable in the long run. The following sections of this paper present salient aspects of the wastewater treatment systems adopted in the two cities[2].

STPs IN DELHI

2. The two pilot plants in Delhi are located couple of kilometres apart on the mouth of two storm water drains (viz. Delhi Gate Nalla and Dr. Sen Nursing Home Nalla) each of which carries more than 40 MLD of sewage into river Yamuna. This stretch of the river is one of the most stressed in terms of incoming organic pollution load. At this point it would be pertinent to mention that adjacent to one of the STPs there is a thermal power plant which supplies electricity to Delhi and it has been dependent on the polluted Yamuna river for its requirement of cooling water. However, at the outset this aspect did govern the selection of STP technology, but later it turned out to be the only factor which has ensured sustainability of O&M of the plants.

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3. In view of the limited capacities of the two plants, the objective of constructing them was not to capture all the wastewater flowing through the drains but to assess the performance and cost effectiveness of an advanced process configuration called ‘BIOFOR’ which is designed to produce effluent of BOD < 10 mg/l and suspended solids < 15 mg/l. This technology configuration comprises a combination of ‘chemically enhanced primary treatment’ followed by a two stage granular media filtration step which is assisted by external aeration. An additional step of disinfection through UV lamp was incorporated subsequently to compare different technology options for treated effluent disinfection.

4. Undoubtedly the chemical dosage for high rate sedimentation is high, being of the order of 60 mg/l of alum as coagulant and 0.2-0.3 mg/l of polyelectrolytes as flocculent. In addition, polyelectrolytes are also used for sludge dewatering at a rate of @ 3 kg/t of dry solids.

5. The power requirement of the technology is 220 kWh/ML (million litre) as compared to activated sludge plant (180 - 225 kWh/ML), facultative aerated lagoon (18-25 kWh/ML) and waste stabilisation pond (negligible) based systems.

6. While being energy and chemical intensive, these plants offer the benefit of compactness, having a foot print of only 0.04 ha/MLD (excluding sludge treatment component which is done at another site) as against activated sludge plant (0.15-0.25 ha/MLD) and waste stabilisation pond (0.8-2.3 ha/MLD) based systems.

Plant performance and life cycle costs

7. The plants are performing consistently well producing effluent BOD between 1-14 mg/l and suspended solids between 11-14 mg/l. The overall system efficiencies for both the parameters are in the range of 94-99.9% respectively. It will be noted that unlike the concern on eutrophication in Hyderabad lakes project as discussed later, these plants are not designed for nutrient removal.

8. Given the location related boundary constraints, it is clear that such high-tech sewage treatment technology options would be rather expensive. Undoubtedly, the unit life cycle cost (capital cost + amortised O&M costs for 35 years, considering 5% rate of interest; and excluding land cost) and the unit annual O&M cost of each of the ‘BIOFOR’ plants come out to be Rs. 3.04 Crore/ML and Rs. 8 Lakh/ML (2003 prices) respectively in comparison to the STPs based on conventional technologies e.g. activated sludge plant at Rs. 1.2-1.7 Crore/ML and Rs. 3-5 Lakh/ML; or facultative aerated lagoon at Rs. 0.66-0.7 Crore/ML and Rs. 2 Lakh/ML respectively.

Sustainability assured by the circumstances

9. In normal circumstances under a developing country scenario, O&M of such types of systems would be unsustainable due to their high recurring costs and low premium on the treated effluent (not withstanding its high quality). In this case as the treated effluent from both the STPs was getting drained into the river, it did not generate any revenue for the operating agency. After running these

plants for about a year, the operating agency was confronted with this major issue of sustaining the O&M costs. Among other measures, it approached the electric supply agency to seek concession in electricity rates. Incidentally, as mentioned earlier, one of the power generation plants of the electric supply agency is located on the adjacent plot. It was learnt that the power plant management was struggling to get good quality and quantity of cooling water. It was incurring heavy cost on treatment of raw water which was being withdrawn from the same polluted stretch of the river. In the course of the negotiations a '**Win-Win Barter Deal'** was struck – the electricity agency agreed to provide free electricity to both the STPs in return for free supply of treated effluent for its cooling water requirements. In due course, the power plant management appreciated the benefits from the barter deal and also agreed to take the responsibility of complete O&M of the plant. As a result it has now deployed its own supervisory technical staff and also agreed to bear the cost of the O&M contractor.

STPs IN HYDERABAD

10. STPs in Hyderabad metropolitan area are being constructed under a different scenario where numerous large and small lakes (numbering over 300) are subjected to severe pollution from domestic and industrial activities. There are no fresh water inflows into the lakes and the entire dry weather flow comprises mixed wastewater. On top of it, the lakes are vulnerable to encroachment. As a result of cumulative discharges from point and non-point sources, the lakes are severely degraded and are characterised by poor water quality, high degree of eutrophication, low aesthetics and odour. At selected locations the problem of encroachment is addressed by constructing a bund and thereby formally demarcating the boundary of the lake. The problem of water quality is addressed by diverting a bulk of the dry weather flow and letting in only that much quantity of treated wastewater which is required to maintain the water balance of a lake. As a result of this approach it has been possible to restrict size of the decentralised STPs between 0.6 to 10 MLD (typical size 2.5-5 MLD).

11. Urban lakes serve as major recreation centres and therefore the project has set an ambitious objective of improving the water quality from 'hypertrophic' state to 'minor' eutrophic state. The purpose behind this step was to contain excessive growth of algae, water hyacinth or other aquatic weeds and consequent odour. In this regard the project has attempted in an unprecedented way to not only reduce the levels of BOD, COD and suspended solids but also to minimise the nutrient levels in the water body. As the available national standards do not prescribe specific norms for nitrogen and phosphorus for lakes, the ambient water quality criteria that has been adopted by the project, as shown in Table 1, comprises a judicious blend of norms prescribed by the Central Pollution Control Board and National River Conservation Programme (NRCP) for inland water bodies (mainly rivers) with those of the Organisation of Economic Co-operation and Development (OECD) for lakes.

12. While the baseline water quality is extremely poor, it will be noticed from Table 1 that the norms for ambient water quality to be attained are very ambitious. From this point of view and recognising the fact that almost in all the lakes no fresh water dilution is available and there is internal loading of Phosphorus, it becomes apparent that the quality of treated effluent to be discharged in to a lake needs to be made as close to the desired ambient water quality as possible. Thus the effluent quality prescribed for the STPs requires final BOD of under 5 mg/l , TSS of under 6 mg/l, Total Nitrogen under 5 mg/l and Total Phosphorus under 0.5 mg/l. On top of this, the criteria also specified

residual chlorine in the treated effluent to be 0.1-0.2 mg/l. It is evident that this criteria is far more stringent compared to what has been adopted even for the high tech ‘BIOFOR’ process in the pilots in Delhi.

Table 1 : Water quality criteria for the Hyderabad lake restoration project

Parameter	Unit	Baseline ambient water quality	Desired ambient water quality	Desired effluent quality
Colour	Hazen		-	10
Turbidity	NTU		-	< 5
TSS	mg/l	≈ 400-600	-	< 6
pH			-	6.5-8.5
DO	mg/l	Nil	> 5	> 3
BOD	mg/l	≈ 40-100	< 10	< 5
COD	mg/l		< 25	< 50
Total P	P, mg/l	≈ 10-20	< 0.1	< 0.5
Total N	N, mg/l	≈ 40-70	< 1.2	< 5
Residual chlorine	mg/l		-	0.1-0.2
Coliform	MPN/ 100 ml	Total col. > 10^{6-8}	E. coli < 100	Total col. < 100
Chlorophyll-a	mg/m3		< 50	
Secchi disk depth	m	< 0.2	> 1	

13. In order to attain such stringent effluent quality, the treatment plants that have been constructed and those under execution comprise an elaborate combination of extended aeration with nitrification and denitrification, chemical precipitation, chlorination, and pressure sand filtration. This is followed by a small wetland at the inlet of the lake to prevent entry of sediments and augment uptake of Phosphorus. It is perhaps for the first time that such an evolved process combination has been adopted in India to achieve high ambient water quality of lakes that can be characterised by high degree of transparency, higher dissolved oxygen and low level of eutrophication. It is pertinent to mention here that only some of the most resourceful municipal bodies in the European context have been able to afford installation of a sand filter at the end of a wastewater treatment plant.

Plant performance and life cycle costs

14. The plants have been able to deliver effluent with BOD and suspended solids under 10 mg/l and 6 mg/l respectively. However, the levels of nitrogen and phosphorus in the effluent are found to be 10 mg/l and 3-4 mg/l respectively and it has been difficult to comply with the discharge criteria decided by the project.

15. Unit life cycle costs and O&M costs are computed by following the same criterion as adopted in case of the pilots in Delhi. It is found that for a 35 year period, the unit life cycle costs (excluding the land costs) are in the range of Rs. 5-9 Crores/MLD. For the lower capacity plants (< 2.5 MLD) this is found to be between Rs. 7-9 Crore/MLD, for 5 MLD capacity plants it is found to be Rs. 5-7.5 Crore/MLD and for 10 MLD plant this is between 5-6 Crore/MLD. All these decentralised plants are of quite low capacity compared to the centralised facilities which are typically in the range of 50-100 MLD. Understandably the former would have the disadvantage of lack of economy of scale. Notwithstanding that, the lifecycle costs turn out to be higher than the comparable pilot size plants installed in Delhi. Furthermore their average annual O&M costs are found to be in the range of Rs. 11 – 16 Lakh/MLD which for a conventional activated sludge plant is found to be around Rs. 3 – 5 Lakh/MLD.

Concerns of sustainability

16. Given the baseline conditions of most of the lakes, attainment of 'minor eutrophic' status through compliance with the ambient water quality norms prescribed in Table 1 above requires substantial reduction in current pollution loads and it comes at a steep price. While the interventions at selected lakes have been able to improve the aesthetics considerably, there is still a long way to go before eutrophication can be avoided. While it is technically and financially difficult to bring down Phosphorus (which happens to be the most critical parameter) in the STPs below 2-3 mg/l, the lakes themselves contribute it significantly through internal loading as a result of the accumulated benthic sludge and dead vegetation. In addition, the process of nitrification and denitrification is rather energy intensive. Moreover, it is not possible to prevent the entry of nutrients through storm water flows. Thus in spite of having an elaborate treatment scheme, it is difficult to assure azure blue water in the urban lakes of Hyderabad which incidentally also have clandestine discharge pipes.

17. Recognising that the high O&M costs may not be sustainable in the long run under the given constraints, the agencies are revisiting the water quality criteria so as to make the systems more affordable in terms of their initial and recurring costs.

CONCLUSIONS

18. While in case of the pilots in Delhi a unique barter arrangement of water with electricity (made possible due to favourable locational advantage) has ensured sustainability of operation of the two sophisticated decentralised STPs, this is not the case with the STPs installed in Hyderabad. From these two scenarios, it becomes evident that advanced technology based STP systems in the Indian context could perhaps be considered only when some one is ready to place high premium on the finished product. Otherwise in the general municipal domain purely for improving the surface water quality and aesthetics around the water bodies such systems may not be sustainable.