ABSTRACT

Sewage treatment plant (STP), an important component in the sewage management systems, which requires proper planning and selection of appropriate cost efficient treatment technology for successful implementation. In this connection, urban planners need quick information as ready reckoner on the unit cost of STP for various capacities and technologies including land area requirement. Many technologies for STP have emerged in recent years. However, Waste Stabilization Ponds (WSP), Activated Sludge Process (ASP), Extended Aeration Activated Sludge Process (EASP) and Sequencing Batch Reactor (SBR) are the widely adopted technologies (WATs) in India. Economic analysis is necessary for the selection of the cost efficient technology from the WATs, which involve costs in terms of capital, operation & maintenance and land. Cost functions, useful tools in predicting the costs, are as function of capacity of STP developed by regression analysis of the costs of STP.

The costs of STPs predicted from the cost functions are applicable for the base year alone and, hence, construction cost indices (CCI) are necessary for updating the cost to some other time period. In India, building construction-cost index (BCI), developed and published annually by the Central Public Works Department, Government of India since 1972 is being used for updating cost estimates of buildings. Similarly Construction Industry Development Council, Government of India, publishes every month CCI for eleven sectors for 78 Indian cities since 2012. However, the BCI and CCI may not be appropriate for updating STP cost since the mechanical and
electrical equipment required for STP are different from other construction projects. Hence, exclusive STP cost indices are required for updating costs.

Cost functions and STP cost indices have not been reported for the widely adopted technologies widely in India. Considering the level of investment required for the construction of STPs, there is a need for research for the development of cost functions based ready reckoner of STP cost indices and economic analysis for the benefit of engineers and urban planners, in order to arrive at reasonable estimates of STPs for appropriate formulation and budget allocation.

For developing cost functions capacities of STPs have been classified into three groups such as small (0.5 to 5 MLD), medium (5 to 50 MLD) and large (50 to 150 MLD) based on population served. Unit cost data have been derived from design and estimation model, which was developed in Microsoft Excel Spread Sheet by formulating the process flow diagrams for the WATs for typical raw sewage characteristics of 350 mg.L\(^{-1}\) of BOD and 450 mg.L\(^{-1}\) of SS and the permissible treated sewage quality of 20 mg.L\(^{-1}\) of BOD and 30 mg.L\(^{-1}\) of SS and adopting design criteria based on the recommendations of CPHEEO, GOI.

Cost functions have been developed with the cost data through regression analysis for the base year of 2014. STP cost indices have been developed for Chennai region, with a basket of nine cost items and their weights using Laspeyres formula. Correlation between STP cost indices and BCI/CCI has been established. STP cost indices for 78 Indian cities for the years 2014 and 2015 have been arrived at. Validation of the cost functions and STP cost indices developed has been done by comparing predicted costs with actual costs of 44 numbers of STPs constructed during different periods in Tamil Nadu, India.
Economic analysis has been done with net present values of the WATs by capitalizing the annual O&M costs, for an economic life of 30 years for civil structures and piping and 15 years for mechanical and electrical equipments, with a discount rate of 8% and adding with capital cost and land cost (10 million rupees/Ha for urban areas and 5 million rupees/Ha for rural areas). The technology with NPV has been selected as the cost efficient technology. Further, sensitivity analysis, with discount rates of 5% and 10% and the unit land cost at 5–15 million rupees/Ha, was conducted to assess the effect of these parameters on the selection of technology.

The best fit equations for the cost functions developed are as per power law for all technological alternatives except for large capacity STPs based on EASP technology for which polynomial equation was found to be the best fit equation. Mean capital costs of STPs based on ASP, EASP and SBR predicted from the cost functions developed were found to be in the order of 17.30, 18.87 and 14.53 million rupees/MLD respectively for small capacity group; 9.32, 11.18 and 9.22 million rupees/MLD respectively for medium capacity group and 6.62, 9.43 and 6.43 million rupees/MLD respectively for large capacity group. It has been concluded from the economic analysis that generally SBR is the choice beyond 15 MLD capacity STPs; ASP is for 5 – 15 MLD; EASP is the choice for less than 5 MLD for urban area; and WSP is the choice for less than 5 MLD for rural areas among the WATs. ASP with power generation is found to be cost efficient technology only for larger capacity STPs (> 50MLD).

Findings of the research would provide a reliable source of information on selection of STP technology and cost functions based STP cost indices would be useful handy tools for engineers and urban planners in India for cost prediction and selection of STP technology.