

Feasibility of packaged wastewater treatment plant

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Abstract : Packaged wastewater treatment plants are smaller version of large scale municipal sewage treatment plants consisting of pre-engineered treatment modules which require comparatively shorter time to erect and install. These treatment plants consume less resources and prove to be a cost-effective wastewater treatment option for developing countries. Wastewater treatment plants can be classified based on the type of treatment technology used to remove contaminants. This is a case study based research where a full-scale wastewater treatment plant operating on the principle of Moving bed bio-reactor technology is examined to understand the feasibility of packaged treatment plant in terms of social, environmental and economic factors.

IndexTerms – Packaged treatment, moving bed bio-reactor, wastewater treatment, decentralized.

I. INTRODUCTION

A decentralized wastewater system is the one where collection, transportation, treatment, recycle or reuse of wastewater takes place near the point of generation which makes it a very cost-effective option for developing countries like India. Packaged wastewater treatment plants can also be referred to as decentralized wastewater treatment system which cater to the sanitation demand of a single household or a small community. In the recent years decentralized approach of sanitation is encouraged by the government of India to alleviate the pressure on the existing infrastructure and achieve sustainable growth of the country.

The new regulations such as integrated township policy established by the government indicates that the responsibility of providing basic infrastructure services like water and sanitation will be transferred to developers to cope with the growing urban sprawl and achieve sustainability (Department of urban development and urban housing, 2007). Therefore, real estate developers opt for packaged waste water treatment plants for their hassle-free installation and management.

With the ever-expanding market of wastewater treatment, it becomes difficult for users to select the technology best suited for their needs. It is not necessary that all the modern technologies can be adopted in all situation as these technologies are not specific to developing countries (Massoud, 2009). A successful wastewater treatment plant is the one that is specific to the needs of user and scalable to fit future demands (Chemtronics India, n.d.)

In view of this an exploratory study is conducted to study one of the latest technology of wastewater treatment i.e. Moving Bed Bio-reactor installed in a tech park at Gandhinagar along with identification of factors that determine the success or failure of such systems. During the study, qualitative and quantitative data has been collected through site visits and personal interview with the developer and user.

1.1 Treatment of wastewater

The treatment process of domestic wastewater generally consists of four stages namely pre-treatment, primary treatment, secondary treatment and tertiary treatment as shown in **Fig.1**. The first two stages of treatment are common in all the different treatment technologies. A general description of the treatment process is given below

Pre-treatment	Primary treatment	Secondary treatment	Tertiary treatment
Flow Equalization Screening Grit Removal	Sedimentation/ volume reduction	Alkaline stabilization Digestion Conditioning	Filtration Disinfection Pathogen removal

Figure 1 Stages of Treatment

Pre-treatment is the screening process where large objects transported along wastewater is removed. This is done to prevent damage and clogging of sewers or pumps. Certain treatment plants also include grit removal process where sand, grit, gravel etc. is removed to prevent abrasion of sewer pipes and equipment (Ramalho, 1983).

Primary treatment is the sedimentation stage which consists of large tanks where heavier particles are allowed to settle at the bottom of the tank and simultaneously floating material such as soap scum, oil and grease is removed. The deposited material or sludge can be pumped out for further treatment (Ramalho, 1983).

Secondary treatment can also be termed as oxidation where biological oxygen demand of wastewater is reduced using microorganisms present in the wastewater which consumes most of the biodegradable organic matter. This biological treatment of water contaminants can be both aerobic and anaerobic in nature.

Tertiary treatment is the final cleansing process where remaining inorganic compounds are removed. Finally, the effluent is filtered and disinfected before it is reused or disposed. In India this process is not insisted upon.

II. GENERAL DESCRIPTION OF THE TECHNOLOGY

MBBR technology is an anaerobic process where the wastewater is treated in the presence of oxygen. The effluent from primary treatment is fed into the MBBR tank. This tank can be of one stage or two stages depending on specific demands. The tank consists of thousands of biofilm carriers where bacteria grows on the internal surface of the carriers and breaks down organic matter and the process is described as attached growth process. The aeration system keeps the plastic carriers in constant motion. The effluent is then transferred to clarifier tank protected by bar screens to prevent entry of the plastic carriers which are completely filled with bacterial growth. This treatment requires sufficient pre-treatment to avoid unnecessary clogging of biofilm carriers which can degrade the treatment efficiency.

This packaged plant can be installed in residential buildings/townships and for commercial complex as well.

2.1 Reuse Options of treated water

The treated water can be used for a number of non-human contact uses such as gardening, flushing, cooling tower, washing vehicles and other non-potable uses.

III. CASE STUDY

3.1 Project Overview

Tech City is India's first smart city project initiated by Government of Gujarat with an aim to provide world class infrastructural facilities to big financial firms around the world. The total area covered by Tech City is 3.58 sq. Km.

The concept of Tech City is based on integrated and sustainable development. To facilitate recycling and reuse of water, a WWTP is installed. This Treatment plant works on the principle of MBBR. The operation and maintenance of the treatment plant is handled by in-house supervisors and operators.

3.2 Project Design

Based on the present occupancy rate of 10,000 population including floating population, the WWTP is designed to treat 2250 m³/day of wastewater. The treated water is used mainly as a source of water for the district cooling system and remaining water is used for horticulture purpose.

3.3 Process Description

This city has an underground network of sewer pipes which collects wastewater from all the buildings and offices conveying it through gravity main to the treatment plant.

- The first stage of treatment is screening of floating materials, removal of grit and primary sedimentation.
- The effluent of equalization tank is transferred to the bio-reactor which contains specially engineered plastic material on which bacteria grows.
- After this process the effluent is fed into a tube settler for secondary clarification.
- The effluent is further treated with chlorine in the tertiary treatment stage which is then stored in a collection tank.

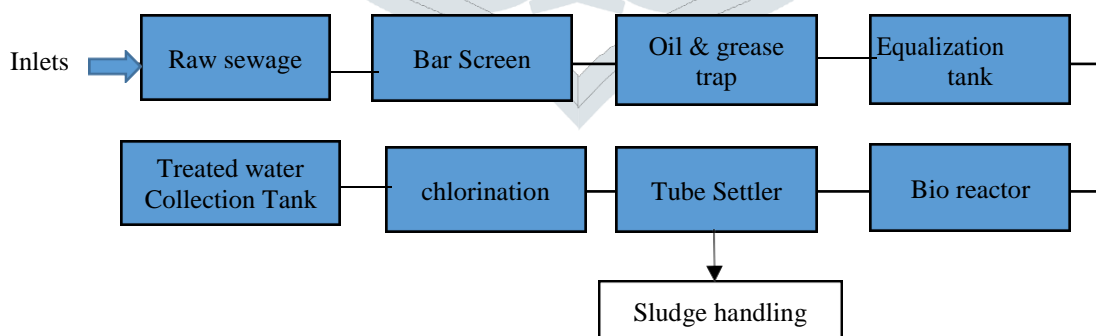


Figure 2 Flowsheet of MBBR process

Capital Costs: The total cost of installing the treatment plant along with sewer network was Rs 14,90,00,000 crores which was recovered according to their financial model

Operations and Maintenance Cost: The annual O&M cost is approximately Rs. 25,00,000 which includes the salary of 30 personnel involved with the operation of the WWTP, admin charge, cost of power consumption and repair and maintenance.

3.4 Advantages

- The benefits of using this technology is that this plant has a very compact design and thus is convenient for residential townships where space is a constraint.
- This technology can be easily upgraded to meet future water demands by modifying the biofilm carriers to increase fill fraction.
- There is no accumulation of sludge in this process and thus it does not require separate sludge handling process.
- Unlike other technology, there is no requirement of monitoring food to microbe ratio in this technology.

3.5 Key Motivation Factors

The motivation behind installing a packaged wastewater treatment plant and reusing treated water is the concern towards the environment. People are aware of the fact that community-based wastewater treatment system reduces the load on the existing infrastructure of the city. Reuse of treated water can also help in fighting water scarcity. The second most important key driver is the government incentives and recognitions that promote decentralized wastewater treatment systems.

IV. DATA ANALYSIS

To study the feasibility of the above packaged treatment plant, the parameters studied are categorized into technical, social, economic and environmental factors as shown in Table 1. below


	Indicator
Economic	Capital cost per cubic meter of wastewater treated (Rs Lakh/m ³)
	Operation Cost per cubic meter of wastewater treated (Rs /m ³)
	Net Present Value (lakhs)
	Source of Fund
	Man Power
Technical	pH
	BOD
	COD
	TSS
	Ability to handle varying flow rate
	Cost and frequency of service
	Uses of sludge
	Potential uses of treated water
	Ease of upgradation
	Maturity of technology
	Resource Utilization
Land Area (m ² /KLD)	
Environmental	Carbon emission Potential (kg CO ₂ – Eq/p.e year)
	Sludge Disposal

Table 1 List of feasibility Indicators

From the financial aspect of analysis, it can be concluded that decentralized treatment plants are not profit earning projects. The sources of generating revenue is almost negligible as the by-products obtained are treated water and a small quantity of organic sludge which is used as manure and cannot be sold unlike solid waste treatment plant where the volume of compost is very high.

For the successful operation of a packaged treatment plant it is very important to assess the sewage generation of the population. It is because the treatment efficiency of the plant depends on the design capacity and the actual volume of wastewater treated. A treatment plant with high capacity and lesser volume of wastewater treated cannot give desired result.

The carbon emission potential of packaged treatment plant decreases with increase in capacity of the plant therefore it is not feasible that a single household be served with a package plant as the electricity consumption would be very high.

4.1 Assessment of social factors

Social factors were analysed in this study by conducting a user perspective survey. This is an important factor because it determines the motivation behind installing a WWTP.

Due to awareness of environmental issues and the cases of water scarcity, the general opinion of the public was a positive approach towards wastewater reuse. But there were some people who had the opinion that treating wastewater is the job of the municipality and it makes no sense to do it in decentralized approach and bear additional cost. Installing a WWTP requires knowledge during the construction and designing phase which is seen as a bottleneck by most of the people.

It can be said from the survey that a sustainable decentralized WWTP should have the following features:

- Aesthetically pleasing
- The plant should not obstruct view and should be located at a safe place with no possibility of mishap.
- No foul smell and quality of water should be maintained.

- Complaint redressal system should be in place.
- The system should be user friendly and produce desired result
- Affordable in terms of fixed cost and running cost.

V. RESULTS AND DISCUSSIONS

It can be concluded from the study that MBBR technology is very suitable for large scale townships. The main governing factor that ensures success of any package plant is the operation and maintenance cost and, in this case, the per head operations and maintenance cost is approximately Rs. 150-200 which is very nominal. But the same treatment plant serving a single household would not be feasible because of high resource consumption and environmental impact.

A package treatment plant as the name suggest is usually consists of one of two chambers which does not enhance aesthetic beauty of the area as compared to other technologies that incorporates root zone treatment of plants where the entire area can be transformed into a garden.

The use of recycled water has drastically reduced the dependence and exploitation of fresh water sources. In the above case study they have successfully achieved 100% reuse of water.

It has been proved that managing centralized wastewater management is a huge burden with respect to economic and environmental perspective and in a similar manner decentralized wastewater treatment plant for a single household is not feasible. Both options are impractical solutions to sustainable wastewater management.

Therefore, there is a need to explore more possibilities of acquiring the benefits of centralized and decentralized wastewater management which can be termed as local management of wastewater serving a small community.

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