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Comparison of Suspended Growth and Attached Growth Wastewater Treatment Process: A Case Study of Wastewater Treatment Plant at MNIT, Jaipur, Rajasthan, India

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ABSTRACT

Attached growth wastewater treatment processes have long been recognized as more energy efficient than suspended growth processes. The rotating biological contactor (RBC) attached growth process has been promoted as being nearly twice as efficient as the most common suspended growth process - activated sludge process (ASP).This paper presents field data from MNIT, Jaipur wastewater treatment plant, with the exception of the secondary treatment process, which in one case is ASP and the other isRBC. The results of this study show RBC process is an approximately 30% more energy efficient process than ASP and In addition, the labor requirements of the RBC facilities were found to be significantly less than for ASP, primarily because of the need for additional process monitoring and management for the ASP process.

Key words: Energy, wastewater treatment, rotating biological contactor (RBC), activated sludge process (ASP), Malviya National Institute of Technology (MNIT)

INTRODUCTION

Raw wastewaters have long been discharged directly to receiving waters (and still are, even in some industrialized countries), hoping their self-purification capacity would take care of our waste. Unfortunately, most receiving bodies failed to do so as they were overcharged with organic and nitrogen pollution resulting in a chronic state of degradation. In most cases, wastewater treatment is therefore needed before effluent discharge. One of the most popular types of treatment is the biological one which more or less mimics some to the natural process fount in a self-purifying receiving body, mainly organic degradation and nitrogen conversion through bacterial action. These can be don’t by attached or suspended microorganisms, giving rise to two main families of wastewater treatment process: (a) attached growth process, and (b) the suspended growth process [1].

ATTACHED GROWTH PROCESSES

The rotating biological contactor (RBC) developed in Germany in the 1960s. RBCs are an attached growth, aerobic, biological wastewater treatment system. A growing market has been reported for both domestic and industrial effluents ranging from small units serving residential dwellings to large ones treating large flows of up to several million liters [2-5]. The principal reasons are easy construction, simplicity of operation and maintenance, stability under shock loads, and low energy consumption. Modifications made to augment performance characteristics of RBCs have made these units more popular in the past two decades.

Physically, they consist of a plurality of parallel, deformed discs mounted perpendicularly on a shaft that is slowly rotated in a tank through which the wastewater to be treated is passed. The shaft is mounted just above the water level in the tank, submerging approximately 40% of the media. The shafts are rotated through the water using one of two methods of propulsion. The first, most common, is the use of an electrical motor, operating through a drive system.

The rotating biological contactor is a fixed biomass system comprising rotating discs. The constant rotation of the disc causes mixing of the liquid. During the treatment process, microbes that remove the organic material in the wastewater (by using the organic material as a food source) attach themselves to the disc surfaces. Biofilm gradually forms on the disc surface, whose thickness is controlled by the shearing force of the discs being rotated through the water. Also, the rotating disc surface alternately comes into contact between air and wastewater and thus acts as an aeration device for wastewater treatment. The surplus microorganisms that are sheared off the discs are carried with the wastewater to clarifiers where they are separated from the treated wastewater [6].

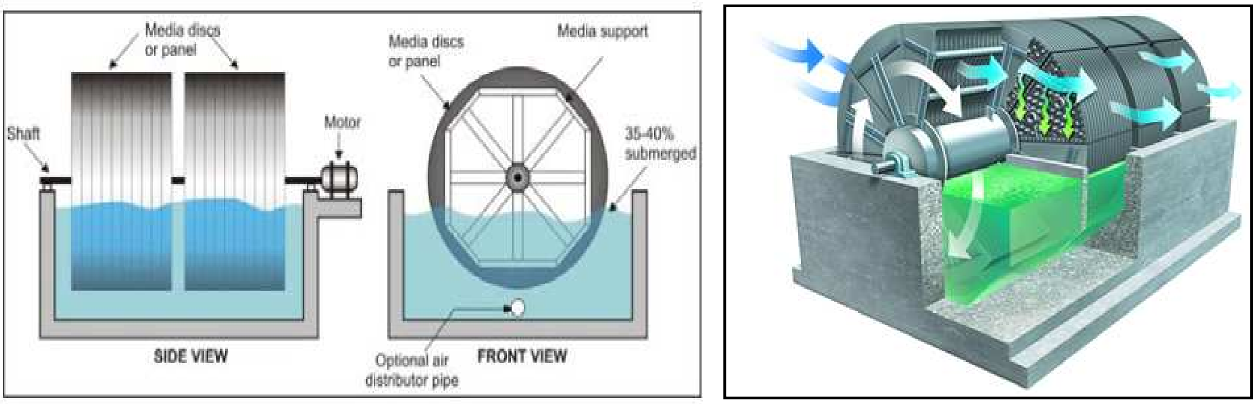

Fig. 1 The rotating biological contactor (RBC)

SUSPENDED GROWTH PROCESS

The conventional activated sludge (ASP) process is a suspended growth technology comprising of an enrichment culture of microbial consortia in order to remove impurities and transform wastewater into environmentally acceptable quality [7]. In this system the culture is retained to maintain convenient sludge age and treatment reaction rates. The microorganisms absorb organic material to grow and form the flocs of biomass [8-9]. In this process the wastewater is introduced to a vessel that has air bubbled into it. The rising air bubbles provide mixing to suspend microorganisms and oxygen for their respiration. The resulting mixture of microorganisms and wastewater are sent to a clarifier where the microorganisms are settled out and returned to the aeration vessel to increase the concentration of microorganisms. Once the desired concentration of microorganisms is reached surplus microorganisms are wasted from the system. A schematic of the process follows [Fig. 2]:

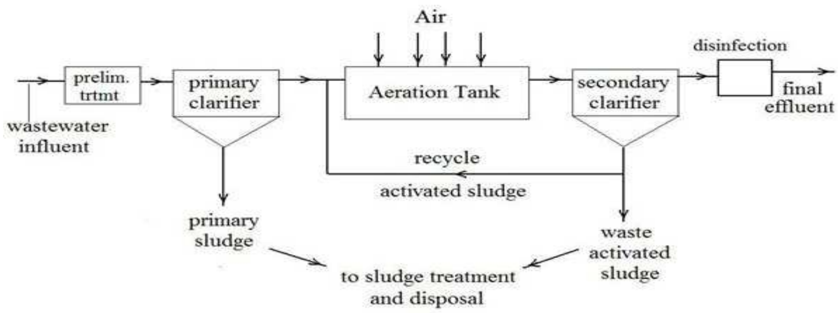

Fig. 2 The activated sludge wastewater treatment flow diagram

Numerous investigations have demonstrated the efficiency of the attached growth unit processes in wastewater treatment, although the key advantages of these practices is rarely exploited in full-scale processes. Thus, it is significantly important for overcoming some of the apparent limitations and evaluates the performance of biological systems where the most suitable technologies are available for on-site wastewater treatment. The comparative research also could lead to knowledge sharing of appropriate selection and operation of treatment techniques, particularly in developing countries [10]. The present study is an attempt to compare and review the suspended growth process and attached growth process for on-site treatment of wastewater treatment plant at MNIT, Jaipur (Rajasthan).

OBSERVATIONS AND CALCULATIONS

Running and Capital cost for the suspended growth and attached growth process has been calculated with assumption that previous existing six aerated lagoons (5 Lagoons + 1 Pond) is replaced by UASB/RBC system having 2 motors of each 1 hp.

- Area of 1 Lagoon = 236.98 m^2.
- Effective volume of Lagoon: 216.74 m^3.

- Design approach to dual Power aerated Lagoons, J.EE Div, ASCE, vol. 108 (June 1982), pp.532-548 is :-
  P/V=0.004(x) + 5 (x < 2,000 mg/l)

where, P/V=Power input per unit Volume, W/m^3 and x=Mixed Liquor suspended solids (MLSS) concentration.
Therefore the Power level for MLSS of 225 mg/l can be calculated as - P/V = 0.004 x 225 + 5 =5.9 W/m^3
Hence for Lagoon, Volume of 216.74 m^3

Cost of Energy

- Power input for 1 Lagoon = 5.9 x 216.74 = 1278.766 Watts
- Since there are 5 Lagoons = 1278.766 x 5 = 6393.83 Watts = 6.393 KW
- Energy consumed in 1 Day = 6.393 x 24 = 153.432 kWh
- Annual Energy Consumption = 153.432 kWh x 365 = 56002.68 kWh
- Cost of energy (Operating Cost) = 56002.68 x Rs.4.5 = **Rs. 2,52,012.06/ year**

Maintenance Cost

- Greasing = Rs.100/week = Rs.100 x 52 = Rs.5200.00 (annual)
- Operators (For 2 Person) = Rs.7000/month = Rs.84,000.00 (annual)

- **Total Running Cost =** Cost of Energy + Maintenance Cost
  = Rs. 2,52,012.06 + Rs. 89,200.00 **= Rs. 3,41,212.06**

Land Requirement = 371.74 Sq.m. X 6 Nos. = 2230.44 Sqm. + 770 Sq.m.(for margins) = **3000.00 Sq.m**
Cost of Land = 3000 m^2 x Rs.10000/m^2 = Rs.300.00 Lacs
Construction Cost = 0.0339 x V 0.7998 (R=0.9907) (Aspect ratio 1: 2)
= 0.0339 x $566.34^{0.7998}$ = Rs. 5.39 Lacs x 6 Nos. = Rs.32.32 x 1.15 = **Rs. 37.191 Lacs**
Mechanical Equipment
Fixed Aerators = Rs 1, 24,756.16

Total Capital Cost = Land Cost +Construction cost + Mechanical Equipment
= Rs 30,000,000.00 + Rs. 3,719,100.00 + Rs. 1, 24,756.16 **= Rs. 33,843,856.16**

Attached Growth Process (UASB/RBC)

Cost of Energy

- Power input for 2 aeration motor each of 1 hp = 2 x 0.746 kW = 1.492 kW
- Power input for 1 pump of 3 hp = 1x 2.238 kW = 2.238 kW
- Total Power input = 1.492 + 2.238 kW = 3.73 kW
- Energy Consumed in 1 Day = 3.73 kW x 24 = 89.52 kWh
- Annual Energy Consumption = 89.52 kWh x 365 = 32,674.8 kWh/ year
- Cost of Energy (operating cost) = 32,674.8 x Rs.4.5 = **Rs.1,47,036.60**

Maintenance Cost

- Greasing = Rs.100/week = Rs.100 x 52 = Rs.5200.00 (annual)
- Operators (For 2 Person) = Rs.7000/month = Rs.84000.00 (annual)

Total Running Cost = Cost of Energy + Maintenance
= Rs. 1, 47,036.60+Nil* = Rs 1, 47,036.60
Land Requirement = 2 x 371.74 Sq.m. + 50 Sq.m. = 793.48 Sq.m. = **800 Sq.m (approx)**
Cost of Land = 800 Sq.m. X Rs. 10000/m^2 = Rs. 8, 000,000.00
Construction Cost **=** Nil**
Mechanical Equipment = Rs.12, 65,000.00***
Total Capital Cost = Land Cost + Construction cost + Mechanical Equipment
= Rs. 8,000,000.00 +Nil+ Rs. 12, 65,000.00*** = <u>Rs. 92, 65,000.00</u>**
Note:
* Maintenance cost is assumed nil for 3 years as it is included in the supply and installation of Equipment
** Since earlier constructed lagoons have been used so no other construction cost is assumed while calculating the capital cost
*** Actual Cost of supply, Installation, testing and commissioning of the plant as per vendors Bill.
This section contains the design, material, procedure, technique or methods used to prepare the Manuscript. Newly introduced design, material, procedure, technique or methods should be described in detail to allow easy repetition. Any modification should be mentioned briefly, with proper references. Techniques which have been previously described should be mentioned in brief only, with proper references, unless they were published in sources that are not easily accessible. The experimental part should be written in sufficient detail to enable readers to review the authors' work.

CONCLUSION

Following conclusion can be drawn from present study -

- The above study shows that UASB + RBC system is the least process on resources in terms of land, energy and finance
- The RBC system studied only requires 4 hp to operate while the aerated lagoon requires 8.56 hp; therefore there is a rather substantial saving in energy.
- Because of low operating costs, the UASB+ RBC is today the cheapest method of municipal sewage treatment, especially when complicated post treatment in not needed.
- In India, power supply is scarce and must be conserved at any cost to keep it available for industrial, agricultural and other uses. Land also needs to be conserved especially since sewage treatment requires very valuable land in the vicinity of cities.

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