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Research Article

# Application of Compact Jet Loop Reactor in Treatment of Industrial Waste Water from Pharmaceutical Industry

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## Abstract

*Present study was carried out to investigate the application of Compact jet loop reactor in the waste water treatment by using activated sludge process. The tests were carried out in the laboratory with synthetic waste water and the effluent from pharmaceutical industry. A laboratory scale Compact jet loop reactor model comprising of an aeration tank and final clarifier was used for this purpose. The Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) of the influent and effluent collected from pharmaceutical industry was measured to find process efficiency at various mixed liquor volatile suspended solids (MLVSS) and hydraulic retention time (θ). The results of the study demonstrated that an efficiency of above 56% for COD and above 66% for BOD could be obtained for above waste sample collected from pharmaceutical industry in Compact jet loop reactor if the ASP is operated at an MLVSS concentration of 3000 mg/l keeping an aeration time of 1 hour.*

**Keywords:** *Activated Sludge, Synthetic waste water (SWW), BOD, COD, Mixed Liquor Volatile Suspended Solids (MLVSS).*

## Introduction

During the last decades, pollution problems reached to an extent that the balance entire ecosystem which is threatened. Water is the main target of pollution. Activated sludge process has been used most widely among biological wastewater treatment process. In the present study, treatment of waste water was carried out by using activated sludge process and investigated to reduce the level of pollution. Usually the extent of pollution is measured in terms of the Biological and Chemical Oxygen Demands (BOD and COD) as well as Suspended Solids (SS).

Traditional wastewater treatment plants are based on the use of selected mixed microbial flocs using recycling of settled biomass, resulting in the development of high performance reactors by increasing biomass concentration inside the reactors (A. Fadvi *et al*, 2005). Some other developments in this technology have resulted in more efficient and compact reactors able to perform better treatment with shorter retention times. Some of these alternative technologies are based on fixed bed (P. Buffiere *et al*, 1995; M. Henze *et al*, 1993) fluidised bed (J. Iza, 1991) up-flow anaerobic sludge bed (UASB) (D. Daffonchio *et al*, 1998) and expanded bed (M. Perez *et al*, 1997) reactors and rotating biological contactors (L. Malandra *et al*, 2003). All of these use biomass flocs or granules free or immobilized, as process catalysts, with the objective of increasing the biomass concentration inside the reactor for faster removal of organic matter.

In the biological stage of waste water treatment plants, the dissolved organic pollutants (in the form of Carbon and hydrogen) are converted to sludge by microorganisms under addition of oxygen (aerobic) (E. A. Naundor *et al*, 1995). The type of equipment used for the secondary treatment is big aeration basins containing either diffused or surface aerators. Recently there has been a shift from conventional treatment basins with a water depth of 3-4 m to large-size tower reactors of height between 15 and 30 m like the “Turmbiologie” of Bayer AG, the Biohoch_ Reaktor of Hoechst AG, or the deep shaft process of ICI with water depths between 50 and 200m (M. Zolkarnik *et al*, 1981). These new developments have greatly reduced the ground surface required as well as the emission airborne pollutants as well as the air intake owing to better oxygen usage. The space-time yield, however, has not improved significantly and the separation of the sludge from the treated water still requires huge clarification or sedimentation tanks. The “Hubstrahlreaktor” proposed by Brauer and Sucker (H. Brauer *et al*, 1979) and the Compact reactor developed at the Technical University Clausthal (U. Wachsmann *et al*, 1984) demonstrate on the other hand a high space-time yield and improved sludge handling properties and thus may be regarded as high performance reactors with respect to the biological waste water treatment.

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## Experimental Setup of Compact Jet Loop Reactor

A laboratory scale Compact Jet Loop reactor made of hollow cylindrical acrylic glass having approximately 15 cm diameter and near about 2m height with an inner draft tube and a height: diameter ratio of about 7:1, making a volume of 18 L with bottom sealed and top opened with a provision of an overflow to hold at least 15L of waste water (Madhukar S. Patil *et al*, 2014) was used in this study. A central coaxial draft tube was placed inside the column for circulation of gas liquid mixture within the reactor. A two fluid nozzle was fitted at the top of the column for admitting the synthetic wastewater into the reactor. When the liquid forces through the nozzle, it sucks in the atmospheric air through the fine metal tube fitted inside the nozzle. It consists of an aeration tank (bucket) of 15 L capacity. One aerator capable of producing very fine air bubbles and provision for uninterrupted power supply for aeration was used.

**Figure 1:** Laboratory scale Compact Jet Loop Reactor

## Materials and Methods

The waste water fed as influent to the Compact Jet Loop reactor was collected from Pharmaceutical industry located in the region of Aurangabad District of Maharashtra, India. Determination of COD and suspended solids (S. S. Dara 2009) were carried out by using $k_2Cr_2O_7$, ferrous ammonium sulphate, $H_2SO_4$. The COD was calibrated using exactly 1gpl pure glucose solution (add 1gm glucose in distilled water and make up volume 1 liter). The COD, $BOD_5$ were measured (S. S. Dara 2009) by using standard procedures. All the chemicals used in the study were A R grade.

## Experimental Procedure

The experiment is carried out using 1 GPL synthetic waste water and fixed MLVSS concentration maintained inside the reactor for different reaction time. Initially, 10L of SWW was taken in a 15L bucket and 2L sludge was added to it. The culture was allowed to grow by aeration (without interruption) for 24 hours. The aeration was then stopped and allowed to settle for 15 minutes. The clear liquid was decanted without losing any sludge. The removed clear liquid was replaced by adding equivalent volume of fresh SWW and the aeration was continued. This procedure was repeated for 5 days. The suspended solids were determined on each day.

The composition of Synthetic Wastewater in mg/L of solution is

| | |
|---|---|
| Glucose: | 1000 |
| Urea: | 225 |
| Magnesium Sulfate: | 100 |
| Potassium Phosphate: | 1000 |
| Calcium chloride: | 64 |
| Ferric Chloride: | 0.5 |

Once enough treated sludge was available, 2-3 L sludge was transferred into 18 L column and 10-13 L waste water sample collected from Pharmaceutical industry was added to it. The fresh synthetic waste water was mixed with the recirculation steam and pumped through the two fluid nozzles into the reactor. The hydraulic retention time inside the reactor was maintained by properly adjusting the flow rate of influent. After reaching the process under steady state the sample of treated effluent was carried out for measuring COD, BOD and MLVSS. In addition, the pH value was also measured. The samples were taken after every 1 hour. This was followed by aeration and the COD was measured (at time 0). After every hour or two hours, the degradation of glucose was determined, mixed liquor volatile suspended solids (MLVSS) values were also determined and plotted. The curve for both the cases was studied and the observed value of suspended solids at every stage finally determines the amount of excess sludge formed.

## Results and Discussion

### *Effluent Sample of Pharmaceutical Industry located in Aurangabad Region*

**Table 1:** COD Removal Efficiency for 1 GPL (SWW) and Industrial Sample with Concentration of MLVSS = 3000 mg/L at Various Time Intervals

| Time (min.) | 0 | 15 | 30 | 45 | 60 |
|---|---|---|---|---|---|
| MLVSS (mg/L) | 2670 | 2740 | 2830 | 2910 | 3000 |
| COD (mg/L) | 268 | 204 | 169 | 145 | 118 |
| %COD Reduction | 0 | 24 | 37 | 46 | 56 |
| $P^H$ | 5.3 | 6.2 | 7.3 | 7.6 | 7.6 |

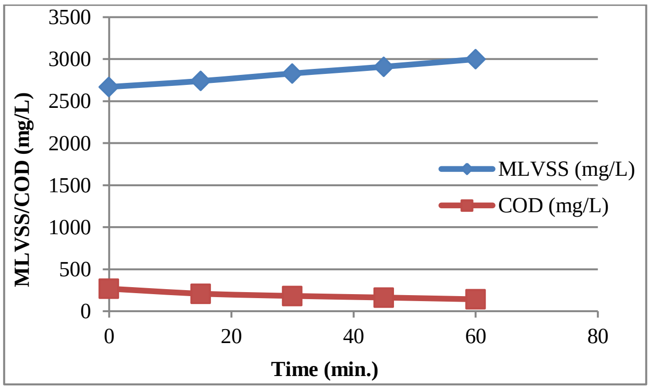

**Figure 2:-** Time Vs. COD/MLVSS Removal Efficiency for Industrial Sample when MLVSS = 3000 mg/L and Various Hydraulic Retention Time.

**Table 2**: BOD Removal Efficiency for 1 GPL (SWW) and Industrial Sample with Concentration of MLVSS = 3000 mg/L at Various Time Intervals

| Time (min.) | 0 | 15 | 30 | 45 | 60 |
|---|---|---|---|---|---|
| MLVSS (mg/L) | 2670 | 2740 | 2830 | 2910 | 3000 |
| BOD (mg/L) | 148 | 110 | 88 | 71 | 51 |
| %BOD Reduction | 0 | 26 | 40 | 52 | 66 |

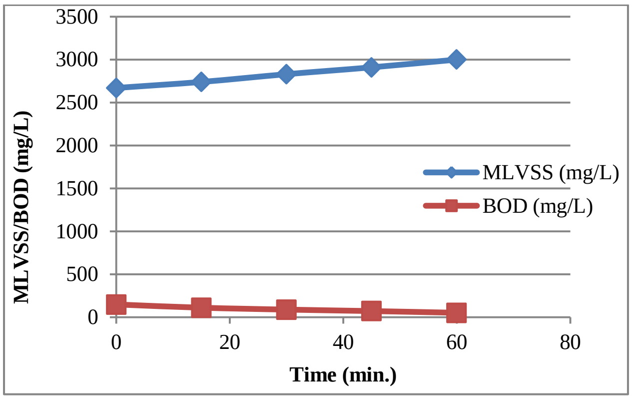

**Figure 3:** Time Vs. BOD/MLVSS Removal Efficiency for Industrial Sample when MLVSS = 3000 mg/L and Various Hydraulic Retention Time.

**Table 3:** % COD/ BOD Removal Efficiency for 1 GPL (SWW) and Industrial Waste Water Sample with Concentration of MLVSS = 3000 mg/L at Various Time Intervals

| **Time(min.)** | **% COD Removal** | **% BOD Removal** |
|---|---|---|
| 0 | 0 | 0 |
| 15 | 24 | 26 |
| 30 | 37 | 40 |
| 45 | 46 | 52 |
| 60 | 56 | 66 |

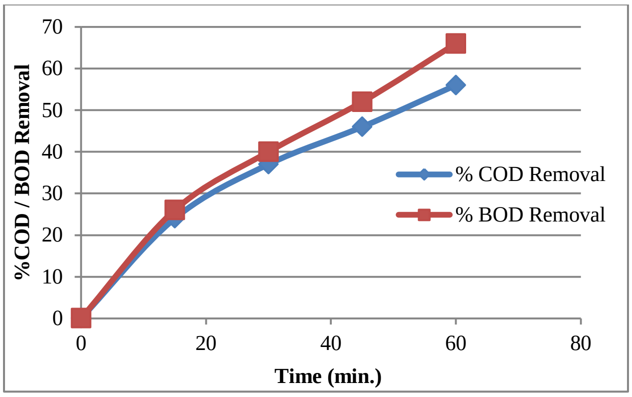

**Figure 4:** Time Vs. % COD/BOD Removal Efficiency for Industrial Sample when MLVSS = 3000 mg/L and Various Hydraulic Retention Time.

The Compact Jet Loop Reactor was operated under steady state to evaluate COD/ BOD removal efficiency for 1 GPL (SWW) & different industrial waste water samples by keeping the MLVSS concentration around 3000 mg/L at various time intervals.

The values of COD/BOD obtained for 1GPL SWW & industrial waste water sample collected from pharmaceutical industry for MLVSS concentration 3000 mg/L and hydraulic retention time of 60, 45, 30 and 15 minutes are depicted in table 1 & 2. The relationships between hydraulic retention time and COD/MLVSS, BOD/MLVSS for above results are shown in figure 2 & 3. It was noted that the COD/BOD value decreases with increase in MLVSS concentration and time.

The treatment efficiency of reactor in terms of COD/BOD removals were studied for concentrations of 3000 mg/L at time intervals of 60, 45, 30 & 15 minutes and the results are depicted in table 3. The relationships between hydraulic retention time and the overall efficiency of the removals indicated by % reduction of COD/BOD for above results are shown in figure 4.

Thus the results indicate that the COD removal efficiency increases up to maximum 56 % and the BOD removal efficiency up to maximum 66 % at MLVSS concentration around 3000 mg/L and an aeration time of 1 hour. It is also observed that the values of both COD and BOD are under the permissible limit given by the general standards for discharge of environmental pollutants (Indian Standard, 2006) decided by Central Pollution Control Board, Ministry of environment & forests, Government of India.

## Conclusion

The systematic application of chemical engineering principles to the biological treatment of waste water has led to a new process which is highly efficient, compact and flexible. The new process offers the possibility of treating waste waters directly at their place of formation and thus incorporating the waste treatment in the original process

The Compact Jet Loop Reactor is found most effective and economical for the treatment of industrial waste water by using activated sludge process and widely used for removing organic components from waste water. The pollution load was estimated by Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD). Results obtained in this study has indicated that percentage reduction of COD reached up to 56 % and percentage reduction of BOD reached up to 66 % in treated effluent at MLVSS concentration of 3000 mg/L and an aeration time of 1hour.

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