

Treatment of Sewage by using Two-Stage Rotating Biological Contactor (RBC)

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Abstract
The rotating biological contactor (RBC) process offers the specific advantages of a bio-film system in treatment of wastewater for removal of soluble organic substance. The present review of RBC focus on parameter like materials used in fabrication of RBC Unit, media used for development of bio-film, HRT, organic and hydraulic loading rate, influent wastewater characteristics, Analysis treated wastewater characteristics, submergence variation, constant RPM, sizing of the reactor. In present study, a lab scale two stage RBC reactor is fabricated to treat sewage. Here work is carried out to check the performance and efficiency of two stage RBC reactor to treat sewage by varying submergence and maintaining constant speed (RPM).From present study, the two stages RBC is varied with 2 submergences for constant speed of disc as 4 RPM with different COD loading rate at optimum HRT. The result obtained when the disk submergence was 40%, the COD removal efficiency for tank1 was 90.31% and for tank1+tank2 were 93.8%. Hence optimum COD loading rate was 640 mg/L at optimum 2hrs HRT and when the disk submergence was 45%, the COD removal efficiency for tank1 was 90.76 % and for tank1+tank2 were 94.6 %. Hence optimum COD loading rate was 520 mg/L at optimum HRT of 1 hr.
Keywords: Two stage Rotating Biological contactor (RBC), sewage, Optimum COD Loading Rate and HRT.

1. Introduction

Domestic Sewage is a liquid waste discharged from Residential area i.e. kitchens, laboratories, wash basins, toilets etc. It is having more than 99% water, but the remainder contains some ions, dissolved solids, suspended solids and harmful microorganism that must be removed from the water before it is used for recreational activities. It is a major carrier of disease (from human wastes) and toxins (from industrial wastes). The main objective of domestic sewage is to ensure that excreta and sullage discharged from communities is properly collected, transported, treated to the required degree and finally disposed off without causing any health or environmental problems. [1]

The first RBC system was used in the early 1900s and consisted of a cylinder with wooden slats [2]. The availability of polystyrene marked the beginning of commercial application of RBCs with the first full-scale system being installed in Germany in 1958 [3] Rotating biological contactors (RBCs) have become a popular method for the treatment of domestic and industrial wastewater during the last decades [4]. The rotating biological contactor (RBC) is an aerobic biological treatment system based on bio-absorption principle [5]. It has been widely used for the secondary treatment of domestic and industrial wastewater [6, 7]. RBC units are widely used in the treatment of wastewater because it is possible to obtain high performance in the removal of dissolved pollutants at the expense of less energy than by using activated-sludge systems [8].

Applications of the RBC reactor can be found in various aerobic treatment processes including dye decolorization, ferrous iron oxidation and the removal of pathogenic bacteria from domestic sewage effluent [9]. RBC are Mechanical secondary treatment system, which are Robust and capable of withstand surges in organic load. The rotating discs support the growth of bacteria and microorganisms present in sewage which breakdown and stabilize organic pollutant. To be successful, microorganisms needs both oxygen to live and food to grow. The Rotating Biological Contactor (RBC) is one of the most efficient fixed film wastewater treatment technologies. It’s well suited for secondary and /or advanced treatment in municipal and industrial applications. In a conventional RBC unit, approximately 40-45 % of the total disc surface area is submerged in the wastewater to be treated. As the discs rotate, the microorganisms attached as bio-film alternatively immerse in the wastewater, and the bio-discs rotate at a speed that allows adequate attached bio-film development. [10]

2. Materials and Methods

2.1 Influent characteristics of sewage

The sewage was used as substrate. No any additional nutrients were given for microorganisms except the nutrients present in the sewage. The characteristics of sewage are given in the table 1.

Table 1: Influent characteristics of sewage

Sl. No.	Parameter	Unit	Obtained values
1	pH	-	7.65
2	TDS	mg/L	720
3	Electrical Conductivity	micro Siemens/cm or mho	1096
4	BOD	mg/L	285
5	COD	mg/L	800
6	TS	mg/L	1400
7	DS	mg/L	700
8	SS	mg/L	700
9	Alkalinity	mg/L	322
10	Acidity	mg/L	202
11	Chloride	mg/L	153.83

2.2Construction of two stage Rotating Biological Contactor (RBC) reactor

Rotating Biological Contactor (RBC) Reactor is very unique and superior technique for wastewater treatment. A two stage lab scale RBC reactor was fabricated using glass for construction of tank and acrylic sheet (non-corrosive, non-reactive) of 5mm thick for construction of disc. The fabrication dimension of individual reactor is 20x20x22cm.The reactor was provided with groove opening of 2.5x2.5cm. Groove was provided at height of 19.5cm from bottom of the reactor and inlet and outlet of the reactor were provided at height of 18cm. A gap of 5cm was provided between two reactors. There are 6 discs mounted over shaft for each reactor the size of disc was 17.8cm diameter and spacing between two discs was 1cm.To increase surface area acrylic beads of size 0.5x0.5x0.5 cm was provided on disc.

As disc was constructed with acrylic sheet it had smooth surface area to make it rough surface area and for the attachment and growth of microorganisms it was provided with mesh. Meshes as rough surface hence attachment of microorganisms take place i.e. Bio-film formation as disc is rotated. A motor of specifications i.e. 1400 rpm, A.C motor (table fan motor) is provided for rotation of disc. [11, 12]

2.3 Lab scale setup of two stage Rotating Biological Contactor (RBC)

The two stage RBC reactor in which each reactor of total volume was 8.8 L and working volume was 6.8 L is constructed with acrylic sheets which are non-corrosive in nature and reactor was placed in series and the schematic diagram of RBC is shown in Fig. Here the disc was rotated at constant speed of 4 rpm and the disk submergence was varied as 40% and 45%. Bio-film formed on disc helped in treatment of wastewater. The reactor was operated with temperature of 29-32^{0}c .Here HRTs was varied i.e. 48, 24, 12, 6, 4, 2 and 1 hr for initial COD concentration of 100mg/L and the optimum HRT was found out. After identifying the optimum HRT gradually the COD loading rate was increased by 100mg/L later at one stage of COD loading rate substrate concentration reduces and there is decreases in COD removal efficiency .Hence to find optimum COD loading rate the COD loading rate was increased at interval of 20 mg/L and optimum loading rate was found out. Later submergence was varied and same procedure was repeated to find out optimum HRT and optimum COD loading rate. [12]

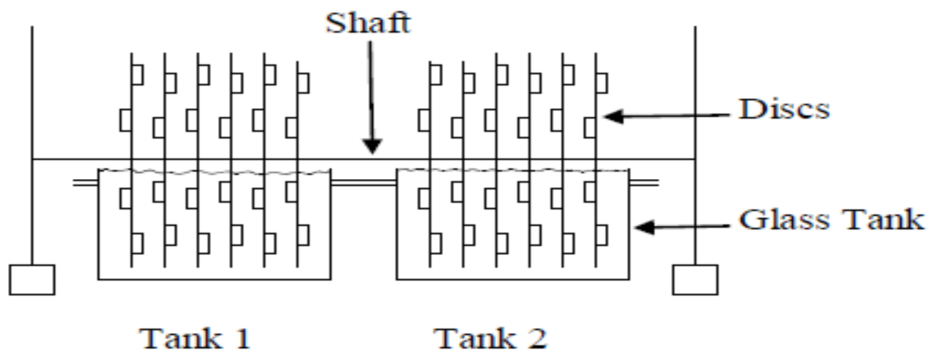

Fig 1: Schematic diagram of Two-Stage RBC

Fig 2: Lab Scale Set up of Two-Stage RBC

2.4 Analysis

Samples from two stage rotating biological contactor were collected and tested for pH, temperature, conductivity, COD, BOD, Chloride, acidity, alkalinity and total solids. Analytical procedures followed in this study were those outlined in Standard Methods (1995) [17].

3. Results and discussions

The study was carried out to know the removal efficiency of COD by using two stage RBC reactor for treating sewage.

3.1 Seeding material for initial Acclimatization and Reactor operation

Acclimatization was required for initial period. A seeding material like cow dung and activated sludge can be used as it consists of large amount of microorganisms which exist in aerobic condition. After referring to many paper it concluded that cow dung to be used as seeding material for initial acclimatization of the reactor so that thick bio-film media is develop on the disc provided in the reactor for treatment of sewage. About 25% of reactor volume (1.7litre) was added to reactor and kept for acclimatization. After acclimatization period of 20days a thick bio-film developed on the disc. Later the reactor was feed with initial COD concentration of 100mg/L later reactor was varied with different submergence i.e. 40% and 45% at constant speed of 4 rpm. The reactor was operated with temperature of 29-32^{0}c Here HRTs was varied i.e. 48, 24, 12, 6, 4, 2 and 1 hr for initial COD concentration of 100mg/L and the optimum HRT was found out.

After identifying the optimum HRT gradually the COD loading rate was increased by 100mg/L later at one stage of COD loading rate substrate concentration reduces and there is decreases in COD removal efficiency .Hence to find optimum COD loading rate the COD loading rate was increased at interval of 20 mg/L and optimum loading rate was found out. Later submergence was varied and same procedure was repeated to find out optimum HRT and optimum COD loading rate. [11, 12]

3.2 COD removal efficiency (%)

3.2.1Performance of RBC reactor at initial COD concentration of 100 mg/L to determine optimum HRT at 40% Submergence and constant rpm as 4rpm

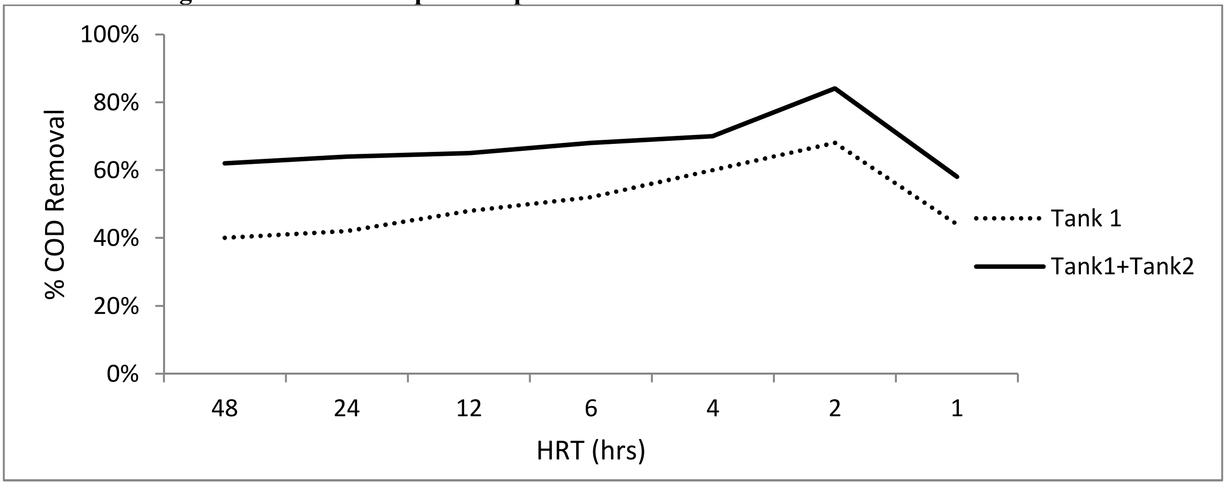

Fig 3: Variation in COD removal efficiency (%) in tank 1+ tank 2 combined during different HRT (hrs)

From the graph it can be considered that the maximum COD removal efficiency (%) was tank 1- 68% and tank 1+tank 2- 84% for 2 hrs HRT. Hence optimum HRT 2 hrs was fixed.

3.2.2Overall performance of RBC reactor for optimum HRT 2 hrs at different COD concentrations at 40% Submergence and constant rpm as 4rpm (mg/L)

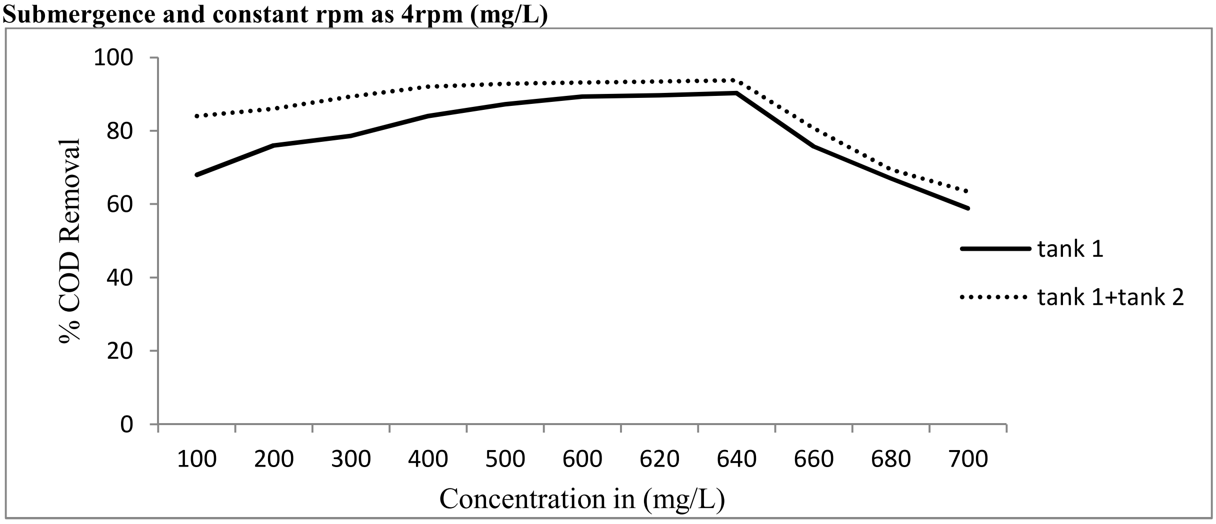

Fig 4: COD removal efficiency in % at different concentrations (mg/L)

From the above Graph it can be considered that the maximum COD removal efficiency (%) for tank 1- 90.31 %, and for tank 1+tank 2- 93.8%. Pradeep et al., reported the different percentage submergence of discs i.e., 40%, 35% and 30% to achieve 99% removal, the HRT's were i.e., 24, 28 and 32 hours respectively [11].Chen et al., achieved the COD and total nitrogen removal rates of 78.8–89.7% and 40.2–61.4%, respectively, in aerobic treatment of low COD municipal-type wastewater at hydraulic retention times (HRT) from 5 to 9 hrs [13]. Najafpour et al., reported 88% COD removal from palm oil mill effluent with 55 hrs HRT [14]. Ebrahimi et al., achieved 96% COD removal from dairy wastewater [15]. Coetzee et al., 2004 reported the reduction of COD of the winery effluent by 23% (from 3828 mg/L to 2910 mg/L) and increased the pH by 0.95 units (from 5.77 to 6.13) at an average retention time of 1hr [16].

3.2.3 Performance of RBC reactor at initial COD concentration of 100 mg/L to determine optimum HRT at 45% Submergence and constant rpm as 4rpm

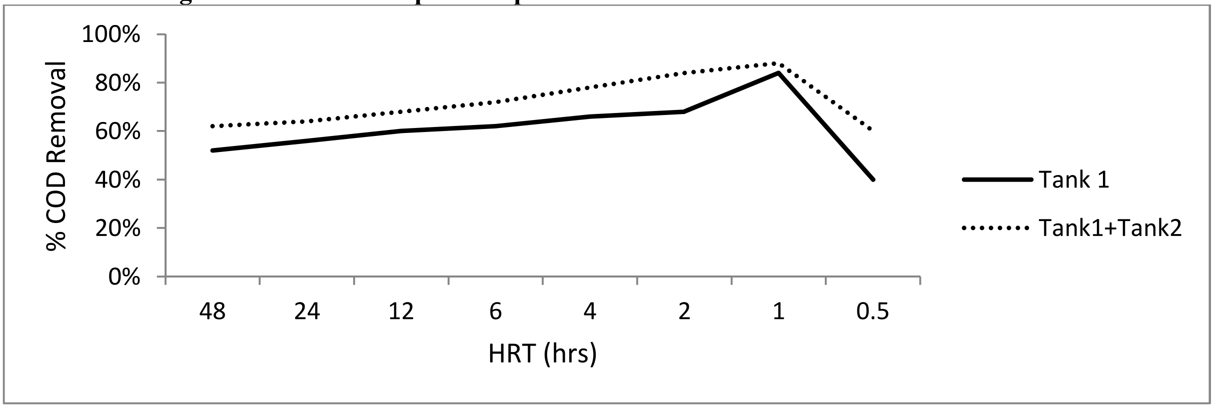

Fig 5: Variation in COD removal efficiency (%) in tank 1+ tank 2 combined during different HRT (hrs)

From the above table it can be considered that the maximum COD removal efficiency (%) was tank 1- 84% and tank 1+tank 2- 88% for 1 hr HRT. Hence optimum HRT 1 hr was fixed.

3.2.4Overall performance of RBC reactor for optimum HRT 1 hr at different COD concentrations (mg/L) at 45% Submergence and constant rpm as 4rpm

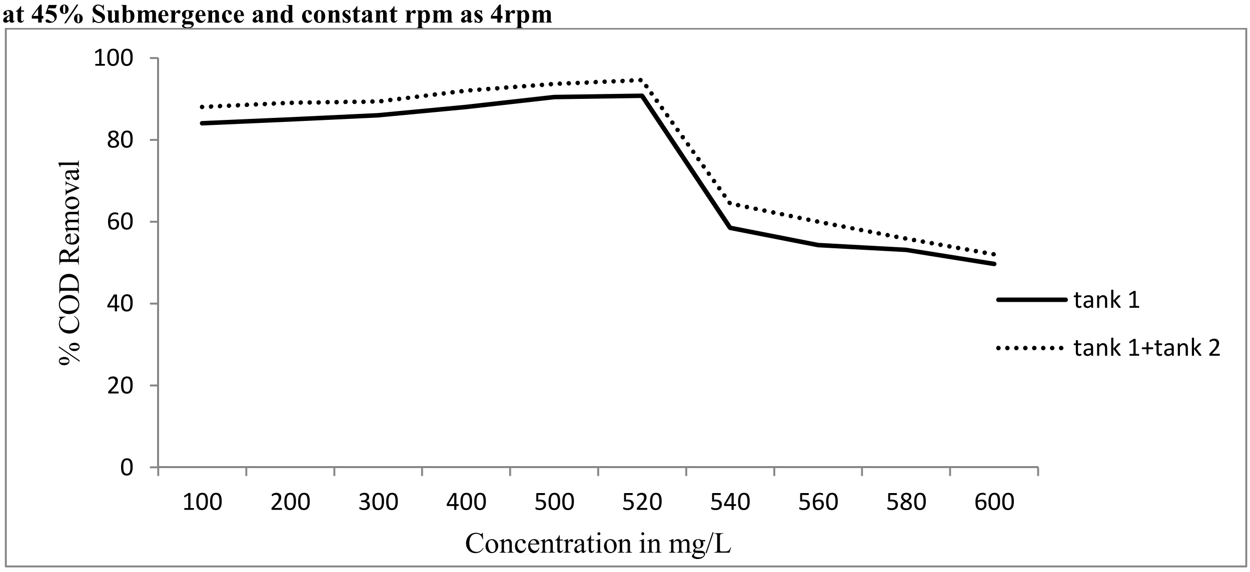

Fig 6: COD removal efficiency in % at different concentrations (mg/L)

From the above Graph it can be considered that the maximum COD removal efficiency (%) for tank 1- 90.76%, and for tank 1+tank 2- 94.6 Pradeep et al., reported the different percentage submergence of discs i.e., 40%, 35% and 30% to achieve 99% removal, the HRT's were i.e., 24, 28 and 32 hours respectively [11].Chen et al., achieved the COD and total nitrogen removal rates of 78.8–89.7% and 40.2–61.4%, respectively, in aerobic treatment of low COD municipal-type wastewater at hydraulic retention times (HRT) from 5 to 9 hrs [13]. Najafpour et al., reported 88% COD removal from palm oil mill effluent with 55 hrs HRT [14]. Ebrahimi et al., achieved 96% COD removal from dairy wastewater [15]. Coetzee et al., 2004 reported the reduction of COD of the winery effluent by 23% (from 3828 mg/L to 2910 mg/L) and increased the pH by 0.95 units (from 5.77 to 6.13) at an average retention time of 1hr [16].

4. Conclusions

Based on the observation and results obtained from this study, the following points were concluded:

1. When the disk submergence was 40%, the COD removal efficiency for tank1 was 90.31% and for tank1+tank2 were 93.8%. Hence optimum COD loading rate was 640 mg/L at optimum HRT of 2 hrs.
2. When the disk submergence was 45%, the COD removal efficiency for tank1 was 90.76 % and for tank1+tank2 were 94.6 %. Hence optimum COD loading rate was 520 mg/L at optimum HRT of 1 hr.
3. Comparing both the submergence, we can conclude that when the disk submergence was 45%, the removal

efficiency was more because the disc area is more in contact with sewage (i.e. air-water interface) due to larger surface area here food to microorganism ratio as well as air supplied will sufficient to treat sewage hence two stage RBC was more effective in treating sewage.

4. For small sewage treatment plant, the capital cost of attached growth process (RBC) is lower than suspended growth system (ASP) therefore; RBC can result in more savings for small communities.
5. The RBC is an efficient method of treating wastewater because of its simplicity to maintain and good sludge settling properties.

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