COMBINED SUSPENDED/ATTACHED GROWTH REACTOR: OXYGEN TRANSFER RATE

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ABSTRACT

Aeration is used for transferring oxygen to wastewater in order to enhance the biological treatment process. There are many of aeration instruments in the market that can be used in activated sludge reactor, which can be classified to either surface aerator of diffused air. The wastewater aeration in the attached growth reactor (rotating biological contactor "RBC" or trickling filter) is aerated through diffusion of air to water bubbles from the atmosphere.

A laboratory model simulating both suspended growth biological reactor and attached growth biological reactor was build in order to investigate the performance of the combined reactor. The RBC with fill and draw cups simulated the attached growth reactor, while the diffused air simulated the suspended growth reactor.

The present paper investigates the rate of oxygen transfer for four different configurations, three of them were tested using tab water and the forth set of experiment was made using primary treated wastewater. First configuration investigated the oxygen transfer rate while the rotating disks operate alone. The second configuration investigated the oxygen transfer rate while the diffused air are in operation alone, and the third configuration investigated the oxygen transfer rate while both of the rotating disks and the diffused air are in operation together. The forth configuration investigated the oxygen transfer rate while both of the rotating disks and the diffused air are in operation together, but using primary treated wastewater sample in stead of the tab water that had been used for the first three sets of experiments. Within the combined reactor the study showed better oxygen transfer rate can be get from the rotating biological contactor fill and draw rather than that of the diffused air system.

INTRODUCTION

The biological wastewater reactors are classified into attached growth and suspended growth. Much work has been carried out with the aim of determining the design parameters and kinetics relationships for RBC treating municipal wastewater, Grady 1983. More work has been made for the activated sludge. In fact biological reactors usually have void space and solid surface, suspended cells grow in void and biofilm grows on the surface. This combined growth concept was used to investigate the oxygen transfer rate for both of the aeration methods used representing the suspended growth and the attached growth.

Rotating biological contactor has some advantages over the trickling filter as its low power consumption, better wastewater contact time, effective sloughing, absence of nuisances, and effective aeration, Ronald, 1976.

Torpey, 1972 has made extensive work on the enriched oxygen atmosphere with RBC. His findings indicate that at high loading, when there may be an oxygen limitation on the initial stage of media, the use of enriched oxygen can approximately double biochemical oxygen demand removal rates. The relative cost of oxygen generation equipment limit the application.

The theory of oxygen transfer rate was originally developed by Lewis and Whitman, 1924. They considered stagnant films at the gas and liquid interface through which mass transfer occurs as follows;

$$N = K_L A(C_s - C_L) = K_g A(P_g - P)$$

Where
K_L = liquid film coefficient, = D_L/Y_L.
C_s = oxygen saturation concentration.
C_L= concentration of oxygen in the liquid.
K_g = gas film coefficient, = D_g/Y_g.
Y_L = liquid film thickness.
Y_g = gas film thickness.

Aeration equipment can be divided into two categories, the first one producing small bubbles from porous medium and the second category use large orifice of hydraulic shear device to produce large air bubbles. Large bubble air diffusion units will not yield the oxygen transfer efficiency of fine bubble diffusers since the interfacial area for transfer is concededly less. On the other hand, these units have the advantages of not requiring air filter and generally requiring less maintenance, and generally operate over a wide range of airflow per unit. The aim of the present work is to investigate the efficiency of oxygen transfer of the combined wastewater reactor.

EXPERIMENTATION

A laboratory scale model was constructed representing the combined growth reactor with a capacity of 90 liter. Rotating discs with fill and draw cups representing the RBC was made with diameter of 60 cm and rotating speed of 10 rpm. The fill and draw cups were made of PVC tubes of diameter 1.25 cm and length 15 cm. The diffused air system was used to represent the suspended growth reactor; a compressor was attached to ½ inch diffused air pipe with 11-outlet diffuser across the length of the reactor. The diffused airflow rate was about 0.1 m^3/min. Figure 1 shows a schematic diagram of the model illustrating all dimensions and arrangements.

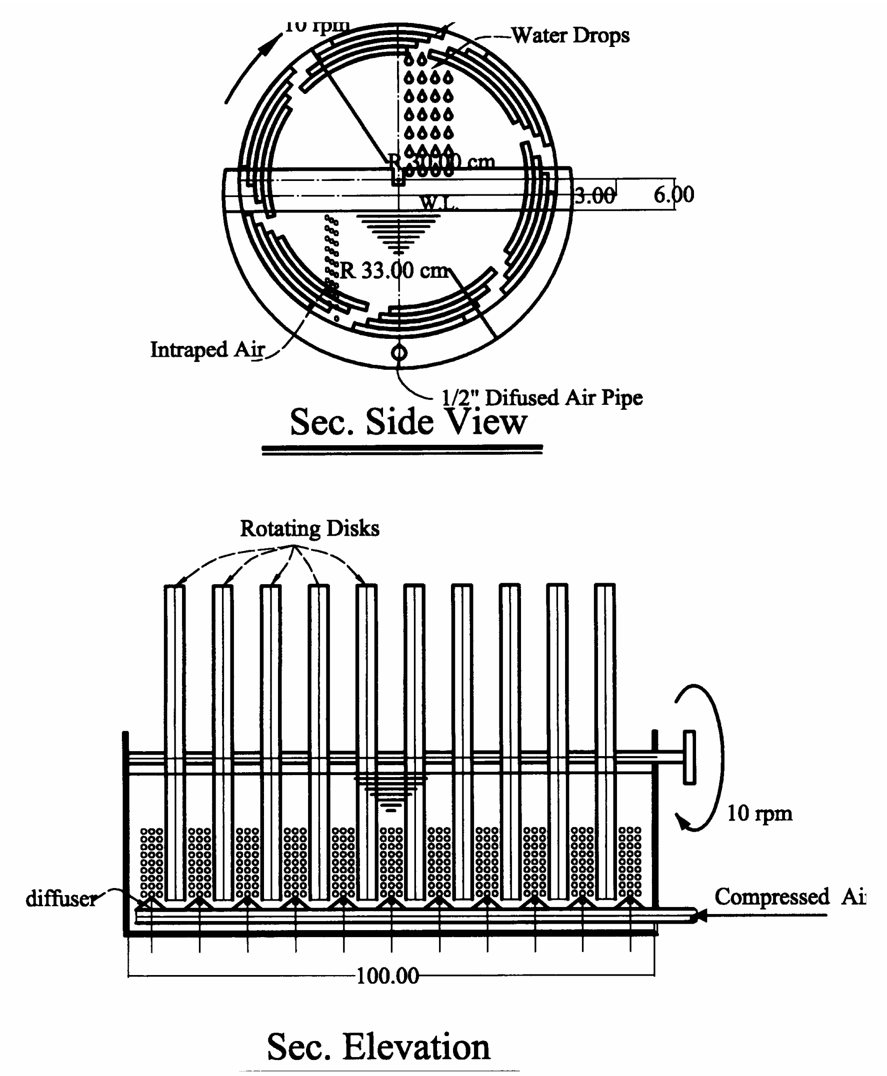

Figure 1 Sketch for the combined growth reactor model

RESULTS AND DISCUSSIONS

The non-steady state aeration procedure has been used in measurement of oxygen-transfer efficiency, Metcalf & Eddy Inc., 1979, as follows,

1- Removal of the dissolved oxygen in the reactor by adding about 6 gm/l of sodium sulfite and trace of cobalt chloride.
2- Mix the tank contents for two minutes.
3- Start the aeration units according to the different run listed below. Measurements of the D.O. were made with a dissolved oxygen meter of

accuracy of 0.01 ppm. The D.O. probe was left at the center of the reactor and the readings (D.O and temperature) were recorded until the D.O reached more than 90 % of the saturation value

4- The difference between the saturation and the measured D.O. was calculated and plotted with time and then the rate of oxygen transfer rates were calculated.

Four sets of oxygenation were made to investigate the rate of oxygen transfer. The first run the RBC was under rotation alone. In this run the oxygen sources were from the contact between the water film attached to the disks surface and the atmosphere, the diffusion of the oxygen from the atmosphere to the water drops from the cups in the rotating disks, and finally from the entrapped air from the cups in the rotating disks when going under the water surface. The second run was made with operating the diffused air only with a rate of about 0.1 m^3/min. The third run was made with both of the RBC and the diffused air under operation. The last run was made under operation of both aeration and using primary treated wastewater instead of tab water.

The following figures (2, 3, 4, and 5) show the time with the difference between the saturation dissolved oxygen and the measured dissolved oxygen for the above mentioned four runs respectively. The reading were fitted using the least square method to exponential equation, and the get the best curve fit equation and the coefficient of regression is shown for each run.

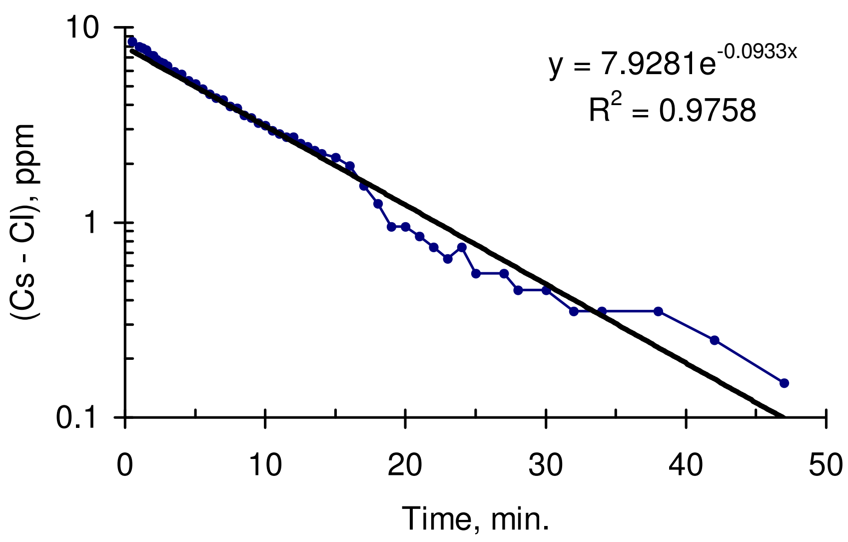

Figure 2 Oxygenation for the tab water with RBC system only

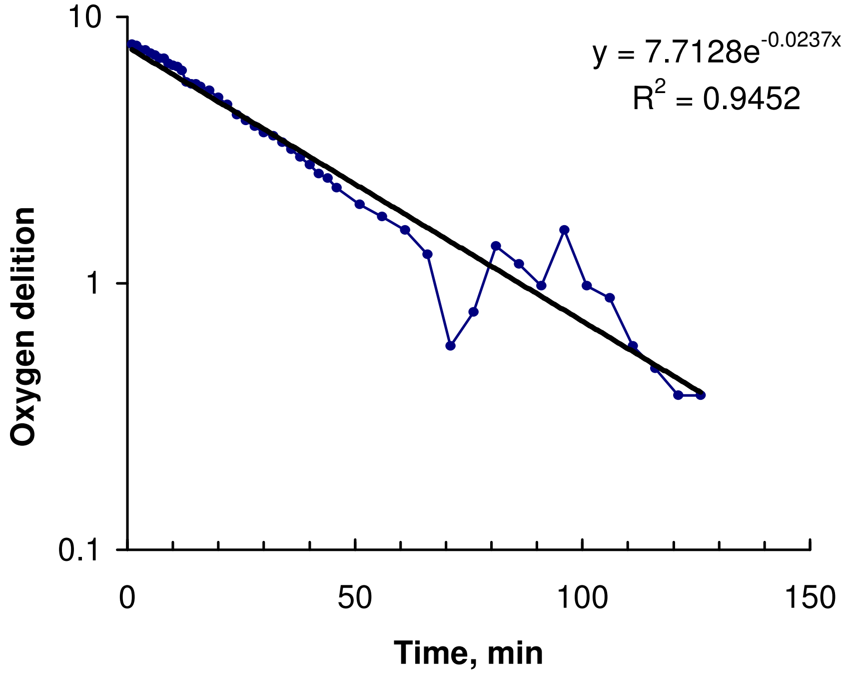

Figure 3 Oxygenation for the tab water with diffused air system only

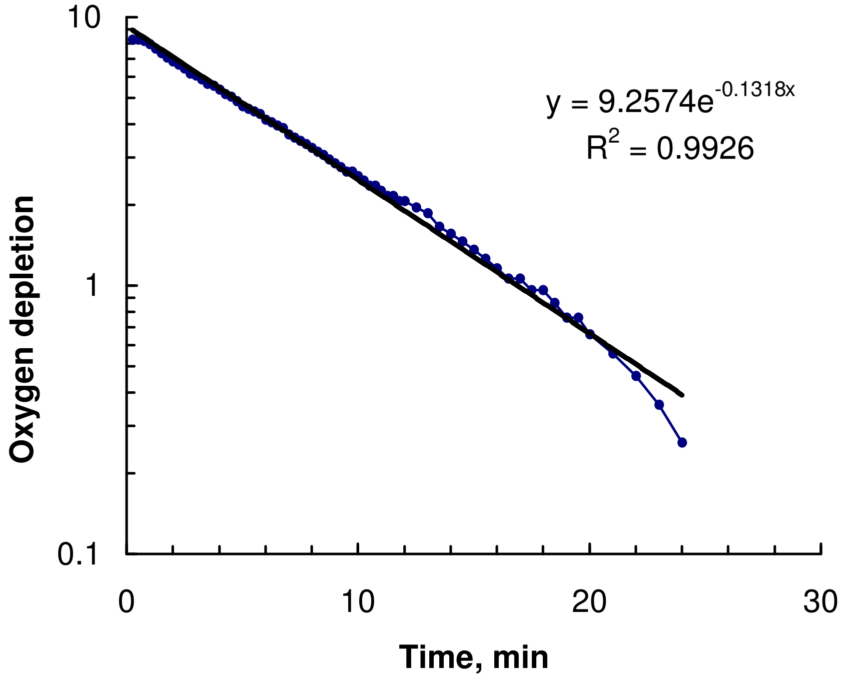

Figure 4 Oxygenation for tab water using the combined system

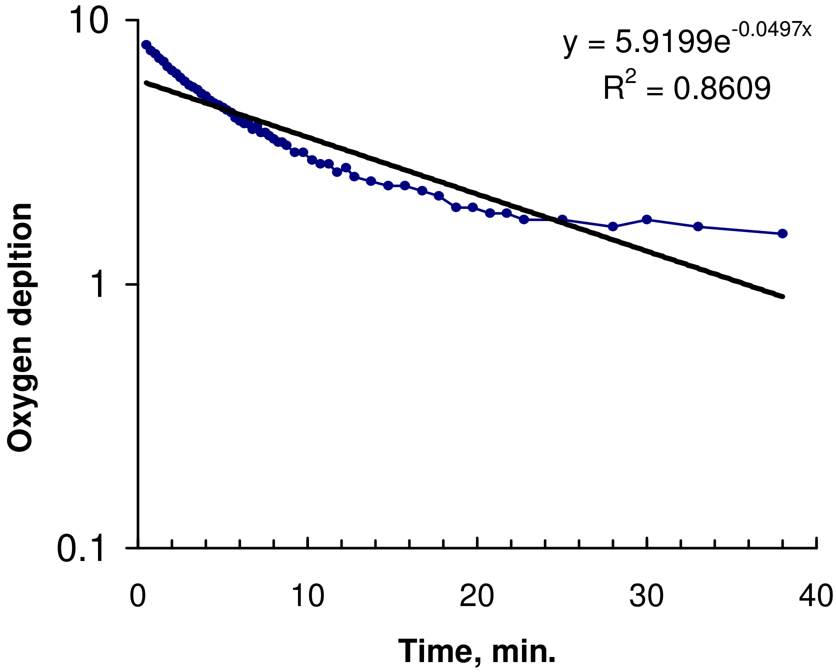

Figure 5 Oxygenation for the primary treated wastewater using combined aeration system

The rate of oxygen transfer, $K_{La,}$ is the slope of the line. The values of K_{La} of the RBC is much higher than that of the diffused air and this may be due to the different source of oxygenation in the tested RBC system mentioned above. Also, it was noticed that the rate of oxygen supply for the primary treated wastewater is about 40 % of that value for the tab water, and this may be attributed to the consumption of the microorganisms in the wastewater sample.

CONCLUSIONS AND RECOMMENDATIONS

Based on the experiments made and their condition the following conclusions can be made:

1- The used RBC system (fill and draw cups) has three sources of oxygen supply to the system and showed better aeration than the diffused air system.
2- A reduction factor of 60 % shall be applied for the oxygen transfer rate if it was based on tab water to consider the microorganism's oxygen uptake in the wastewater.
3- It is recommended to investigates the mixing regime of the system used in order to be able to have a base for the design of such system. In addition testing the system for the organic matter removal and the nitrification process is required.

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