Aerobic Biotreatment of Hospital wastewater

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Abstract

This study aimed to use aerobic packed bed in biotreatment of the wastewater that discharge from AL-KARAMA hospital in Baghdad. The performance of packed-bed was examined for elimination of the organic compounds from wastewater under aerobic conditions. The parameters studied were: inoculums concentration, wastewater circulation rate through the bed, packing type and the temperature. The results show that the system efficiently removed about 82% of the chemical oxygen demand (COD) and 80% of Biological oxygen demand (BOD), while percent reduction in turbidity was about 92% and reduction in nitrate concentration was about 87%. It was found that temperature of 37^{o}C , circulation rate of 10 L/min and inoculums concentration of 3% gave the best results for biotreatment of wastewater.

Key words: Packed bed, wastewater treatment, BOD, COD

Introduction

Hospital wastewater contained various types of potentially hazardous and toxic materials, such as microbial pathogens, chemicals, disinfectants and pharmaceuticals [1]. The characteristics required proper processing system in order to limit negative impacts on the environment and outside hospitals. These chemical compounds can provoke the pollution of the natural environment by entailing a biological imbalance. So it seems important to consider upstream treatments to hospital wastewater before their discharge in the municipal sewage system.

Biological treatment methods have traditionally been used for the management of pharmaceutical wastewater. They may be subdivided into aerobic and anaerobic processes [2]. Aerobic applications include activated sludge, membrane batch reactors and sequence batch reactors. Anaerobic methods include anaerobic sludge reactors, anaerobic film reactors and anaerobic filters. A number of pilot scale studies were conducted using Sequence batch reactors (SBRs) and Membrane bioreactors (MBRs) in an attempt to improve the effectiveness of treatment. [3,4]

The wastewater characteristics play a key role in the selection of biological treatments. Solvents, activated pharmaceutical ingredients (APIs), intermediates and raw materials represent biologically recalcitrant substances which affect the efficiency of biological treatment systems. [5,6]

The purpose of this research was to study the performance of packed bed system in removal of pollutants from AL-KARAMA hospital wastewater under several operating conditions of the system.

Material and methods

Packed bed system:

The experimental system was designed and installed in the institute of Genetic engineering and Biotechnology / University of Baghdad. The system treatment capacity of AL-KARAMA hospital wastewater was 40 L/day.

Fig.(1) shows a schematic diagram of the packed bed reactor ,which is constructed of 10" polyethylene cylinder of 25 cm diameter and 150cm high. The bed is fitted with a sampling point. Feed streams into the bed are air and wastewater .The air stream is uniformly bubbled in the liquid phase via perforated tube to provide oxygen for microorganisms and to create a mixed wastewater, while the feed wastewater is pumped to the top part of the bed and distributed through the packing. As a result, gas bubbles coales and escape through the top of the bed, while the liquid flows toward the bottom of the bed.

Microorganisms in the aerated packed bed grow and degrade organic matter contained in the wastewater. After several circulations of liquid product through the bed, the liquid exit from the bottom of the bed through a bottom port. The feed wastewater is kept in the feed tank which fitted with an immersion heater to maintain constant temperature through the experiment. Also another immersion heater is positioned in the top of the bed to ensure temperature uniformity. Flow rate of liquid through the bed is achieved by the use of a variable speed Watson Marlo pump.

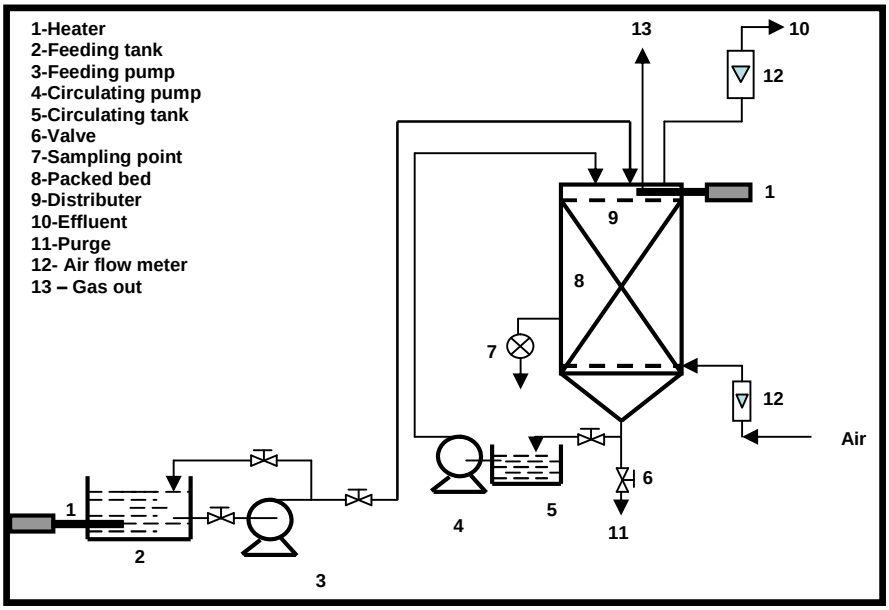


Fig. (1): Schematic diagram of the fixed film packed bed bioreactor.

Collection of samples:

Sterile 500 ml glass bottles were used to collect effluent sample from the system of treatment. Samples were collected every five hours during the study period. Duplicate samples were collected and stored in a refrigerator. After collection all the samples were processed.

2.3- Material and Analytical Instruments

Operation of packed bed required preparation of the wastewater feed. The wastewater was prepared and mixed in the feed tank with inoculums of isolate *Klebsiella pneumonia* (previously isolated and diagnosed). Part of this wastewater was pumped through the system to fill the bed. During the initial preparation period temperatures of both immersion heaters were adjusted and kept constant to reach steady state conditions. Then followed by adjustment of the air feed flow rate. Finally, nutrients, (NaCl-8gm/L, K_2HPO_4-1.21 gm/L, KH_2PO_4-0.34 gm/L with pH 7.3), were added to sustain proper growth of microorganism cells. Experimental measurement starts with addition of the wastewater through the top of the bed, where cells are attached to the packing by covalent bonding. A period of time (4-10 hr) is allowed for complete contact and bonding before flow of fresh medium is started [7]. After that the feed pump is operated and flow through the bed is allowed to circulate several times, and then exit the bed via bottom opening. Liquid samples are taken at constant time interval from the sampling point in the bed. COD, BOD, turbidity, NH_4-N and pH were measured in accordance with the standard methods [8]. The operating parameters throughout the experiments were:

Air flow was fixed at 120 L /hr.
Total hold up was 25 lit
Liquid circulation rate: 2– 10 L/min
Temperatures: 25, 37, 45 ^oC

3- Results and discussion

Wastewater samples were collected from AL-KARAMA hospital sewage. The composition of the wastewater is presented in Table (1).

Table (1): Characteristics of wastewater from AL-KARAMA hospital.

Item	Measured value
COD	470- 490
BOD_5 (mg/L)	270-285
NH4+-N (mg/L)	15-20
Turbidity (NTU)	80 -100
pH	6-8
TSS (mg /lit)	250
TDS (mg/lit)	390

The following analysis focuses on characterization of biotreatment systems of hospital wastewater microorganisms in a packed bed reactor. To accomplish this task several experiments were performed covering different conditions. The parameters studied in this analysis were; inoculums concentration, wastewater circulation rate, bed temperature and packing type.

Effect of inoculums Concentration

Three values of inoculums concentration of isolate *Klebsiella pneumonia* (previously isolated and diagnosed) were used in this study. These values were 1%, 2% and 3%. Fig.(2) shows that the values of BOD is decreased with increasing the concentration of inoculums. This behavior is caused by the higher growth rate of microorganisms at high values of inoculums concentrations which lead to higher rate of organic matters degradation in wastewater. This effect is agreed with the results reported by Madukasi [9].

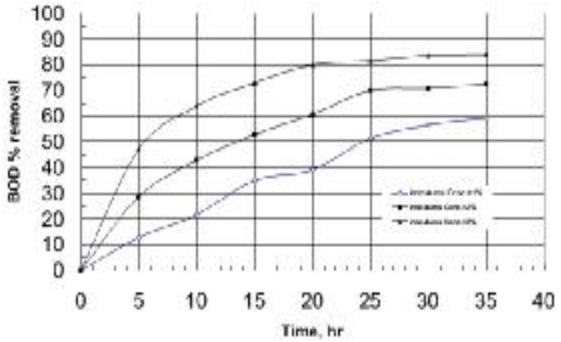


Fig.(2); Effect of inoculums concentration on BOD removal. (Circulation rate =10 L/min., T=37°C, packing is olypropylene mesh, 20 mesh.)

Effect of circulation rate

Three values of circulation rates were tested; 4, 6 , 10 L/min. Fig.(3) shows that the rate of decreasing COD is higher when circulation rate is increased. Circulation rate of 10 L/min. gave higher removal of COD.

Turbidity of wastewater was also studied at different circulation rates. Fig.(4) shows that using circulating rate of 10 L/min results in about 92% removal of turbidity. Oktem[10]. reported that increasing circulation rate leads to decreasing in turbidity. Also Fig. (5) shows 85% removal of nitrate concentration occurs at 10 L/min circulation rate the point which in agreement with that mentioned by Suarez (11). This behavior can be interpreted as high circulation rate leads to high turbulence within the circulating eddies of the liquid and increase in rate of aeration and growth of microorganisms. So more broth organic is degraded.

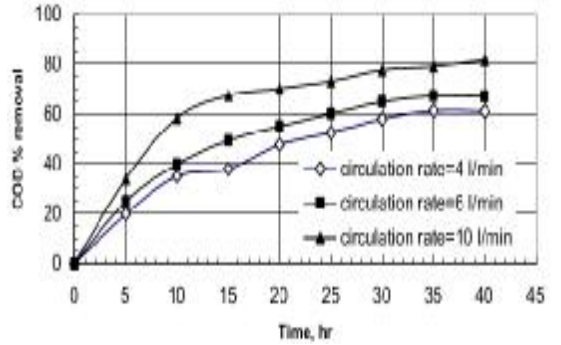


Fig.(3): Effect of circulation rate on COD removal. (Inoculums conc. =3%, T=37°C, Packing is Polypropylene mesh, 20 mesh.)

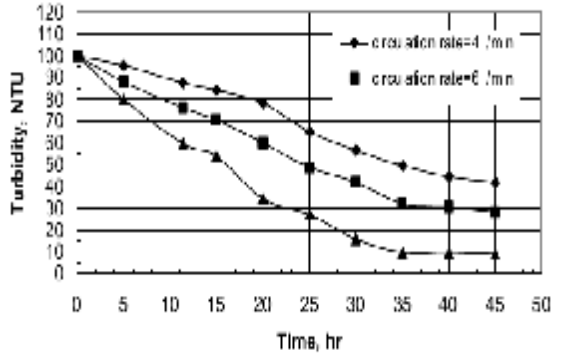
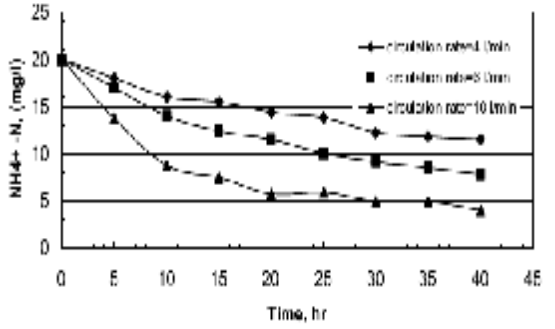


Fig. (4): Effect of circulation rate on turbidity of wastewater. (Inoculums conc. =3%, T=37°C, packing is Polypropylene mesh, 20 mesh.)



Fig(5) : Effect of circulation rate on Nitrate concentration. (Inoculums conc. =3%, T=37°C, packing is Polypropylene mesh, 20 mesh.)

Effect of temperature

Fig. (6) shows the effect of temperature upon the action of the microorganisms in degradation of organic matters in the wastewater. The results show that the removal efficiency of BOD is increased as the temperature increases from 25°C to 37°C but it decrease when the temperature is increased to 45°C. This is due to the effect of temperature on the activity of the microorganisms. It is well known that temperature above 40°C affects the membrane composition of microorganisms, e.g. the phospholipids fatty acid composition changes with temperature and hence affect the enzymatic system of the bacteria. This leads in turn to decreasing the removal of BOD. So the best operating temperature is about 37°C. This result is agreed with the results reported by Dalrymple [12] who reported that 37°C is the best temperature for treatment.

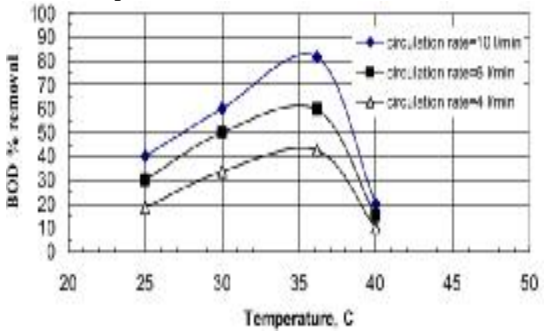
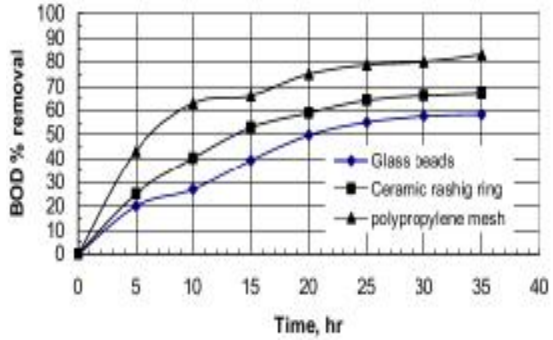


Fig.(6); Effect Temperature on BOD removal. (Time =35 hr, Inoculums conc. =3%, Circulation rate = 10 L /min., packing is Polypropylene mesh, 20 mesh.).

Effect of Packing Type

Three types of packing were used in this study. They are; 1- Polypropylene mesh (20 mesh). 2- Ceramic rashig ring (1/4 in). 3-glass beads (1cm). Fig.(7) shows that packing type of polypropylene mesh gives most decrease in value of COD about 83%, while glass beads give the lowest value of percent removal (55%) . That is because the packing which provide adequate interstitial space for cell entrapment, such as mesh packing, result in faster biomass loading rates. Also the roughness of the packing is a factor as noted in the comparison of the glass and ceramic rashig rings. Although all packing surface were coated with gelatin to assure a monolayer of cells, polypropylene mesh enable a better coating and provided spaces for subsequent layers of the cell to accumulate [13].



Fig(7): Effect of packing type on BOD removal. (Inoculums conc. =3% , circulation rate = 10 L /min., T=37 ^{o}C.)

Conclusions

1- The removal efficiency of BOD is increased as the concentration of isolate inoculums of *Klebsiella pneumonia* increased. Concentration of inoculums of 3% gives the best result.

2- Packing type of Polypropylene mesh (20 mesh) gives highest value of BOD removal efficiency which reaches to about 83%.

3- BOD removal efficiency is increased as the circulation rate of wastewater through the bed increased.

4- Turbidity and Nitrate concentration are reduced with increasing circulation rate. The best circulation rate through the bed is 10 L/min.

5- Optimum BOD removal efficiency occurs at about 37^{o}C.

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المعالجة الحيوية الهوائية لمياه صرف المستشفيات

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الملخص:

تهدف هذه الدراسة الى استخدام العمود المحشو للمعالجة الحيوية الهوائية لمياه الصرف الصحي الخارجة من مستشفى الكرامة الواقعة في بغداد. في هذا البحث تم اختبار اداء عمل العمود المحشو في ازالة وتحلل المركبات العضوية من مياه الصرف تحت ظروف هوائية. المتغيرات التي تم دراستها تتضمن تركيز اللقاح ،معدل تدوير المياه الملوثة خلال العمود ،نوع الحشوة المستخدمة ودرجة الحرارة. بينت النتائج ان الجهاز يزيل تقريبا 82% من الاوكسجين الطلوب كيمياويا (COD) وكذلك 80% من الاوكسجين المطلوب حيويا (BOD). بينما كانت نسبة ازالة العكورة 92% ونسبة ازالة ايونات النتروجين بحدود 87%. اوضحت النتائج العملية ان درجة حرارة 37م ْ ومعدل تدوير 10 لتر / دقيقة وتركيز لقاح 3% تعطي افضل النتائج لمعالجة مياه الصرف.