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SLAUGHTERHOUSE WASTEWATER TREATMENT USING AEROBIC SEQUENCING BATCH BIOFILM REACTOR

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ABSTRACT

The bench scale sequencing batch biofilm reactor (SBBR) has been applied for treatment of wastewater of a local slaughterhouse in Mansoura. Six slaughterhouse wastewater samples were placed in the reactor and aerated and examined. The BOD (biochemical oxygen demand) and COD (chemical oxygen demand) and pH and temperature were determined. Experiments were performed to study the relationships between pH, and COD and BOD and biofilm carrier's area in six slaughterhouse wastewater samples. Influent BOD ranged from 1500 to 3000 mg/ℓ and effluent BOD concentration was generally about 50 mg/ℓ in most cases. The sequencing batch biofilm reactor represents an efficient system for treatment of slaughterhouse wastewater.

Key words : *Slaughterhouse wastewater, Aerobic treatment, Sequencing.*

INTRODUCTION

The quantity of slaughterhouse wastewater mainly depends on the design, location ,area , operation practices, and the cleaning methods used or blood disposal method .

Slaughterhouse effluent contains high levels of organic matter due to the presence of manure, blood and fat. It contains high levels of total organic carbon (TOC) ,suspended solids, phosphorus is originated due to the presence of manure and stomach contents in the effluent and the presence of blood in wastewater, contribute to higher level organic contaminants.(Hossaini *et al.,* 2013) .

Slaughterhouse wastewater is very harmful to the environment. (Masse' and Masse 2000). Effluent discharge from slaughterhouses has caused the deoxygenation of rivers (Quinn and Farlane 1989) and the contamination of groundwater (Sangodoyin and Agbawhe 1992).

For large-scale slaughterhouses, on-site biological treatment is recommended to remove organic carbon and nutrients before the wastewater is discharged to surface waters or local wastewater treatment plants (EC, 2005) .

The selection of wastewater treatment

process is based on the qualities of effluent and influent volume and type of influent, investment and operating costs and so on (Ruiz *et al.,* 1997).

Sequencing batch reactor (SBR) is a fill-and-draw activated sludge treatment system that could be applied for treating organic wastewater (Keller *et al.,* 1997; Carucci et al., 1999; Laughlin *et al.,* 1999).

The sequential batch reactors (SBR), are distinguished by their adaptability to varying conditions, since individual treatment phases can be easily modified, exchanged, added or removed. They are able to remove carbon, nitrogen and phosphorus in one single unit under properly controlled conditions (Brito *et al.,* 2006; Rodrigues *et al.,* 2001; Wilderer *et al.,* 2001).

The SBR system still has some disadvantages such as high excess sludge produced and high sludge volume index (Burnett *et al.,* 1997) .

The SBR can be combined with biofilm growth on the surface of a support material, originating the sequencing batch biofilm reactor (SBBR). In SBBR systems, high concentrations of biomass can be maintained independently by settling characteristics of the biological aggregates and hydraulic retention time of the reactor (Nicolella *et al.,* 2000) .

As the SBBR system was operated under relatively high concentration of biomass (3000-7000 mg/ℓ), therefore in addition to biological activity of the sludge, its physical characteristic was of high significance. Many researchers recognize SVI (Sludge Volume Index) as the best parameter characterizing sludge settling properties. SVI is also a good indicator of sludge bulking. A proper SVI value, especially below 100 mg/l, is of major importance in the activated sludge systems (Tyagi, 1990).

Sirianuntapilboon *et al.* (2005) reported that a SBBR system could increase COD removal efficiency, improve sludge quality, reduce the amount of excess bio-sludge, and also reduce acclimatization period of the system. Startup of the SBBR system was 2–3 days faster than the SBR system in reaching steady state.

The SBBR was a successful, reliable and promising biological treatment system to achieve high COD removal efficiency (Zinatizadeh *et al.,* 2011) . The biofilm grown on a carrier material suspended in an aeration tank has several advantages over other conventional systems: the reactor does not need sludge or a water recirculation system to reach high microorganisms concentration (Qdegaard *et al.,* 1994) .

Aerobic treatment involves the degradation of organics by microorganisms in the presence of oxygen. The systems require daily maintenance by a trained technician and daily drainage of accumulated sludge (Masse’ and Masse 2000). Microorganisms require free dissolved oxygen to reduce the biomass in the wastewater. The biological sludge must be treated before disposal (Johns, 1995). Aerobic treatments are very effective at reducing odours and pathogens (Skjelhaugen and Donantoni, 1998).

EXPERIMENTAL SETUP

Slaughterhouse wastewater was collected from Mansoura local slaughterhouse in Mansoura in 10ℓ plastic containers. The samples were collected in the morning or early afternoon. The untreated (raw) wastewater was sampled after the screening or settling of coarser solids. The laboratory-scale SBBR was constructed at the Sanitary Engineering Laboratory, Mansoura University, (Figure1) shows the experimental setup of the present study. The reactor was made up as a rectangular shaped from plexyglas material of volume 150ℓ. The configuration of the laboratory-scale sequencing batch biofilm reactor (SBBR) system was the same as that of SBR system, but only seven steel biofilm carriers were added in the reactor. The biofilm carriers have a nominal diameter 30 cm and each biofilm carrier has a steel frame supporting a steel net plain with a plastic arm. The biofilm carriers were fixed using a steel bar inside the reactor. The effective surface area of the biofilm carriers that is available for biofilm growth is 1.0 m^2. The system was equipped with three air bubble diffuser systems (model, JAD U9900) during the treatment transferred about 0.2 liters of oxygen per minute. The reactor was seeded by bacteria from a local water treatment plant. The system was run for about 30 days with synthetic wastewater to complete the formation of biofilm on the carriers. The synthetic wastewater has been used in the present experiment in which one litre of this waste consisted of 300 mg/ℓ of molasses and 100 mg/l of glucose a source of carbon, as well as some traces of $(NH_4)2SO_4$(30 mg/ℓ as NH_4-N), NaH_2PO_4(31 mg/ ℓ asPO_4-P), 50 mg/ℓ yeast extract, $NaHCO_3$ (1,075 mg/ℓ as $CaCO_3$ alkalinity) as source of nutrient (Moharram and Renu 2005a, b & c; 2012). The synthetic wastewater was prepared once every week and stored at 4℃ in a refrigerator and used along the week. The slaughterhouse wastewater was added in the sequencing batch biofilm reactor of 120 ℓ and each sample was observed for a day time and samples taken at different retention times (4,8,12, 18,24 hrs). The different samples were examined (COD , BOD , pH and temperature).

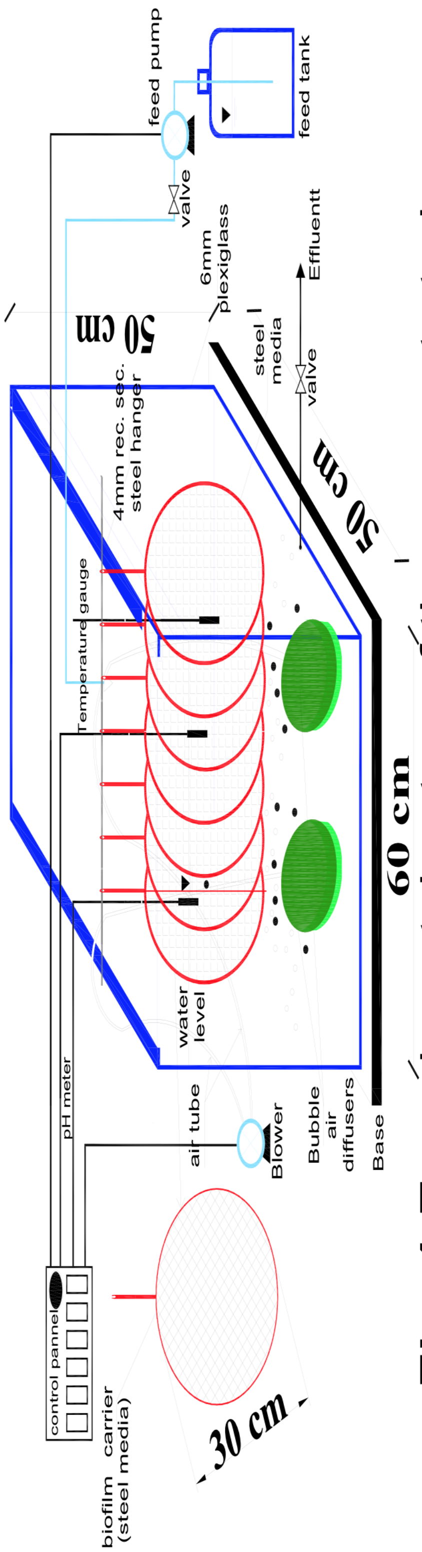

Fig. 1 Experimental setup of the present study

RESULTS AND DISCUSSION

Blood is rich in BOD, chlorides, and nitrogen. It has an ultimate BOD of 405,000 mg/ℓ and a BOD5 between 150,000 and 200,000 mg/ℓ (Waste education series, 2012). However in slaughterhouses, blood is mixed with large amount of washing water so the BOD may decrease to 1500 - 3000 mg /ℓ . The composition of six slaughterhouse wastewater samples is given in Table 1.

Table (1) : 1 Charateristics of wastewater samples from a local slaughterhouse at Mansoura.

SAMPLE No.	COD mg/	BOD mg/	PH	temp°C
1	3422	1556	6.7	29.5
2	5467	2485	7.2	31.0
3	4982	2265	5.9	31.0
4	6570	2986	5.5	33.0
5	4980	2264	8.0	30.0
6	8000	3636	5.9	35.0

Treatment under constant biofilm carrier's area :

Effect of retention time on COD:

Figure 2 shows the relationship between COD in mg / ℓ and retention time (R.T.) in hours under constant biofilm carrier's area (85 cm^2 / ℓ wastewater) and different initial BOD values (2485 ,2265 ,1555 ,2986 ,2264 ,3636 mg/ ℓ). The present study indicates that for wastewater treatments, an ultimate COD degradation of approximately 75.5% occurred at approximately 10 hours retention time. Generally, the 12 hours retention time showed the best removal performance because the following COD values have not experienced a significant change. COD is the total measurement of all chemicals (organics & in-organics) in the water / wastewater which the bacteria dissolve by the time. So the COD decreases by the time passage.

Effect of retention time on pH and temperature:

Figure 3 shows the relationship between pH and retention time (R.T.) in hours under constant biofilm carrier's area (85 cm^2/ ℓ wastewater) and different initial BOD values (2485, 2265, 1555, 2986, 2264, 3636 mg/ℓ). It was observed that the wastewater became more acidic as the retention time passage because of the formation of some acids as a result of the aerobic treatment interactions.

Effect of retention time on COD removal efficiency:

Figure 4 shows the relationship between COD removal efficiency percent and retention time (R.T.) in hours under constant biofilm carrier's area (85 cm^2 /ℓ wastewater) and different initial BOD values (2485, 2265, 1555, 2986, 2264, 3636 mg/ℓ). After 12 hrs R.T. the best removal efficiency value of the treatment was observed. COD is the total measurement of all chemicals (organics & in-organics) in the water / wastewater which the bacteria dissolve by the time . So the COD decreases by the time , also the COD removal efficiency increases by the time .

Effect of retention time on BOD:

Figure 5 shows the relationship between BOD in mg / ℓ and retention time (R.T.) in hours under constant biofilm carrier's area (85 cm^2 / ℓ wastewater) and different initial BOD values (2485, 2265, 1555, 2986, 2264, 3636 mg/ ℓ). It was observed that BOD deceases by time. Maximum decrease was obtained at 12 hrs R.T. The BOD values depends on the dissolved organic matter in the wastewater samples. The BOD is a measure of, the amount of oxygen that require for the bacteria to degrade the organic components present in water / wastewater so by time the bacteria needs more oxygen to dissolve the organic matter in wastewater so BOD decreases.

Treatment under variable carrier's areas:

Effect of retention time on COD:

Figure 6 shows the relationship between COD in mg / ℓ and retention time (R.T.) in hours under variable biofilm carrier's area (0, 35, 60, 85 cm^2 / ℓ wastewater) and constant initial BOD (3000 mg / ℓ). As the biofilm carrier's area decreases, the COD decreases for the same retention time. COD is the total measurement of all chemicals (organics & in-organics) in the water / wastewater which the bacteria dissolve by the time. So the COD decreases by the time passage.

Effect of retention time on COD removal efficiency:

Figure 7 shows the relationship between COD removal efficiency percent and R.T. in hours under variable biofilm carrier's area (0, 35, 60, 85 cm^2 / ℓ wastewater) and constant initial BOD (3000 mg / ℓ). As the biofilm carrier's area decreases, the COD removal efficiency decreases for the same retention time. COD is the total measurement of all chemicals (organics & in-organics) in the water / wastewater which the bacteria dissolve by the time . So the COD decreases by the time , also the COD removal efficiency increases by the time passage.

Effect of retention time on BOD:

Figure 8 shows the relationship between BOD in mg / ℓ and retention time (R.T.) in hours under variable biofilm carrier's area (0, 35, 60, 85 cm^2 / ℓ wastewater) and constant initial BOD (3000 mg / ℓ). As the biofilm carrier's area decreases, the BOD decreases for the same retention time. The BOD values depends on the dissolved organic matter in the wastewater samples. The BOD is a measure of, the amount of oxygen that require for the bacteria to degrade the organic components present in water / wastewater so by time the bacteria needs more oxygen to dissolve the organic matter in wastewater so BOD decreases.

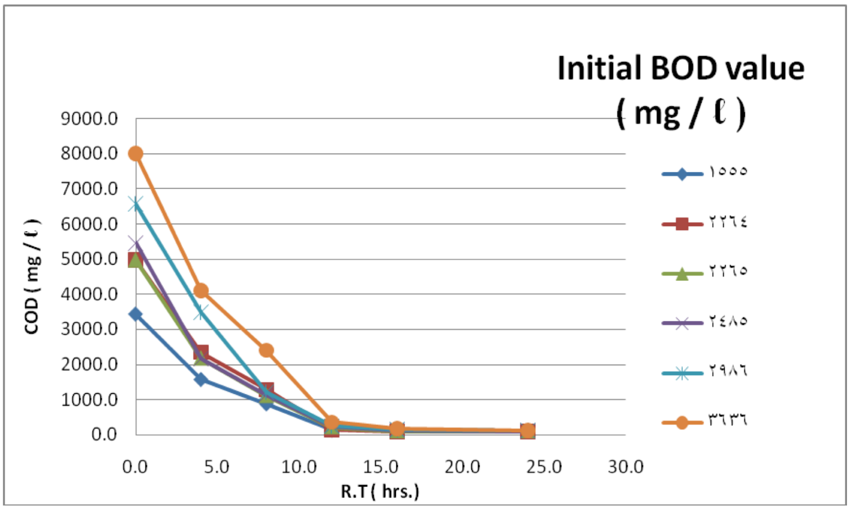

Fig. (2) : The relationship between COD and R.T. under constant biofilm carrier's area (85 cm^2 / ℓ wastewater) and different initial BOD values.

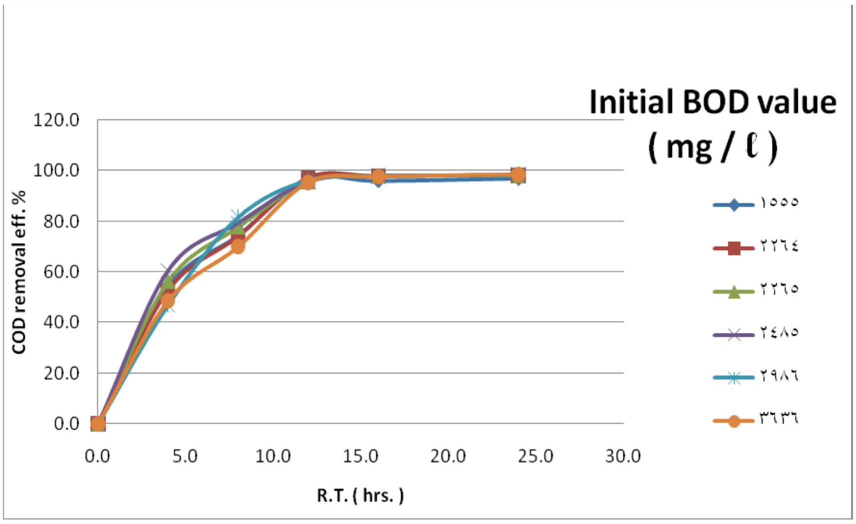

Fig. (3) : The relationship between COD removal efficiency percent and R.T. in hours under constant biofilm carrier's area (85 cm^2 / ℓ wastewater) and different initial BOD.

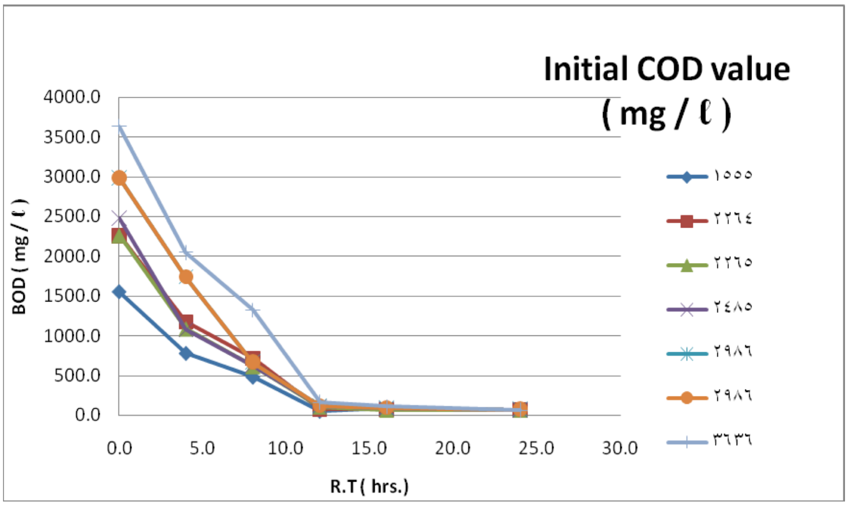

Fig. (4) : The relationship between BOD in mg / ℓ and R.T. in hours under constant biofilm carrier's area (85 cm^2 / ℓ wastewater) and different initial BOD values.

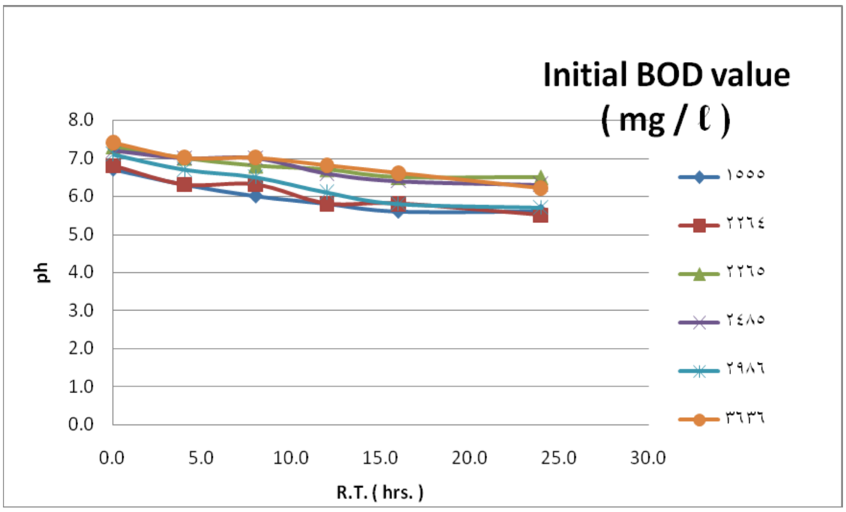

Fig. (5) : The relationship between pH and R.T. in hours under constant biofilm carrier's area (85 cm^2 / ℓ wastewater) and different initial BOD values.

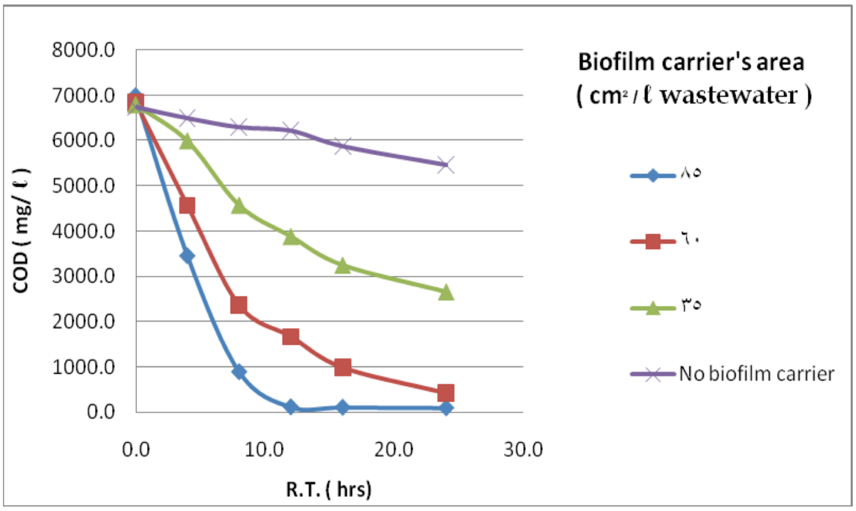

Fig. (6) : The relationship between COD in milligram / liter and R.T. in hours with variable biofilm carrier's area (cm^2/ ℓ wastewater) and constant initial BOD value 3000 mg/ ℓ

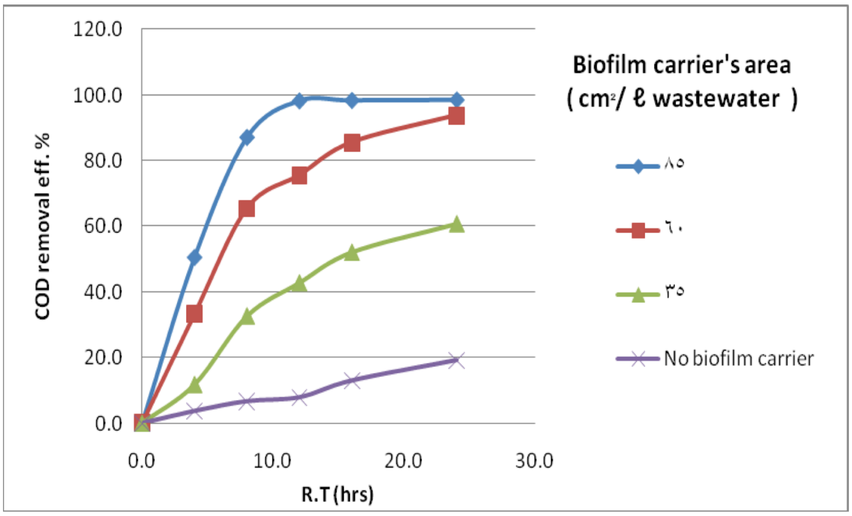

Fig. (7) : The relationship between COD removal efficiency percent and R.T in hours with variable biofilm carrier's area (cm^2 / ℓ waste-water) and constant initial BOD value 3000 mg/ ℓ .

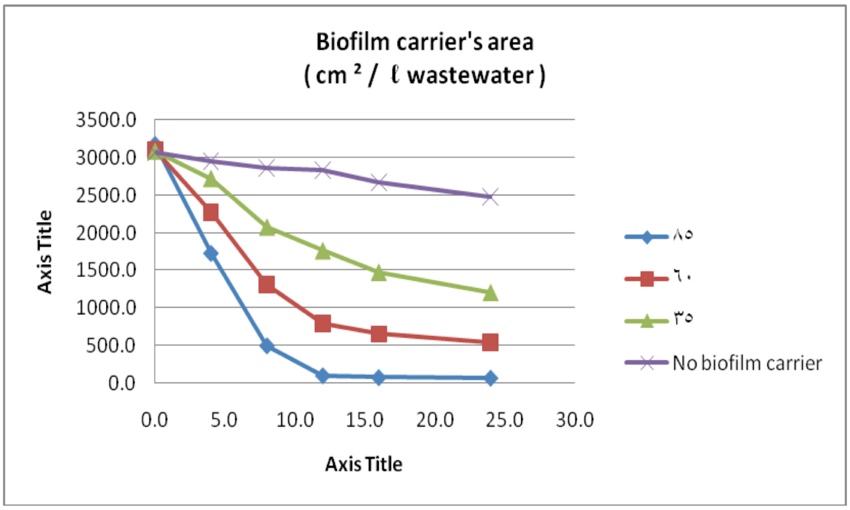

Fig. (8) : The relationship between BOD in milligram / liter and R.T. in hours with variable biofilm carrier's area (cm^2/ ℓ wastewater) and constant initial BOD value 3000 mg/ ℓ .

CONCLUSION:

It was found that under constant biofilm carrier's area, maximum degradation of COD and maximum decrease in BOD occur after 12 hours retention time. It was also observed that wastewater become more acidic as the retention time increases. Under constant retention time, both COD and BOD decrease as the biofilm carrier's area increases.

The SBBR proved to be a very flexible tool, and was particularly suitable for the treatment of slaughterhouse wastewater; characterized by high nutrient content and by frequent changes in composition and therefore affecting process conditions.

Experiments were performed to study the relationships between pH, and COD and BOD and biofilm carrier's area in six slaughterhouse wastewater samples. Influent BOD ranged from 1500 to 3000 mg/ ℓ and effluent BOD concentration was generally about 50 mg/ℓ in most cases.

Sequencing biofilm batch reactors represent efficient system of wastewater treatment in slaughterhouse and meet environmental standards. The system requires a daily maintenance by a trained technician and daily drainage of accumulated sludge. Water used in slaughterhouse must be sterilized to avoid infection by harmful viruses and bacteria.

This study established that systemizing and standardizing a model-based optimization of SBBRs. (Sequencing batch biofilm reactor) is important to ensure an objective and detailed search for an optimal optimal operating operating strategy and for internal quality check also to compare different optimization studies.

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الملخص العربى

معالجة مياه صرف المجازر باستخدام المفاعل ذو الدفعات والنمو

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تم تطبيق المفاعل المتسلسل ذو الدفعات والنمو الملتصق (SBBR) لمعالجة مخلفات المجازر السائلة من أحد المجازر المحلية بالمنصورة . وضعت ستة عينات من مخلفات المجزر السائلة في المفاعل مع التهوية لمدة يوم كامل . تم تحديد (BOD) الطلب البيوكيميائي على الأكسجين و (COD) الطلب الكيميائي على الأكسجين و (pH) الرقم الهيدروجيني و درجة الحرارة . وقد أجريت تجارب لدراسة العلاقات بين درجة الحموضة، ومحتوي COD و BOD ومساحة حامل البيوفيلم في مجزر محلي على عينات من المخلفات السائلة الناتجة من المجزر. وباختبارها وجد أن قيمة BOD تراوحت 3000-1500ملجم/ اللتر وكان تركيز BOD بعد المرور بالمفاعل حوالي 50 ملجم / اللتر في معظم العينات .وبذلك نستنتج أن المفاعل المتسلسل ذو الدفعات والنمو الملتصق يمثل نظام فعال لمعالجة المخلفات السائلة للمجازر .

JOESE 5

SLAUGHTERHOUSE WASTEWATER TREATMENT USING AEROBIC SEQUENCING BATCH BIOFILM REACTOR

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