International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54

Effect of Increasing Streptomicin Loading Rates on the Removals of Streptromycin in c ABR/ CSTR Reactors

Seçil Tüzün, Delia Teresa Sponza[x]
Dokuz Eylül Univeersity, Engineering Faculty, Environmental Engineering Department, Buca- İzmir Turkey

Abstract: In this study the anaerobic treatability of streptomycin was investigated in a sequential anaerobic baffled reactor (ABR)/ completely stirred tank reactor (CSTR) system. The ABR reactor was operated continuously through 83 days using glucose as primary substrate with constant streptomycin concentration of 200 mg/L. 200mg/L streptomycin gives an additional COD concentration to total COD thought continuous operation. 200 mg/l of streptomycin gave approximately a COD of 131.38 mg/L. The effects of decreasing hydraulic retention times (HRT) (38.4-19.2-12.8-9.60-7.68 days) on COD, antibiotic removal efficiencies and gas productions in anaerobic baffled (ABR) reactor were investigated at constant streptomycin concentration of 200mg/L. Moreover, the effects of decreasing HRT on the change of, volatile fatty acid (VFA) accumulation were investigated in the effluent and in the compartments of ABR reactor.

In this study, to toxic effect of streptomycin concentration on methane Archaea was investigated using anaerobic toxicity (ATA) test under batch conditions in the beginning of the study in order to determine in the IC_{50} (the streptomycin concentration which caused 50% decreases in the methanogenic activity) value of the streptomycin. The IC_{50} value for streptomycin was found as 292.06 mg/L. In the continuous operation of APR reactor, for maximum COD efficiency (E=90%) and methane percentage(58%) the optimum streptomycin concentration and streptomycin loading rate were found as 200 mg/L and 0.180 kg/Lday, respectively. The total COD removal efficiencies changed between 81% and %95 at different HRTs (38.4-19.2-12.8-9.60-7.68 days) in anaerobic/aerobic reactor system. The maximum COD removal efficiencies at constant streptomycin (200mg/L) concentration were obtained as 89% and 95% in the ABR and CSTR reactor effluents at a HRT of 19.2 days. Maximum total gas, methane gas productions and methane percentage were found as 504 l/day, 446.4 l/day and 58% , respectively at a HRT of 9.60 days. Before a HRT of 9.60 days, the daily total gas, ethane gas productions and methane percentage decreased through HRT. Maximum total gas, methane gas productions and methane percentage were found as 504 L/day, 446.4 L/day and 58%, respectively, at a HRT of 9.60 days. 259.2 L/day total gas, 187 L/day methane gas and 42% methane percentage were obtained at a HRT as long as 38.4 days. This indicated the inhibition effect of HRT on methane Archeae. In the continuous operation of APR reactor, for the total volatile fatty acids (TVFA) values in the effluent of the ABR reactor were found as zero when the HRTs decreased from 38.4 days to 7.68 days**.** TVFA concentration was higher in the first compartment that other compartments in ABR. TFVA concentration decreased from 608 mg/l to 26 mg/L in the first compartment when the HRT decreased from 38.4 days to 19.2 days. The effluent TVFA concentrations were approximately zero at all HRTs. Bic.Alk. concentrations were lower in the first compartment than that the others compartments. This indicates the utilization of alkalinity to buffer the (TVFA) and CO_2 produced from the anaerobic co-metabolism of streptomycin and COD. In anaerobic reactor system the TVFA/Bic.Alk. ratio gives necessary information to determine the stability of the anaerobic reactor. If the TVFA/Bic.Alk. ratio is lower than 0.4, the reactor is stable (Behling et al., 1997). The TVFA/Bic.Alk. ratio varied between 0.099 and 0.005 in effluent as the HRTs were decreased from 38.4 days to 7.68 days. The antibiotic removal efficiencies at constant streptomycin (200mg/L) concentration were obtained as 66% and 74% in the ABR and CSTR reactor effluents at a HRT of 12.8 days.The total maximum streptomycin removal efficiency was 74% in the sequential reactor system at an influent streptomycine concentration of 179.57 mg/L at a HRT of 12.8 days. In this study it was found that the “streptomycin” antibiotic was mainly degraded (59.79 mg/L) in anaerobic ABR reactor while the remaining part of this antibiotic (47.54 mg/L) was removed in the aerobic CSTR reactor. In this study, the acute toxic effect of synthetic wastewater containing streptomycin was investigated, separately, through anaerobic/aerobic degradation at decreased HRTs (38.4-19.2-12.8-9.60-7.68 days) using Daphnia magna test. The acute toxicity test results performed with Daphnia magna showed that the EC_{50} values decreased from influent 400 mg/L to 132 mg/L, and to 20 mg/L in the effluents of ABR and aerobic reactor at a HRT of 38.4 days. The total acute toxicity reduction in sequential ABR CSTR reactor effluent was 95%.

Keyword: Aerobic continuous stirred tank reactor system (CSTR), anaerobic baffled reactor (ABR), daphnia magna, streptomycin, toxicity

International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54

Introduction

Antibiotics are an important group of pharmaceuticals in today's medicine. In addition to the treatment of human infections, they are also used in veterinary medicine such as streptomycin. Bacteria that are resistant to antibiotics are present in surface water (Kümmerer, 2009). Antibiotics are found in ground water at concentrations below than 10 µg/L. The source of antibiotics in ground water originating from the leaching the fertilized fields with animal slurry and from the waters passing through the sediments (Kümmerer, 2009).

The anaerobic treatability studies concerning the pharmaceuticals and antibiotics are limited with few studies: The performance of an upflow anaerobic filter (UAF) treating a chemical synthesis-based pharmaceutical wastewater was evaluated under various operating conditions (B Kasapgil Ince, A Selcuk and O Ince, 2002).The performance of an up-flow anaerobic stage reactor (UASR) treating pharmaceutical wastewater containing macrolide antibiotics was investigated (Shreeshivadasan Chelliapan, Thomas Wilby, Paul J. Sallis, 2006).The performance of a lab-scale hybrid up-flow anaerobic sludge blanket (UASB) reactor, treating a chemical synthesis-based pharmaceutical wastewater, was evaluated under different operating conditions. This study consisted of two experimental stages: first, acclimation to the Pharmaceutical wastewater and second determination of maximum loading rate(OLR) 1 kg COD/m^3d (Yalcin Aksin Oktem, Orhan İnce, Paul Sallis, Tom Donnelly, Bahar Kasapgil Ince, 2007).A four-compartment periodic anaerobic baffled reactor (PABR) was run in a 'clockwise sequential' switching manner continuously fed on chinese traditional medicine industrial wastewater (Xiaolei Liu, Nanqi Ren, Yixing Yuan, 2009).

The anaerobic baffled reactor (ABR) is high rate anaerobic reactor offering two-phase separation with a single vessel. The literature survey shows that there is a lack on the anaerobic treatment of streptomycin and chloramphenicole by ABR. In other words, no study was found in the literature for the ABR reactor treating the wastewaters containing streptomycin.

Streptomycin is an antibiotic drug, the first of a class of drugs called amino glycosides to be discovered, and was the first antibiotic remedy for tuberculosis. Streptomycin was first isolated on October 19, 1943 by Albert Schatz, a graduate student, in the laboratory of Selman Abraham Waksman at Rutgers University. The chemical identities of the streptomycin and physical and chemical characteristics of the streptomycin, in Tables 1 and 2, respectively (Wikipedia,2009).

It has been known for more than six decades that certain fungi and bacteria are capable of producing chemical substances which have the capacity to inhibit the growth of, and even to destroy, pathogenic organisms. Only within the last twelve or thirteen years, however, have antibiotics begun to find extensive application as chemotherapeutic agents. Among these, penicillin and streptomycin have occupied a prominent place. Penicillin is largely active against gram-positive bacteria, gram-negative cocci, anaerobic bacteria, spirochetes and actinomycetes; streptomycin is active against a variety of gram-negative and acid-fast bacteria, as well as against gram-positive organisms which have become resistant to penicillin.

Since the discovery of streptomycin, the production and clinical application of this antibiotic have had a phenomenal rise**.** The streptomycin producing strain of Streptomycin griseus was isolated in September, 1943, and the first public announcement of the antibiotic was made in January, 1944. Before the end of that year, streptomycin was already being submitted to clinical trial. Within 2 years, the practical potentialities of streptomycin for disease control were definitely established.

Materials and Methods

Experimental Setup

A schematic of the lab-scale sequential ABR and CSTR reactors used in this study are presented in Figure 1. The effluent of the anaerobic ABR reactor was used as the influent of aerobic CSTR reactor. The ABR reactor was rectangular box having the dimensions 20 cm wide, 60 cm long and 40 cm high. The ABR reactor with the active reactor volume (38.4 L) was divided into four equal compartments by vertical baffles. Each compartment was further divided into two by slanted edge (45◦C) baffles to encourage mixing within each compartment. Therefore, down-comer and up-comer regions were created. The liquid flow is alternatively upwards and downwards between compartment partitions. This provided effective mixing and contact between the wastewater and biomass at the base of each upcomer. In other words, during upflow, the waste flow contact with the active biomass and it is retained within the reactor providing a homogenous distribution of wastewater. An additional mixing was not supplied to the compartments of the reactor. The width of the downcomer was 4 cm and the width of the up-comer was 11 cm. The passage of the liquid from each compartment to another was through an opening with size 40 mm×10 mm which located about 80 mm from the top of each compartment.

The liquid sampling ports were located at 40 mm back of the effluent opening of each compartment. The sludge sampling ports were also located in the center of the compartments and 80 mm above from the bottom of the each compartment. The influent feed was pumped using a peristaltic pump. The outlet of the ABR was connected to a glass U-tube for controlling the level of wastewater. The produced gas was collected via porthole in the top of the reactor. The operating temperature of the reactor was maintained constant at 37±1 ^{o}C by placing the ABR reactor on a heater. A digital temperature probe located in the middle part of the second compartment provided the constant operation temperature. This provided a homogenous temperature in whole compartments of ABR reactor. The aerobic CSTR reactor consisted of an aerobic (effective volume=9 L) and a settling compartment (effective volume = 1.32 L).

Seed of the Reactors

Partially granulated anaerobic sludge was used as seed in the ABR reactor. The seed sludge was obtained from an anaerobic upflow anaerobic sludge blanket reactor containing acidogenic and methanogenic partially granulated biomass taken from the Pakmaya Yeast Beaker Factory in Izmir, Turkey. Activated sludge culture was used as seed for the aerobic CSTR reactor and it was taken from the activated sludge reactor of Pakmaya Yeast Beaker Factory in Izmir. The volatile suspended solid (VSS) concentration of seed sludge in ABR reactor was adjusted as 25 g/L. The mixed liquor solids concentration (MLSS) in the CSTR were adjusted between 3000 and 4000 mg/L.

Composition of Synthetic Wastewater

Streptomycin concentration varying between 25 and 400 mg/L was used through continuous operation of the ABR reactor. Glucose was used as primary substrate giving a COD concentration of 3000 ± 100 mg/L. Vanderbilt mineral medium was used in synthetic wastewater as mineral source. This mineral medium consisted of the following inorganic composition (in mg/l): NH4Cl, 400; $MgSO_4.7H_2O$, 400; KCl, 400; $Na_2S.9H_2O$, 300; $(NH_4)_2HPO_4$, 80; $CaCl_2.2H_2O$, 50; $FeCl_3.4H_2O$, 40; $CoCl_2.6H_2O$, 10; KI, 10; $(NaPO_3)_6$, 10; L-cysteine, 10; $AlCl_3.6H_2O$, 0.5; $MnCl_2.4H_2O$, 0.5; $CuCl_2$, 0.5; $ZnCl_2$,0.5; NH_4VO_3, 0.5; $NaMoO_4.2H_2O$, 0.5; H_3BO_3, 0.5; $NiCl_2.6H_2O$, 0.5; $NaWO_4.2H_2O$, 0.5; Na_2SeO_3, 0.5 (Speece, 1996). The anaerobic conditions were maintained by adding 667 mg/l of Sodium Thioglycollate (0.067 %) which is proposed between 0,01-0,2% (w/w) for maintaining the strick anaerobic conditions (Speece, 1996). The alkalinity and neutral pH were adjusted by addition of 5000 mg /L $NaHCO_3$.

Analytical Methods

The dissolved COD was measured calorimetrically by using closed reflux method (APHA AWWA, 1992). Firstly the samples were centrifuged 10.0 min at 7000 rpm. Secondly, 2.5 ml samples were mixed with 1.5 ml 10216 mg/l $K_2Cr_2O_7$, 33.3 g/l $HgSO_4$ and 3.5 ml 18 M H_2SO_4 containing 0.55% (w/w) Ag_2SO_4. Thirdly the closed sample tubes were stored in a heater with a temperature of 148°C for two hours. Finally, after cooling, the samples were measured at a wave-length of 600 nm with a Pharmacia LKB NovaPec II model spectrophotometer.

Gas productions were measured with liquid displacement method. The total gas was measured by passing it through a liquid containing 2% (v/v) H_2SO_4 and 10% (w/v) NaCl (Beydilli, Pavlosathis & Tincher, 1998). Methane gas was detected by using a liquid containing 3% NaOH to scrub out the carbon dioxide from the biogas (Razo-Flores et al., 1997). The methane gas percentage in biogas was also determined by Dräger Pac®Ex methane gas analyzer. The H_2S gas was measured using Dräger (Stuttgart, Germany) kits in a Dräger H_2S meter. H_2 gas was measured using (Dräger Pac®Ex) H_2 meter. N_2 gas was measured by discarding of the sum of CH_4 + H_2S + H_2 gases from the total gas.

Biomass was measured as total suspended solid (TSS) and volatile suspended solid (VSS) in anaerobic reactors. Biomass in aerobic tank was measured as mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solids (MLVSS). Assays were performed according to Standard Methods for Examination of Water and Wastewater (APHA AWWA, 1992).

Bicarbonate alkalinity (Bic.Alk.) and total volatile fatty acid (TVFA) concentrations were measured simultaneously using titrimetric method proposed by Anderson & Yang, (1992). The test was carried out as follows: firstly the pH of the sample was measured, secondly the sample was titrated with standard sulphuric

acid (0.1 N) through two stages (first to pH=5.1, then from 5.1 to 3.5), and finally the VFA and Bic.Alk. concentrations were calculated with a computer program by solved the Eqs (1) and (2).

$$A_1=\frac{[HCO_3^-]*([H]_2-[H]_1)}{[H]_1+K_C}+\frac{[VA]*([H]_2-[H]_1)}{[H]_2+K_{VA}} \quad (1)$$

$$A_2=\frac{[HCO_3^-]*([H]_3-[H]_1)}{[H]_3+K_C}+\frac{[VA]*([H]_3-[H]_1)}{[H]_3+K_{VA}} \quad (2)$$

where A1 and A2 are the molar equivalent of the standard acid consumed to the first and second end points; [HCO_3^-] the bicarbonate concentration; [*VA*] the volatile fatty acid ion concentration; [*H*]1,2,3 the hydrogen ion concentrations of the original sample and at the first and the second end points; K_c is the conditional dissociation constant of carbonic acid; K_{VA} is the combined dissociation constant of the volatile fatty acids (C_2–C_6), this pair of constants was assumed, being 6.6×10^{-7} for bicarbonate and 2.4×10^{-5} for volatile acids.

ATA test was performed at 35°C using serum bottles with a capacity of 150 ml as described by Owen, Stuckey, Healy, Young, McCarty, (1979) and Donlon et al. (1996). Serum bottles were filled with 2000 mg VSS/L of biomass, 3000 mg /l of glucose-COD, suitable volume from the Vanderbilt mineral medium, 667 mg /l of sodium thioglycollate providing the reductive conditions and 5000 mg /l of $NaHCO_3$ for maintaining the neutral pH. Before ATA test, the serum bottles were batch operated until the variation in daily gas production was less than 15% at least for 7 consecutive days. After observing the steady-state conditions, increasing concentration streptomycin and chloramphenicole were administered to serum bottles asmslug-doses from concentrated stock solutions of these chemicals. The effects of Streptomycin and Chloramphenicole on methane gas production were compared with the control samples. Inhibition was defined as a decrease in cumulative methane compared to the control sample. IC_{50} value indicates the 50% inhibition of methane gas production in serum bottles containing toxicant. This value shows the presence of toxicity. This value shows the toxicant concentration caused 50% inhibition in the methane gas production.

The SMA test was conducted in 150 ml serum bottles at 35 °C under anaerobic conditions. Serum bottles were filled with 3000 mg/l of glucose-COD, with suitable amount of Vanderbilt mineral medium, 667 mg/l of sodium thioglycollate for to provide the reductive conditions and 5000 mg/l of $NaHCO_3$ for maintaining the neutral pH and 2000 mg VSS/L of biomass. Maximum specific methanogenic activity was calculated from the total methane production through 3 days with the method proposed by Owen et al., (1979) as follows:

$$\text{SMA } (gCH_4\text{-COD/g VSS day}) = \frac{\text{produced methane volume (ml) x 395 ml/ l gCOD}}{\text{sample (ml) x incubation time (day) x biomass concetration (g/l)}}$$

Toxicity was tested using 24 h born *Daphnia magna* as described in Standard Methods (2005). Test animals were obtained from the Science Faculty in Aegean University in Izmir. After preparing the test solution, experiments were carried out using 5 or 10 Daphnids introduced into test vessel. These vessels were controlled with 100 ml of effective volume at 7- 8 pH, providing minimum dissolved oxygen concentration of 6 mg/l at a ambient temperature of 20-25°C. Young *Daphnia magna* are used in the test (in first start ≤24 h old). A 24 h exposure is generally accepted for a *Daphnia* acute toxicity test. Results were expressed as mortality percentage of the *Daphnias.* The immobile animals which were not able to move were determined as the death of *Daphnias.*

Antibiotics Measurements

Streptomycin Measurement

Preparation of 1000 mg/L Streptomycin stock standard; 0,5 g streptomycin is weighted in a beaker, it was put into a 500 ml of volumetric flask and it was filled with HPLC grade deionized water. 5, 50, 100, 150, 300 mg/L standard Streptomycin solutions were prepared from the 1000 mg/L of Streptomycin Stock Standard.

HPLC Conditions for Streptomycin Analysis

A C-18 250x4,6 mm. (id), column (ACE) was used The mobile phase consisted of the HPLC grade Acetonitrile at pH=3, Sodium Phosphate Buffer + Sodium 1-Hexanesulphonic Acid ratio was (8:92), The flow rate was 1ml/min, the column temperature was 20 ^{o}C, the wave length was 195 nm (UV) and the injection volume was 10 microliter.

1 L sample was centrifuged using a filter with a pore size of 0,20 micrometer. The vials was filled with 2 ml of centifuged sample and it was injected into sampling portes of the HPLC (Kurosawa, N.; Kuribayashi, S.; Owada, E.;et all 1985).

Operation Conditions

The adaptation period is very important since the bacterial population used as seed is going to be exposed to the Streptomycin in an anaerobic environment of the ABR reactor. In order to acclimation the partially granulated biomass in the ABR reactor, the anaerobic reactor was operated with synthetic wastewater through 92 and 12 days without streptomycin for reach to steady-state conditions. HRT and OLR were 19,2 days and 156,25 kgCOD/ m^3 days, respectively.

Sludge retention time (SRT, θC) is the total quantity of active biomass in the reactor divided by the total quantity of active biomass withdrawn daily. Since no sludge wasting was applied for granule formation in the ABR reactor, SRT in this reactor was determined using equations (3) and (4) (Metcalf & Eddy, 1991)

$$SRT = \frac{V_r * X_r}{Q_e * X_e + Q_w * X_w} \quad (3)$$

Q_w and X_w were defined as flow rate and microorganism concentrations, respectively in wasted sludge stream. The term Q_w*X_w only makes sense if there is a waste sludge stream. Since no sludge wasting was applied in the ABR reactor, SRT can be expressed as follows:

$$SRT = \frac{V_r * X_r}{Q_e * X_e} \quad (4)$$

The sludge wasting in a conventional CSTR reactor occurred from the settling tank and the solids in the effluent (X_e) were taken into consideration. Therefore, SRT in this reactor was calculated by using equation (6) with rearranged equation (5).

$$SRT = \frac{V_r * X_r}{Q_e * X_e + Q_w * X_w} \quad (5)$$

V_r and X_r are effective volume of reactor and microorganism concentration in the aeration tank. *Qe* and *Xe* were defined as flow rate and microorganism concentration measured in the settling tank. Q_w and X_w are the flow rate and microorganism concentration wasted from the reactor. The CSTRs used in this study are recycled reactors. In other words, the sludge was recycled 100% from the settling tank to the aeration tank. If the concentration of microorganism in the effluent of the settling tank is low, X_e is negligible (Metcalf & Eddy, 1991). In this study, the activated sludge was withdrawn from the inside of the aeration stage, the microorganism concentration in the reactor (Xr) was equal to the wasted microorganism concentration (Xw). Therefore, in this study the SRT in CSTR was calculated using equation (6).

$$SRT = \frac{V_r}{Q_w} \quad (6)$$

In this study, SRT (θc) in the CSTR reactor was adjusted as 20 days by discarding a certain amount of sludge volume from the aeration stage of the CSTR reactor. HRT in anaerobic reactors and CSTR were calculated using equation (7).

$$HRT = \frac{V_r}{Q} \quad (7)$$

Vr and *Q* were defined as reactor volume (l) and influent flowrate (L/day), respectively.

In the first step study OLR, HRT, streptomycin and chloramphenicole consentrations were 0,156 kg COD/m^3 days, 19,2 days, 25–400 mg/L and 50–340 mg/L, respectively.

In the second step study OLR, HRT, streptomycin and chloramphenicole concentration were 0,078-0,156 – 0,234 – 0,312 – 0,391 kg COD/m^3 days, 38,4 – 19,2 – 12,8 – 9,60 – 7,68 days, 200 mg/L and 130 mg/L, respectively.

Results and Discussion

Anaerobic Toxicity Assay (ATA) Results for Streptomycin

This batch test provided FOR THE information on the C ONTİNUOUS potential loading capacity of the ABR. The streptomycin concentrations caused 50% decreases in the methanogenic activity (decrease of methane gas production) were calculated as IC_{50} value. The IC_{50} value for streptomycin was found to be 292.06 mg/L as shown in the figures 2.

Start-up of Period of the ABR

The ABR reactor was operated through 92 days without streptomycin under steady-state conditions to acclimate the granular sludge to ABR reactor. Figure 3 shows the COD removal efficiencies in the ABR during the start-up period. The COD removal efficiency was 10% ON DAY 4 days WHİLE it reached 70% after 71 days. The COD removal efficiencies remained stable 82% after an operation period of 85 days. Figure 4 shows the methane gas percentages in the ABR during the start-up period. The methane gas production and methane percentage reached 69,12 L/day and 45% , respectively after 44 days at an organic loading rate of 0,16 Kg COD / m^3 day. The daily methane gas production and methane percentage remained stable at 96 L/day and 56%, respectively, after 64 days of the start-up period. Figure 5 shows the total gas percentages in the ABR during the start-up period. The total gas production and methane percentage reached 100,8 L/day and 45%, respectively at operation time of 44 days. The daily total gas production and methane percentage remained stable at 187,2 L/day and 56%, respectively, after 64 days of the start-up period.

Effect of Increasing Streptomycin Concentration on the COD Removal Efficiencies in ABR Reactor

In this study, the effect of increasing streptomycin concentrations on COD removal efficiencies was investigated in ABR. The operation of the ABR with streptomycin was started at an influent streptomycin concentration of 25 mg/L, and then streptomycin concentration was subsequently increased from 25, 50, 75, 100, 150, 175, 200, 240, 280, 320, to 400 mg/L (At OLRs from 0.188 to 0,156 kg COD/m^3 day). The effect of streptomycin concentration on the COD removal efficiencies in ABR was shown in Figure 6. Although the influent COD concentration was kept constant at 3000 mg/L with glucose, the influent COD concentrations increased with increasing streptomycin concentration since streptomycin give additional COD to synthetic wastewater. The influent COD concentration was 3660 mg/L at a streptomycin concentration of 25 mg/L while it was measured as 2990 mg/L at a streptomycin concentration of 400 mg/L. The COD removal efficiency was 90,72% at an initial streptomycin concentration of 25 mg/L introduced to ABR. In a study performed by Liu at al., (2009) the COD removal efficiency was found as 82.47% at an organic loading rate of (ORL) 2 kg COD/m^3*day in Chinese traditional medicine industrial wastewater. The COD removal efficiency found in this

study is comparable higher than that aforementioned study. The COD removal efficiency was measured approximately as 81,96 % at a streptomycin concentration of 320 mg/L. The maxsimum COD removal efficiency was between 89-95 % at streptomycin are concentration of 100-150 mg/L. When the streptomycin concentration was increased to 400 mg/L the COD removal efficiency was measured as 67,55 % (Figure 6.)

Effect of Increasing Streptomycin Concentration on the VFA, Bicarbonate Alkalinity (Bic.Alk.) concentrations and VFA/Bic.Alk. ratio in ABR Reactor

Figure 7 shows the variations in VFA concentrations and VFA/Bic.Alk. ratios in the ABR reactor at increasing streptomycin concentrations. As the streptomycin concentrations increased from 25mg/L to 400 mg/L the VFA concentration increased from 0 mg/L to 191 mg/L. Figure 8 shows the variations of Bic.Alk. concentrations through 268 days of operation period. Their concentrations were approximately 3600-1900 mg/l in the effluent. The Bic.Alk. concentrations decreased in the effluent, step by step. VFA/ Bİc.Alk. ratios varied between 0,368 and 0,005 in the effluent of ABR reactor at increasing streptomycin concentration(from 0 mg/L up to 400 mg/L).This showed that the ABR reactor operated under steady-state conditions since the VFA/ Bİc.Alk. ratios were lower than 0.5(Behling et al., 1997).The HCO_3 alkalinity also remained between 1250 and 2500 mg/L indicating the buffer capacity of the ABR reactor for methanogenesis (Speece, 1996)

The Variations of COD Removal Efficiency in Compartments of the ABR Reactor at Increasing Streptomycin Concentrations

In this study, the effect of increasing streptomycin concentrations on COD removal efficiencies was investigated in four compartments of the ABR reactor. COD removal efficiencies were high (98%) in compartment IV compared to the other compartments. The COD removal efficiency increased from 8,5% to 96,9% until a streptomycin concentration of 200 mg/L. Then the COD removal efficiency decreased from 96,9% to 82% after 200 mg/L at compartment IV (see 9.(d)).As shown in fig.9 (a), the COD removal efficiency values in the compartment I was lower than the other compartments. The COD removal efficiency values in the first compartment varied between 8,29% and 32,69% at all streptomycin concentrations. The COD removal efficiency values increased to 67,10 and to 88,10 in compartments II and III. Figure 9. (b),(c), shows the COD removal efficiencies in the compartment II (varied between 8,29% and 68,85%)and compartment III (varied between 8,29% and 80,72%).

The Variations of VFA, Bicarbonate Alkalinity (Bic.Alk.) and VFA/Bic.Alk. ratio in Compartments of the ABR Reactor at Increasing Streptomycin Concentrations

Figure 10 shows the VFA, VFA/Bic.Alk. ratio variations in the ABR reactor at increasing streptomycin concentrations from 0 mg/L up to 400 mg/L. VFA concentrations were high in the compartment I compared to the other compartments, because in compartment I the activity of acidogens was a maximum rate (See 10. (a)). VFA concentrations decreased from 1200 mg/l to 208 mg/l as the streptomycin concentrations increased from 25 mg/L up to 400 mg/L in first compartment. VFA concentrations decreased in compartments II, III and IV. VFA concentrations decreased from 1341 mg/L to 157 mg/L until a streptomycin concentration of 25 mg/L while the VFA concentration was zero until a streptomycin concentration of 400 mg/L in compartment IV. The VFA concentrations zero at a streptomycin concentration of 400 mg/L in compartment III (See 10. (c)).The VFA concentrations decreased from 794 mg/L to 191 mg/L until a streptomycin concentration of 25 mg/L while the VFA concentrations were zero in compartment II at all streptomycin concentration (See 10. (b)). VFA concentrations decreased from 1341 mg/L to 112 mg/L until a streptomycin concentration of 25 mg/L and the VFA concentration were zero until a streptomycin concentration of 400 mg/L in compartment IV. The VFA concentrations decreased from 191 mg/l to 0 mg/l at a streptomycin concentration of 400 mg/L in compartment IV (See 10. (d)).

The Bicarbonate Alkalinity (HCO_3) and VFA/Bic.Alk. ratio variations in all compartments of the ABR reactor at increasing streptomycin concentrations (from 0 mg/L up to 400 mg/L) were shown in Figure 11. Figure (11.(a)) indicates a low concentration of HCO3 concentration from 3803 mg/L down to 1817mg/L was present in the compartment I when the ABR reactor was operated at streptomycin concentration in the range 0 mg/L - 400 mg/L. However, in compartment IV, the HCO_3 alkalinity concentrations increased to 1931 mg/L at a streptomycin concentration 400 mg/L (see figure 11. (d)). HCO_3 concentrations decreased from 3771 mg/L to 1858 mg/L at a streptomycin concentration of 400 mg/L in compartment II. After that HCO_3 concentrations

decreased from 3648 mg/L to 1858 mg/L at a streptomycin concentration of 400 mg/L in compartment III. The HCO_3 concentrations in the compartment IV is higher than the others compartments in the ABR reactor.

Generally it was found that in the first compartment of ABR reactor the acidogenesis is the major step of the anaerobic treatment. The third and fourth compartments are the major removal steps for methanogenesis. Therefore the VFA concentrations were high in while the HCO_3 alkalinities were low in the first compartment of ABR.

Effect of Increasing Antibiotic Dose on Gas Production and Methane Percentage in Anaerobic ABR Reactor.

Biogas production was monitored through the operation of the ABR reactor, particularly for detection the methanogenic activity. From Figure 12 it can be seen that the methane gas production rates increased from 0 L/day to 144 L/day at a streptomycin concentration of zero. Then methane gas production rates increased from 144 L/day to 259,2 L/day , respectively. As the streptomycin concentration was increased from 0 mg/L to 280 mg/L, the methane gas production decreased from 259 L/day to 172,8 L/day . The methane percentages of biogas increased from 0% up to 53% until a streptomycin concentration of 200 mg/L. The methane percentages of biogas were decreased to 48%, when the streptomycin concentration increased from 200 mg/L to 400 mg/L. In a study performed by Liu at all (2009) methane gas production was found as 12 L/day (OLR=1.04 kg COD/m^3*day), 30 L/day (OLR=2.01 kg COD/m^3*day) and 66 L/day (OLR=6.17 kg COD/m^3*day) for firth, second and third compartments, in ABR reactor respectively. In this study the methane percentages are comparable higher than that aforementioned study.

From Figure 13 it can be seen that the total gas production rates increased from 0 L/day to 259,2 L/day in the operation of ABR without streptomycin. After that the total gas production rates increased from 259,2 L/day to 504 L/day, respectively as the streptomycin concentration increased from 0 mg/L to 175 mg/L. The total gas production also, decreased from 504 mg/L to 208,8 mg/L . The methane percentages of biogas were increased from 0% up to 53% until a streptomycin concentration at 200 mg/L then the methane percentages of biogas decreased to 48%, when the streptomycin concentration increased from 200 mg/L to 400 mg/L.

Effect of Hydraulic Retention Time (HRT) on The Performance of ABR Reactor

Effect of HRTs on The COD Removal Efficiency in ABR Reactor. The effect of hydraulic retention times (HRTs) on the COD removal efficiency was shown in Figure 14.The influent streptomycin concentration was kept constant as 200 mg/L. As shown in Figure 14, the influent COD concentration was approximately 3600-2900 mg/L since 200 mg/L streptomycin gives an additional COD concentration to total COD thought continuous operation. 200 mg/L of streptomycin gave approximately a COD of 131,38 mg/L. 90% COD removal efficiency was obtained at a HRT of 19,2 days in ABR reactor. When the HRT was decreased from 12,8 days to 7,68 days, the COD removal efficiency decreased from 89% to 76%, respectively. Akunna & Clark, (2000) investigated the performance of an anaerobic baffled reactor treated a whisky distillery wastewater at different four HRTs (10, 7, 4 and 2 days). The maximum COD removal efficiency was observed at a HRT of 4 days (E=93%). Oktem, Ince, Sallis, Donnelly & Kasapgil, (2007) investigated the performance of anaerobic sludge blanket reactor treated a chemical synthesis – based pharmaceutical wastewater at two HRTs (1and 3 days). COD removal efficiency increased from 58% to 78% with the HRT was increased from 1 to 3 days. Kuscu & Sponza, (2009) found that as the HRT decreased from 10,38 days to 2,5 days the COD removal efficiencies in the anaerobic and anaerobic/aerobic reactor effluents decreased from 94% to 92% and from 98% to 97%, respectively.

Effect of HRTs on Total Volatile Fatty Acid (TVFA), Bicarbonate Alkalinity (Bic. Alk.) and TVFA/Bic.Alk. Ratio Variations in ABR Reactor. Figure 15 shows the TVFA in the effluent of ABR at decreased HRTs. The highest VFA concentration (191 mg/L) was found at a HRT of 38,4 days. After this HRT, TVFA concentration in the effluent decreased and was measured as 9 mg/L at a HRT of 7,68 days. From Fig. 15, it can be seen that Bic.Alk. concentrations in effluent decreased from 191 to 9 mg/l since the HRT were decreased.

HuaJun Feng, LıFang Hu, Dan Shan, ChengRan Fang and DongSheng Shen (2008) investigated the performance of an anaerobic baffled reactor treated dilute wastewater the HRT decreased from 18 h to 9 h, and the final concentration of effluent VFAs increased from 8 mg/L to 22 mg/L, respectively.

From Figure 16, it can be seen that Bic.Alk. concentrations increased from 1931 mg/L up to 2199 mg/L when HRT decreased from 38,4 to 9,60 days. After that Bic. Alk. concentrations decreased to 1972 mg/L a HRT of 7,68 days.

In anaerobic reactor system TVFA/Bic.Alk. ratio gives necessary information to determine the stability of the anaerobic reactor. If the TVFA/Bic.Alk. ratio is lower than 0.4, the reactor is stable. When the TVFA/Bic.Alk. ratio is lower than 0.8, the reactor system is moderately stable or unstable (Behling et al., 1997). As shown in Fig. 15. The TVFA/Bic.Alk. ratio varied between 0.099 and 0.005 in effluent as the HRTs were decreased from 38,4 days to 7,68 days. ABR reactor was stable as reported by Behling et al., (1997) since the TVFA/Bic.Alk. ratios in the effluent were lower than 0.4.

Effect of HRTs on Gas Productions and Methane Percentage in Anaerobic ABR Reactor.

From figure 17 it can be seen that the methane gas production increased from 144 L/day up to 446,4 L/day as the HRT decreased from 38,4 to 9,60 days as the streptomycin concentration constant at a 200 mg/L. the maximum methane percentages (58%) has obtained at a HRT of 19,2 days. However, the methane gas production decreased from 446,4 L/day to 288 L/day at a HRT of 7,68 days. Maximum methane gas production (446,4 L/day) was obtained at 9,6 days of HRT.

From figure 18 it can be seen that the total gas production increased from 259,2 L/day up to 504 L/day as the HRT decreased from 38,4 to 9,60 days as the streptomycin concentration constant at a 200 mg/L . But total gas production decreased from 504 L/day to 432 L/day at a HRT of 7,68 days. Maximum total gas production (504 L/day) was obtained at 9,60 days of HRT.

The methane percentages of the biogas were approximately 38-40% at a HRT of 38,4 days. After that methane percentages increased from 36% up to 53% at a HRT of 19,2 days. However the methane percentages increased from 35% up to 46% as the HRT decreased from 19,2 to 7,68 days. When the ABR system reached to a stabilized state under the OLR of 6.0 kg COD/m^3 d and HRT of 39,5 days, the total amounts of biogas in the four compartments were 73.2 L/d, 30.8 L/d, 8.6 L/d, and 1.3 L/d, respectively(Ge-Fu Zhu, Jian-Zheng Li ,Peng Wu, Hui-Zheng Jin , Zheng Wang , (2008)).

Effect of Compartments of ABR on COD Removal Efficiencies at Different HRTs

In this study, the effect of decreases in HRTs on COD removal efficiencies was investigated in four compartments of the ABR reactor. Figure 19 shows the effect of compartmentalization on COD removal efficiencies at different HRTs. As shown in the figure 19 (a), in compartment I the COD removal efficiencies were approximately 77% at a HRT of 19,2 days. The COD removal efficiency was low at a HRT of 7,68 in the compartment I. Figure 19. (b),(c), shows the COD removal efficiencies in the compartment II (varied between 64,23% and 78,08%)and compartment III (varied between 71,61% and 86,02%) (see figure 19.(b),(c)). COD removal efficiency increased from 64,23% to 87,19% in the second compartment when HRTs decreased from 38,4 days to 19,2 days. However the COD removal efficiency decreased from 87,19% to 62,50% in compartment II when the HRT decreased from 19,2 to 7,68 days (see figure 19.(b)). COD removal efficiency increased from 71,61% to 88,10% in the initial compartment when the HRT decreased from 38,4 days to 19,2 days. However COD removal efficiency decreased from 88,10% to 70,44% in compartment III when the HRT decreased from 19,2 to 7,68 days (see figure 19.(c)).In compartment IV the COD removal efficiencies were high (89,89%) at a HRT of 19,2 days compared to the other HRTs. The COD removal efficiency increased from 62,49 % to 89,89% as the HRT decreased from 38,4 days to 19,2 days . Then the COD removal efficiency decreased from 89,89 % to 78,59 % when the HRT decreased from 19,2 days to 7,68 days in compartment IV (see figure 19.(d)). Therefore for the maximum COD removal efficiency the optimum HRT was found to be 19,2 days.

In a study at soybean protein processing wastewater of Ge-Fu Zhu, Jian-Zheng Li ,Peng Wu, Hui-Zheng Jin , Zheng Wang , (2008) at a HRT of 39,5 days. After the acclimatization of the anaerobic activated sludge in 24 days, the ABR was subjected to a steady-state operation and the removal of total COD from the wastewater was remarkable (above 92%); At the second stage, the COD removal increased continually when the volume loading rate enhancing, basically about 94%. But at the third stage, when an influent 8000 mg COD/L was applied to the ABR, acidification phenomenon happened during the initial period (65–67 days) because of increasing volume loading rate that resulted in the declination of COD removal to 80%. Four days later, the COD removal was improved to 94% without adopting any measurement (influent COD concentration 8000 mg/L). The COD removal in the last stage was similar to the third stage, when increased volume loading rate

further, the total COD removal efficiencies in the ABR system remained as 97% and the effluent COD concentration was under 300 mg/L.

Effect of Compartments of ABR on VFA, Bic. Alk. and VFA/Bic. Alk. ratio at Different HRTs

Figure 20 shows the TVFA and TVFA/Bic.Alk. ratio variations in all compartments on decreased HRTs. In the compartment I at the VFA decreased from 608 mg Acetic acid /L to 26 mg Acetic acid /L when HRT decreased from 38,4 days to 19,2 days. But VFA increased from 26 mg Acetic acid/L to 425 mg Acetic acid /L when the HRT decreased from 12,8 to 7,68 days(see figure 20.(a)). In the compartments II and III at the VFA nearly zero mg/L firths four HRTs (38,4 - 19,2 - 12,8 - 9,60 days), but VFA was found 26 mg/L at a HRT of 7,68 days (see figure 20.(b,c)).Figure 20(d) shows the VFA in the compartment IV , the VFA almost 9 mg/L at all HRTs. S. Ghaniyari-Benis, R. Borja,S. Ali Monemian, V. Goodarzi, (2009), who studied synthetic medium-strength wastewater, found that the VFA concentration of 913 mg/L, 1154 mg/L and 1258 mg/L were achieved at HRTs of 24h, 16h and 8h, respectively, in compartment I . In compartment II the VFA concentrations were found as 371 mg/L, 458 mg/L and 959 mg/L at HRTs of 24h, 16h and 8h, respectively. VFA concentration of 223 and 228 mg/L were achieved at HRTs of 24 and 16 h. Decreasing of HRT to 8 h gave a VFA concentration of 458 mg/L in compartment III of multistage anaerobic biofilm reactor. For all HRTs the VFA production in the first compartment was significantly greater than that in other compartments and it decreased from input to output.

Figure 21 shows the Bic.Alk. and TVFA/Bic.Alk. ratio variations in all compartments on decreased HRTs. In compartment I, when the HRT decreased from 38,4 days to 19,2 days, the HCO_3 concentrations increased from 1509 mg/L up to 1972 mg/L. When the HRT decreased from 38,4 days to 19,2 days, the HCO_3 concentrations decreased. When the HRT decreased from 19,2 days to 7,68 days the HCO_3 concentrations decreased from 1972 mg/L to 1550 mg/L (see 21(a)). Similar results were found for Compartments II, III and VI. The HCO_3 concentrations increased from 1972 mg/L up to 2045 mg/L when the HRT decreased from 38,4 days to 9,60 days in compartments II and IV. The HCO_3 concentrations increased from 1972 mg/L up to 2126 mg/L when the HRT decreased 38,4 days to 9,60 days in compartment III. However the VFA concentrations decreased to 1858 mg/L and to 1972 mg/L in compartments II - III and at a HRT of 7,68, respectively(see figure 21(b,c,d)).

In anaerobic reactor system TVFA/Bic.Alk. ratio gives necessary information to determine the stability of the anaerobic reactor. If the TVFA/Bic.Alk. ratio is lower than 0.4, the reactor is stable. When the TVFA/Bic.Alk. ratio is lower than 0.8, the reactor system is moderately stable or unstable (Behling et al., 1997). As shown in Fig. 20 and 21. The TVFA/Bic.Alk. ratio varied between 0.403 and 0.274 in compartment I, as the HRTs were decreased from 38,4 days to 7,68 days. The TVFA/Bic.Alk. ratio varied between 0.005 and 0.014 in compartments II, III and IV as the HRTs were decreased from 38,4 days to 7,68 days.ABR reactor was stable as reported by Behling et al., (1997) since the TVFA/Bic.Alk. ratios in the all compartments were lower than 0.4.

Kinetic studies Streptomycine utilization rates and specific growth rates at increasing STR concentrations of 25, 50, 75, 100, 150, 175, 200, 240, 280, 320, to 400 mg/L were used to determine biokinetic parameters from the regression of data for each experiment. Streptomycine utilization rate (r, mg STR/L.day wAS determined from the difference between reactor influent and effluent STR concentrations according to the following
mass balance equation:

$$r = Q(STR\ inf - STR\ eff) / V$$

where STR inf is the influent srt concentration (mg/l), STReff is the effluent STR concentration (mg /L, Q is the flowrate m3/day.

Removal Efficiencies in Aerobic CSTR Reactor System.

Figure 22 shows the COD removal efficiencies of aerobic CSTR reactor. The COD removal efficiency in this reactor system were up to 94,52% until a HRT of 19,2 days. After that COD removal efficiency of the reactor decreased from 94,52% to 85,70% when the HRT were decreased from 19,2 days to 7,68 days in. For maximum COD removal efficiency (E=94,52%) the optimum HRT was found as 19,2 days.

Figure 23 shows the overall VFA and VFA/Bic.Alk. ratio of aerobic reactor. Although the VFA and HCO_3 alkalinity were the key parameters in the anaerobic reactors in this study it was aimed to monitor their concentrations in the aerobic CSTR reactor since the effluent of anaerobic ABR reactor it was used as the feed

of the aerobic CSTR reactor. In aerobic CSTR reactor the VFA concentrations increased from 0 mg /L to 258 mg Acetic acid /L when the HRT were decreased from 38,4 days to 9,60 days. However the VFA concentrations decreased from 258 mg/L to 0 mg/L when the HRT decreased from 9,60 days to 7,68 days. For the lowest VFA concentrations (258 mg/L) the optimum HRT was found as 9,60 days.

Figure 24 shows the Bic.Alk. and VFA/Bic.Alk. ratios of aerobic reactor system. In aerobic CSTR reactor system the HCO_3 concentrations decreased from 123 mg /L to 81 mg /L when the HRT decreased from 38,4 days to 19,2 days. However, the HCO_3 concentrations increased from 81 mg /L to 1087 mg /L when the HRT decreased from 19,2 days to 7,68 days. The best HCO_3 concentrations was found to be 1087 mg/L, for the maximum growth of methanogen in the anaerobic conditions at a HRT of 7,68 days.

Specific Methanogenic Activity (SMA) in ABR at Different HRTs. *Figure 25 shows the SMA values of mixed sludge taken from the all compartments of ABR during continuous operation of ABR at different HRTs. The SMA is an indicator of methanogenic activity in anaerobic systems. As shown in Figure 25, the SMA values increased from 0.111 to 0.218 g COD-CH4/ gVSS when the HRT decreased from 38.4 days to 7.68 days. In other words the maximum SMA was found to be 0.218 g COD-CH4/ gVSS day for HRTs between 7.68 and 9.60days. This could be explained by the high flow rates in the ABR reactor resulting in increases in the activity of the methanogenes.*

Assessment of Toxicity of Sequential Anaerobic ABR/Aerobic CSTR Reactor System. *Daphnia magna test is accepted as acute toxicity test. Results were expressed as mortality percentage of the Daphnids. After the test samples contining streptomycin was diluted, the experiments were carried out using 10 Daphnids. The Daphnids was added to into every one test vessel at the beginning time (t=0).After 24 h of incubation time, EC_{50} value (the concentration inhibited 50% of Daphnia magna) was found.*

The acute toxicity test results performed with *Daphnia magna* showed that the EC_{50} values decreased from influent 400 mg/L to 132 mg/L , and to 20 mg/L in the effluents of ABR , in aerobic reactor effluent at a HRT of 38.4 days. (see in a table 4.6) . The total acute toxicity reduction in sequential ABR CSTR reactor effluent was 95%. At a HRT of 19,2 days EC_{50} values decreased from influent 400 mg/L to 120 mg/l , and to 61,2 mg/L in the effluents of ABR , in aerobic reactor effluent. The total acute toxicity reduction in sequential ABR CSTR reactor effluent was 85%. At a HRT of 12,8 days EC_{50} values decreased from influent 400 mg/L to 82 mg/L , and to 46 mg/l in the effluents of ABR , in aerobic reactor effluent. The total acute toxicity reduction in sequential ABR CSTR reactor effluent was 89%. At a HRT of 9,60 days EC_{50} values decreased from influent 400 mg/L to 82 mg/L , and to 42 mg/L in the effluents of ABR , in aerobic reactor effluent. The total acute toxicity reduction in sequential ABR CSTR reactor effluent was 90%. After that the EC_{50} values decreased from influent 400 mg/L to 114 mg/L, and to 78 mg/L in the effluents of ABR , in aerobic reactor effluent at a HRT of 7,68 days. The total acute toxicity reduction in sequential ABR CSTR reactor effluent was 80%. The maximum acute toxicity removal was found at the maximum HRT of 38.4 days studied during the operation of anaerobic ABR reactor. This could be attributed to high HRT which is enough for toxicity removals of 200 mg/L streptomycin antibiotic. During this HRT the microorganisms have enough time to contact and to acclimate to 200mg/L streptomycin antibiotic in ABR.

Variations of Streptomycin Removal Efficiency in the ABR Reactor at Increasing HRTs. *Figures 26, 27 and 28 shows the HPLC chromatogram of the samples taken from the anaerobic reactor influent, effluent and aerobic CSTR effluent at a constant influent streptomycin concentration of 200 mg/L at a HRT of 12,8 days. A Streptomycin peak was 59,79 mg/L in HPLC chromatogram of the effluent of ABR reactor samples. This showed that streptomycin was biodegraded with removal efficiencies of 66%- 74% in ABR and CSTR reactors at a HRTs of 12,8 days. (See table 4). In figure 26 the chromatogram of streptomycin showed that the peak was appeared after 2.319 min, in HPLC analysis. This corresponded to a streptomycin concentration of 179,57 mg/L. As seen in figure 27, the streptomycin concentration was measured as 59,79 mg/L in the effluent of the ABR. The streptomycin removal efficiency was 66% at a HRT of 12,8 days. The streptomycin concentration was measured as 47,54 mg/L in the aerobic CSTR effluent corresponding a removal efficiency 74%. In this study it was found that the "streptomycin" antibiotic was mainly degraded (179,57 mg/L) in anaerobic ABR reactor while the remaining small part of this antibiotic (47,54 mg/L) was removed in the aerobic CSTR reactor.*

Conclusions

The streptomycin and chloramphenicole concentrations caused 50% decreases in the methanogenic activity (decrease of methane gas production) (IC_{50}) were calculated as 292,06 mg/L and 252,49 mg/L, respectively.

ABR reactor reached to steady-state conditions after an operation period of 92 days at a streptomycin concentration of 25 mg/L. The COD removal efficiency was found as 84% after 92 days of the start-up period. The daily methane gas production, total gas production and methane percentage remained stable at 69,12 L/day, 100,8 L/day and 45% ,respectively.

ABR reactor reached to steady-state conditions after an operation period of 12 days at a chloramphenicole concentration of 50 mg/L. The COD removal efficiency was found as 82% after 12 days of the start-up period. The daily methane gas production, total gas production and methane percentage remained stable at 439,2 L/day and 48%, respectively.

The removal of Streptomycin in ABR and ABR/CSTR Reactor System

1. The COD removal efficiency was 67,55% at a streptomycin concentration of 400 mg/L. The maximum COD removal efficiency was 89,27% at a streptomycin concentration of 200 mg/L. The ABR reactor exhibited high COD (E=94-95%) removal efficiencies until a HRT of 19,2 days.
2. The maximum total, methane gas and methane percentage were found as 432 L/day, 288 L/day and 58%, respectively, for the streptomycin concentration of 200 mg/L. The total gas and methane gas production rates increased from 259,2 to 504 L/day and from 144 to 446,4 L/day, respectively as the HRT decreased from 38,4 days to 9,60 days. The methane percentages of the biogas were approximately 38-40% at a HRT of 38,4 days. The methane percentages increased from 36% up to 53% at a HRT of 19,2 days. The methane percentages increased from 35% up to 46% as the HRT decreased from 19,2 to 7,68 days.
3. The highest VFA concentration (191 mg/L) was found at a HRT of 38,4 days. The VFA concentrations in the effluent decreased to 9 mg/L at a HRT of 7,68 days. VFA was 0 mg/L at all streptomycin concentrations until a streptomycin concentration of 400 mg/L. TVFA/Bic.Alk. ratios in the effluent and in the compartments of ABR were lower than 0.4. These results indicated the stability of ABR reactor at increasing streptomycin concentrations and decreasing HRTs.
4. The COD removal efficiency in sequential anaerobic ABR/aerobic CSTR reactor system was 94,52% at a HRT of 19,2 days. After that, the COD removal efficiency of the total reactor performance decreased from 94,52% to 85,70% when the HRT was decreased from 19,2 days to 7,68 days in sequential anaerobic ABR/aerobic CSTR reactor. For maximum COD removal efficiency (E=94,52%) the optimum HRT was found as 19,2 days.
5. In *Daphnia magna* acute toxicity test the wastewater containing 200 mg/L of streptomycin concentration was found to be toxic (% inhibition = 100%) in the influent of anaerobic ABR/aerobic CSTR reactor system. The acute toxicity reduction in sequential ABR/ CSTR reactor system effluent was 95% at a HRT of 38,4 days. The acute toxicity removal decreased from 95% to 80% as the HRTs decreased from 38,4 days to 7,68 days.
6. In this study it was found that the " streptomycin " antibiotic was mainly degreaded (179,57 mg/L) in anaerobic ABR reactor while the remaining small part of this antibiotic (47,54 mg/L) was removed in the aerobic CSTR reactor. The streptomycin removal efficiency was 66% at a HRT of 12,8 days in the anaerobic ABR effluent. The streptomycin concentration was measured as 47,54 mg/L in the aerobic CSTR effluent corresponding a removal efficiency 74%.

References

[1]. Akunna, J. C., & Clark, M. (2000). Performance of a granular-bed anaerobic baffled reactor (GRABBR) treating whisky distillery wastewater. *Bioresource Technology.*, 74, 257–261.
[2]. APHA-AWWA, (1992). *Standard Methods for the Examination of Water and Wastewater, 17th edition. American Public Health Association/American Water Works Association/Water Environment Federation,* Washington DC, USA.
[3]. B Kasapgil Ince, A Selcuk and O Ince, 2002
[4]. Behling, E., Diaz, A., Colina, G., Herrera, M., Gutierrez, E., Chacin, E., (1997). Domestic wastewater treatment using a UASB reactor. *Biores. Technol*., 61, 239- 245.
[5]. Beydilli, M. I, Pavlosathis, S.G., & Tincher, W.C. (1998). Decolorization and toxicity screening of selected reactive azo dyes under methanogenic conditions. *Water Scienc. and Technology* 38(4-5), 225-32.
[6]. Donlon, B., Razo-Flores, E., Lettinga, G., &. Fıeld, A. J. (1996). Continuous detoxification, transformation and degradation of nitrophenols in upflow anaerobic sludge blanket (UASB) reactors. *Biotechnoogyl. and Bioeng*., 51, 439-449.
[7]. Ge-Fu Zhu, G., F., Li, J., Z., Wu, P., Jin, H., & Wang, Z. (2008). The performance and phase separated characteristics of an anaerobic baffled reactor treating soybean protein processing wastewater. *Bioresource Technology.*, 99, 8027–8033
[8]. Halling, S. (2000). Algal toxicity of antibacterial agents used in intensive farming.*Chemosphere, 40, 731-739*
[9]. Huajun, F., Lifang, H., Dan, S., Chengran, F., Yonghua, H., & Dongsheng, S. (2008) Effects of Temperature and Hydraulic Residence Time (HRT) on Treatment of Dilute Wastewater in a Carrier Anaerobic Baffled Reactor. *Biomedical and Environmental Sciences*, 21, 460-466
[10]. Huajun, F., Lifang, H., Dan, S., Chengran, F., Yonghua, H., & Dongsheng, S. (2008). Effects of operatonal factors on soluble microbial products in a carrier anaerobic baffled reactor treating dilute wastewater. *Journal of Environmental Sciences*, 20, 690-695.
[11]. Kurosawa, N.; Kuribayashi, S.; Owada, E.; Ito, K.; Nioka, M.; Arakawa, M.; Fukuda, R.; J. Chromatogr., Biomed. Appl., 11 Oct 1985, 44 (2 (J.Chromatogr., 343)), 379-385
[12]. Kuscu, O. S., & Sponza, D. T. (2009). Effects of nitrobenzene concentration and hydraulic retention time on the treatment of nitrobenzene in sequential anaerobic baffled reactor (ABR)/ continuously stirred tank reactor (CSTR) system *Bioresource Technology.*, 100, 2162–2170.
[13]. Kümmerer, K (2009). Antibiotics in the aquatic environment – A review – Part II. *Chemosphere*, 75, 435-441
[14]. Liu, X., Nangi, R., & Yuan, Y,. (2009). Performance of a periodic anaerobic baffled reactor fed on chinese traditional medicine industirial wastewater. *Bioresource Technology*, 100, 104-110
[15]. Metcalf & Eddy. (1991). Wastewater Engineering: treatment, Disposal and Reuse. Mc Graw.Hill.Inc.
[16]. Oktem, Y., Ince, O., Sallis, P., Donnelly, T., & Ince, K. B. (2007). Anaerobic treatment of a chemical synthesis- based pharmaceutical wastewater in a hybrid upflow anaerobic sludge blanket reactor. *Bioresource Technology*, 99, 1089-1096
[17]. Owen, W.F., Stuckey, D.C., Healy, J.B., Young, JR. L.Y., & McCarty, P. L. (1979). Bioassay for monitoring biochemical methane potential and anaerobic toxicity, *Water Research*, 13, 485-492.
[18]. Razo-Flores, E., Luijten, M., Donlon, B. A., Lettinga, G., Field, J. A. (1997). Biodegradation of selected azo dye under methanogenic conditions. *Water Science Technology*, 36 (6-7), 65-72.
[19]. Shreeshivadasan Chelliapan, Thomas Wilby, Paul J. Sallis, 2006
[20]. Speece, R.E. (1996). Anaerobic biotechnology for industrial wastewater. Tennessee: Archae Press, 5840 R.E. Lee, Dr. Nashville, 37215.
[21]. Standart Methot (2005).
[22]. Ubay, G. (1989). Kinetic modelling of UASBR's. MSc thesis. Faculty of Science, Istanbul Technical University, (in Turkish).
[23]. Uyanik, S., Sallis, P. J., & Anderson, G. K. (2002). The effect of polymer addition on granulation in an anaerobic baffled reactor (ABR). Part I: process performance. *Wat. Res.*, 36, 933–943.
[24]. Vossoughi, M., Shakeri, M., & Alemzadeh, I. (2003). Performance of anaerobic baffled reactor treating synthetic wasterwater influenced by decreasing COD/SO4 rations. *Chem. Eng and Process.*, 42, 811-816.
[25]. Yalcin Aksin Oktem, Orhan İnce, Paul Sallis, Tom Donnelly, Bahar Kasapgil Ince, 2007

[26]. Wang, J., Huang, Y., & Zhao, X. (2004). Performance and characteristics of an anaerobic baffled reactor. *Bioresource Technol*ogy, 93(2), 205-208.
[27]. Weifen, W., Hong, L., Changhu, X., & Jamil, K. (2004). Elimination of chloramphenicol, sulphamethoxazole and OXYtetacycline in shrimp, Penaeus chinensis following medicated-feed treatment. *Environment Internatıonal,* 30, 367-373
[28]. Wikipedia. (n.d.).*Streptomycin*, Retrieved August 8, 2009, from http://en.wikipedia.org/wiki/Streptomycin
[29]. Zhu, G., F., Li, J., Z., Wu, P., Jin, H., & Wang, Z. (2008). The performance and phase separated characteristics of an anaerobic baffled reactor treating soybean protein processing wastewater. *Bioresource Technology.*, 99, 8027–8033

Table 1. The chemical identities of the streptomycin (Wikipedia,2009).

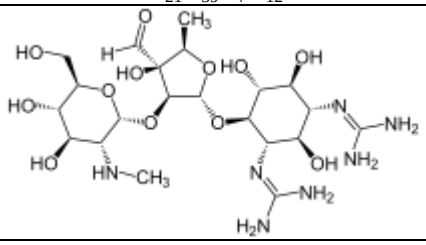
Characteristics	**Streptomycin**
Chemical name	Streptomycin
Chemical formula	$C_{21}H_{39}N_7O_{12}$
Chemical structure	

Table 2. The physical and chemical characteristics of the streptomycin (Wikipedia,2009).

Property	**Streptomycin**
Molecular weight	581.574 g/mol
Melt point	12 °C (54 °F)
Color	White
Half life	5 to 6 hours
Excretion	Renal
Bioavailability	84% to 88%
Routes	Intramuscular, intravenous

Table 3 Variations of acute toxicity values (EC_{50} for Daphnia magna) through influent, ABR, CSTR reactor effluents and total sequential reactor system

HRT Days	EC_{50} ABR influent (mg/L)	Dilution (%)	EC_{50} ABR Effluent (mg/L)	Toxicity Removal (%)	EC_{50} Aerobic Effluent (mg/L)	Toxicity Removal (%)	EC_{50} Removal in Sequential Total System Effluent (%)
38,4	400	66	132	%67	20	%85	%95
19,2	400	60	120	%70	61,2	%49	%85
12,8	400	41	82	%80	46	%43	%89
9,60	400	41	82	%80	42	%49	%90
7,68	400	57	114	%72	78	%32	%80

Table 4 Variations of Streptomycin concentrations in the influent, effluent of the ABR Reactor in the effluent of the Aerobic CSTR and in total reactor system versus decreasing HRTs at an initial Streptomycin concentration of 200 mg/L

HRT Days	Antibiotic ABR Influent (mg/L)	Antibiotic ABR Effluent (mg/L)	Antibiotic ABR Effluent Removal (%)	Antibiotic Aerobic Effluent (mg/L)	Antibiotic Removal in Sequential Total System Effluent (%)
38,4	180,71	83,74	54%	48,54	73%
19,2	178,41	82,12	53,4%	49,90	72%
12,8	179,57	59,79	66%	47,54	74%
9,60	181,48	75,38	58%	54,26	71%
7,68	180,48	86,43	52%	72,04	60%

Figures Captions

Fig.1. Schematic configuration of lab-scale anaerobic (ABR)/aerobic (CSTR) sequential reactor system.
Fig.2. IC_{50} value for Streptomycin in anaerobic sludge (IC_{50}= 292,06 mgL^{-1})
Fig.3. COD removal efficiencies in the ABR during the start-up period in ABR
Fig.4. Methane gas production and methane percentages in the ABR during the start-up period in ABR.
Fig.5. Total gas production and methane percentages in the ABR during the start-up period in ABR
Fig. 6. Effect of streptomycin concentration on COD removal efficiencies in ABR reactor
Fig.7. The variations of VFA in ABR at increasing streptomycin concentrations.
Fig.8. The variations of HCO3 in ABR at increasing streptomycin concentrations.
Fig.9. Effect of streptomycin concentration on COD removal efficiencies in all compartments. (a- compartment 1, b-compartment 2, c-compartment 3, d- compartment 4)
Fig.10. The variations of VFA in ABR at increasing streptomycin concentrations in the all compartments. (a-compartment 1, b-compartment 2, c-compartment 3 d- compartment 4)
Fig.11. The variations of HCO3 in ABR at increasing streptomycin concentrations in the all compartments. (a-compartment 1, b-compartment 2, c-compartment 3 d- compartment 4)
Fig.12. The variations of methane gas production and methane percentage in ABR at increasing streptomycin concentrations.
Fig.13. The variations of total gas production and methane percentage in ABR at increasing streptomycin concentrations.
Fig.14. The effect of HRTs on COD removal efficiencies in ABR
Fig.15. The variations of VFA and VFA/Bic.Alk. ratio in the effluent of ABR at decreased HRTs.
Fig.16. The variations of Bic.Alk. and VFA/Bic.Alk. ratio in the effluent of ABR at decreased HRTs
Fig.17. Methane gas production and methane percentage in ABR at decreased HRTs
Fig.18. Total gas production and methane percentage in ABR at decreased HRTs
Fig.19. The variations of COD in ABR at decreased HRTs in the all compartments. (a- compartment 1, b-compartment 2, c-compartment 3 d- compartment 4)
Fig.20. The variations of VFA in ABR at decreased HRTs in the all compartments. (a- compartment 1, b-compartment 2, c-compartment 3 d- compartment 4)
Fig.21. The variations of HCO3 in ABR at decreased HRTs in the all compartments. (a- compartment 1, b-compartment 2, c-compartment 3 d- compartment 4)
Fig.22. The overall COD removal efficiency in aerobic (CSTR) reactor system
Fig.23. The overall VFA and VFA/Bic.Alk. ratio in aerobic (CSTR) reactor
Fig.24. The overall HCO3 and VFA/Bic.Alk. ratio in aerobic (CSTR) reactor
Fig.25. SMA values in ABR at different HRTs.
Fig.26. HPLC chromatogram in the influent of ABR at 12,8 days of HRT
Fig.27. HPLC chromatogram in the effluent of ABR at 12,8 days of HRT
Fig.28. HPLC chromatogram in the effluent of CSTR at 12,8 days of HRT

International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54

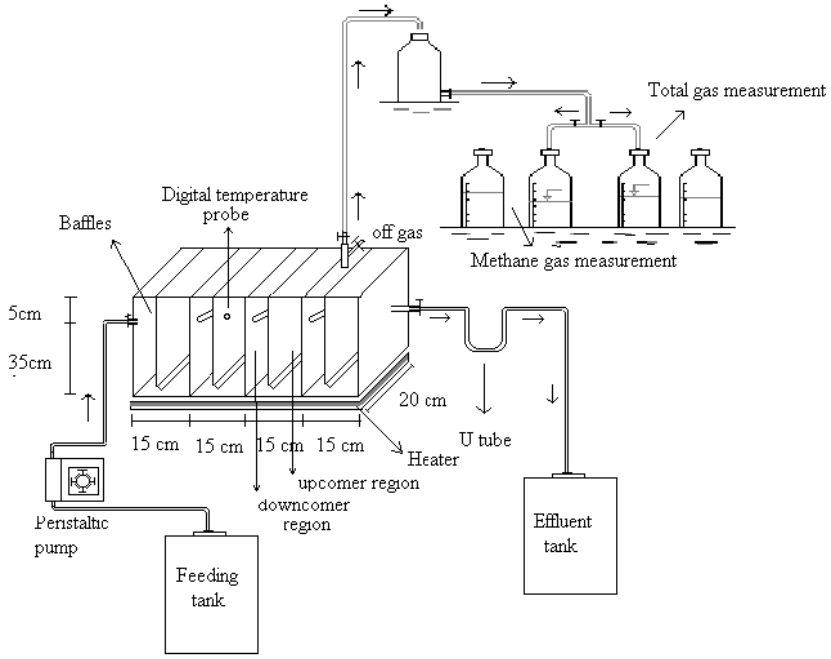


Fig.1.

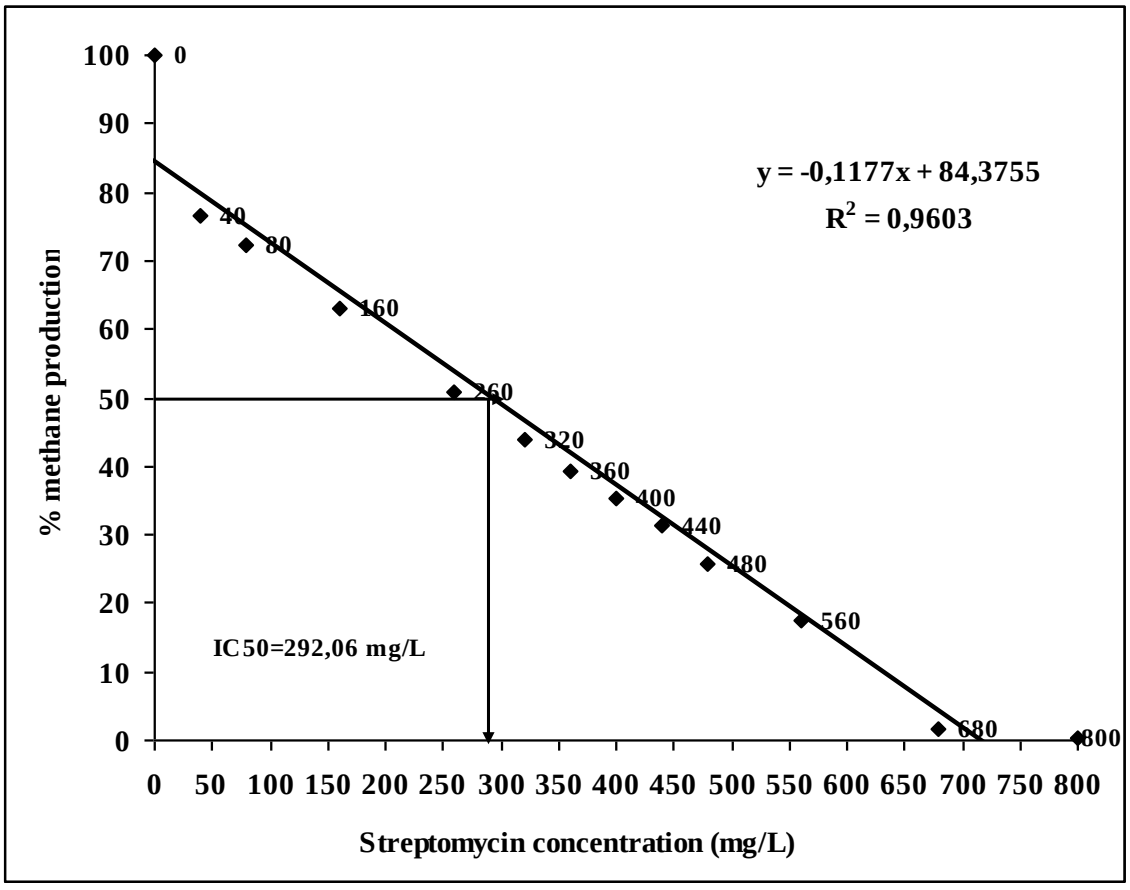


Fig. 2.

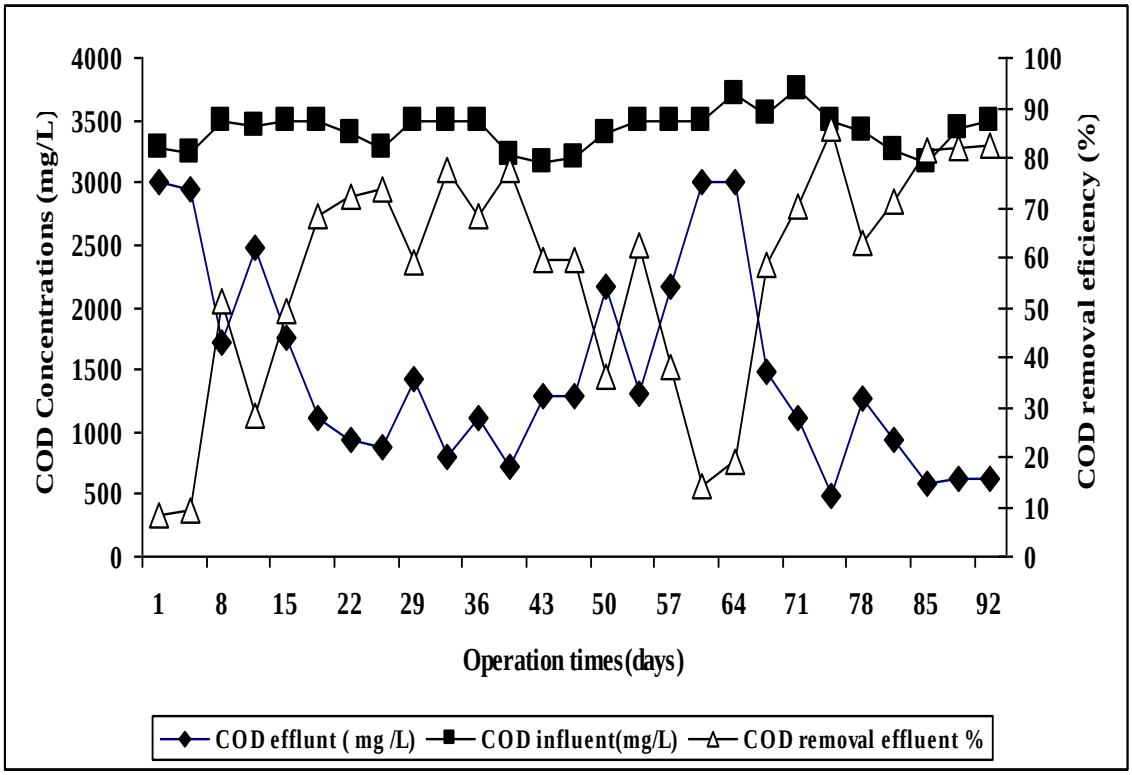

COD Concentrations (mg/L)
COD removal eficiency (%)
Operation times(days)
COD efflunt (mg /L)
COD influent(mg/L)
COD removal effluent %

Fig. 3.

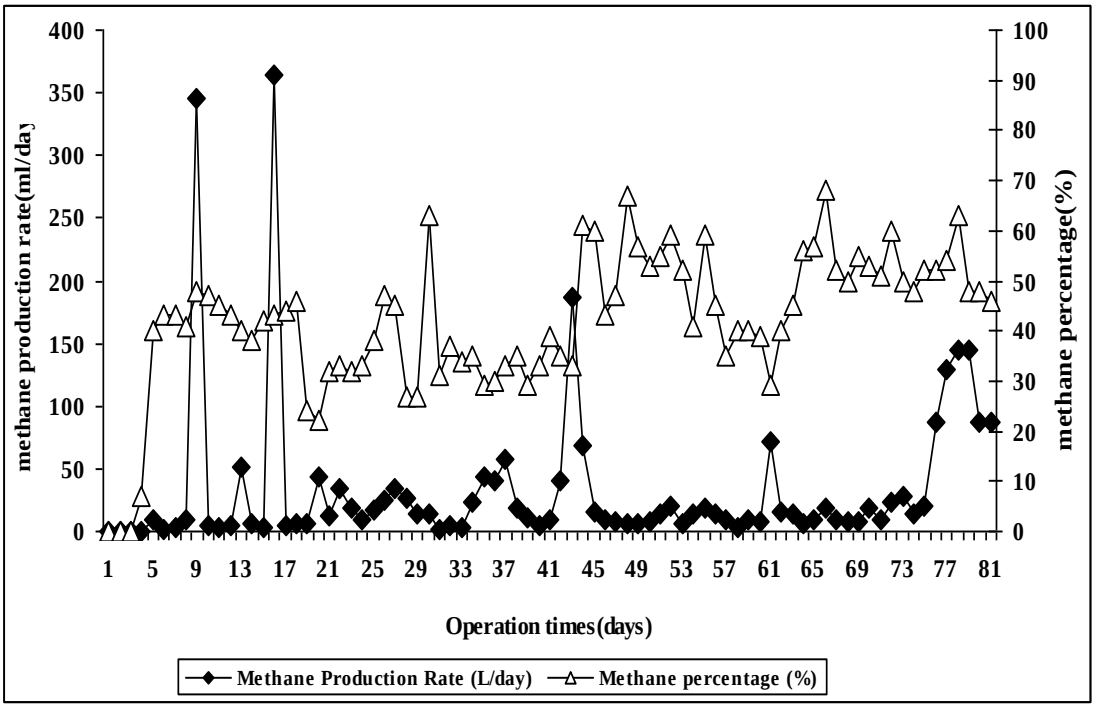

methane production rate(ml/day
methane percentage(%)
Operation times(days)
Methane Production Rate (L/day)
Methane percentage (%)

Fig. 4.

International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54

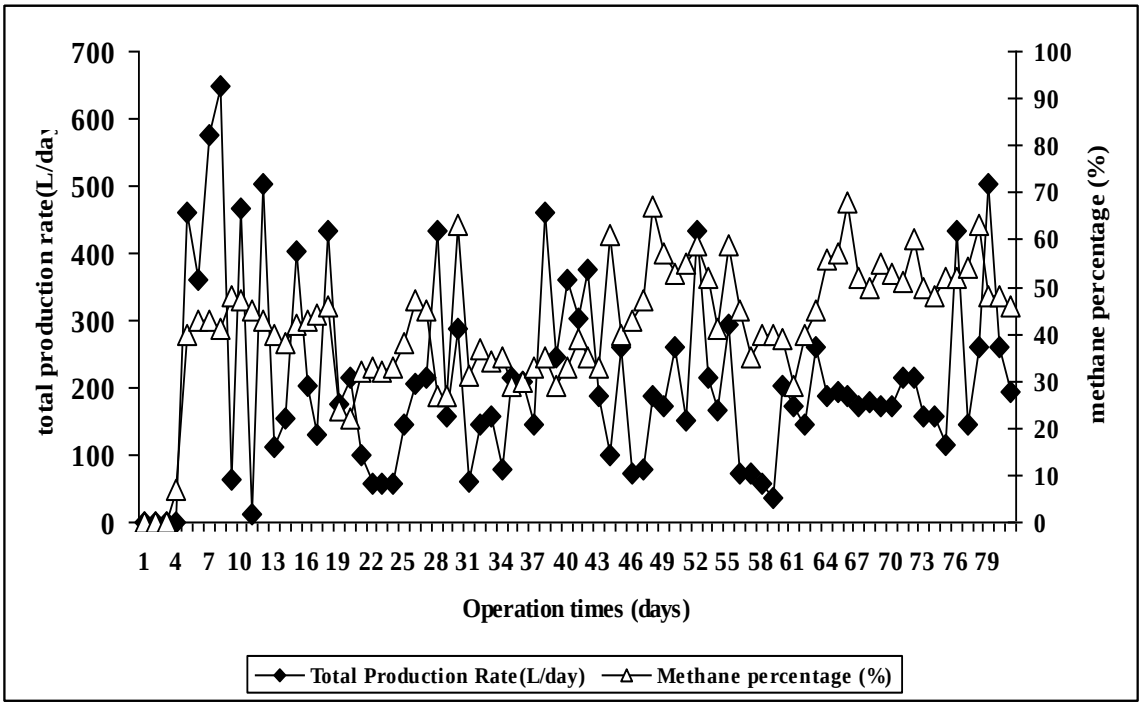


Fig. 5.

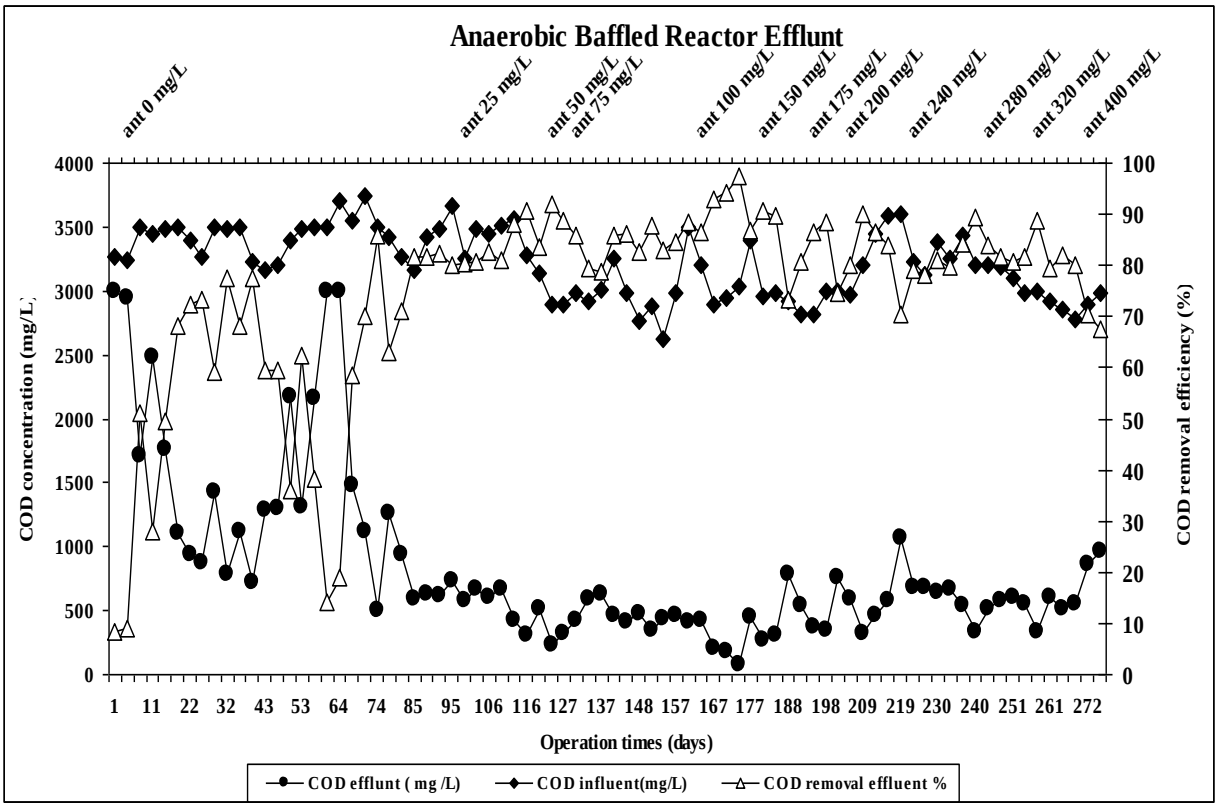


Fig. 6.

International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54

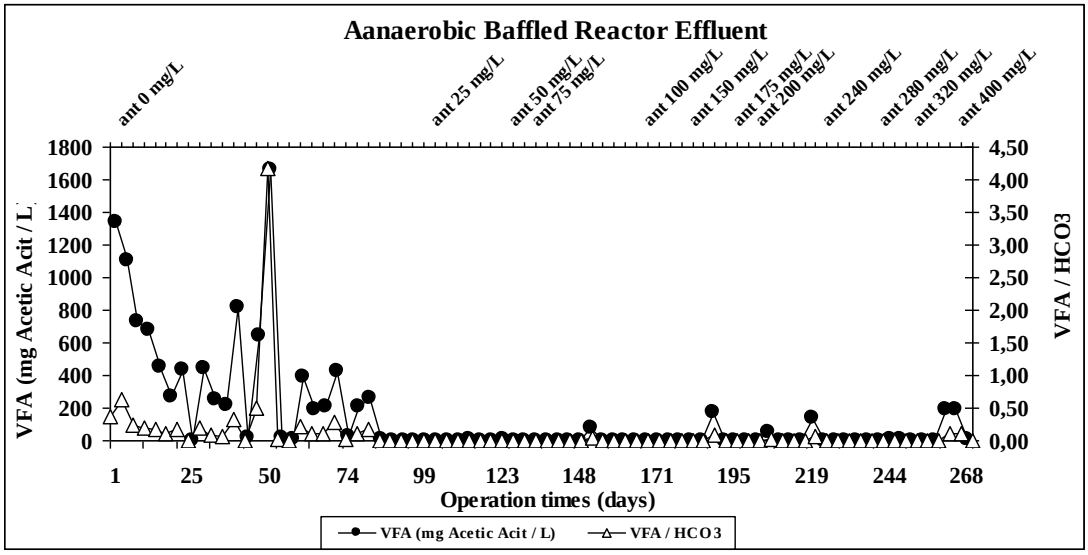


Fig. 7.

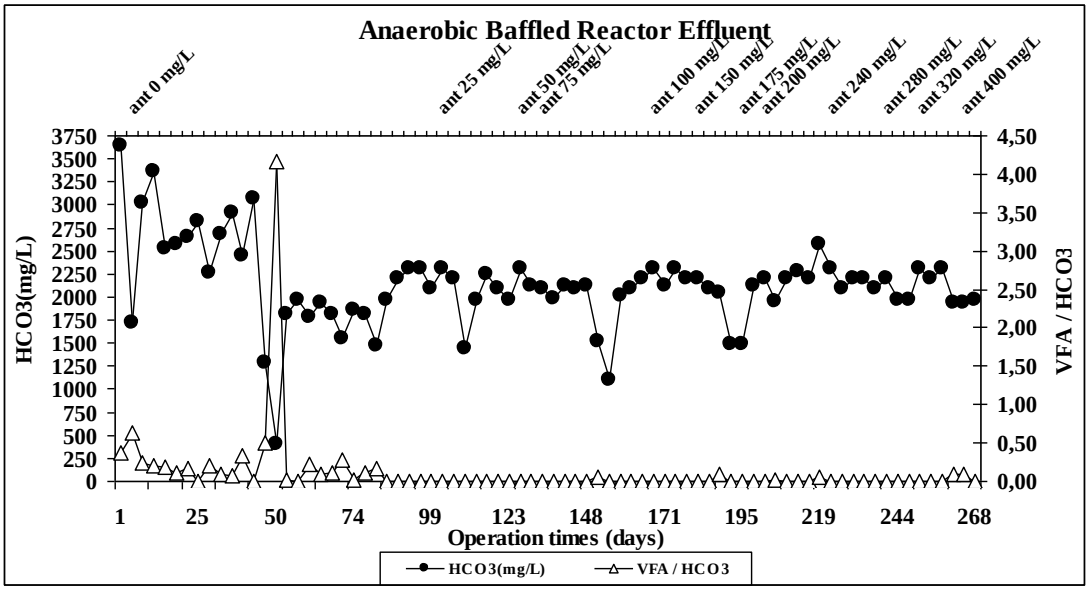


Fig. 8.

International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54

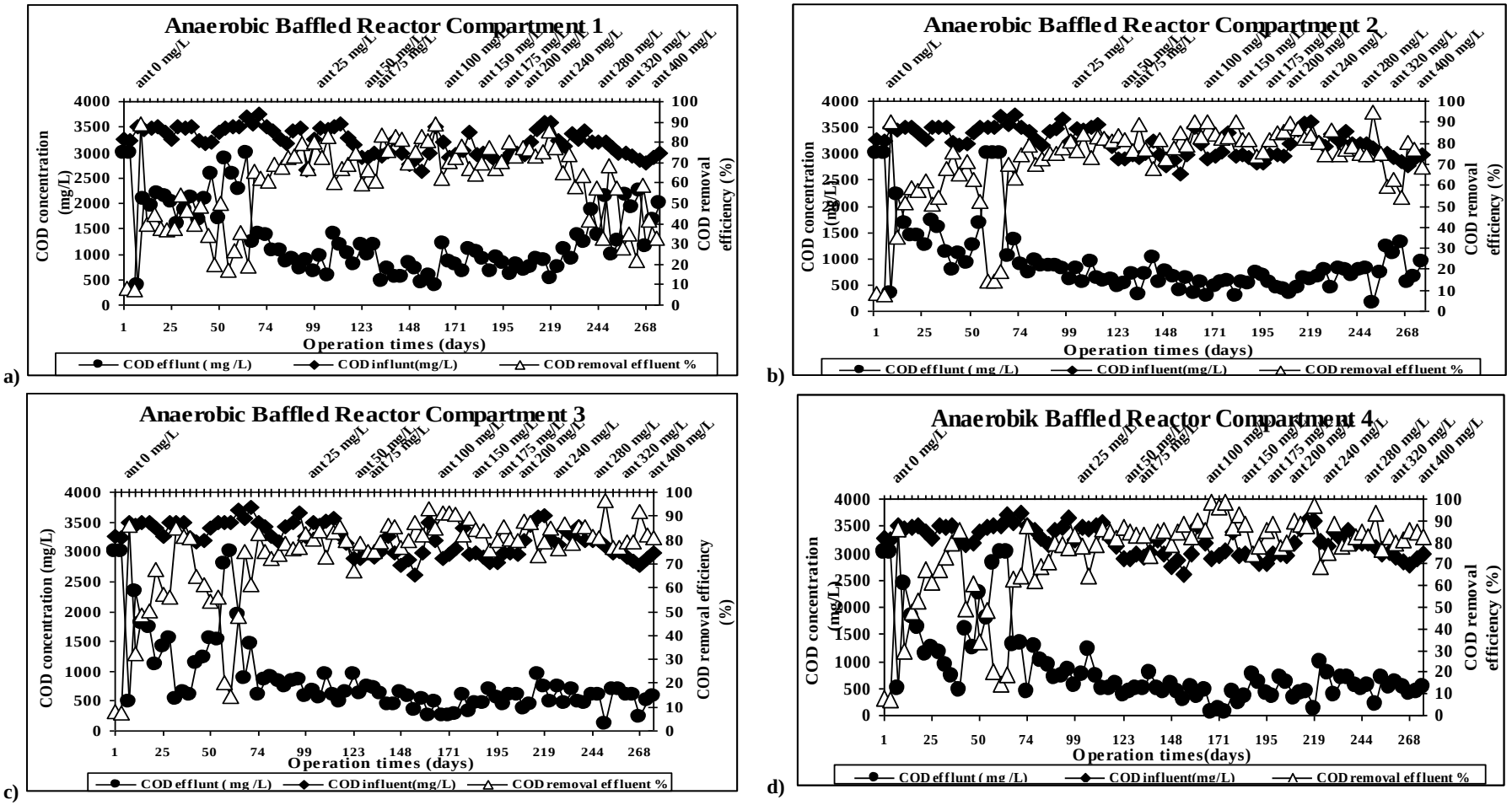


Figure 9

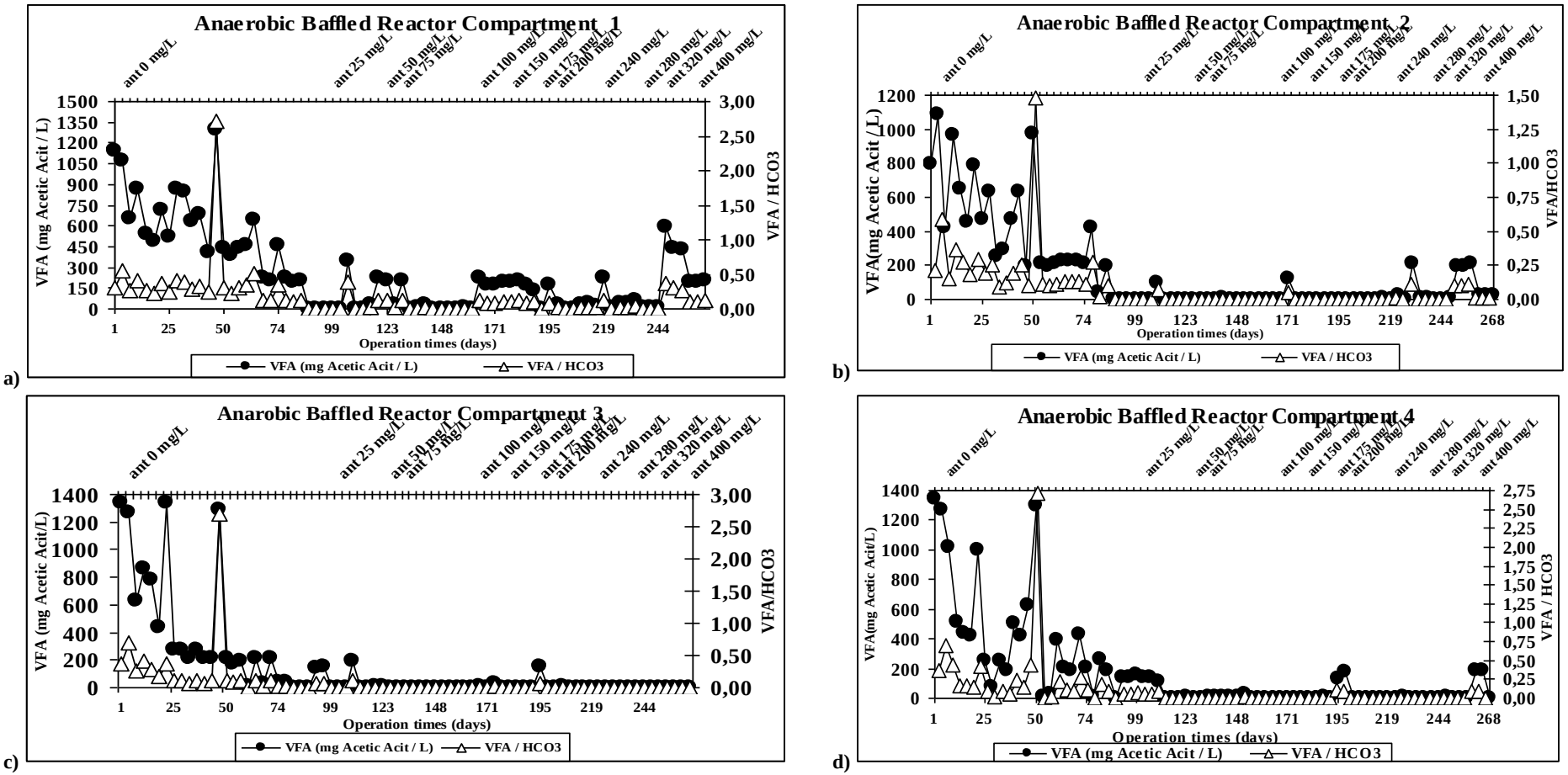

Anaerobic Baffled Reactor Compartment_1
ant 0 mg/L
ant 25 mg/L
ant 50 mg/L
ant 75 mg/L
ant 100 mg/L
ant 150 mg/L
ant 175 mg/L
ant 200 mg/L
ant 240 mg/L
ant 280 mg/L
ant 320 mg/L
ant 400 mg/L
VFA (mg Acetic Acit / L)
VFA / HCO3
Operation times (days)
a)
Anaerobic Baffled Reactor Compartment_2
b)
Anarobic Baffled Reactor Compartment 3
c)
Anaerobic Baffled Reactor Compartment 4
d)

Figure 10

International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54

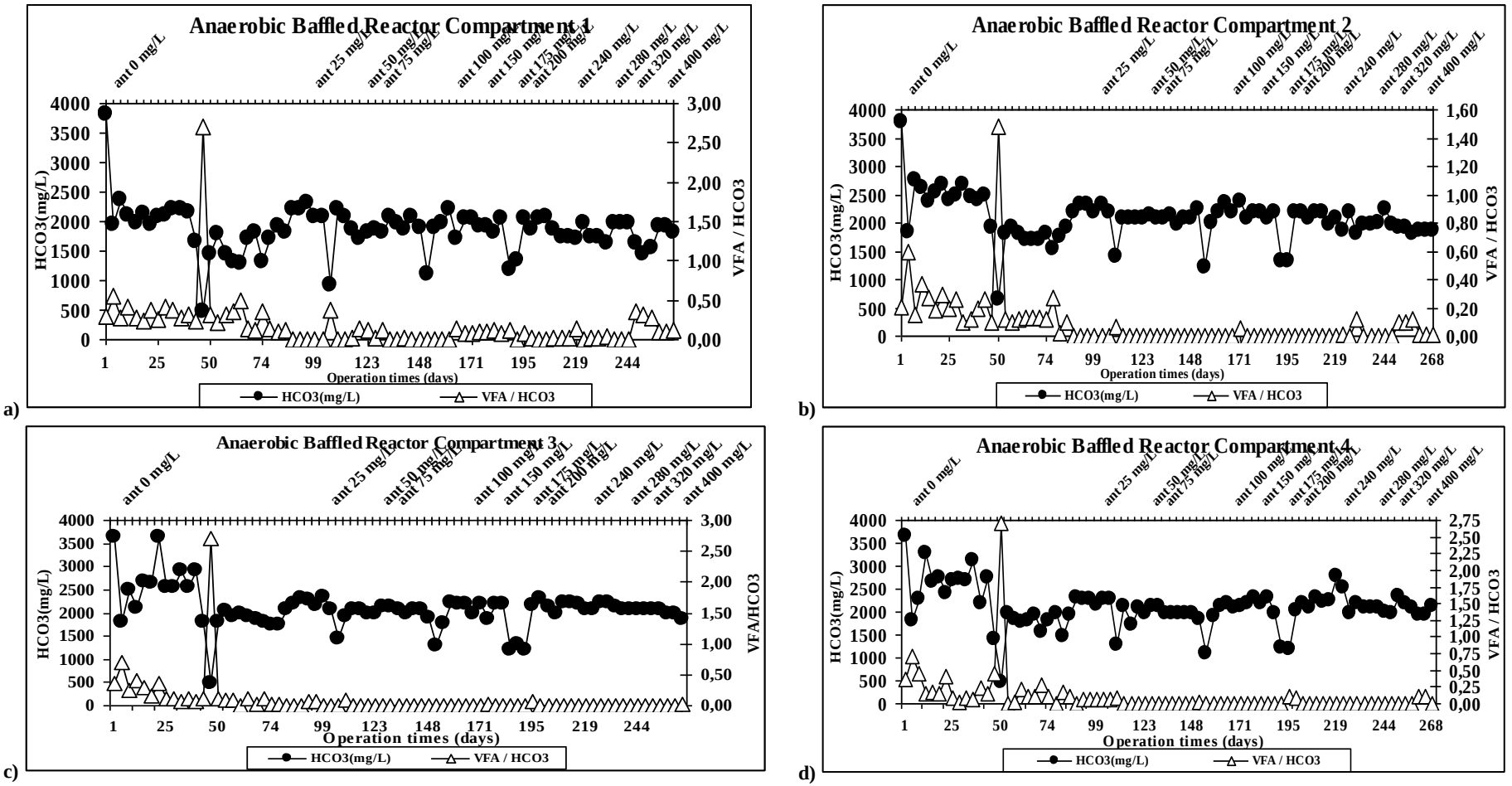


Figure 11

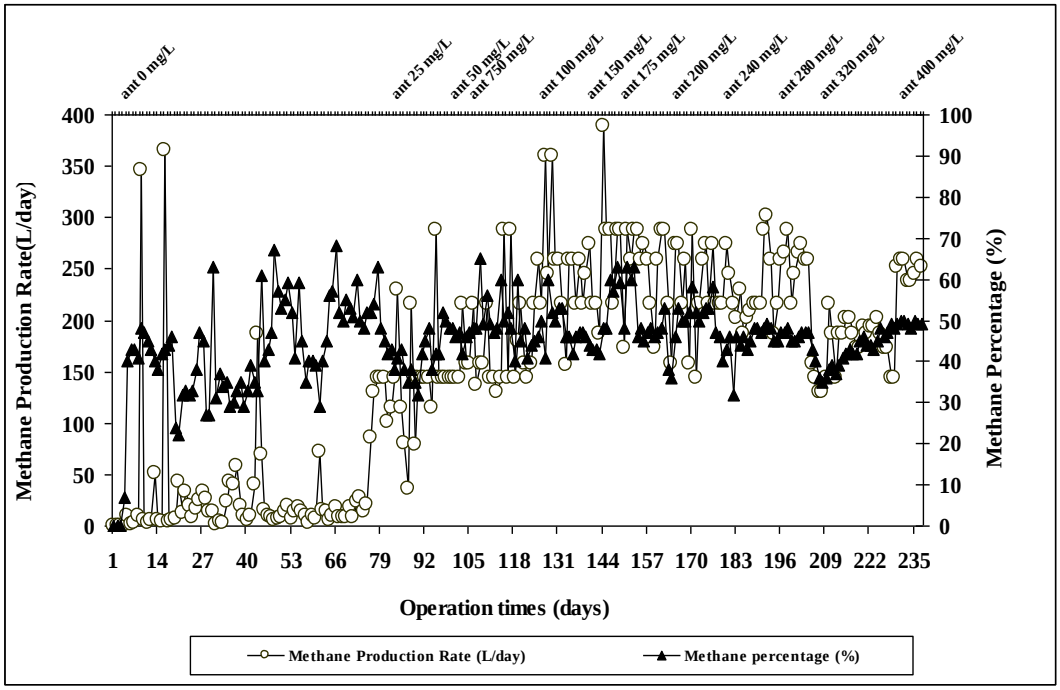


Figure 12

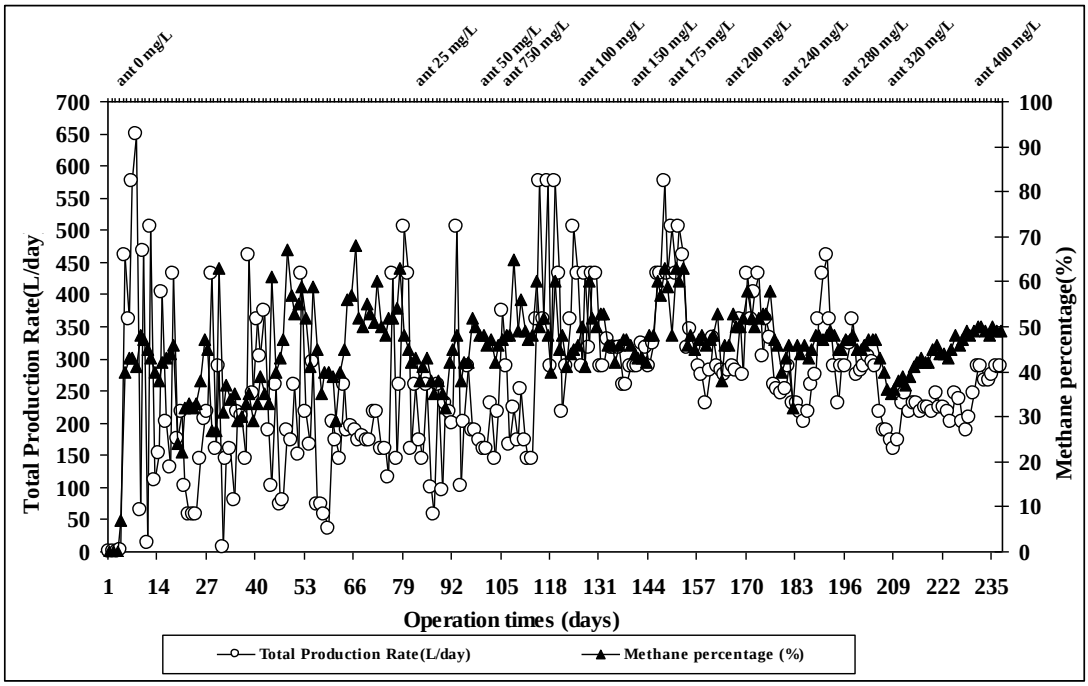


Figure 13

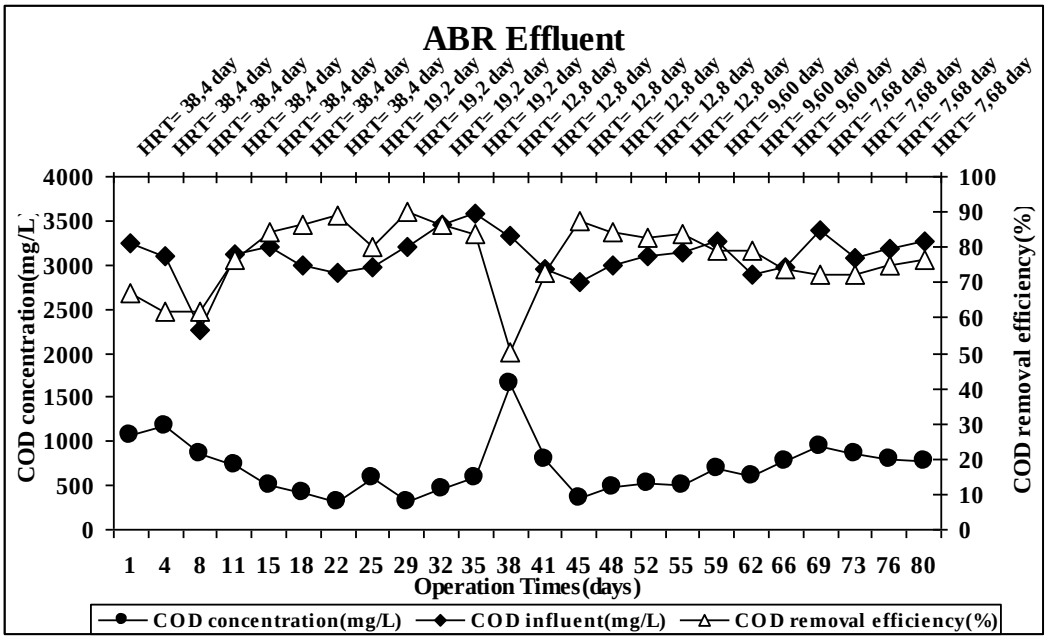


Figure 14

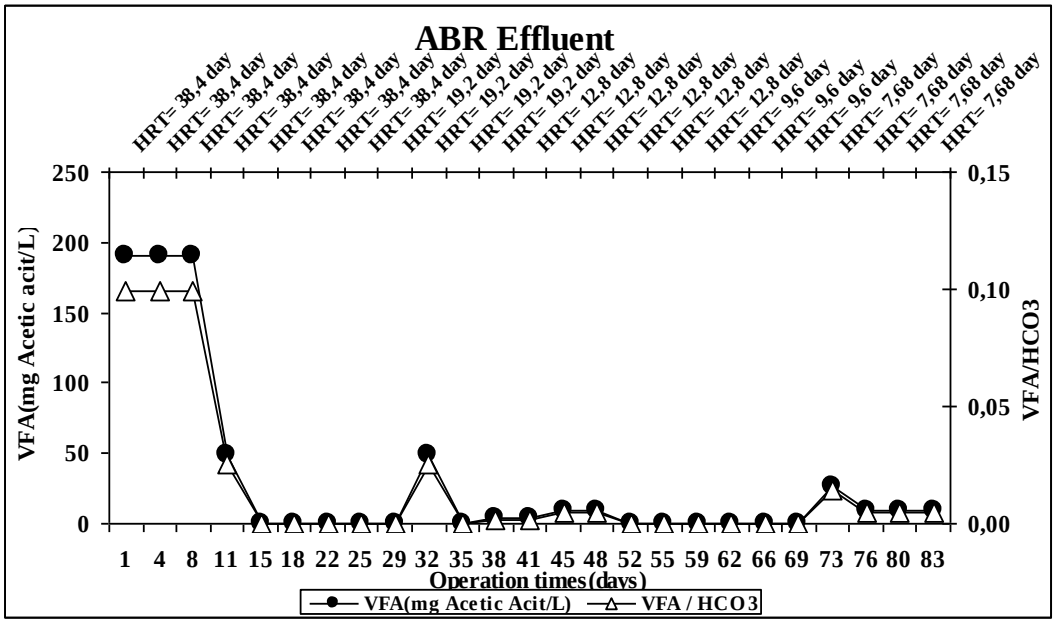


Figure 15

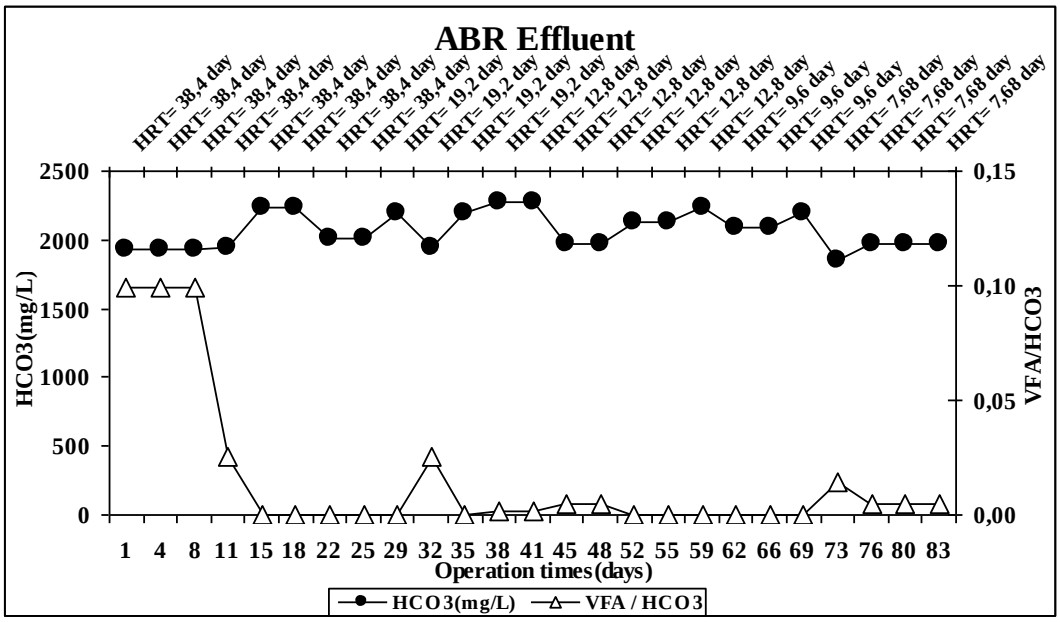


Figure 16

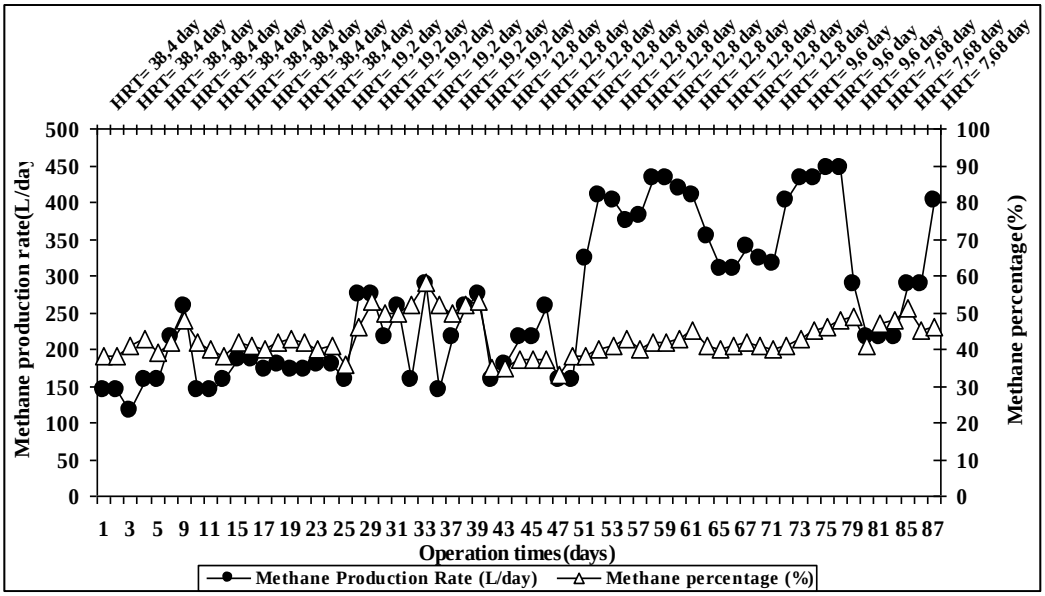


Figure 17

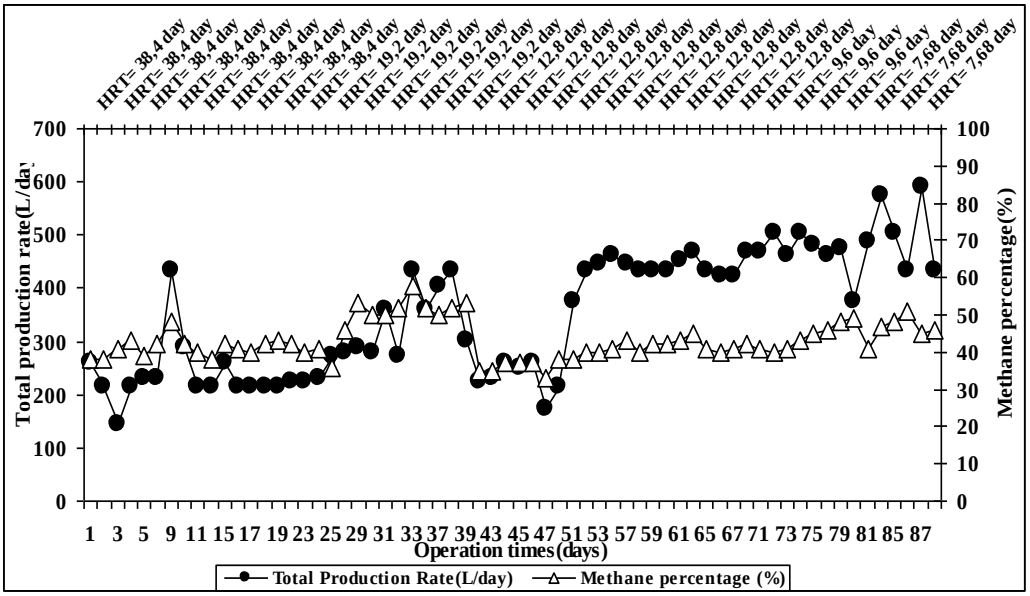
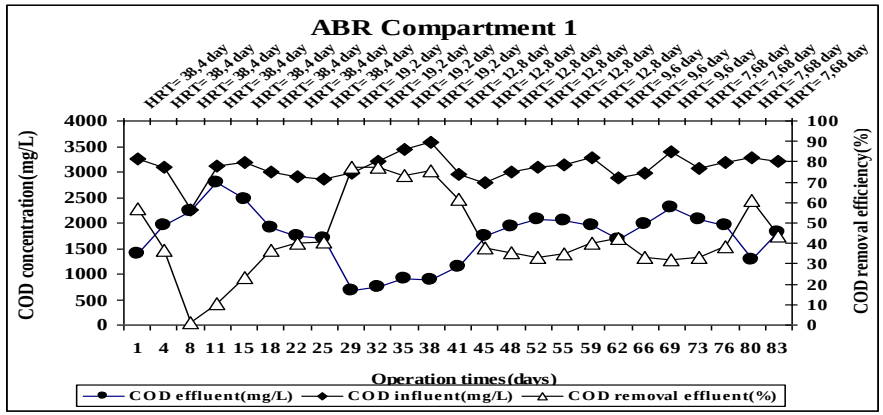
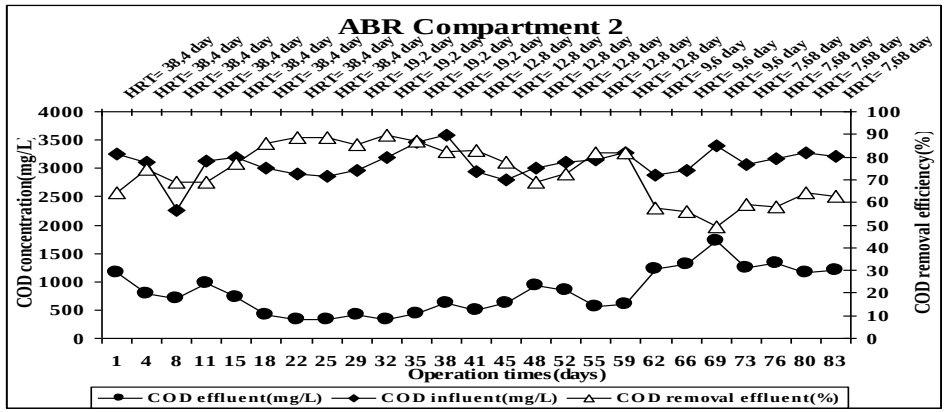

HRT= 38,4 day
HRT= 19,2 day
HRT= 12,8 day
HRT= 9,6 day
HRT= 7,68 day
Total production rate(L/day)
Methane percentage(%)
Operation times(days)
Total Production Rate(L/day)
Methane percentage (%)

Figure 18

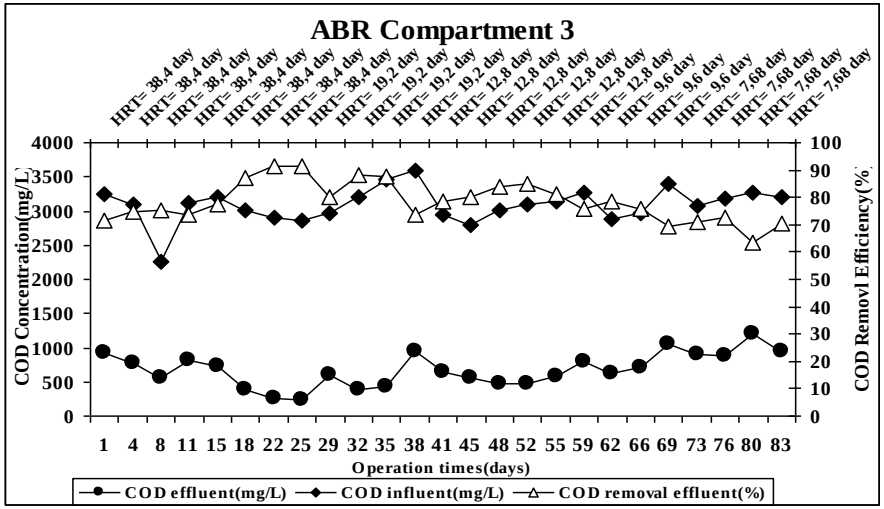
International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54



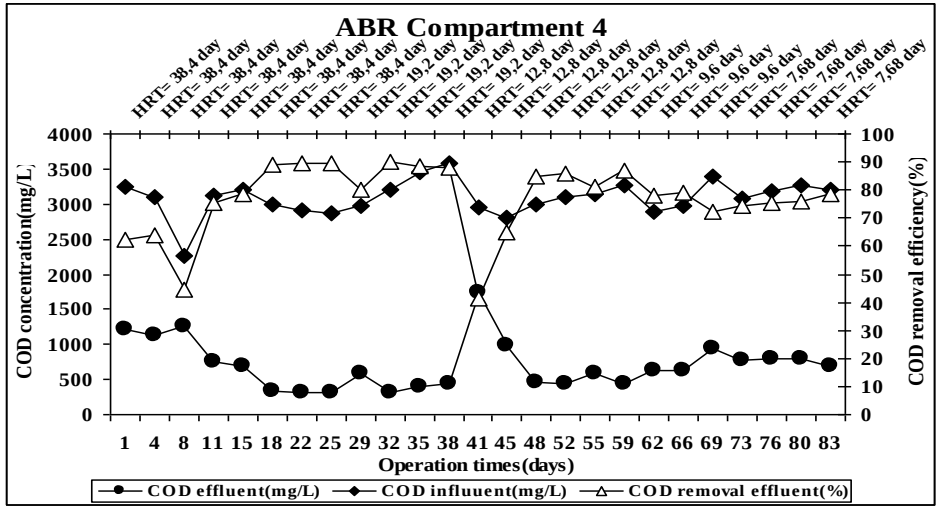
a)



b)



c)



d)

Figure 19

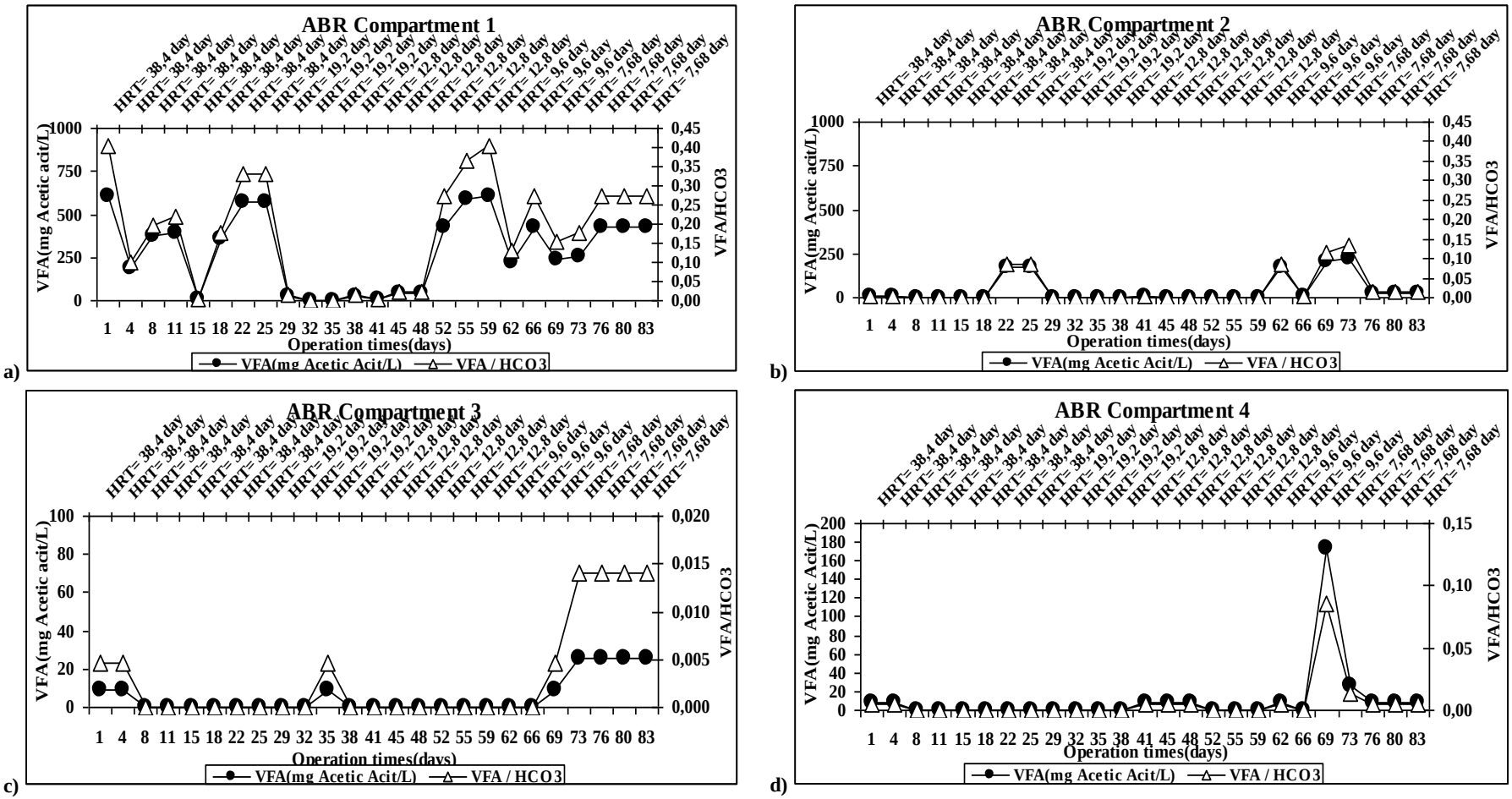

ABR Compartment 1
VFA(mg Acetic acit/L)
VFA/HCO3
Operation times(days)
VFA(mg Acetic Acit/L)
VFA / HCO3
a)
ABR Compartment 2
b)
ABR Compartment 3
c)
ABR Compartment 4
d)

Figure 20

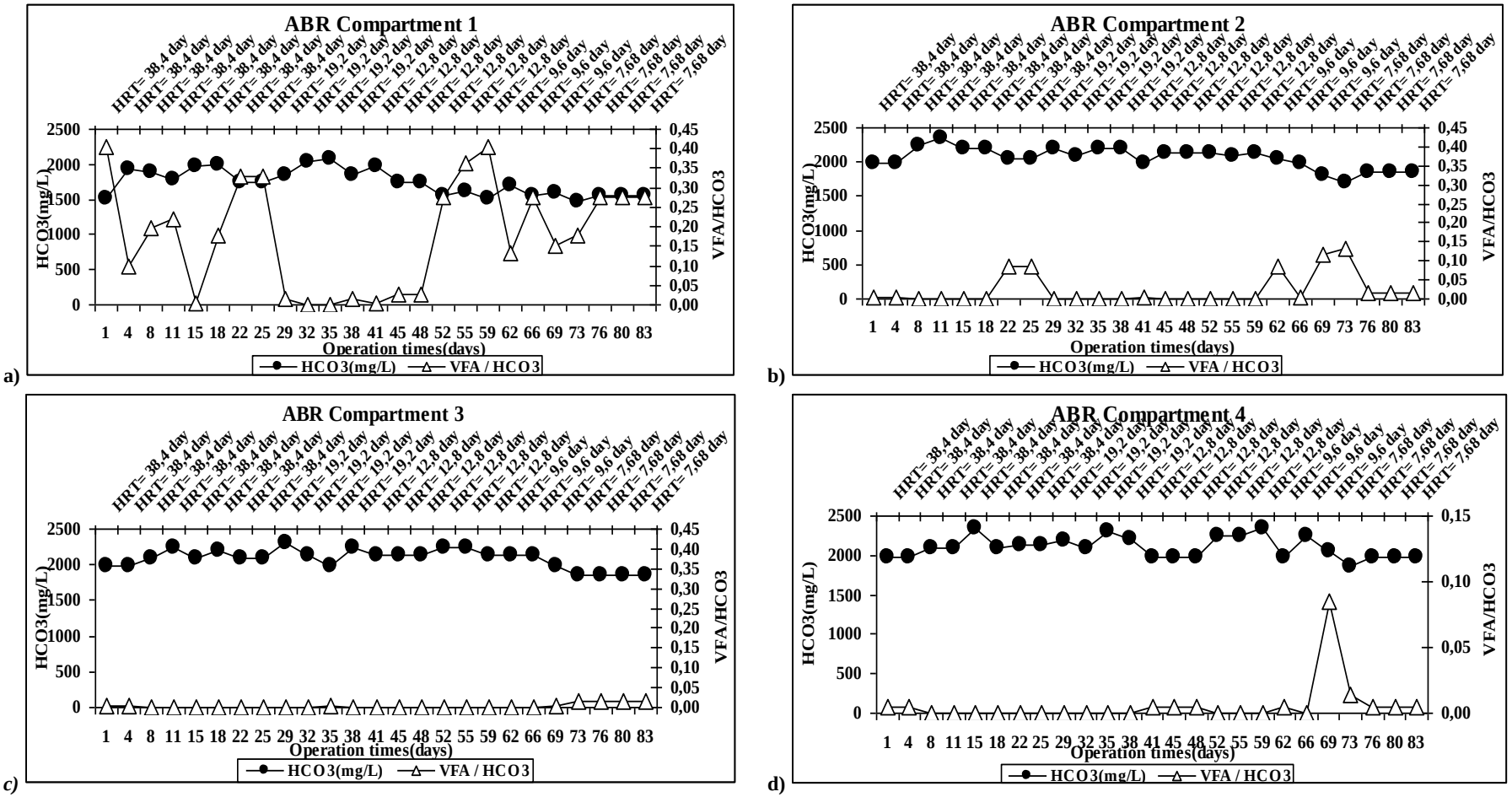

ABR Compartment 1
ABR Compartment 2
ABR Compartment 3
ABR Compartment 4
HRT= 38,4 day
HRT= 19,2 day
HRT= 12,8 day
HRT= 9,6 day
HRT= 7,68 day
HCO3(mg/L)
VFA/HCO3
Operation times(days)
HCO3(mg/L)
VFA / HCO3
a)
b)
c)
d)

Figure 21

International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 20-54

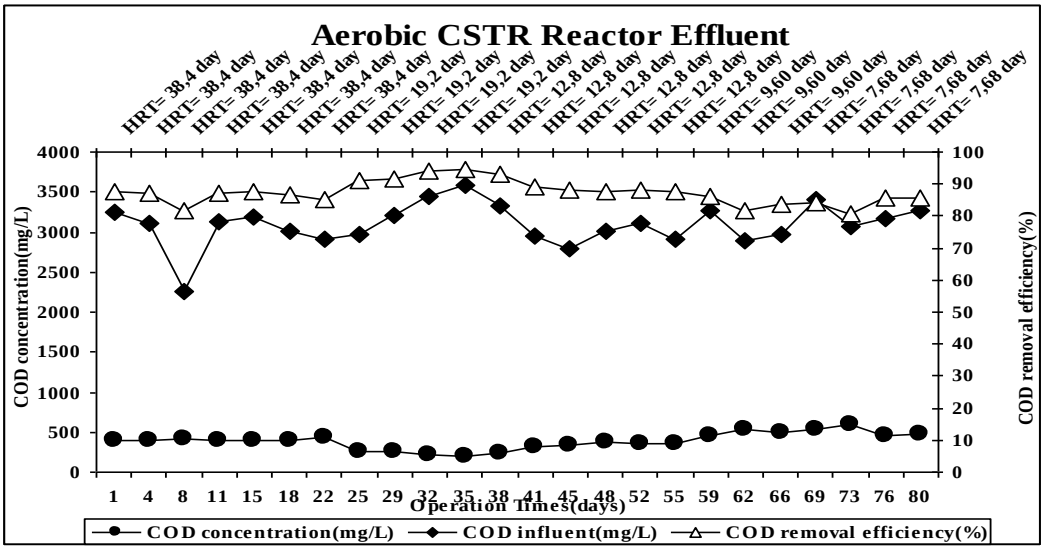


Figure 22

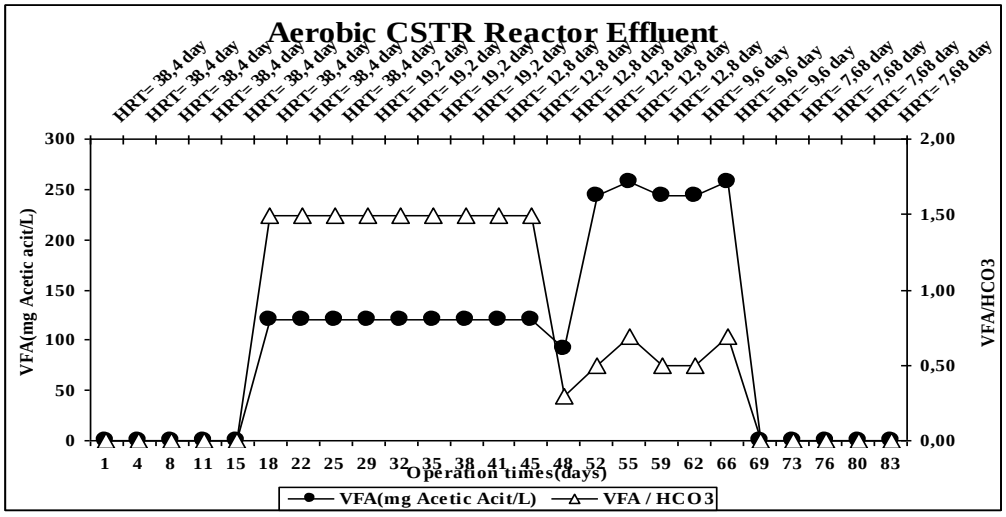


Figure 23

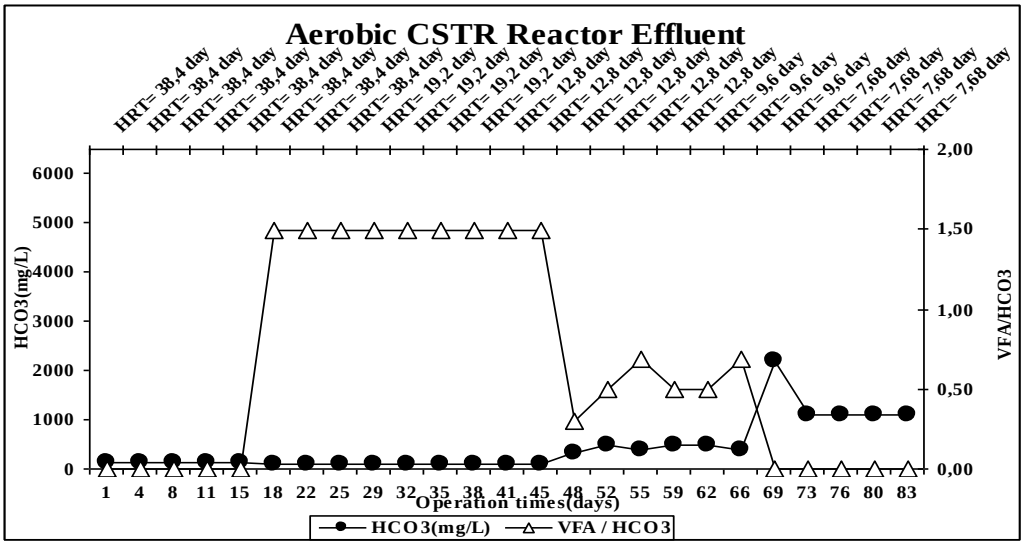


Figure 24

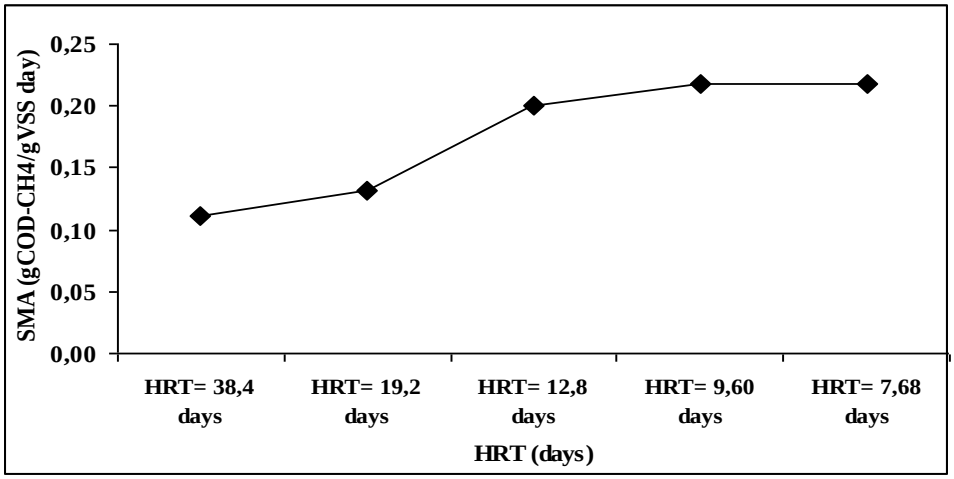


Figure 25

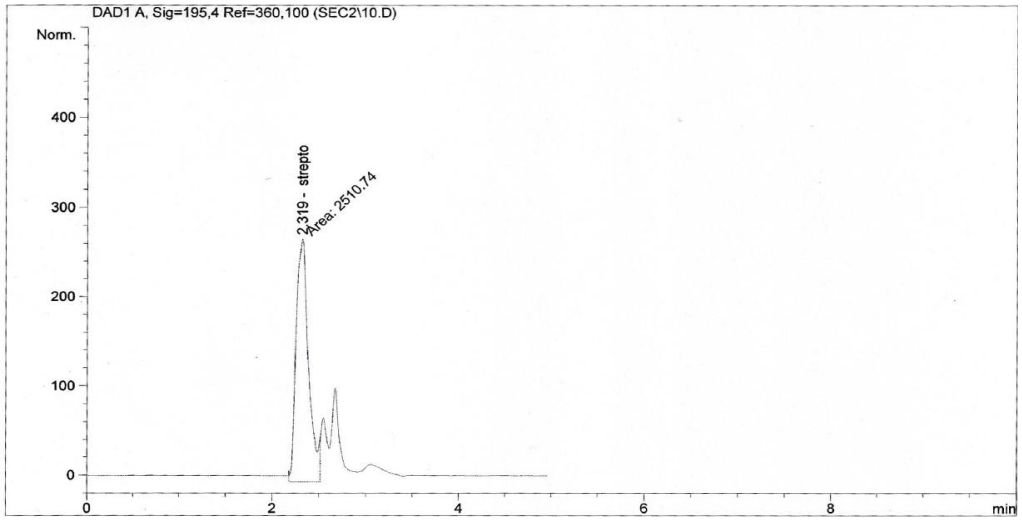


Figure 26

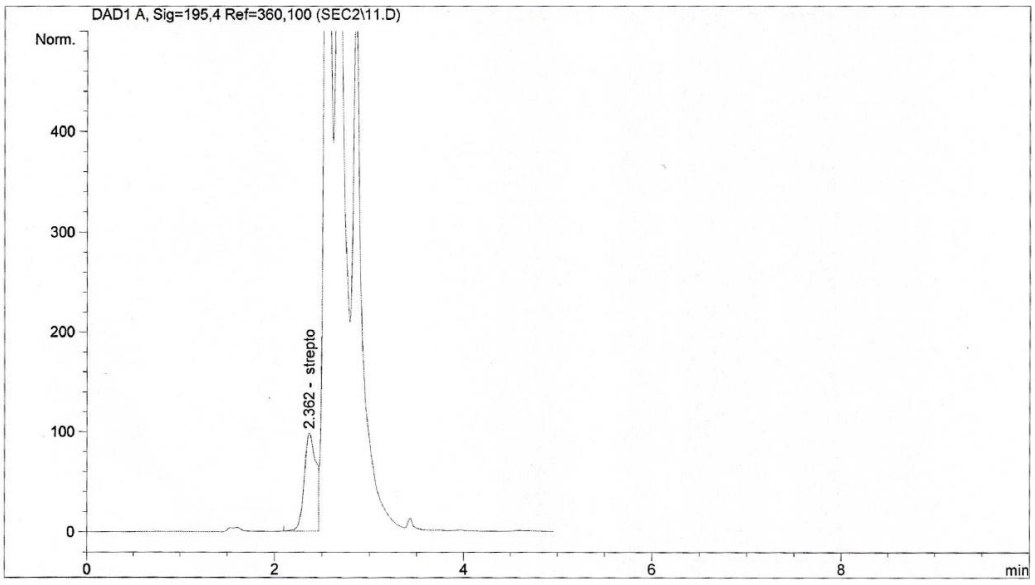


Figure 27

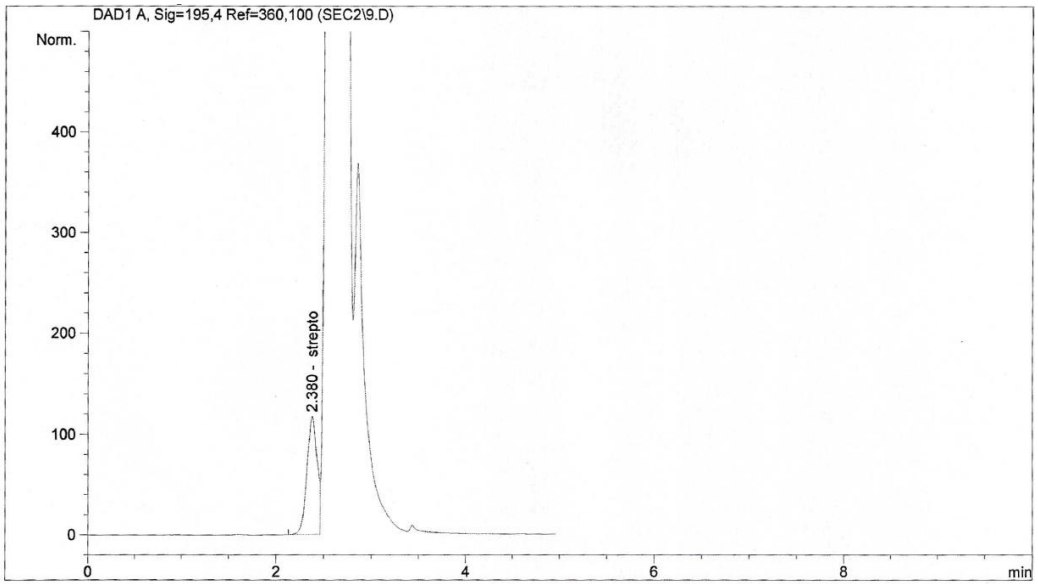

DAD1 A, Sig=195,4 Ref=360,100 (SEC2\9.D)
Norm.
400
300
200
100
0
2.380 - strepto
0
2
4
6
8
min

Figure 28