SEMARAK ILMU
PUBLISHING

Semarak Engineering Journal

Journal homepage:
https://semarakilmu.my/index.php/sej/index
ISSN: 3036-0145

Assessment of Combined System Up Flow Anaerobic Sludge Blanket and Sequencing Batch Biofilm Reactor (UASB+SBBR) Technology to Treat Dairy Wastewater

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ARTICLE INFO

Article history:
Received 12 February 2026
Received in revised form 21 March 2026
Accepted 18 May 2026
Available online 9 June 2026

Keywords:
SBBR; Biofilm; UASB; Biogas; COD; BOD; TN; PO_4^3; TSS; HRT

ABSTRACT

Biological treatment of dairy wastewater was investigated using Up flow Anaerobic Sludge Blanket reactor followed by Sequencing Batch Biofilm Reactor (UASB+SBBR).The present study were carried out in a laboratory-scale UASB reactor volume (70 L) is a cylindrical shape with the total height 132cm,The effective depth is 100cm with diameter 30cm.then, SBBR is a square shape tank volume(70 L) with 40cm length and 40cm width and the effective depth is 44cm.this study aims was included an assessment of an industrial dairy wastewater in Al-Samawa City - Iraq by using combined system. Raw dairy wastewater was fed to the combined system (UASB+SBBR) under different Concentration. Two-month of The start-up period allowed for biofilm growth on the Kaldnes (K1) in SBBR and the production of gas from a UASB in varying quantities indicates its stability, These indicators were to ensure that the regime reached a steady-state. the steady-state in the combined system that lasted 3 months during the winter. The (UASB+SBBR) was operated through different influent concentrations and HRT/cycle time of (6,12,18,24)hr. This study was included daily water analysis for various physic-chemical factors. The results have shown successful applicability of the combined system at HRT/cycle time was 24hr and Flow rate 2.91 L/h, these value optimal for simultaneous organics and nutrients removal. The combined system was used to achieve COD, BOD,TN, PO43- and TSS, The recorded of this parameter on maximum removing (96.879% , 95% , 79.4% 81.132%, 93.312%) during the treatment, respectively .The maximum biogas production in UASB was 2.52 L /day at HRT 24hr.

1. Introduction

Water contamination is one of the biggest global issues, since water is the most essential resource for human survival and is currently confronting unheard of difficulties. Due to (population growth,

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https://doi.org/10.37934/sej.15.1.1128

the improvement of different species, the scarcity of clean water, and agriculture), consumption waters are becoming more and more crucial for treating, reusing, and recycling. Wastewater is produced in vast quantities by industrial waste. Wastewater was dumped into land and water systems due to the rapid development of many industries [1]. Alternative methods of treatment are becoming more popular due to the high cost of treating wastewater from the food industry and stricter discharge laws. The kind of wastewater, operating costs, and required effluent quality all influence the choice of biological treatment method. Wastewater from food processing companies, including milk processing, generates large amounts of wastewater with high COD, BOD, and TKN concentrations of up to 11,000 mg/l, 5900 mg/l, and 720 mg/l, respectively. They are consequently treated biologically [2]. Dairy wastewater contains Whey proteins, lipids, lactose, and minerals. Soluble organic matter, suspended particles, and gaseous organic matter are all found in fluid waste. These substances give water an unpleasant taste and smell, give it tone and turbidity, and promote eutrophication, which is crucial for raising the biological oxygen demand (BOD). Additionally, it has disinfectants and detergents from the washing and rinsing procedures, which raise the requirement for chemical oxygen (COD). Dairy wastewater have a high organic content, and a relatively high temperature. As a result, untreated dairy discharge into water bodies causes ecological imbalance and deterioration of water quality, necessitating treatment. To eliminate or lessen harm to the environment [3]. Anaerobic, aerobic, or a combination of both methods are used by the dairy industry to treat wastewater. Aerobic systems need an energy source to supply the oxygen needed to absorb the organic matter, while anaerobic systems are designed to handle high strength wastes and use methane gas [4]. Anaerobic treatment techniques are growing in popularity for the treatment of different wastewater. Up flow anaerobic sludge blanket (UASB) reactor is an appealing alternative for treating sewage, particularly in poor nations where a low-cost, dependable wastewater treatment solution is required [5]. Up-flow Anaerobic Sludge Blankets (UASB) are utilized as the fundamental biological treatment method for wastewater with a high organic strength. However, further treatment is especially crucial because anaerobic treatment by itself typically cannot ensure that the effluent satisfies discharge standards. The aerobic system which improves the quality of the effluent, and it has a better treatment effect on wastewater with lower chemical oxygen demand (COD) concentrations. It also achieves a good removal efficiency on soluble biodegradable organic matters in wastewater. Consequently, industrial wastewater treatment has made extensive use of anaerobic–aerobic systems, particularly for high strength effluent [6]. Anaerobically treated effluents can be post-processed using a sequencing batch reactor (SBR). It is made up of a batch reactor that runs for a number of cycles. Fill, react, settle, decant, and idle phases typically make up the cycle. By using these times, one reactor can function as both a clarifier and a train of reactors. An SBR can achieve most of what a continuous flow plant with many reactors running under various conditions can do by adjusting these durations within a single cycle [7]. Sequencing Batch Biofilm Reactors (SBBR) are SBR that use biofilm media. They are typically designed with a fixed bed layout with clay or plastic (Kaldnes) media [8]. Attaching microorganisms for biological wastewater treatment is the foundation of the SBBR. Due to its many benefits, SBBR, a new biological sewage treatment technology, has increased biomass while producing less sludge. It is also simple, easy to use, and effective in treating sewage [9]. the sequencing batch biofilm reactor (SBBR), which alternates between anoxic and aerobic conditions. An efficient technique for eliminating nitrogen and phosphorus. Additionally, SBBR creates an anoxic microzone in the inside of the biofilm due to the gradation of dissolved oxygen (DO) during the aeration phase. It is possible to accomplish simultaneous nitrification and denitrification (SND), which involves nitrification on the biofilm's surface and denitrification in its interior layers. As a result, SBBR has been utilized to simultaneously remove nitrogen and phosphorus from various wastewater types [10].

The Studies on the treatment by UASB and SBBR reported by various authors:

Alem Sobrinho et al., [11] examined a UASB-activated sludge system that was fed 90% industrial wastewater as influent. For chemical oxygen demand COD and biological oxygen demand BOD, the UASB reactor attained removal efficiencies of about 70% and 80%, respectively. Ganesh et al., [12] presented A study on low strength dairy wastewater in a UASB reactor with COD of 1200–2000 mg/L, 75–85% treatment efficiency was achieved by a reactor. According to Ozturk et al., [13] SBBR outperformed SBR in terms of COD, ammonium, and phosphate removal efficiency in the treatment of dairy wastewater. Additionally, SBBR's effluent quality was more stable than SBR's under the same operating conditions. with nutrient removal and ammonium removal of 66.0% for SBR and 85.1% for SBBR, and COD removal of 63.5% for SBR and 81.8% for SBBR.

The effects of biofilm filling rates, varying cycle durations, and organic loading rates on organic and nutrient removal in sequencing batch biofilm reactors (SBBR) were investigated by Elhawary et al., [14] Their synthetic sample had a C: N: P ratio of 100: 10: 1.9, which was quite similar to wastewater from homes. According to the results, a medium filling rate of 25% produced a higher removal efficiency for BOD, COD, TN, and TP than a 50% fill rate. The elimination efficiency of TP and TN increased from 72 and 53% to 76 and 57%, respectively, as a result of changing the (aeration-settling) cycle time from (8-2) to (6-4) hours. More BOD, COD, and TP were eliminated at greater organic loading rates.

Although most studies examined the UASB single system and studies SBBR as a single system, but the studies on Combined systems of (UASB+SBBR) were limited and these studies have not focused on effectiveness of combined system at low temperatures under different operating conditions Hydraulic Retention Time (HRT)/Cycle time (6,12,18,24) hr.

In this study, a UASB was used for the pre-treatment of the dairy wastewater. Then a SBBR were adopted to treat the UASB effluent. The aim of this study is to evaluate the effectiveness of combined system (UASB+SBBR) for dairy wastewater at low temperature in removing the pollutants by a laboratory- scale and compare the effluent with discharge standards to produce wastewater suitable for irrigation.

2. Materials and Methods

2.1 Description of the Combined system (UASB+SBBR)

The major parts of the Combined system plant which is used in this study are the Feed tank, Up flow Anaerobic Sludge Blanket (UASB) , Sequencing Batch Biofilm Reactor (SBBR),and Secondary clarifier, pump, mixers, control panel, aeration systems, flow meter Glass, and Gas rotameter. A schematic diagram for the Combined system (UASB+SBBR) is depicted in figure 1. In this study, Kaldnes K1 biofilm carrier elements were used, are made of polyethylene and are shaped like small cylinders (Length:7.2mm ,Diameter:9.1mm).The Kaldnes carriers have a Density 0.96 g/cm^3.Surface area of 500m^2/m^3.The Kaldnes biofilm carrier element is illustrated in figure 2.

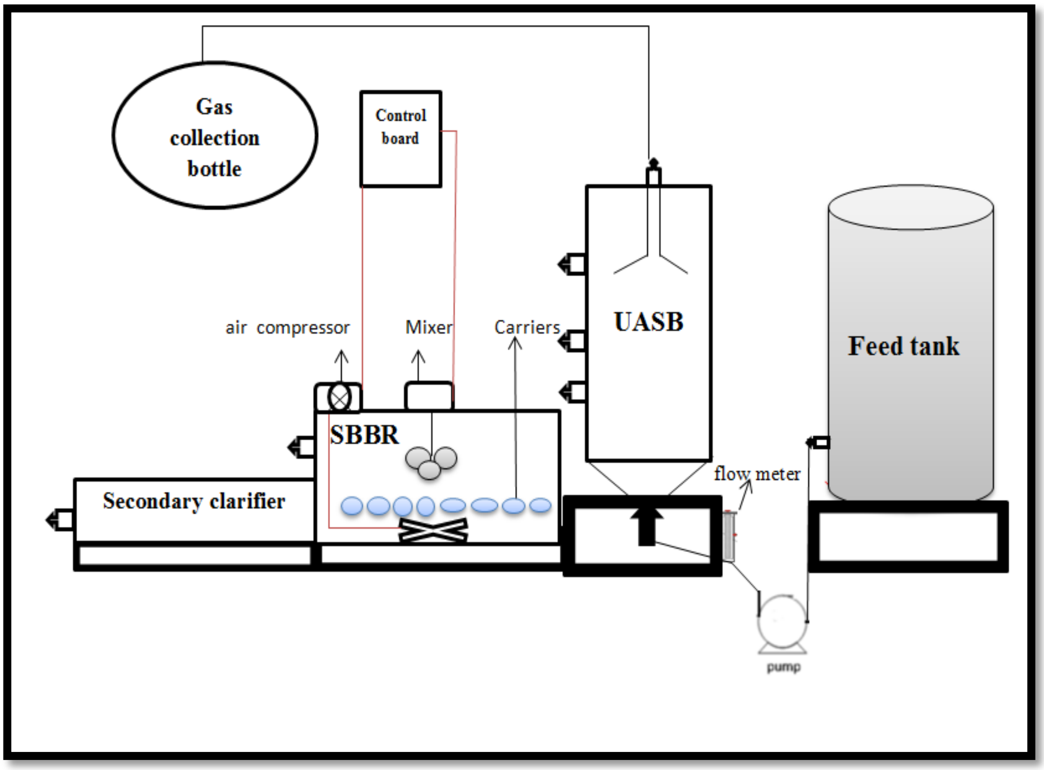


Fig. 1. Schematic Diagram for the (UASB-SBBR)

Fig. 2. Kaldnes K1 biofilm media carrier

2.2 Reactor set-up and operation

During the start-up period which lasted for two months, the combined system (UASB+SBBR) filling the activated sludge for both reactors. We add the sludge and cow dung to the UASB an amount of 10% of the reactor volume where the formation of sludge granulation at temperatures (35-37ºC) and an up flow velocity (V_{up}) (0.04)m/h. And add sludge 10% of the reactor volume to the SBBR. in the SBBR, filling media ratios of 50% from K1 were operated in a batch mode with raw wastewater taken from dairy factory. After the start-up period, four discharge were adopted (11.6,5.8, 3.8,2.91) l/h at the combined system (UASB+SBBR) operation for HRT/Cycle time (6,12,18,24) hr during three month at low temperature (October ,November ,December),the made HRT in UASB equal to cycle time in SBBR, This is in order to standardize the processing time of the Combined system. because, the UASB feeds the SBBR directly. Tables (1,2) show the operating conditions for the UASB and SBBR respectively.

Table 1
Design parameters for the UASB

Parameters	Value
Volume (L)	70
Diameter(ϕ) (cm)	30
Height(cm)	132
HRT(hr)	6,12,18, 24

Table 2
Design parameters for the SBBR

Parameters	Value
Volume (L)	70
length (cm)	40
effective depth(cm)	44
Width(cm)	40
Cycle Time(hr)	6,12,18, 24

2.3 Analytical methods and collection samples

DO, pH and temperature were examined by a digital device. The COD, BOD, TN, PO_4^{3-} and TSS, under the standard method [15]. The samples tests are analyzed by using DR5000 and DR1900 Hach spectrophotometric. The samples of wastewater are filtered by using filter paper (pore size 0.45 µm). For this research, the samples Collecting from the effluent of dairy wastewater from (dairy factory) in Al-Samawa City at Mid-South Iraq and filling each one with a (30 liters) plastic. Samples were taken for analysis from the influent and effluent of the combined system throughout October, November and December, once time every week. Apart from (pH, DO, Temperature), which were measured daily and the results averaged weekly. Figure (3) presents the test flow chart of the experiment.

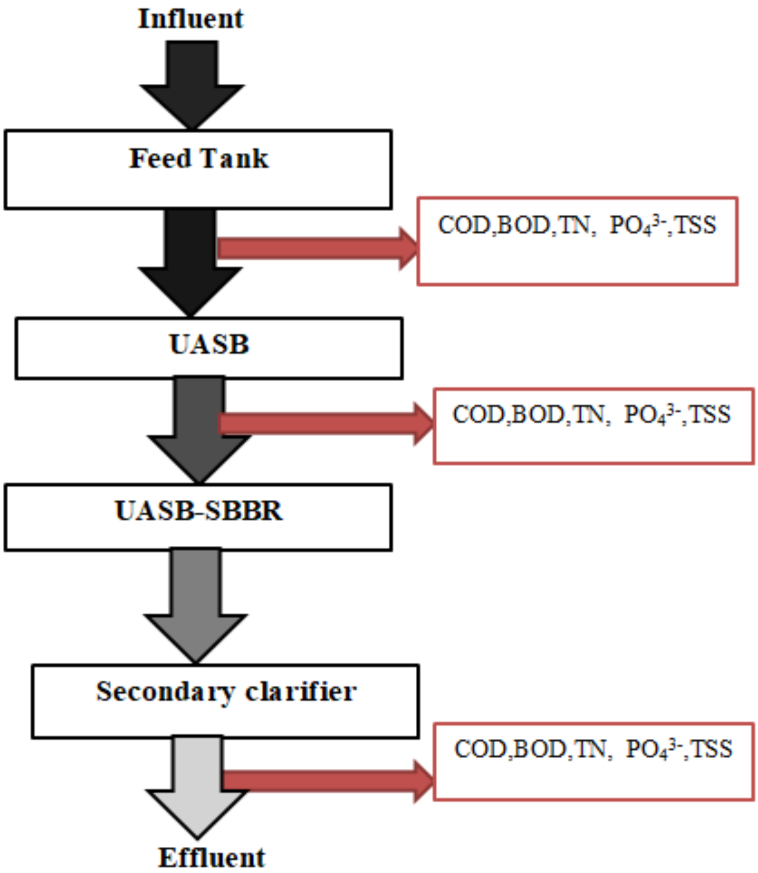


Fig. 3. Test Flow Chart of the Experiment

3. Results and Discussions

The combined system can be divided into two periods: start-up and steady state. The combined system operated during the start-up period before to the steady-state period. in start-up period, the rates of removal held at COD and BOD 75.739% and 65.189%, respectively. this indicates to the steady state period is reached. at the steady-state, The DO and PH values for dairy wastewater were 2.6–5 mg/L and 8.2–8.75, respectively, at temperatures (12-30) C°.

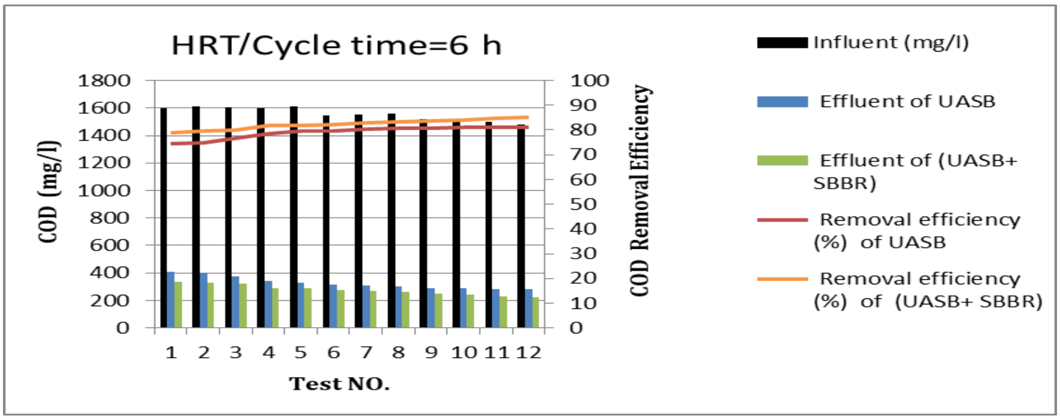
3.1 Effect of HRT/Cycle time on the removal of COD

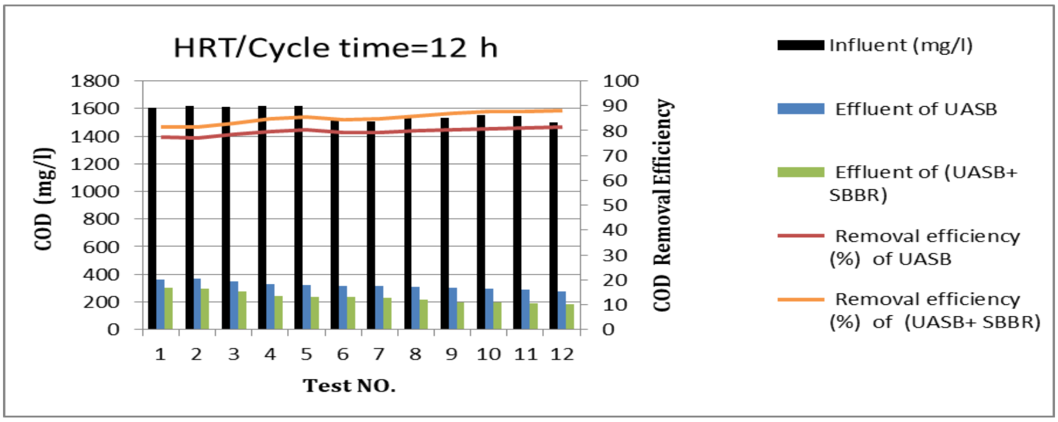
Figure 4 shows the performance of the UASB and (UASB+SBBR) with respect to COD removal efficiency at different HRT/cycle time. During HRT/cycle time 6hr, the COD concentrations of UASB and (UASB+SBBR) effluent were decreased from (410) mg/L to (280) mg/L and (335) mg/L to (220) mg/L, respectively. The COD removal efficiency was increase from 74.375% to 81.042% for UASB and 79.062% to 85.104% for (UASB+SBBR).at HRT/cycle time 12hr, the COD concentrations of UASB and (UASB+SBBR) effluent were decreased from (360) mg/L to (275.5) mg/L and (300.2) mg/L to (180) mg/L, respectively. While the removal efficiency was increase from 77.570% to 81.633% for UASB and 81.295% to 88% for (UASB+SBBR). at HRT/cycle time 18hr, the COD concentrations of UASB and (UASB+SBBR) effluent were decreased from (299) mg/L to (210) mg/L and (250) mg/L to (149) mg/L, respectively. While the removal efficiency was increase from 81.645% to 85.839% for UASB and

84.653% to 89.952% for (UASB+SBBR).at HRT/cycle time 24hr, the COD concentrations of UASB and (UASB+SBBR) effluent were decreased from (210) mg/L to (74) mg/L and (170) mg/L to (46) mg/L, respectively. While the removal efficiency was increase from 87.155% to 94.979% for UASB and 89.602% to 96.879% for (UASB+SBBR).

The result of COD treatment verified that the UASB effluent contained residual of COD. These leftover COD were successfully eliminated by as a post treatment step via SBBR after a UASB reactor. in the combined system (UASB+SBBR), effectiveness in removing COD by using K1 carriers in the SBBR, this carrier allowed for the formation of biofilm, theses contributed to the higher treatment performance of combined system on COD elimination. The presence of the K1 carriers leads to increased removal efficiency and the nature of the biofilm contributed to the creation of aerobic and anaerobic environments, ultimately leading to improved removal efficiency. This finding confirms the theory that were in line with other earlier investigations. For example, Sirianuntapiboon et al., [16] treated dairy wastewater using SBBR and SBR and found that the COD removal efficiency of SBR and SBBR was 63.5% and 81.8%, respectively. And Torres and Foresti,[17] attained a greater COD removal effectiveness of 91% In a combined UASB–SBR system for domestic wastewater. The effluent efficiency in the present study was like other combined systems published in the literature. The performance of the (UASB–SBBR) used in this study is compared with other combined systems in Table (3).

According to the results, (HRT, cycle time) 24hr is a better for removing COD. Due these results were given the best elimination at the lowest concentrations where they satisfy all requirements.





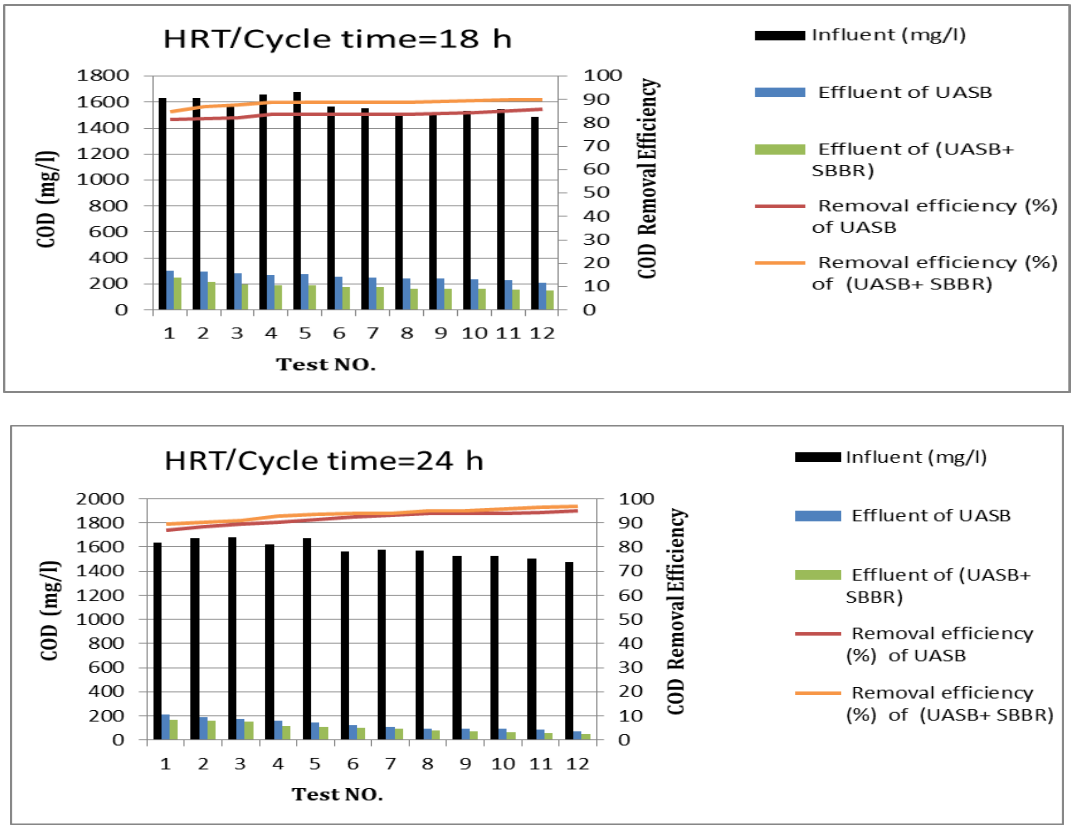


Fig. 4. COD Variations at different HRT/cycle time

3.2 Effect of HRT/Cycle time on the removal of BOD

The BOD performance in the UASB and combined system (UASB+SBBR) is illustrated in Figure(5). BOD in the UASB and (UASB+SBBR) effluent concentration at HRT/cycle time 6hr in test (12), was 190 mg/L with removal efficiency 69.354% then reduced to 178 mg/L with removal efficiency 71.290% in the (UASB+SBBR).at HRT/cycle time 12hr,the effluent concentration was 140 mg/l with removal efficiency 76.271% in UASB then reduced to 129 mg/L with removal efficiency 78.135% in the (UASB+SBBR). when increased HRT/cycle time to 18hr that the UASB effluent was 111 mg/L with removal efficiency 79.444% then reduced to 91 mg/L with removal efficiency 83.148% in the (UASB+SBBR).at HRT/cycle time 24hr the effluent of UASB was 38 mg/L with removal efficiency 93.666% then reduced to 30 mg/L with removal efficiency 95% in the(UASB+SBBR).when, HRT/cycle time increased, The concentration of BOD will decrease. Long enough HRT in UASB will allow anaerobic sludge and dairy wastewater to come into contact for extended periods of time, increasing the organic matter breakdown process.

The effluent efficiency in this study was similar to other UASB–aerobic systems documented in the literature. In a combined UASB–CSBR system, Khan et al., [18] attained BOD removal efficiency of 83%.

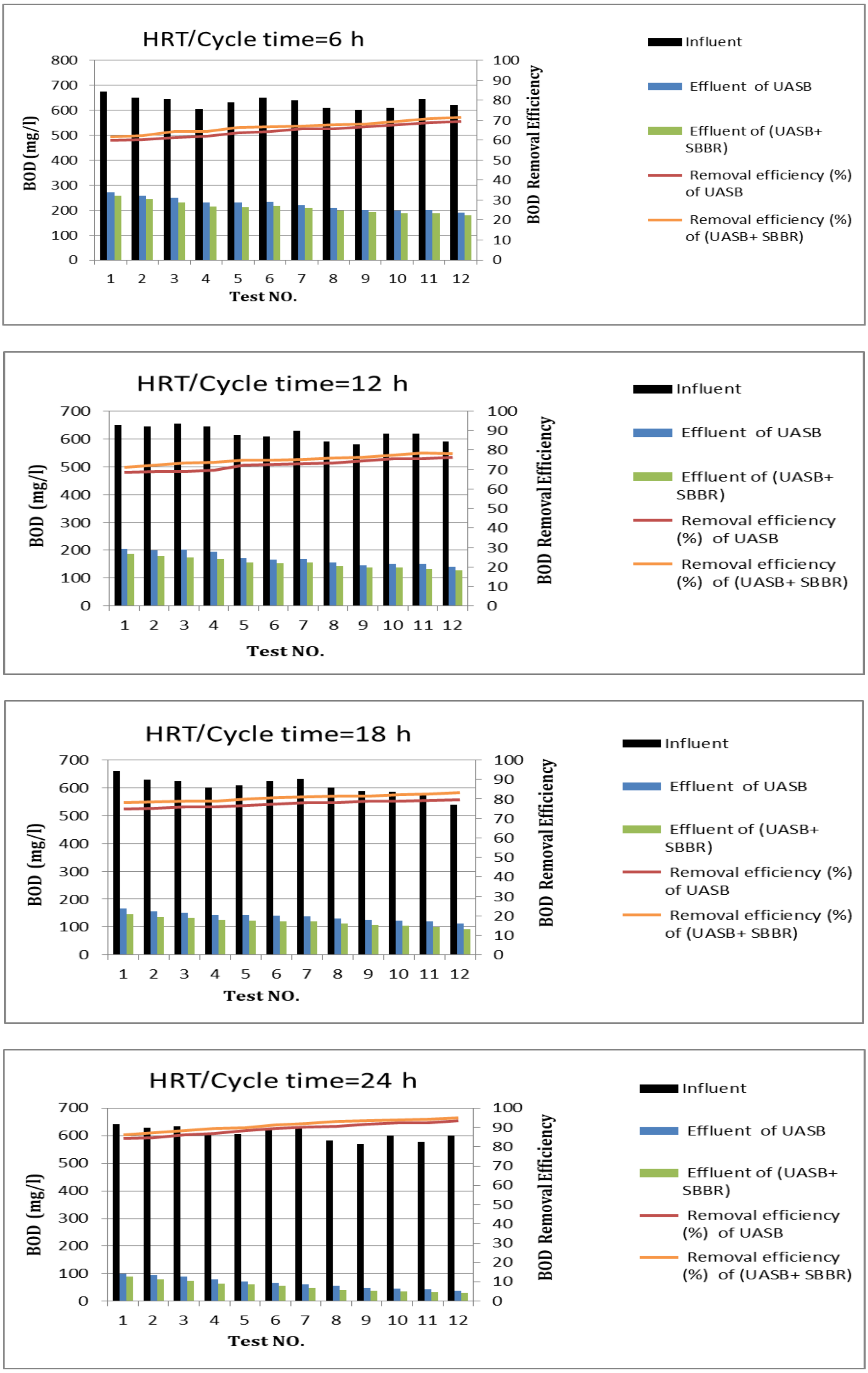


Fig. 5. BOD Variations at different HRT/cycle time

3.3 Effect of HRT/Cycle time on the removal of TN

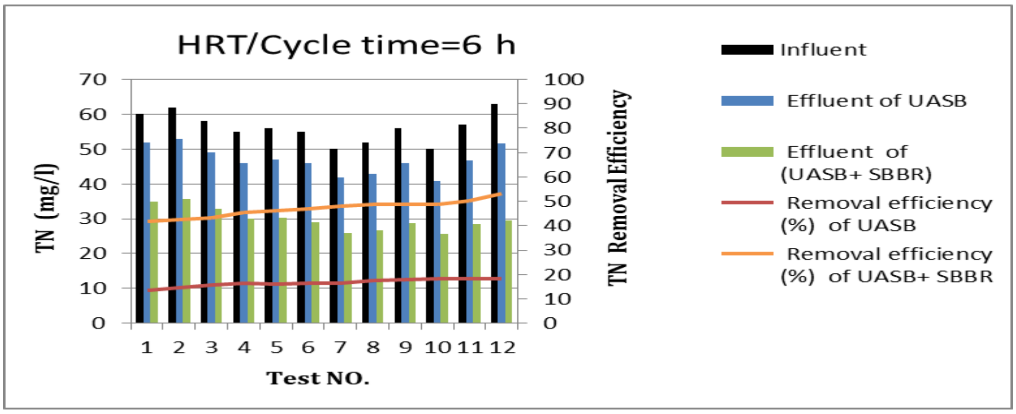
The Total Nitrogen (TN) variations in UASB and (UASB+SBBR) are shown in figure (6). It is clear from Figure that the TN in the UASB and (UASB+SBBR) effluent concentration at HRT/cycle time 6hr in test (12), was 51.5 mg/L with removal efficiency 18.253% then reduced to 29.5 mg/L with removal efficiency 53.174% in the (UASB+SBBR).at HRT/cycle time 12hr the effluent concentration was 32.5 mg/l with removal efficiency 18.75% in UASB then reduced to 16.8 mg/L with removal efficiency 58% in the (UASB+SBBR). when increased HRT/cycle time to 18hr that the UASB effluent was 46.7 mg/L with removal efficiency 19.482% then reduced to 19.6 mg/L with removal efficiency 66.206% in the (UASB+SBBR).at HRT/cycle time 24hr the effluent of UASB was 38.6 mg/L with removal efficiency 22.8% then reduced to 10.3 mg/L with removal efficiency 79.4% in the(UASB+SBBR).

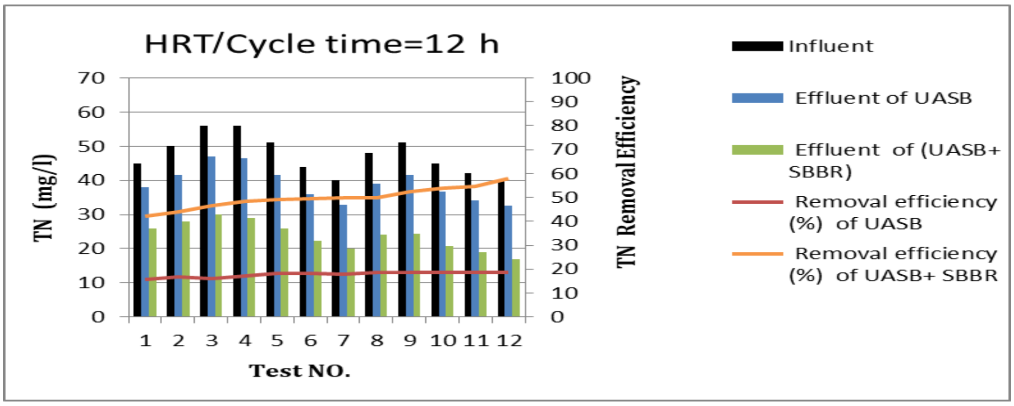
Within the pH range that is suitable for biological treatment, pH is a crucial parameter for nitrification. The average values of pH (8.4 to 8.6) occurred in the cycle time 24hr, when the maximum removal of TN was observed.

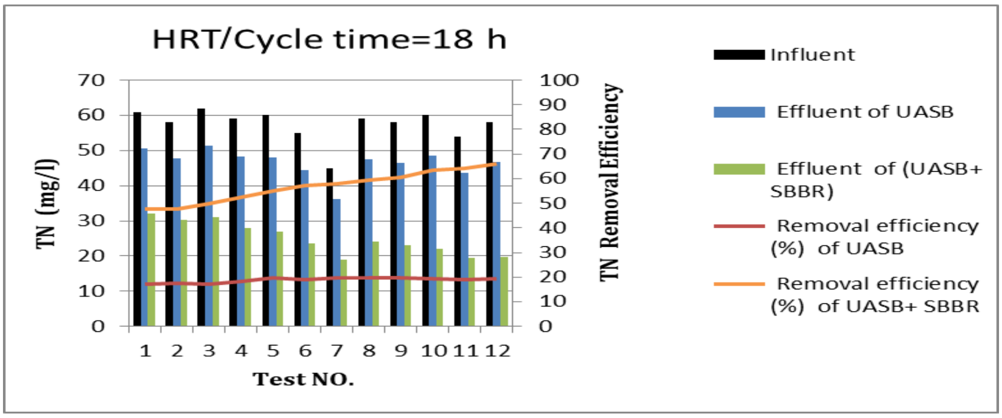
The nitritation-denitrification process is heavily influenced by temperature. It is in charge of microbial activity, growth rate, and decay rate. The ideal temperature range for nitrification in wastewater is between (15–30) º C. Low temperatures impede nitrification, and it may take up to five times as long to complete nitrification in the winter compared to the summer [19].

we modified other parameters to compensate for the lower growth rate of the nitrifiers at low temperatures to improve the performance of the combined system, such as (increasing of the HRT/cycle time, increasing pH).

according to the result, notice that the UASB does not remove TN efficiently, Minor removal occurred as a result of absorption. Where the actual removal occurred in the SBBR, this removal depends on the aeration time (2hr to 16hr) at Cycle time from 6hr to 24hr.







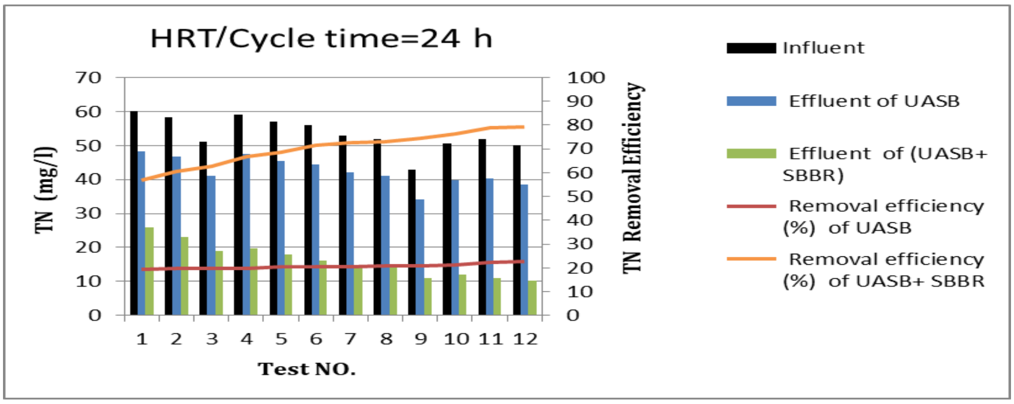


Fig. 6. TN Variations at different HRT/cycle time

3.4 Effect of HRT/Cycle time on the removal of PO_4^{3-}

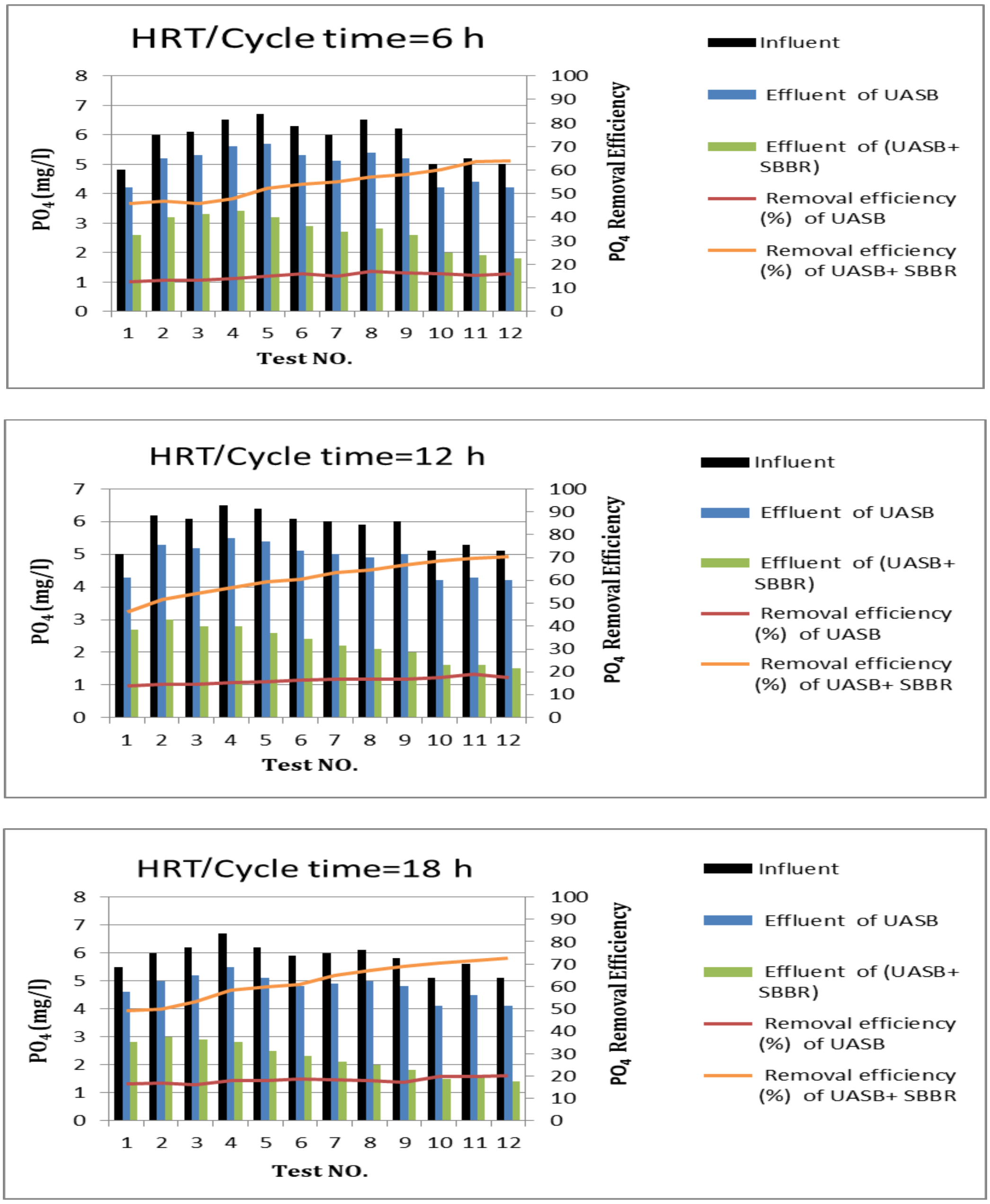
The results of PO_4^{3-} removal are shown in Figure(7), The results indicate that the Phosphate removal efficiency were increased from 16% to 64%.while,the concentrations decreased from 4.2mg/L to 1.8mg/L in UASB and (UASB+SBBR)respectively in test (12) at HRT/Cycle time 6hr..as HRT/Cycle time increased from 6hr to 12hr, the removal efficiency were increased from 17.647% to 70.588%.while,the concentrations decreased from 4.2mg/L to 1.5mg/L in UASB and (UASB+SBBR),respectively. while, at HRT/Cycle time 18hr, the removal efficiency were increased from 19.921% to 72.656%.while,the concentrations decreased from 4.1mg/L to 1.4mg/L in UASB and (UASB+SBBR),respctevly.as HRT/Cycle time increased from 18hr to 24hr, the removal efficiency were increased from 22.641% to 81.132%.while,the concentrations decreased from 4.1mg/L to 1mg/L in UASB and (UASB+SBBR),respectively.

Phosphate removal is difficult in a UASB reactor. Therefore, using post treatment by (SBBR) were successfully. phosphate removal is dependent on the aeration time in SBBR. the Aeration time was, (6,11,16) hr at Cycle time (12,18,24) hr respectively.

During the anaerobic stage of the SBBR cycle, phosphorus is released into the reactor's bulk fluid. then, when the reactor is aerated, Phosphorus-accumulating organisms (PAOs) then absorb phosphorus [20].

This finding confirms to the Sousa and Foresti [21] ran a bench-scale system that treated synthetic wastewater that mimicked home sewage using a UASB reactor and two SBR in tandem. Both the cycle duration in the SBR and the hydraulic detention period in the UASB reactor were 4 hours. The phosphate removal system (57%) .and This fact was also observed by Torres and Foresti,[17] In an experimental system composed up of UASB and SBR, phosphate removal efficiencies (72%) only occurred at the 2-hr for domestic sewage treatment.

The combined system (UASB+SBBR) show acceptable efficiency of PO_4^{3-} removal from wastewater at HRT/Cycle time of (12,18,24)hr.



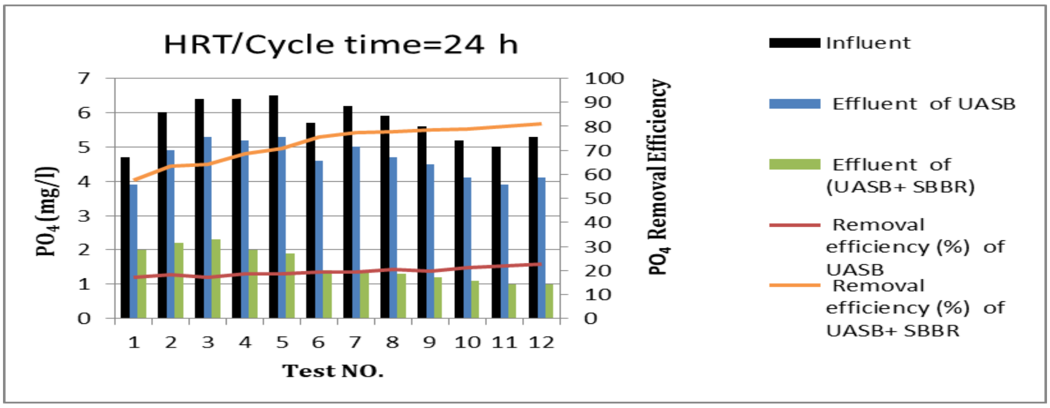


Fig. 7. PO_4 Variations at different HRT/cycle time

3.5 Effect of HRT/Cycle time on the removal of TSS

Total suspended solid concentrations of influent, effluent, and removal efficiency versus HRT/Cycle time in UASB and (UASB+SBBR) are shown in Figure (8). the effluent TSS concentrations decreased from 215mg/L to 160mg/L while, the removal efficiency were increased from 67.814% to 76.047% in UASB and (UASB+SBBR)respectively in test (12) at HRT/Cycle time 6hr.as HRT/Cycle time increased from 6hr to 12hr, the removal efficiency were increased from 73.746% to 80.678%.while,the concentrations decreased from 178mg/L to 131mg/L in UASB and (UASB+SBBR),respectively. while, at HRT/Cycle time 18hr, the removal efficiency were increased from 79.421% to 87.781%.while,the concentrations decreased from 128mg/L to 76mg/L in UASB and (UASB+SBBR),respctevly.as HRT/Cycle time increased from 18hr to 24hr, the removal efficiency were increased from 91.878% to 93.312%.while,the concentrations decreased from 51mg/L to 42mg/L in UASB and (UASB+SBBR),respectively.

The long settling time experienced in the UASB and SBBR played a significant role in TSS removal. the combined system (UASB+SBBR) obviously eliminated TSS, because the biofilm in the SBBR may adsorb and breakdown insoluble pollutants.

This finding confirms to Torres and Foresti [17] achieved a higher removal efficiency for TSS, 84% in a combined UASB–SBR system for domestic wastewater. And Cao and Ang [22] attained a TSS removal effectiveness of 94.5%. in a combined UASB–SBR system for municipal sewage treatment.

The results illustrated that the HRT/cycle time in range (6,12,18) hr did not significantly affect effluent TSS concentration and it did not meet the specifications.

Finally we can conclude that the HRT/cycle time 24hr is optimal for removal of TSS and could meet with (Iraqi Specifications from WWTPs, Environmental Health and Safety).

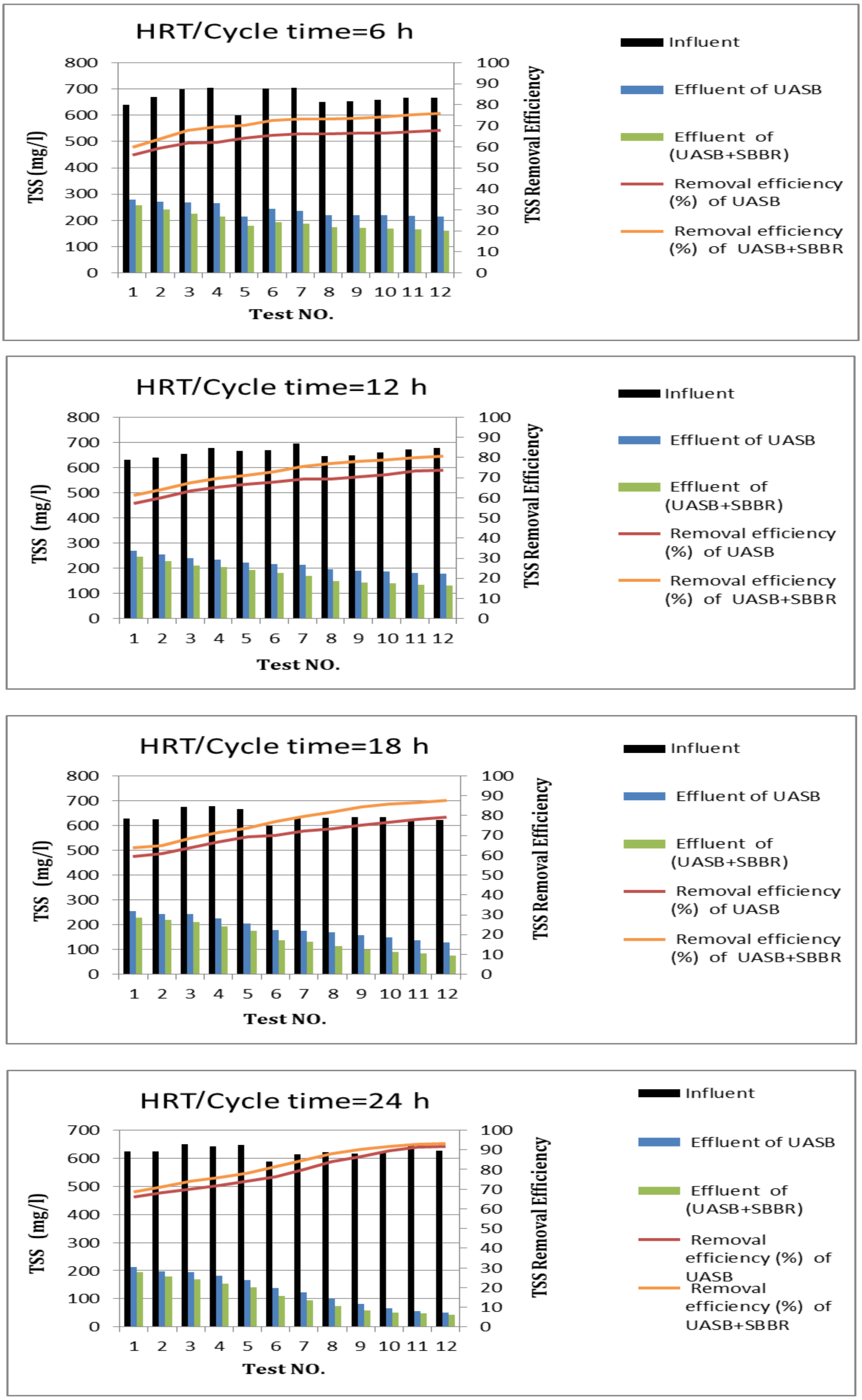


Fig. 8.TSS Variations at different HRT/cycle time

3.6 Biogas Production from UASB

The measured biogas production during the study ranged between 0.249 L/day and 2.52 L/day, with an OLR of 5.908 kgCOD/m^3.d and 1.474 kgCOD/m^3.d, respectively. figure(9), showed that HRT increased from 6 h to 24 h followed by an increase generation of biogas. The maximum biogas produced was 0.249 L /day at HRT 6hr.while, 0.806L /day at HRT 12hr.when increased HRT to 18hr,the Biogas production was 1.296L /day.at HRT 24hr,The maximum biogas production was 2.52L /day. that meaning, The biogas generated increased with an increase in the OLR.

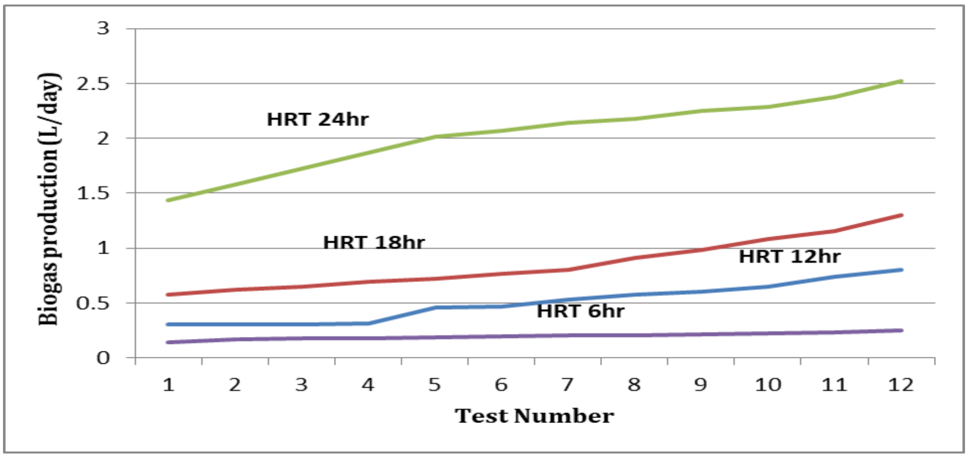


Fig. 9. Biogas Production at different HRT

3.7 Comparing with other combined system Studies

Table (3) show The removal efficiency of present study (UASB+SBBR) was compared with the removal efficiencies of other combined system studies. This study's COD removal efficiency was consistent with all other studies. The BOD removal efficiency was the closest to that of research by Khan et al.,[18], and Low than to that of research by Moawad et al.,[23].The PO_4 removal efficiency closest to that of research by Sousa & Foresti [21] ;Torres& Foresti,[17]. This study's TSS removal efficiency was lower than that of Cao & Ang [22] ; Moawad et al., [23], but it was closer to that of Torres & Foresti [17] ; Khan et al., [18].

3.8 Comparing the quality of effluent with Standards

Table (4) compares the quality of the combined system (UASB+SBBR) effluent to standards for the discharge of treated wastewater into could be used for reuse such us irrigation .Comparison the effluent COD of combined system (UASB+ SBBR) with discharge standards , concluded that the COD for the (UASB+ SBBR) at HRT/Cycle time 24hr were acceptable according to the all standard. While, HRT/Cycle time 18hr meet for Environmental Health and Safety only. for BOD, the HRT/cycle time in combined system (UASB+SBBR) obtained in 24hr meet to (Iraqi Specifications from WWTPs ,Environmental Health and Safety).the effluent concentration of TN could meet with Jordanian Standard only at HRT/cycle time (6,12,18,24)hr. At HRT/Cycle time of (12,18,24)hr the effluent PO_4^{3-} could meet with Iraqi Specifications from WWTPs. for TSS, the HRT/cycle time 24hr could meet with (Iraqi Specifications from WWTPs, Environmental Health and Safety).

Table 3
Comparison combined system(UASB+SBBR) with other integrated (UASB-aerobic) systems

System	Temperature (°C)	HRT/Cycle time (hr)	Overall removal efficiency (%)					Reference
			COD	BOD	TN	PO_4	TSS	
(UASB+SBBR)	12–30	6-24	79.062-96.879	61.777-95	41.666-79.4	45.833- 81.132	59.843-93.312	This study
UASB–2 SBR	30 ± 1°C	4	95	---	---	57	---	[21]
UASB–SBR	21	HRT 6hr,cycle time (4, 6,12, 24)	91	---	---	72	84	[17]
UASB–cSBR	32	HRT 8hr,cycle time (4, 6,8)	---	83	---	---	90	[18]
UASB–SBR	30	6	86.4	---	---	---	94.5	[22]
UASB–SBR	25	4	92	---	---	---	---	[24]
UASB–SBR	14–28	HRT 4hr,cycle time (6, 8,12)	94	97		---	98	[23]

Table 4
The effluent standards of certain pollutants for Irrigation Purposes

Parameter	Iraqi Specifications from WWTPs [25]	Environmental, Health and Safety [26]	Jordanian Standard [27]
BOD(mg/l)	40	50	30
COD(mg/l)	100	250	100
TN (mg/l)	-	10	45
PO_4^{3-} (mg/l)	3	-	-
TSS(mg/l)	60	50	50

4. Conclusion

Dairy Wastewater treatment performance of the combined system (UASB+SBBR) was studied. The combined system displayed high COD, BOD, TN, PO_4^{3-}, and TSS removal performance depending on the condition of operation selected. Under low temperature the improve of the combined system (UASB+SBBR) efficiency at increase the HRT/cycle time was succeeded to achieve good COD, BOD, TN, PO_4^{3-} and TSS removal, with effluent results could meet with standard. indicating high COD removal efficiencies between 89.602% and 96.879% with effluent could meet to all standard ranged between 170mg/L to 46mg/L at HRT/cycle time 24hr. while, BOD removal efficiencies between 92.204% and 95% with effluent could meet to all standard ranged between 48.8mg/L to 30mg/L at HRT/cycle time 24hr. TN removal efficiencies between 41.666% to 79.4% with effluent could meet to Jordanian Standard ranged between 35mg/L to 10.3mg/L at HRT/cycle time (6,12,18, 24)hr. the PO_4^{3-} removal efficiencies between 46% to 81.132% with effluent could meet to Iraqi Specifications from WWTPs standard ranged between 2.7mg/L to 1mg/L at HRT/cycle time (12,18, 24)hr. the TSS removal efficiencies between 90.437% to 93.312% with effluent could meet to Iraqi Specifications from WWTPs standard and Environmental Health and Safety ranged between 59mg/L to 42mg/L at HRT/cycle time 24hr. while, The biogas production increased with increasing HRT in UASB. The maximum biogas produced was in the range of 0.249 L/day to 2.52 L/day at HRT from 6hr to 24 hr with organic loading rates of 5.908 kg COD/m^3.d to 1.474 kg COD/m^3.d, respectively. organic matters were consistently eliminated in the UASB, while total nitrogen and phosphate were primarily eliminated in the SBBR depending on the anoxic/aerobic time. The quality of the treated dairy wastewater met standards for regulating wastewater discharged for Irrigation Purposes. Because it is a more flexible, efficient, and economical choice for treating dairy wastewater, the combined system (UASB+SBBR) is attractive than utilizing only UASB or SBBR units. Finally we can conclude that the HRT/Cycle time of (24) hr and Flow rate 2.91 L/h are optimal for simultaneous organics and nutrients removal.

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