SEQUENTIAL ANAEROBIC/AEROBIC TREATMENT OF PHRAMACEUTICAL WASTEWATER

Dr. Mohammed Ali I AL-Hashimi
Asst. Prof. University of Technology
Baghdad-Iraq

Abbas Hadi Abbas
Asst. lecturer. University of Tikrit-Iraq

ABSTRACT

The continuous sequential biological anaerobic/aerobic treatment of Samarra Drugs Factory wastewater (pharmaceutical wastewater) was evaluated under different operation conditions of hydraulic retention time (HRT). A pilot plant of upflow anaerobic filter (UAF) was used for anaerobic stage followed by air diffuser for aerobic stage. The UAF was fabricated from polyvinyl chloride (PVC) pipe with 14 cm diameter and 140 cm height. The UAF was packed with (2.54-3.82) cm inert gravel as a media .Three ports along the UAF were fixed at distance of (30cm) to evaluate the reactor efficiency with respect to the depth. The system was operated for (135days) continuously .Seeding and acclimation of anaerobic bacteria for start- up of UAF was achieved within (34days) by using glucose and trace nutrient with gradually replacing pharmaceutical wastewater, then the system was operated completely with pharmaceutical wastewater for three runs with three values of HRT, each run was 30 days. The values of HRT were (24 hrs, 18hrs, and 12hrs) for anaerobic stage and (20 hrs, 15hrs, and 10hrs) for aerobic stage respectively. The UAF was operated with mesophilic bacterial growth, in which the temperature maintained with the range of 35-37 °C. The removal efficiency for chemical oxygen demand (COD), biochemical oxygen demand (BOD) Nitrate (NO_3), Phosphate (PO_4), Sulphate (SO_4), Total suspended solids (TSS) by anaerobic filter were evaluated, while only the removal efficiency for COD and BOD were evaluated with the sequential anaerobic/aerobic treatment. The system was subjected to pharmaceutical wastewater with COD concentration ranged (740-1100 mg/L) and BOD concentration ranged (298-400 mg/L). The removal efficiency of COD and BOD were 87%, 90% for anaerobic stage and 92%, 93% for anaerobic/aerobic stage respectively. The biogas production was (0.55 m^3/Kg $COD_{removed}$). The efficiency of anaerobic filter with respect to the depth showed that the first third was the more effective in COD removal.

KEYWORDS

Hydraulic retention time (HRT), Upflow anaerobic filter (UAF)

INTRODUCTION

Pharmaceutical industries discharge a variety of highly toxic and persistent organic in their wastewater. Hence, successful removal of these organics is necessary (Chen, et .al 1994)[4]. A combination of sequential anaerobic/aerobic wastewater treatment are used to obtain secondary standards, since the aerobic treatments appears to be promising for effluent Polishing (Chung, et. al 1982)[7]. Pharmaceutical wastewater are comprised of substrata which are difficult to treat in biological system. Based on the production processes, the Pharmaceutical industry can be divided into five categories, namely fermentation, natural product extraction, chemical synthesis, formulation, and research and development. (Ince, et. al 2002)[11]. Jennett and Dennis (1975) [12] used the anaerobic mesophilic fixed film reactor (anaerobic filter) for the first time of treatment of pharmaceutical wastewater from specific sources. Sach, et. al (1982) [18] followed the same process to treat pharmaceutical wastewater from different sources. Hamdy, et. al (1992)[10] studied the treatment of pharmaceutical wastewater by using anaerobic mesophilic and thermophilic fixed film reactor. Chen, et. al (1994)[4] used also anaerobic filter for treatment of pharmaceutical wastewater. They applied wastes having organic loading rate ranged from (1-10kgCOD/m^3.day) and achieved (70-90) % COD removal. Nandy and Kaul(2001) [15] studied the upflow anaerobic fixed film reactor for treatment of herbal-based pharmaceutical wastewater. The upflow reactor was fabricated from PVC column of (0.11m) diameter and (2.25) heights and packed randomly with (150) nylon scrubbers. The wastewater with organic loading rate ranged from (10-48kgCOD/m^3.days) was applied and COD removal efficiency ranging (46-50) % was achieved. Ince, et. al (2002) [11] studied the anaerobic filter for treatment of chemical synthesis –based pharmaceutical wastewater. They achieved 76% COD removal by applying wastewater with strength of (7.5kgCOD/m^3.day). Buitron, et .al (2003) [3] studied the performance of sequencing anaerobic/aerobic treatment of Pharmaceutical wastewater with biofilter. The system successfully treated pharmaceutical wastewater with COD removal efficiency ranging (95-97) % by applying organic loading rate of (5.7 kgCOD/m^3.day). Morse, et .al (2002) [14] studied the anaerobic/aerobic sequence for treatment of pharmaceutical wastewater. The packed bed reactor reduced total organic carbon (TOC) concentration and denitrifies the wastewater by converting nitrates to nitrite to nitrogen gas.

Pharmaceutical wastewater characteristics and analytical methods

The wastewater was taken directly from equalization tank of Samarra Drugs Factory which classified as formulation (drug mixing) plant. The factory lies in Samarra city to the north of Baghdad about 120km. This factory produced about 300 types of pharmaceutical formulae (antibiotics and different drugs). The factories are run by 2054 personnel till April 2004. The average wastewater discharged from the factory was (18.7 m^3/hr). The sources of wastewater are from process operation wastewater, utility operation wastewater, and sanitary sewage. The characteristics of pharmaceutical wastewater of this factory and analytic methods are listed in Table 1. The analyses were carried out according to the Standard Methods for examination of water and waster (APHA, AWWA, WPCF 1985) [1], as shown in Table (1).

EXPERIMENTAL WORK

The pilot plant

It is included upflow anaerobic filter and aerobic diffuser in a sequential process. A pilot plant was built and installed near wastewater equalization tank of Samarra drugs factory and fed directly from it .A pilot plant consists of:

A)- Upflow anaerobic filter (UAF)

Its fabricated from PVC pipe with 14cm (5.5") inside diameter and 140 cm (55") height and its similar to the model of Jennett and Dennis (1975) [12]. Perforated plastic plate was placed in the bottom of the pipe (10cm above the base of pipe) for uniformity influent wastewater dispersion upward. Three sample ports were placed at 30 cm interval along the pipe height. The samples ports were extended to the center of pipe (column). The pipe was filled with 1.00m height with smooth and inert gravel as media. This gravel passed sieve opening 3.82 cm (1.5") and retained on sieve opening 2.54 cm (1"). The void ratio of this packed media was 0.43 and thus the worked volume of the filter was 6.6 L. Specific surface area of this packed media was 108 m^2/m^3.

B) -Aerobic Stage

Aeration pump type (Tropica 5510) manufactured by China was used to supply Oxygen for 5.5 plastic bottle. This pump maintained oxygen at least 2 mg/l for aerobic process requirement.

C)-Hydraulic system

Hydraulic system consisted of 500L ground galvanized tank at + 0.00 m level, (500 L) elevated tank NO.1 at + 4.00 m level with overflow hose, and (500 L) elevated tank NO.2 at+3.00 m level .The later tank has a mixer with revolution rate 40rev/min, heat exchanger for maintaining temperature 35$\pm$2 °C for mesophilic bacterial growth requirement and floater to keep constant wastewater influent head.

D)- Liquid Displacement Method for Measuring Biogas

Two symmetrical glass bottles, each has volume 5000 ml, were placed horizontally on the cabinet and connected directly to the hose of the generated biogas. Each has two pipes, one in the upper side and other was in the lower side. The two lower pipes were connected tightly like a bridge pipe to allow the solution passing easily from one bottle to another. The used solution consisted of 10% NaCl and 2% H_2SO_4 (Tanak and Matsu 1986) [21].

Fig (1) and Fig (2) show schematic diagram and photograph of the pilot plant.

Seeding and Start up for the upflow Anaerobic Filter

Seeding and startup were done in the same manner as followed by Jennett and Dennis (1975) [12], as shown in the Table (2). Anaerobic Filter started by injecting (30g) of seed sludge into lower one third of a filter that contained simulated substrata of glucose and trace nutrients in order to provide sufficient nutrient for anaerobic growth. Nitrogen and Phosphorus were added to the feed solution as they were prepared. Nitrogen in the form of ammonium chloride and Phosphorus in the form of dibasic potassium phosphate were added so that phosphorus: nitrogen: carbon ratio were 1:5.9:100 the seed sludge used was obtained from septic tank of the Samarra Drugs Factory. The filter was initially maintained during the starting period with the simulated substrata of (1000mg/L) glucose and trace nutrients at HRT of (48hr). During the course of starting period, the filter was acclimated to pharmaceutical waste by gradually replacing a portion of glucose organic load with pharmaceutical waste. The waste percentage was increased by 20percent. By the end of the starting period, the organic load received by the filter was composed totally of pharmaceutical waste. Hydraulic retention time was reduced to (36hours) (1.5day) with continuous pharmaceutical wastewater and showed steady COD removal state.

Sequential Operation Anaerobic/ Aerobic System

After (34days) of continuous operation as shown in table (2) the upflow anaerobic filter and aeration system were operated for three runs. Each run had operated for thirty days (one month). The first, second and third anaerobic runs were operated with hydraulic retention time HRT (1day, 0.75day and 0.5day) respectively while aerobic runs were operated with HRT (0.833day, 0.625day and 0.416day) respectively. The following influent and effluents parameters were measured for upflow anaerobic filter and then calculated the removal efficiencies for (COD, BOD, NO_3, PO_4, SO_4, chlorides and TSS) and also the biogas generation. for aerobic stage, two parameters (COD and BOD) were measured and calculated removal efficiencies as shown in Tables (3), (4), (5), (6), (7), and (8) .To evaluate the efficiency of the depth of upflow anaerobic filter samples from ports at height 30 cm, 60cm, 90 cm and 100cm from the bottom to the top of the reactor were taken.

RESULTS AND DISCUSSION

Upflow Anaerobic Filter Operation During Seeding and Start- up Period

As shown in table (2), the acclimation was achieved in the 34^{th} day (stage 6), in which steady biogas generation was (1.80L/day) and high COD removal 85%. Jannett and Dennis (1975) [12] reported that the acclimation was to be complete in the

40th day, as shown in Table (2). During the startup (acclimation) period, the pH reduced to 5.8 in the 20th day (stage 4) due to formation of acetic acid. The pH was adjusted to maintain its range of (7.2- 7.4) by addition NaOH. . The removal of COD decreased from 85% in the 16th day (stage 2) of operation to 33% in the 18th day (stage 3) then it increased up to 81% in the 26th day (stage 6). The sudden decrease may be attributed to the existence of toxic materials and acidity during the transition stages (2, 3, 4, and 5).

Upflow Anaerobic Filter Operation After Acclimation Period

Table (3), shows the change of COD removal efficiency with time progress. It can be noted that the maximum COD removal was 87% in the (65th day) with HRT=24 hr. This may be attributed to complete of anaerobic attached biofilm.

Effect of HRT on COD and BOD Removal

A more important indicator of anaerobic filter performance is Hydraulic Retention Time HRT. Tables (3), (4), and (5) showed decreasing of COD and BOD removal with increasing with HRT. Chen, et. al (1994) [4] attributed that the microbial ecosystem groups of microorganisms which interact to convert the organic matter into methane and carbon dioxide, the product from a reaction carried out by one group of bacteria would then serve as a substrata for the subsequent specialized bacteria group. When HRT was changed, an imbalance in microbial interactions would be initially resulting before a new balance could be established. The improved fatty acid removal could therefore have been due to readjusted microbial community. This suggested the possibility of HRT being used to select appropriate bacteria community, which can degrade the fatty acid, and thus COD removal rate was improved with increase of HRT.

Effect of Organic Load on the COD Removal Efficiency

Tables (3), (4), and (5) showed that COD removals varied between 87- 39 % for COD organic load (0.76-2.2 $kg/m^3.d$) respectively. These results agreed with the studies of Backman, et. al (1985) [2] , Choi, et. al (1984) [6], Choi, et. al (1991)[5] and Nandy and kaul(2001)[15].

Nandy and kaul (2001) [15] attributed this result to the fact that in all pharmaceutical Industries, the production processes are in batches. This lack of homogeneity leads to variation in wastewater quality and quantity, resulting in a wide fluctuation in treatment units in the term of organic and hydraulic loading. This may have harmful effect on anaerobic biological processes causing destabilization of microbial population and leading to volatile fatty acid (VFA) accumulation that can acidify the reactor and therefore inhibit methanogenic microorganisms.

Nitrates Removal

Tables (3), (4),and (5) shows the increase of average nitrates removal with the increase of HRT, The average nitrates removals were 47%, 59% and 79% with HRT 12 hr, 18 hr and 24 hr respectively and also the increase of nitrates removal with the increase of COD% removal. NO_3 removal ranged from 42 % to 89% with COD removal 39% to 87% respectively. The removal of NO_3 was attributed to dentrification processes developed under anaerobic condition (Negulesu 1985)[16] and (Steel. and McGhee 1982)[20]. Dentrification is the reduction of nitrate (NO_3) to nitrogen gas (N_2) as shown below:

$$NO_3 \rightarrow NO_2 \rightarrow NO_{(g)} \rightarrow N_2O_{(g)} \rightarrow N_{2\,(g)}$$

Phosphates Removal

Tables (3), (4), and (5) show the increase of phosphates removal with the increase of percent COD removal. This result corresponded with the study of Hamdy et. Al (1992) [10]. The range of phosphate removal was (38%-78%) for COD removal (39%-87%) respectively, also the above tables showed that the increase of phosphates removal with the increase of HRT. The averages of phosphates removal were (42%, 48%, 74%) with HRT (12hr, 18hr, 24hr) respectively The phosphates removal was attributed to the requirements of phosphates for supporting anaerobic growth as nutrient since it is available in wastewater.

Chlorides Concentrations

Chloride concentration in influent and effluent are relatively the same, as shown in Tables (3), (4) and (5) since chlorides are inert and are not affected by passage through the wastewater treatment plant, this results agreed with the study of white, et. al (2004) [23]. The elimination of chlorides in the effluent is attributed to fluctuation in sampling procedures because the values of influent and effluent are almost equal. These results are compatible with the study of Correa, et. al (2003) [8] .

Sulphates Removal

Tables (3), (4), and (5) show the increase of sulphate removal with the increase of COD removal. The sulphate removal ranges from (53%-94%) with COD removal (39%-87%) respectively, also these Tables showed the increase of average sulphate removal with the increase of HRT. These results corresponded with the study of Hamdy et. al.(1992) [10] .The sulphate and sulphite in the wastewater will be reduced to sulphide in anaerobic reactors (Sarner 1990) [19] .Sulphate is utilized sulphur reducing bacteria as an electron acceptor (EL. Bayoumy et. al 1998) [9]. Hydrogen sulphide is the major end produced (Trudinger. 1969) [22]. High concentration of sulphate and sulphide might, also be toxic to methane bacteria (khan, et.al 1978) [13]. However these substances are reduced to hydrogen sulphide by sulphate reducing bacteria and should normally not reach toxic level.

Total Suspended Solids Removal

The removal of TSS in the first run (24 hr) increased with the progress of the operation days as shown in the Table (3) and ranged from 80%-88%. This was attributed to the development in the attached biofilm and that led to the increase of the filtration efficiency due to the decrease in the void ratio. In addition to high COD removal occurred since solid removal related with COD removal in the filter. As shown in Tables (4) and (5) TSS removal efficiency at the second and third runs was (86%-72%) and (68-53) % respectively with the time of progress .This may be attributed to the decrease in HRT (increasing inlet wastewater velocity). This result was corresponded with the studies of Backman, et. al (1985)[2] and Jennett and Dennis (1975) [12]. Jennett and Dennis (1975)[12] stated that the major factor effected solid loss to be hydraulic loading, since the major fluctuation in effluent TSS occurred after the decrease in HRT, also percent TSS removal increased with the increase of COD removal. This agreed with the results of the study done by Backman, et. al (1985) [2]. The increase of generation biogas in the run3 may be sufficient to flush out any loosely trapped organic located in the upper section of media, since Jennett and Dennis (1975) [12] stated that the solids within the anaerobic filter did not become firmly attached to the surface of gravel and also the biogas may contribute in washing out the upper layer of slaughter biofilm as a result of gas bubbles passing through filter media.

Behaviour of Anaerobic Filter in COD Removal with Respect to the Height

For evaluating the height behavior of anaerobic filter in COD removal efficiency, samples were withdrawn from a filter at various heights from the ports at (30 cm, 60 cm, 90 cm, and 100 cm) from bottom to top. Figures (3) to (8) showed the COD removal and effluent of COD at different depths. All figures showed that the lower 30 cm is the most effective in COD removal efficiency. This result agreed with the studies of Jennett, and Dennis (1975)[12] ,Sach, et. al (1982)[18] Young, and Dahab (1983)[24], Hamdy, et. al (1992) [10], and Nandy and kaul (2001)[15] .These curves indicated that height rate of waste conversion to volatile acid and direct methane formation proceeded concurrently and resulted in high COD removal in lower level of the filter normally.

Generation of Biogas

Tables (3), (4) and (5) show the generation of biogas due to anaerobic digestion activity with the time progressing. As shown in the Tables the biogas tends to increase at the first run then decrease in the second run and later returns to increase in the third run. This is attributed to the quantity of digested COD mass. Figure (9) showed a linear relationship that the generated biogas flow rate increased with the increase of COD mass removal. The slope of this line represented the biogas yield which equals to 0.5529 liter/g COD $_{removed}$. This result corresponded with the studies of Oleson, et. al (1990)[17] and Nandy and kaul (2001)[15] .The main ratios of biogas were methane (CH_4) and carbon dioxide (CO_2). Oleson, et. al (1990) [17] concluded that methane and carbon dioxide represented 2/3 and 1/3 biogas respectively.

Anaerobic/Aerobic Sequential Treatment Process

Aerobic treatment stage was used to increase the removal efficiencies of (COD and BOD) for anaerobic treated wastewater as well as to improve the undesirable color to more acceptable limit. Tables (6), (7) and (8) showed the COD and BOD effluent from anaerobic/aerobic sequential treatment processes. It can be noted that at least COD and BOD effluent are achieved in the first run with HRT (24 hours anaerobic + 20 hours anaerobic as sequence). This led to COD effluent to be (60 mg/L) and BOD effluent (28mg/L) at (65th day) of operation the system as shown in Table (6). These limits are accepted in the allowable Iraqi standards. The results showed high removal of BOD and COD corresponded to 93% and 92% respectively. The color of anaerobic treated wastewater changed from pale-amber to gray then the color became pale clear light yellow due to (anaerobic/aerobic) sequential treatment, these results were corresponded to the study of Buitron et.al (2003) [3].

CONCLUSIONS

1-The mesophilic upflow anaerobic filter has a good performance in removing COD, BOD, nitrate, phosphate, sulphate and TSS for the pharmaceutical wastewater.

2-HRT is very important indicator for upflow anaerobic filter in removing COD, BOD, nitrate, phosphate, sulphate and TSS. The removal efficiencies were 87%, 90%, 89%, 78%, 94%, and 88% achieved respectively in the 65th day of Operation with (HRT=24hrs). It was observed that the removal efficiencies decreased with the decrease of HRT.

3-The lower third (30cm) of upflow anaerobic filter height shows to be the most effective in COD removal.

4- The generation of biogas is related to quantity (mass) of COD removed. The biogas yield is 0.55 m3/kg COD removed.

5-The comparisons of effluent treated wastewater with Iraqi allowable limits were acceptable in the 65th day of operation for discharging to Iraqi rivers.

6- Improvement in color and odor were observed for sequential treated anaerobic/aerobic wastewater.

RECOMMENDATION

1- Studying the toxic and hazardous materials resulted from pharmaceutical wastewater and their effect on biological treatment public health, aquatic environmental and soil.

2- Studying the performance of anaerobic filter in removing heavy metals existing in pharmaceutical wastewater.

3- Studying the different anaerobic unit media and temperature on the performance of anaerobic filter.

4- Studying the effect of recycling from aerobic to anaerobic on the nutrient removal (denitrification – nitrification– denitrification)

5- Feasible study of biogas as heating fuel.

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Table (1) Characteristics of Wastewater and Analytic Methods Used.

Parameter	Concentration range	Analytic methods
Temperature ºC	26.0-30.2	Temperature meter
pH	7.2-8.4	pH meter
BOD mg/l	298-400	Oxygen meter+incubator
COD mg/l	740-1100	Dichromate closed reflux
TSS mg/l	72-170	Gravimetric-filtration and drying
NO_3 mg/l	1.1-7.6	Spectrophotometer
PO_4 mg/l	1.9-5.0	Spectrophotometer
SO_4 mg/l	88-400	Gravimetric
Chlorides mg/l	30-70	Titration with AgNO3
Alkalinity mg/l	380-480	Titration with HCL
Biogas		Liquid displacement method
Heavy metals		Atomic Absorption Spectrophotometer
Cu mg/l	Nil-0.02	
Fe mg/l	0.185-1.517	
Zn mg/l	Nil-0.0235	
Pb mg/l	Nil-0.68	

Table(2)Performance of anaerobic filter During Seeding and Startup

Stage	Days	HRT (hr)	Substrata	pH effl.	COD removal%	Biogas l/d
1	2	48	Glucose 100%	7.5	10	0.16
	4	=	=	7.4	15	0.24
	6	=	=	7.2	30	0.49
	8	=	=	7.0	49	0.82
	10	=	=	6.8	57	0.94
	12	=	=	6.3	68	1.12
	14	=	=	6.1	79	1.30
2	16	=	20% waste 80% Glucose	6.0	85	1.40
3	18	=	40% waste 60% Glucose	5.9	33	0.49
4	20	=	60% waste 40% Glucose	5.8	47	0.66
5	22	=	80% waste 20% Glucose	7.4	61	0.84
6	24	=	100% waste	7.3	69	0.92
	26	=	100% waste	7.2	81	1.07
	30	36	100% waste	7.3	85	1.80
	34	=	100% waste	7.2	85	1.80

Table (3) The Removal Efficiencies and Gas Flow Rate During the First Run (HRT 24 hours)-Anaerobic Treatment

Days	COD in mg/l	Q l/d	OLR kgCOD/ m^3.d	COD r%	BOD r%	NO_3 r%	PO_4 r%	SO_4 r%	Cl r%	TSS r%	Biogas l/d
35	980	6.6	0.98	71	74	69	73	80	10	80	2.31
40	960	=	0.96	75	77	73	75	82	9	83	2.37
45	1000	=	1.00	77	79	75	78	85	Nil	80	2.51
50	880	=	0.88	82	84	79	77	88	2	87	2.41
55	860	=	0.86	84	87	84	70	87	23	89	2.35
60	750	=	0.75	86	89	87	70	89	10	86	2.12
65	760	=	0.76	87	90	89	78	94	12	88	2.21
Avge	884	6.6	0.88	80	84	79	74	86	9	85	2.32

Table (4) The Removal Efficiencies and Gas Flow Rate During the Second Run (HRT 18 hours)-Anaerobic Treatment

Days	COD in mg/l	Q l/d	OLR kgCOD/ m^3.d	COD r%	BOD r%	NO_3 r%	PO_4 r%	SO_4 r%	Cl r%	TSS r%	Biogas l/d
70	800	8.8	1.06	68	73	63	52	81	NIL	86	2.40
75	820	=	1.09	64	72	66	54	79	10	78	2.32
80	840	=	1.12	61	70	60	50	78	7	76	2.25
85	844	=	1.125	59	70	61	47	78	NIL	76	2.00
90	740	=	0.986	55	68	59	46	76	11	75	1.81
95	860	=	1.14	54	68	52	46	74	8	76	2.01
100	880	=	1.17	53	64	50	40	72	NIL	72	2.12
Avge	826	8.8	1.1	59	69	59	48	77	5	77	2.13

Table (5) The Removal Efficiencies and Gas Flow rate During the Third Run (HRT 12 hours)- Aaerobic Treatment

Days	COD in mg/l	Q l/d	OLR kgCOD/ m^3.d	COD r%	BOD r%	NO_3 r%	PO_4 r%	SO_4 r%	Cl r%	TSS r%	Biogas l/d
105	820	13.2	1.64	51	66	50	45	69	Nil	68	2.76
110	840	=	1.68	50	64	49	43	67	14	72	2.77
115	830	=	1.66	48	63	48	44	63	Nil	63	2.64
120	880	=	1.76	44	60	49	43	62	Nil	58	2.56
125	900	=	1.80	42	61	45	42	60	Nil	60	2.49
130	1000	=	2.00	41	60	44	41	54	Nil	58	2.70
135	1100	=	2.2	39	58	42	38	53	8	53	3.30
Avge	910	13.2	1.82	45	62	47	42	61	3	62	2.74

Table (6) COD and BOD Removal Efficiencies for Anaerobic/Aerobic first RUN

HRT	Time of Operation (days)	COD % Removal	BOD % Removal
Anaerobic 24 hours + aerobic 20 hours	35	73	75
	40	76	79
	45	79	81
	50	85	86
	55	87	88
	60	89	92
	65	92	93

Table (7) COD and BOD Removal Efficiencies for Anaerobic/Aerobic second RUN

HRT	Time of Operation (days)	COD % removal	BOD % removal
Anaerobic 18 hours + aerobic 15 hours	70	70	75
	75	68	73
	80	65	72
	85	62	71
	90	57	71
	95	56	70
	100	55	69

Table (8) COD and BOD Removal Efficiencies for Anaerobic/Aerobic third RUN

HRT	Time of operation (days)	COD % removal	BOD % removal
Anaero bic 12 hours + aerobic 10 hours	105	54	70
	110	54	68
	115	50	65
	120	47	64
	125	43	64
	130	42	63
	135	42	61

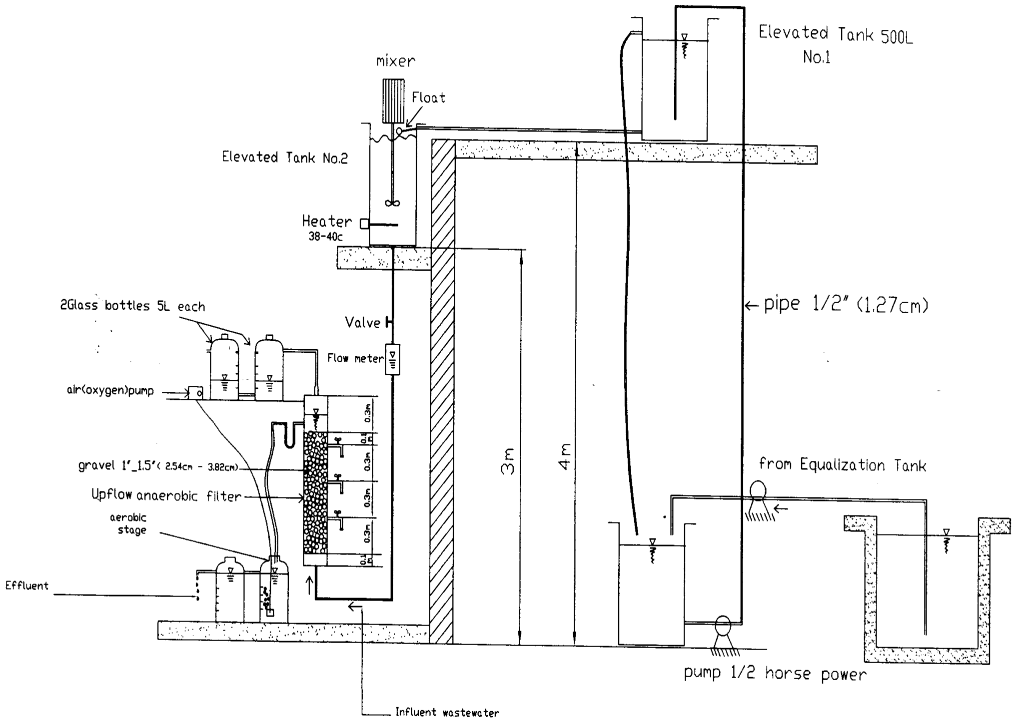

Fig (1) Schematic diagram of the pilot plant.

Fig(2) Photograph of the pilot plant.

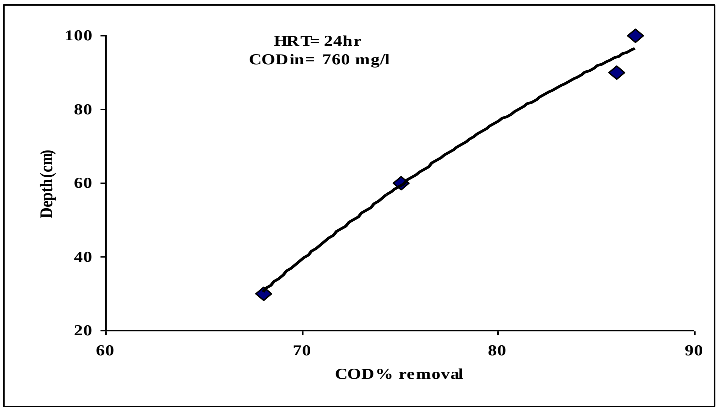

Fig (3) The COD removal with the depth of filter (1st run)-anaerobic treatment.

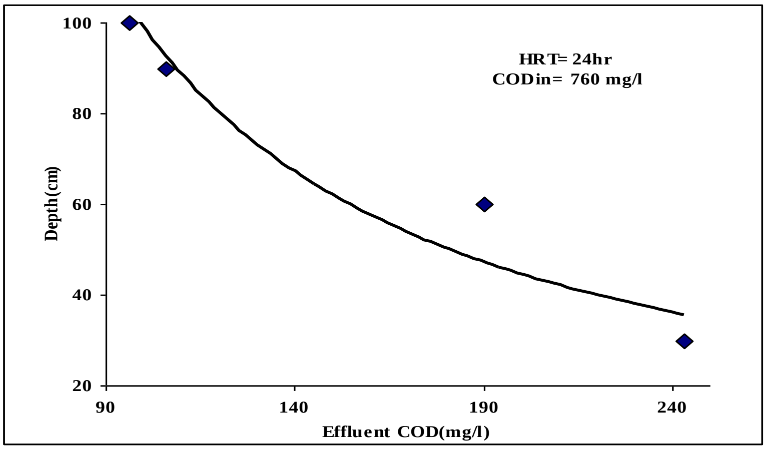

Fig (4) The Effluent COD with the depth of filter(1st run)-anaerobic treatment.

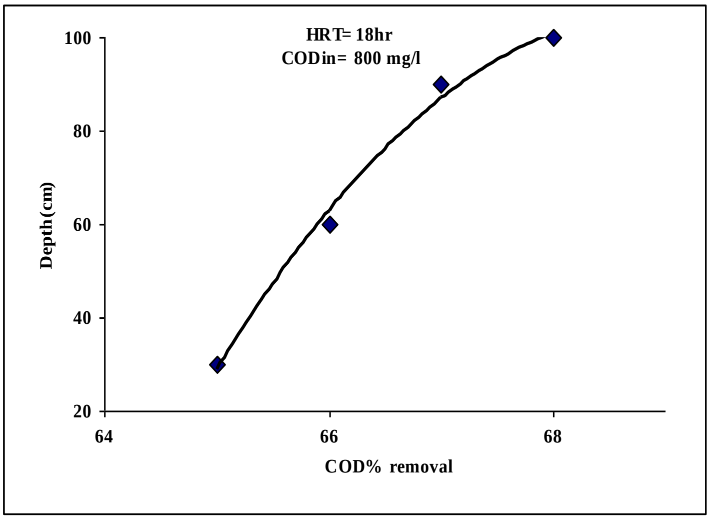

Fig (5) The COD removal with the depth of filter (2nd run)-anaerobic treatment.

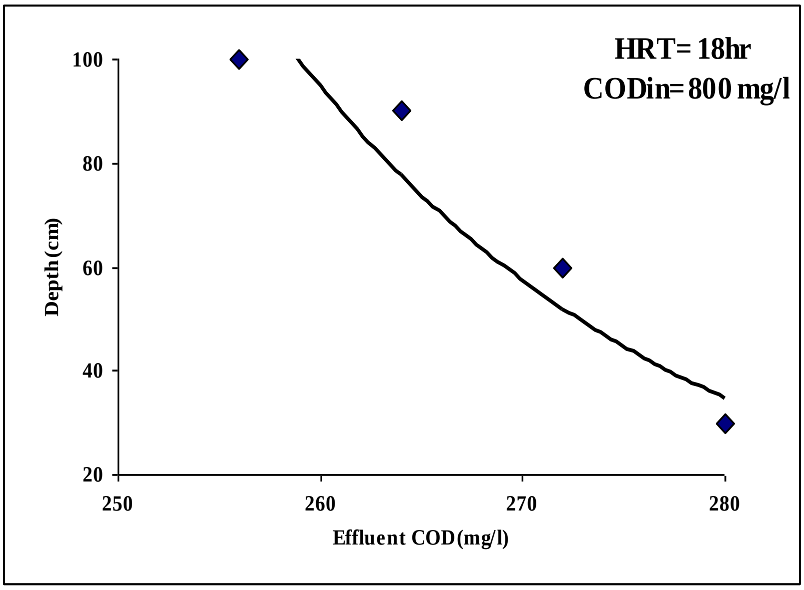

Fig (6) The Effluent COD with the depth of filter (2nd run)-anaerobic treatment.

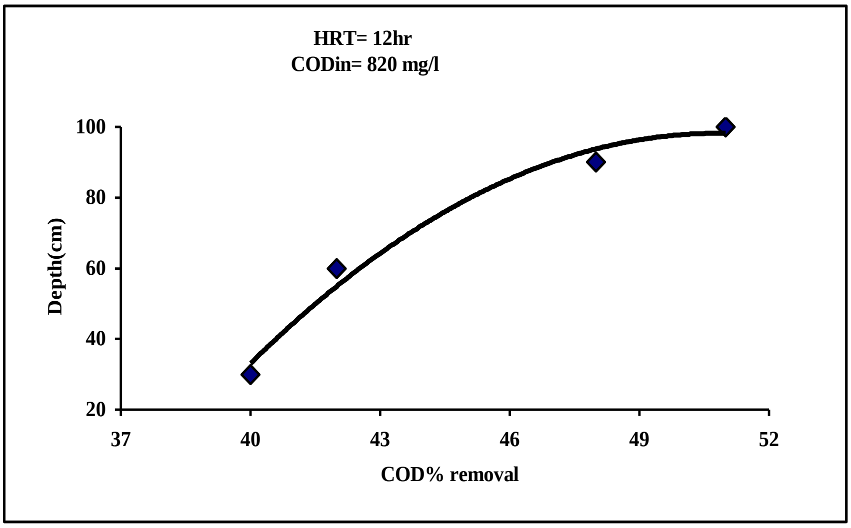

Fig (7) The COD removal with the depth of filter (3rd run)-anaerobic treatment.

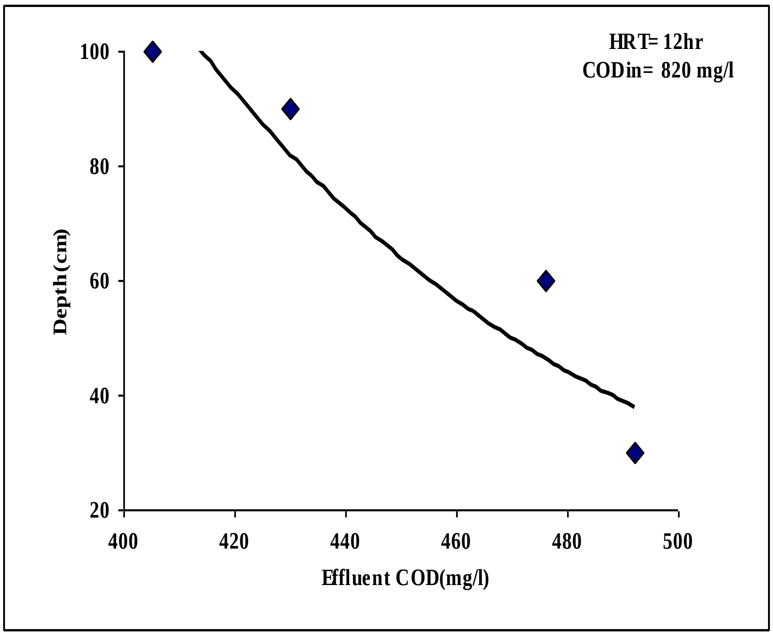

Fig (8) The Effluent COD with the depth of filter (3rd run)-anaerobic treatment.

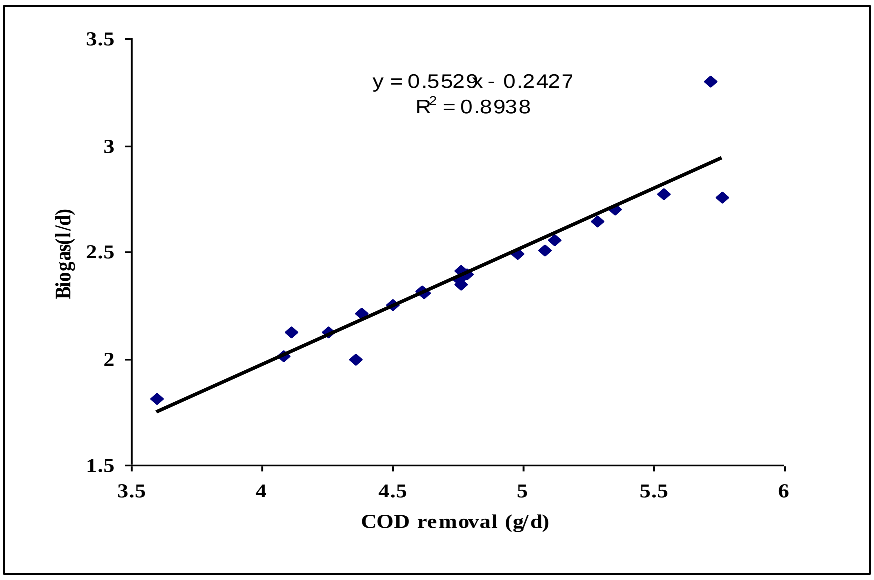

Fig (9) The Biogas flow rate with COD removal–anaerobic treatment.

المعالجة المتعاقبة اللاهوائيه/الهوائية لمياه الفضلات الناتجة من الصناعات ألصيدلانية

د.محمد علي إبراهيم الهاشمي
أستاذ مساعد
قسم هندسة البناء والإنشاءات
الجامعة ألتكنولوجيه

عباس هادي عباس
مدرس مساعد
قسم الهندسة المدنية- كليه الهندسة
جامعة تكريت

ألخلاصه

تم دراسة ألمعالجه المستمرة المتعاقبة اللاهوائيه\الهوائية لمياه الفضلات الناتجة من معمل أدويه سامراء (مخلفات صيدلانية), وقد تم تقييم تلك المعالجة تحت حالات مختلفة من التشغيل باستخدام مدد متغيره لفترة البقاء الهيدروليكي, تم استخدام منظومة رياديه تتكون من مرشح لاهوائي ذو جريان صاعد إلى الأعلى للمرحلة اللاهوائيه تعقبه ألمرحله ألهوائيه باستخدام ناشر الهواء, تمّ تصنيع المرشح اللاهوائي من أنبوب بلاستك ذو قطر داخلي مقداره 14سم وارتفاع مقداره 140 سم وقد تم تعبئة متر واحد من المرشح(كحشوه) باستخدام الحصى العابر منخل ذو فتحه 3.82 سم والمتبقي على منخل ذو فتحه 2.54 سم, تمّ وضع ثلاث فتحات جانبيه على طول المرشح وبمسافة 30 سم بين فتحه وأخرى لغرض تقييم كفاءة المرشح مع العمق, أما ألمرحله الهوائية فقد تمّ استخدام مضخة هواء تضمن بقاء تركيز الأوكسجين 2 ملغم\لتر على الأقل في وعاء التهوية, تم تشغيل المنظومة لمده 135 يوم بصورة

مستمرة, تم انجاز عمليه تكاثر البكتريا لغرض أقلمتها والبدء بعمليه تشغيل المرشح اللاهوائي بمدة 34 يوم باستخدام الكلوكوز وقليل من المغذيات ومن ثم القيام بالتعويض التدريجي بمياه الفضلات ألصيدلانيه لحين الوصول إلى استخدام الفضلات ألصيدلانيه 100%, تم تشغيل المنظومة لثلاث سلاسل, كل سلسله كانت مدتها 30 يوم وقد استخدم ثلاثة قيم لفترة البقاء الهيدروليكي كانت (24ساعه، 18ساعه، 12 ساعة) للمرحلة اللاهوائيه و(20 ساعه، 15 ساعة، 10 ساعات) للمرحلة الهوائية على التعاقب. تمّ تشغيل المرشح اللاهوائي الصاعد بدرجه الحرارة 35–37 م^o لضمان النمو للبكتريا وسطيه الحرارة, تم تقييم كفاءة الإزالة للمرشح اللاهوائي بواسطة حساب كفاءة الازالـه للمتطلب الكيماوي للأوكسجين، المتطلب البايوكيمياوي للأوكسجين، النترات، الفوسفات، الكبريتات، المواد العالقة بينما تم تقييم كفاءة الازالـه للعملية المتعاقبة اللاهوائية\الهوائية باستخدام كفاءة الازالـه للمتطلب الكيماوي للأوكسجين والمتطلب البايوكيمياوي للأوكسجين, تم تعريض المنظومة لمياه الفضلات الصيدلانية التي تمتلك تركيز للمتطلب الكيماوي للأوكسجين بمدى(700–1100) ملغم\لتر والمتطلب البايوكيمياوي للأوكسجين بمدى (298–400)ملغم\لتر, تراوحت قيم كفاءة الازاله للمتطلب الكيماوي للأوكسجين 87%–90% للمرحلة اللاهوائية و92%–93% للمرحلة المتعاقبة اللاهوائية\الهوائية على التعاقب, كانت قيم الغاز البيولوجي المتولد من المرشح اللاهوائي 0.55 م^3\كغم COD مزال, تم تقييم كفاءة الازالـه للمرشح

اللاهوائي مع العمق وتبين أن الثلث الأسفل 30 سم هو الأكثر فعاليه في أزاله المتطلب الكيماوي للأوكسجين.

الكلمات الدالة

COD المتطلب الكيماوي للأوكسجين.

BOD المتطلب البايوكيمياوي للأوكسجين.

UAF المرشح اللاهوائي ذو الجريان الصاعد إلى الأعلى.

HRT فترة البقاء الهيدروليكي.