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RESEARCH ARTICLE

The treatment of baker's yeast wastewater by an up flow anaerobic sludge blanket (UASB) reactor

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ABSTRACT

The objective of the research is to study the ability of baker's yeast wastewater (BYW) treatment by a Up Flow - Anaerobic Sludge Blanket (UASB) reactor. The effect of the temperature of BYW on the efficiency of treatment in a UASB was investigated and the experiments showed that it is possible to achieve good removal efficiency of chemical oxygen demand (COD) (10200-16320) mg L^{-1} when the temperature of BYW is about (35±2)°C and hydraulic retention time (HRT) = 24 h. The removal efficiency fit with temperature value of wastewater in UASB reactor for the following values of temperature of (11±2; 16±2; 26±2; 26±2; 31±2; 35±2) °C. The removal efficiencies of COD were: (36.6%; 37.9%; 43%; 44.2%; and 48.8%) respectively. The effect of changing the values of HRT on the efficiency removal at a temperature (35±2) °C value was investigated. The experiments illustrated that it is possible to achieve good removal efficiency for high concentrations of COD when the temperature of the BYW is fixed at (35±2) °C and HRT>=24 h. The removal efficiency fits with HRTs values. For the following values of HRTs: (18; 24; 30; 36) h, the removal efficiencies of COD were: (32.9%; 48.8%; 48.95%; 51.3%) respectively.

Keywords: Anaerobic biological treatment, UASB reactor, baker's yeast wastewater

1. INTRODUCTION

The high organic load wastewater discharged from industries is one of the most critical causes of pollution in the nature if left untreated. It contaminates the groundwater and, if it is discharged into the sewer network without sufficient treatment, it causes an increase in the organic and hydraulic loads in sewage treatment plants [1]. This may cause operational problems that can reduce the efficiency of treatment. In spite of the existence of BYW in many governorates of Syria, there are no treatment plants to treat the wastewater from baker's yeast. This wastewater is heavily polluted so it is very important to find the best way to treat it. In anaerobic reactors, maintenance of sufficient methanogenic population is critical for stable performance of the systems. Also, the methanogenic activity is very important for operation UASB reactors [2].

The production of baker's yeast by fermentation which generally uses molasses as the raw materials includes operations and processes such as molasses preparation, fermentation, and separation and drying of yeast, it produces a large quantity of wastewater [3, 4]. Various treatment methods like biological process, physico-chemical treatment, adsorption, membrane process, reverse osmosis, coagulation/flocculation and oxidation processes, have been attempted for the treatment of BYEs [3].

The objective of the research is to study the ability of BYW treatment by a UASB reactor and recognize the effect of changing the temperature degree of baker's yeast wastewater on the efficiency removal of the pollutants and define the best HRT for achieving the best efficiency removal of pollutants.

In this research, the effect of the temperature of baker's yeast wastewater on the efficiency of treatment in UASB was investigated. UASB reactor was selected because UASB reactors have been strongly used for industrial and domestic wastewater treatment [5] UASB reactors have not mechanical equipment and there is no need for primary sedimentation and sludge thickeners, and low sludge production with good settling properties in general. Also UASB reactors are economical to build, their

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operational conditions are suitable for the climate in Syria and they are easy to operate and produce CH_4 which can be used to generate electricity and heat.

The flow of Aleppo BYW is about 853 m^3 day^{-1}. The efficiency of treatment of BYW of Aleppo baker's yeast factory was studied by the UASB reactor with continuous flow. The characteristics of BYW which was studied in the research are :COD(12385-27600) mg L^{-1}, Total dissolved solids (TDS):(13482-23106) mg L^{-1}, Total suspended solids (TSS): (428-1460) mg L^{-1}, pH: (6.42-7.65) mg L^{-1}, SO_4^{2-}:(1850-3980) mg L^{-1}, PO_4^{3-}: (290-500) mg L^{-1}, NH^{4+}: (243-740) mg L^{-1}, oil and grease (160-359) mg L^{-1}, Na^+: (738-1038) mg L^{-1}, and K^+ (621-1090.5) mg L^{-1}.

The BYW is considered highly polluted the concentration of COD in it is about (12385-27600) mg L^{-1}, and the average value of concentration of COD is 13650 mg L^{-1}. The average value of COD is very high and it is higher than value of COD of domestic wastewater in Aleppo city which is about 650 mg L^{-1}, about 21 times. So, it causes an increase in organic loads on Aleppo wastewater treatment plant. pH value of BYW for most samples is below than 7 which mean that BYW is the value of acidic wastewater same result reported by the references [6, 7] which can lead to a serious danger to the public sewer system because acid water causes erosion in the public sewer system. BYW contains high concentrations of SO_4^{2-} and sometimes its value is up to 3500 mg L^{-1}, which causes the release of H_2S, which is considered as a hazardous gas that can lead to risks to the workers working in the maintenance of sewerage networks. As well as causing damage to public sewerage systems a high concentration of sulphate reduces the efficiency of anaerobic biological treatment [8], it also contains high concentration of oil and grease. sometimes its value is up to 350 mg L^{-1}, which damages the public sewerage system, the pumping station and the treatment plant, and contains high concentrations of TDS, TSS, and TS, increasing the amount of sludge formed at the main treatment plant and increasing the value of organic loads. The average flow of BYW in Aleppo is about 850 m^3 day^{-1}, which equals to the discharged flow of 5667 persons of Aleppo as the organic load of this factory is equal to the organic load from 119000 persons so it is necessary for treat this wastewater. The concentration of TDS for the industrial wastewater of baker's yeast is (13482-23016) mg L^{-1}. So, it is expected to be inhibited the activity of methanogenic/anaerobic bacteria because of the high the salinity which will minimize the efficiency of BYW treatment according to the references, [7, 9]. Because the biological wastewater treatment was inhibited by high concentration of SO_4^{2-}, total nitrogen, eventually becoming reduced to toxic H_2S and high total nitrogen content [10].

Authors hope that the outcomes of this research contribute to solving the problem of pollution of the environment by BYW. Anaerobic treatment is the preferred biological treatment because of its effectiveness in treating high-strength wastewater [11]. Anaerobic treatment is one of the most important processes used for the treatment of high organic load wastewater.

2. MATERIALS AND METHODS

All experiments were performed according to the international Standard Methods for the Examination [12] adopted in the field of wastewater and industrial analysis and a real (not make up the laboratory) BYW was used in all stages of the research.

2.1. Design of Experimental UASB Reactor

Laboratory experiments were carried out in a plastic reactor with a total height of 92. 5 cm. The high-water level was 85 cm leaving 7.5 cm free height above the surface of the wastewater. The diameter of the reactor around the sludge bed was 10 cm, Fig 1. The temperature of wastewater in UASB reactor was controlled by a thermostat. The reactor was surrounded by insulant material to keep the temperature in the reactor steady, also a thermostat was used to control the temperature inside the reactor.

1- Feeding tank of raw wastewater
2- Pipes for carrying treated wastewater form UASB
3- Valves for control HRT value in the reactor
4-Flow meter
6- Dome for gas separating
7- Opening for exhaust the gases.
8- Pipes for carrying treated wastewater form UASB
9- Small tank for treated wastewater
10-Pipes and valve for drawing surplus sludge for UASB reactor.

Fig 1. Longitudinal section and pic of the experimental UASB Reactor

3. RESULTS AND DISCUSSION

3.1. UASB start up

The characteristics of the untreated BYW which was studied in startup phase of the treatment are showed in the following the Table 1.

Table 1. The characteristics of BYW which used in startup stage

Parameter	Value
pH	7.65
T°.C	16.5
TS (mg L^{-1})	23946
TDS (mg L^{-1})	23106
TSS (mg L^{-1})	840
COD (mg L^{-1})	27600

All the volume of wastewater during startup phase was recycled and the HRT values was :24 hours according to the reference [13]. The temperature of wastewater was (16±2) °C within the laboratory reactor this temperature without any controlling it is the temperature of the laboratory room, that mean there was not any heating or cooling to control the temperature control, this operational conditions are suitable for the climate in Syria .

The entire flow was also recycled and no sedimentation was made to circulate the waster water to increase the concentration of the biomass within the laboratory UASB.

The results of start up phase are showed in the Table 2. After 34-38 days of the reactor. The value of the COD was fixed and there was no change in its value .

The startup of UASB rector was achieved after 38 days of starting feed the wastewater and the recycle ratio was 100% in closing loop. The removal efficiency of COD was about 49% because the biological wastewater treatment was inhibited by high concentration of SO_4^{2-}, total nitrogen [10] and high total dissolved solids.

3.2. The effect of the temperature of BYW on the efficiency of treatment in UASB

The effect of temperature on the efficiency of treatment of BYW by a UASB reactor was investigated by opeating the UASB reactor for 132 days after achieving startup, the duration of any stage under various operating temperatures continued about 6 days during it many samples were taken and analyzed and the average value showed in the Table 3, the temperature of BYW inside UASB was controlled by automatic thermostat which was used only for heating the BYW inside UASB reactor.

According to the reference [14] when COD value is more than 10000 mg L^{-1}, it is recommended that HRT in UASB equal or more than 24 hours, so HRT was fixed at 24 hours.

Table 3. The efficiency removal of pollutants of the experimental UASB according to the different values of the temperature of BYW

Parameters	Temperature (°C)				
	11±2	**16±2**	**26±2**	31±2	35±2
pH_i	7.15	6.6	6.5	6.42	6.67
pH_e	7.64	7.44	7.56	7.79	7.82
COD_i (mg L^{-1})	15840	15133	15040	15065	12385
COD_e (mg L^{-1})	10042.6	9397.6	8572.8	8406.3	6341.1
COD removal %	36.6	37.9	43	44.2	48.8
ORL (kg COD	15.84	15.133	15.040	15.065	12.4
TS_i (mg L^{-1})	17603	14603	24290	19418	14700
TS_e (mg L^{-1})	17022	14123	22046	18081.4	13220.4
TS removal %	3.3	3.3	9.2	6.9	10.1
TSS_i (mg L^{-1})	1460	428	1063	881	1218
TSS_e (mg L^{-1})	1367	398	426.7	548.8	727.4
TSS removal %	6.4	7.0	59.9	37.7	40.3
TDS_i (mg L^{-1})	16768	14175	23227	18537	13482
TDS_e (mg L^{-1})	16236	13725	21619.3	17292.6	12493
TDS removal %	3.17	3.2	6.92	6.7	7.3

Table 2. Startup phase results

Parameter	The time from startup (time) day								
		1	**3**	**5**	**18**	**20**	**25**	**27**	**34**
COD (mg L^{-1})	20	22320	21600	17971	16320	16800	15400	14000	14100
COD removal efficiency (%)	0	19.1	21.7	34.9	40.9	39.1	44.2	49.3	49
TSSe (mg L^{-1})	840	---	126	450	105	175	145	--	---
TSS removal efficiency (%)	--	--	85	43	88	79	83	--	---
TSe (mg L^{-1})	23946	---	22216	--	22760	22840	--	---	--
TS removal efficiency (%)	--	---	7.2	--	5.2	4.6	--	--	--

The relation between temperature and the efficiency for COD removal is represented in the following equation and Fig 2.

$$COD_r=0.4433\times(T)+31.13 \quad (1)$$

Where T is temperature of wastewater in UASB reactor (°C) and COD_r is COD removal efficiency (%).

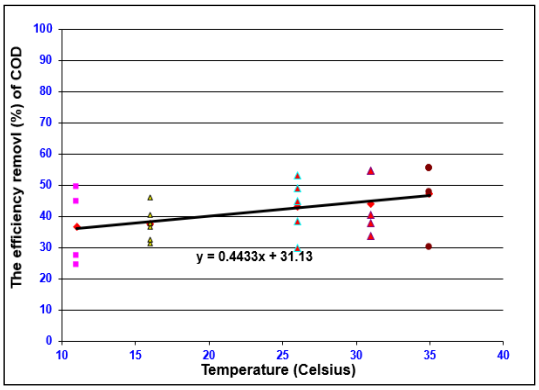

Fig 2. The relation between Temperature and the efficiency removal of COD

The volume organic rate load (ORL) applied to the laboratory UASB with in temperature (9-37) °C for BYW was (12.4-15.84) kg COD removal m^{-3} day^{-1} for COD value 12000-16000 mg L^{-1} and HRT=24hours and the same result reported by the references [6, 15]. Whereas: $OLR=COD_i$ /HRT, COD_i: COD value before the treatment.

The efficiency removal of COD did not exceed 48.8% it is probably due to the high value of salinity, which studies the effect of methanogenic inhibitors: IC50 (inhibitory concentration 50%) for TDS: Salts (eg. Na^+, K^+, Ca^{2+}) of the anaerobic toxicity is IC50 = 4.700-7.600 mg L^{-1}. The concentration of TDS for the industrial wastewater of baker's yeast is (10790-23860) mg L^{-1}. So it is expected to be inhibited the activity of methanogenic/anaerobic bacteria because of the high the salinity, which will minimize the efficiency of BYW treatment. The same result was reported by the references [9, 10].

The efficiency removal of COD, TDS and TS increase with increasing the temperature of wastewater.

The efficiency removal of TDS and TS in UASB rector which treating BYW is too low (about 3.17 to 7.34% for TDS and 3.3-10% for TS). Increasing of wastewater temperature had not a very clear effect of removal TDS and TS.

pH we observed that slight increase in pH values of treated water from wastewater because of the development of reactions in anaerobic reactors that may be dependent, the release of CO^2 gas increases the value of treated wastewater pH because it is known that CO_2 has acidic properties when dissolved in water [16].

3.3. The effect of HRT on efficiency removal of UASB reactor with in temperature (35±2) °C

The effects of HRT on the efficiency of treatment in a UASB reactor was studied so that HRT was changed and the temperature in the reactor constant between (35±2) °C this value was choosed because it is the normal temperature of wastewater in Syria during Summer season and it is found that the best removal of COD occurs at it. The temperature of BYW was controlled by automatic thermostat which was used only for heating the BYW inside UASB reactor.

The duration of any stage under various operating HRT continued about 5 days during it many samples were taken and analyzed and the average value showed in the Table 4.

Table 4. The efficiency removal of pollutants of the experimental UASB according to the different values of HRT

Parameters	HRT (hours)			
	18	**24**	**30**	**36**
pHi	6.61	6.67	7.22	6.55
pHe	7.46	7.76	7.37	7.82
COD_i (mg L^{-1})	10540	12384	10200	13320
COD_e (mg L^{-1})	7072.3	6341	5207	6487
COD removal %	32.9	48.8	48.95	51.3
ORL (kg COD $m^{-3}.day^{-1}$)	14.05	12.38	8.18	8.89
TS_i (mg L^{-1})	13883	14700	13473	16313
TS_e (mg L^{-1})	11776.2	13220.4	11683.3	13130
TS removal %	15.2	10.1	13.3	19.5
TSS_i (mg L^{-1})	1073	1218	1163	890
TSS_e (mg L^{-1})	353.4	727.4	446.5	364.6
TSS removal %	67.1	40.3	61.6	59.0
TDS_i (mg L^{-1})	12810	13482	12310	15423
TDS_e (mg L^{-1})	11422.6	12493	11237	12799.4
TDS removal %	10.8	7.3	8.7	17.0

ORL applied to the laboratory UASB with in HRT value (18-36) h for BYW was (8.18-14.05) kg COD m^{-1} day^{-1} in a temperature value (35±2) °C. The same result reported by the reference [6, 15].

The efficiency removal of COD for BYW in UASB reactor is about (32.9-51.3) % and depends on HRT and temperature of wastewater in HRT value (18-36) hours and a temperature value (35±2) °C. The efficiency removal of COD did not exceed 51.3%. It is probably due to the high value of salinity.

It is higly recommended that using UASB reactor for treatment of high organic loading wastewater such as wastewater from yeast factories but the efficiency for COD removal would not exceed 48 % at HRT =24 hour and the temperature is between (35±2) °C, which can be obtained by heating UASB reactor by CH_4. The maximum efficiency removal of COD was:51.3% at

HRT value=36 hours, temperature is between (35±2) °C the same result reported by the references [9, 10].

It was found that the relation between HRT and the efficiency for COD removal was (Fig 3):

$$COD_r = -0.0941 \times HRT^2 + 6.0037 \times HRT - 43.782 \quad (2)$$

Where: HRT: is the hydraulic retention time (h),COD_r: is the efficiency removal (%)of COD.

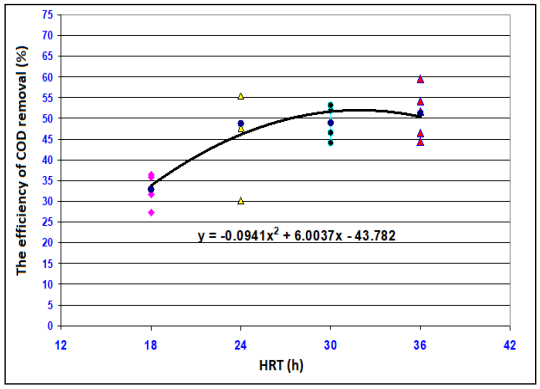

Fig 3. The relation between Temperature and the efficiency removal of COD

pH: We observed that slight increases in pH values of treated water from waste water.

The efficiency removal of TDS and TS in UASB rector which treating the industrial wastewater of baker's yeast is too low about 3.17 to 7.34% for TDS and 3.3-10% for TS. Increasing of wastewater temperature had not a very clear effect of removal TDS and TS.

If wastewater from yeast factories would be treated by a UASB reactor,another sequential reactor must be put. To achieve good quality of treated wastewater. It is highly recommended to investigated other method for treat baker's yeast wastewater such as evaporation because it contains high concentration of TS and TDS, so it is recommended to the advanced treatment of biologically treated BYW with membrane processes was studied to produce recovered water that was suitable for agricultural irrigation. In addition to water recover, the reference reported that electrocoagulation (EC) was employed for removals of color, COD and total organic carbon (TOC) from baker' s yeast effluents in a batch EC reactor using aluminum electrodes[3]. The removal efficiencies showed a high significance of the model. The maximum color, COD and TOC were 88%,48% and 49% [3].

4. CONCLUSIONS

The startup of UASB rector was achieved after 38 days of starting feed the wastewater and the recycle ratio was 100% in a closing loop. The removal efficiency of COD was about 49% at the end day of startup face.
The relation between temperature and the efficiency for COD removal is represented in the following equation:

$$CODr = 0.4433 \times (T) + 31.13 \quad (3)$$

Whereas: T: temperature of wastewater in UASB reactor (°C), CODr: COD efficiency removal (%).

It is highly recommended to investigated other method for treat baker's yeast wastewater, such as evaporation, because BYW contains high concentration of TS and TDS, so it is recommended to the advanced treatment of biologically treated BYW with membrane processes or any other advanced method to reuse the treated wastewater for irrigation.

REFERENCES

[1]. A. Saghir, "Industrial wastewater treatment in Arabic world," *Arabic scientific publishers*, Lebanon, 2017.

[2]. R. Rajakumar, T. Meenambal, P.M. Saravanan, P. Ananthanarayanan, "Treatment of poultry slaughterhouse wastewater in hybrid upflow anaerobic sludge blanket reactor packed with pleated poly vinyl chloride rings," *Bioresource Technology,* Vol. 103 (1), pp. 116–122, 2012.

[3]. E. Gengec, M. Kobya, E. Demirbas, A. Akyol and K. Oktor, "Optimization of baker's yeast wastewater using response surface methodology by electrocoagulation," *Desalination,* Vol. 286, pp. 200–209, 2012.

[4]. Y. Zhou, Z. Liang and Y. Wang, "Decolorization and COD removal of secondary yeast wastewater effluents by coagulation using aluminum sulphate," *Desalination,* Vol. 225, pp. 301-311, 2008.

[5]. A. Saghir. and S. Hajjar, "Anaerobic treatment for high organic load industrial wastewater by UASB reactor," *Research Journal of Aleppo university Engineering series*. Vol. 58, 2007.

[6]. T. Ciftci. and I. Ozturk, "Nine years of full-scale anaerobic-aerobic treatment experiences with fermentation industry effluent," *Water Science and Technology,* Vol. 32 (12), pp. 131-139, 1996.

[7]. N. Deveci and G. Ciftci, "A mathematical model for the anaerobic treatment of Baker's yeast effluents," *Waste Management*, Vol. 21 (1), pp. 99-103, 2001.

[8]. S.K. Khanal, J.C. Huang, "Effect of high influent sulfate on anaerobic wastewater treatment," *Water Environment Research,* Vol. 77 (7), pp. 3037-3046, 2005.

[9]. K.V. Lo, A. Chen and P.H Liao, "Anaerobic Treatment of Baker's Yeast Wastewater:II.Sulfate Removal," *Biomass: of British*, Vol. 23 (1), pp. 25-37 ,1989.

[10]. M. Koplimaa, A. Menert, V. Blonskaja, T. Kurissoo, S. Zub, M. Saareleht, E. Vaarmets and T. Menert, "Liquid and gas chromatographic studies of the anaerobic degradation of baker's yeast wastewater," *Procedia Chemistry,* Vol. 2 (1), pp. 120–129, 2010.

[11]. M.E Ersahin, H. Ozgun, R.K. Dereli and I. Ozturk, "Anaerobic Treatment of Industrial Effluents:An Overview of Applications," Available: https://www.intechopen.com/books/waste-water-treatment-and-reutilization/anaerobic-treatment-of-industrial-effluents-an-overview-of-applications, DOI: 10.5772/16032, 2011.

[12]. E.W. Rice, "*Standard Methods for the Examination of Water and Wastewater*," 22nd

Edition, American Public Health Association, American Water Works Association and Water Environment Federation, Washington DC, USA, 2014.

[13]. M.M. Ghangrekar, "Design of an UASB Reactor," Available. https://docslide.net/documents/design-of-an-uasb-reactor.html, 2005.

[14]. S. Sung, "Anaerobic Water Treatment Technologies," Accessed: http://www.wpeiic.ncku.edu.tw/resources/Aeaerobic%20Water%20Treatment.pdf, (2008).

[15]. M.M. Ghangrekar, "Design of an UASB Reactor," https://www.scribd.com/document/86683056/Design-of-an-UASB-Reactor, 2002.

[16]. L.F Burton and G. Tchobanoglous,"*Wastewater Engineering-Treatment- Disposal- Reuse*," 3rd Ed, Metcalf and Eddy. Inc ,McGraw- Hill, New York, 1991