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ARTICLE

POST-TREATMENT OF BAKER'S YEAST WASTEWATER BY COMBINATION OF TWO STAGE SEQUENCING BATCH REACTOR (SBR) AND INTERMEDIATE O3/GAC

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ABSTRACT

Background: *The baker's yeast wastewater characterized by high contents of organic load and dark brownish color by melanoidin pigment content. At present study, a pilot scale of combination system involving two stage of sequencing batch reactor and intermediate advanced oxidation process by O3/GAC was evaluated for simultaneous removal of COD and color from baker's yeast wastewater as post-treatment process. The influent was subjected to anaerobic baffled reactor-biological activated carbon as pretreatment. To analyses the resuls, response surface methodology was applied to gain the optimize operating of interactive effect of 2 independent variables on the response. It was revealed that initial COD concentration and HRT influenced COD and color removal, respectively. The interactive effect of HRT of (6, 12 and 24 h) for both SBR and initial COD concentration of 2000, 3000 and 4000 mg/L were conducted as experiment variables. The optimal result has revealed the COD, BOD5 and decolorization reached to as high as 97.4%, 97.9% and 66.35% in series collective result, respectively, as far by underwent condition the HRT: 24h in both SBR system and initial COD concentration of 2000 mg/L as the best performance of COD and color removal in combination system. Based on obtained result a post-treatment combination of (SBR1-O3/GAC-SBR2) in baker's yeast wastewater verified as operative and satisfies technology for high strength wastewater in terms of attain the direct environmental regulation.*

KEY WORDS
Baker's yeast wastewater, Advanced oxidation process, Sequencing batch reactor, Ozonation

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INTRODUCTION

Molasses widely used as sugar-rich by product from sugar product process that uses as raw material in fermentation industries. Molasses wastewater containing high organic load and have dark color, which makes restriction for direct aquatic environmental discharge and even wastewater plant. In view, the dark brown melanoidin pigment are the primary cause in molasses wastewater that are product of the non-enzymatic reaction between sugar and amino acids, peptides or proteins (Millard reaction) [1]. Dearth of comprehensive understanding about melanoidin structure, has led to preventing the progressing of sufficient process removal [2]. Mainly the baker's yeast wastewater content high chemical oxygen demand (COD) of 4000-130000 mg/L, Biological oxygen demand (BOD5) of 200-96000 mg/L, have dark brownish color and nonbiodegradable pollutants [3,4].Due to requirement of high energy and environmental conservation point of view, the anaerobic digestion process has been attracted as promising technology. several research have been focused on high strength wastewater by different anaerobic treatment such as anaerobic filter (AF), biopack system, anaerobic membrane bioreactors (AnMBR), fluidized bed reactor (FBR), immobilized cell reactor (ICR), up-flow anaerobic sludge fixed film (UASFF) reactor, up-flow anaerobic sludge blanket (UASB) reactor, anaerobic hybrid digester, membrane anaerobic system (MAS), and modified anaerobic baffled reactor (ABR) [5,6,7,8,9,10]. As far the aerobic treatment disadvantageous such as high energy consumption, the alone usage of it does not applicable and moreover up to 50% of COD convert to sludge [11]. It is regarding that cost effective of anaerobic treatment of baker's yeast wastewater by biological treatment as pretreatment and subsequently the aerobic treatment as supplementary method can be raised as desirable technology [12,2]. The individual usage of biological treatment cannot be obtain complete and acceptable reduction of organic contaminant and it can be employed with other processes such as AOPs, membrane processes, bio compositing, oxidation by Fenton, enzymatic treatment, electro coagulation, and ultrasound treatment [13,12,14]. Generally AOPs related to methods in which oxidant hydroxyl radicals (●OH) generation in the reaction process. Radicals (●OH) act as highly reactive that have oxidation potential of 2.80 volt, which can improve the biodegradability [15]. The reaction occurs at the temperature and pressure of environment. The combination system such as O_3/H_2O_2, UV/TiO_2, UV/O_3, catalytic ozonation (O_3/GAC, O_3/ TiO_2), and the O_3/GAC oxidation processes, based on AOP is further common reacted by ●OH and oxygen radical [16,17,18,19]. The advanced oxidation processes such as ozonation have been documented as promising technology which has been expansively used for organic compound treatment into carbon dioxide and water [20]. Oxidation by Ozone can be effective as oxidation process that reach to 80% for simultaneous decolonization for biologically treated and COD reduction between 15-25% [21,13]. Generally ozonation process does not satisfactory and appropriate in terms of meeting the stringiest discharge standard [22]. Activated carbon has been known for organic pollutant removal in wastewater treatment but relatively high cost of it leads to limitation of applying [23]. Activated carbon adsorption is one of the methods among various technologies that has been assessed for color and COD removal in wastewater contain of melanoidin [24]. Using of activated carbon following ozonation has been proved the effectiveness processes for decrease the specific and non-specific toxicity but generally the necessity of renewed and regeneration has been needed due to kept the adsorption capacity of activated carbon [25]. Regarding the usage of ozonation processes has been evaluated in the presence of granular activated carbon as an appropriate combination, owing to the adsorption and catalysis of activated carbon, GAC/O3 that has been verified as effective on powerful synergic aim to removal of refractory organic[26]. Hence the combination of GAC/O3 in comparison to individual ozonation process of textile wastewater proved the higher efficiency for COD removal and it enhanced 20-40 percent in compare to either method alone [27,28]. In wastewater treatment processes in order to approach the optimal operation, the HRT of system is considered as effectiveness parameter. The effect of HRT in both real and synthetic wastewater treatment processes in wide range has been examined by numerous researchers [27,30]. And the removal of COD in most of studies were reported up to 60-95% and about 33-94 % for organic compound [27,31,30]. is taken in to account that individual usage of addressed method does not encounter the environmental regulation, which base on published result, the proper combination of biological treatment along with other methods can be more functioning as pre-treatment or post-treatment [32]. Due to high cost required by using of activated carbon, it was justified for high organic content of baker's yeast treatment contribute to a necessity of pretreatment by anaerobic digestion aim to reducing the organic load and energy cost point of view, but the effluent cannot afford the discharge in to aquatic environment. So it would be gained the objective through sequencing batch reactor (SBR) in terms of providing advantageous include high operation of MLSS and resistance to shock load. [33]. has been demonstrated that biological processes based upon a SBR are effective for COD, BOD and nutrient removal from industrial wastewater. On the other hand, Due to prove the applicably and effectively method for Treatment of molasses wastewater which in confined published about being raised as environmental challenges in science and lack of effective design, so presenting a beneficial study suggestion about providing combined operation of treatment processes should be required. So far by literature review about treatment of high organic load and color through biological system and subsequently O3/GAC as intermediate treatment was not evaluated. The aim of this study was to develop a combination of two stage SBR system along with O3/GAC as post-treatment for simultaneous removal of COD and color from baker's yeast and determining the operational variable for the optimal removal of COD and color from baker's yeast wastewater through RSM.

MATERIALS AND METHODS

Characterization and generation of baker's yeast wastewater

Wastewater was procured from Razi Alcohol and Baker's yeast industry, Ahvaz. Iran. Large quantities of wastewater produce in this industry which was consisted of low, medium and strength wastewater, that first produce in the equipment cleaning, floor washing and second through manufacturing, centrifuges, rotary vacuum filters and yeast separator that produce the strength wastewater. In local plant Combination of these wastewater treated anaerobically. the real wastewater was used after being subjected to integrated anaerobic baffled reactor-biological activated carbon (ABR-BioGAC) which was run in another simultaneously project as pretreatment, nevertheless its final effluent still has brown color and it must be furthered treated supplementary by an aerobic post-treatment, when the effluent samples of anaerobic digestion system attain to the desirable concentration in terms of different level of COD, the effluent were collected and refrigerated at 4ºC. The detail chemical properties of influent are presented in [Table 1].

Configuration and operation of SBR1-O3/GAC-SBR2

Table 1: The chemical properties of used baker's wastewater through the study

		Initial COD (mg/L)	
	2000	3000	4000
COD (mg/L)	2000±120	3000±120	4000±120
BOD (mg/L)	990±50	1429±50	2018±50
Color (absorbance)	0.954	1.111	1.321
Turbidity (NTU)	3.6	10.8	8.5
Alkalinity	2000±200	2500±200	2800±200
pH	8.07	8.22	8.67
ORP	-69	-66	-103

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scale of 3 containers that was involved of two independent stage of SBR with working volume of 1Lit was combined with an intermediate O3/GAC stepwise with equal volume which was set in series. It should be mentioned that three reactor operated individually in the series. The schematic diagram of SBR1-O3/GAC-SBR2 reactor is presented in [Fig. 1]. In setup phase the activated sludge of soft drink factory treatment plant (Zamzam Company), Kermanshah, Iran was used, the range value of mixed liquor suspended solid (MLSS) of 4000-6000 mg/L was maintained for both SBR. COD concentration was diluted to attain the desired COD value (2000 mg/L) for startup phase. The temperature was kept constantly at 25 ˚C during the startup and operation phase. Primarily in startup phase the samples were collected in HRT of 48h in every 12h and afterward, reduced to HRT of 24h, it was continued as long as steady- state accomplishment. To afford the appropriate condition for microorganism growth in startup phase, nutrients such as nitrogen and phosphorous was added to the reactor to gain the COD: N: P ratio of 100:7:1. And it allows to the biomass to acclimation the influent substrate. The 3 consequence stages were composed of a primary biological system, O3/GAC located as middle step and the effluent was subjected too by second SBR. Operational phase of SBR was done in five stage of conventional SBR treatment which were consisted of filling, reaction, settlement, decant, and idle. For aeration of SBR to support microbial growth, the aeration pump was installed through porous stone that was equipped at the bottom of reactor to supply steady distribution. The aeration pump (Model ACO-5505), power of 6.5W, pressure of 0.25 Mpa and output rate of 5.5 L.min was used. The different HRT were conducted in biological stage, and then the aeration pump was quitted and allowed the system to fully settle of sludge that was lasted about 1h, then the wastewater was exhausted, and the reactor was set up again with fresh influent.

Granular activated carbon

The commercial carbon material was applied in present study. It must be noted that, the optimal constant rate of 100 mg/L of GAC was identified previous by pre-testing. The GAC has total surface area of 900 (m2/g), length of 3 mm, Diameter of 1 mm in the experiment, and it should be mentioned that GAC was not replaced and regenerated during the experiments of operational phase.

Ozonation procedure

Before the operational phase, the optimal time of 1 h was determined for ozonation process. Based on the characteristic of ozone generator, it was operated base on the 50 mg/h in constant determinant time of ozonation. Correspond on detailed feature, the ozone generator (Model UVOX 300), power of 1.5A, ozone output of 50 mg/H, the maximum ozone concentration of 70 ppb, and the proper temperature of 0-30˚C was used. The ozone experiments were performed in bubble column reactor with working volume of 1lit. Aimed at ozone generation a mercury lamp with power of 300 watt was used, the lamp was covered with stainless steel vessel. By employing the aeration pump, the oxygen molecules were broken down through exposed to UV light and distribution of ozone gas in forms of bubble gas was fed in to wastewater entirely.

Analytical chemical

Chemical oxygen demand (COD) was measured according to titrimetric method, five day Biological oxygen demand (BOD5) was analyzed following incubator method, pH and Turbidity were measured using digital pH meter (WTW Co) and Turbidity meter (HACH Co). All of experiments were carried out based on standard method for water and wastewater [43]. For analyze the decolorization of the combined system the spectrophotometer (JENWAY Co) was used. For prevent turbidity, the samples were filtered with centrifuging at 6000 rpm for 20 min, finally the max wavelength of 435 nm was determined by spectrophotometer. Samples were kept in 4˚C and all of the experiments at least repeat 3 times. To calculate the percentage removal of parameter (degradation and decolorization), the following equation 1 was used:

(1) $\% \text{ Removal} = (C0-C)/C0 \times 100$

Where C0 and C are the initial and final concentrations of organic compounds and color, respectively.

Experimental set up

In this study full factorial experiment design was used to study the effect of two or more independent variable upon a response variation, the factorial experiment design was determined the experimental run, which proposed all possible experiment in order to diminishing the error. By considering of two factor (a*b), the maximum possible experiments will be proposed. The two independent variables, hydraulic retention time (HRT) and the initial COD concentration were identified at three levels, 1(minimum), 0(central) and 1(maximum) which are demonstrated in [Table 2]. Totally 27 experiment run were carried out throughout the operational phase.

Table 2. Experimental range and levels of the independent variables

Variables	Range and Level		
	-1	0	1
Hydraulic retention time in SBR1 (h)	6	12	24
Hydraulic retention time in SBR2 (h)	6	12	24
Initial COD (mg/L)	2000	3000	4000

Mathematical modeling

In the present study RSM was used which involves the estimation of coefficient in a mathematical modeling that predicted the response and was employed for the model adequacy [34,35].It was applied for interpretation of data that obtained from experimental run which were analyzed through the applied of design expert 6.0.1 version aim to optimal removal of COD, BOD5 and color with respect to simultaneous effect of 2 independent variable of hydraulic retention times (HRT) and initial COD concentration. All of data were subjected to analysis of ANOVA, regression analysis to investigate the interaction between the variables and response and the three dimensional response surface plots for explore the optimum condition with respect to the simultaneous effect of variables on response.

RESULTS

Startup phase

The startup phase of reactor was continued in order to obtain the desirable configuration of system by comprehensive daily analyze in startup phase through COD removal, pH, turbidity and alkalinity test of effluent. It was lasted about 30 days. By considering the longer time to achieve the acclimation of microorganism in regard to conducting the higher value of COD to the reactor, while the desired value of COD reached below 1000 mg/L.

Table 3: Results for all responses throughout the operational phase in SBR1-O3/GAC-SBR2

Run	Variables			COD removal (%)			BOD removal (%)			Color removal (%)		
	Initial COD (mg/l)	HRT in SBR1 (hour)	HRT in SBR2 (hour)	SBR1	O3/GAC	SBR2	SBR1	O3/GAC	SBR2	SBR1	O3/GAC	SBR2
1	2000	6	6	61.27	65.22	85.36	37.6	62.86	90.59	1.78	34.38	47.48
2	2000	6	12	61.27	65.22	88.23	37.6	62.86	93.09	1.78	34.38	55.45
3	2000	6	24	61.27	65.22	91.81	37.6	62.86	94.19	1.78	34.38	59.43
4	2000	12	6	68.23	92.47	93.03	69.59	91.49	95.19	3.7	32.7	49.58
5	2000	12	12	68.23	92.47	93.74	69.59	91.49	96.19	3.7	32.7	58.17
6	2000	12	24	68.23	92.47	95.34	69.59	91.49	96.79	3.7	32.7	62.36
7	2000	24	6	77.41	84.94	96.98	79.87	81.48	97.69	4.82	41.29	55.97
8	2000	24	12	77.41	84.94	97.22	79.87	81.48	97.99	4.82	41.29	62.57
9	2000	24	24	77.41	84.94	97.74	79.87	81.48	98.34	4.82	41.29	66.35
10	3000	6	6	50.98	77.86	85.46	52.02	75.92	88.55	2.07	31.53	45.18
11	3000	6	12	50.98	77.86	89.83	52.02	75.92	92.65	2.07	31.53	52.92
12	3000	6	24	50.98	77.86	96.64	52.02	75.92	96.99	2.07	31.53	56.88
13	3000	12	6	60.29	76.94	77.33	57.8	71.55	85.02	5.6	35.49	48.42
14	3000	12	12	60.29	76.94	83.12	57.8	71.55	87.82	5.6	35.49	54.54
15	3000	12	24	60.29	76.94	86.21	57.8	71.55	89.5	5.6	35.49	58.68
16	3000	24	6	64.4	72.86	76.28	67.77	67.66	79.28	7.9	37.44	49.32
17	3000	24	12	64.4	72.86	81.44	67.77	67.66	87.4	7.9	37.44	56.43
18	3000	24	24	64.4	72.86	86.74	67.77	67.66	88.94	7.9	37.44	60.75
19	4000	6	6	56.04	82.16	87.88	63.2	80.42	90.85	2.04	31.41	46.55
20	4000	6	12	56.04	82.16	91.04	63.2	80.42	93.45	2.04	31.41	52.46
21	4000	6	24	56.04	82.16	94.02	63.2	80.42	95.83	2.04	31.41	54.88
22	4000	12	6	66.57	78.9	81.94	61.1	74.03	85.38	3.25	37.62	49.35
23	4000	12	12	66.57	78.9	89.22	61.1	74.03	89.75	3.25	37.62	60.1
24	4000	12	24	66.57	78.9	92.23	61.1	74.03	94.44	3.25	37.62	63.66
25	4000	24	6	69.92	72.25	72.81	72.37	69.17	77.69	6.8	40.42	52.38
26	4000	24	12	69.92	72.25	76.67	72.37	69.17	83.29	6.8	40.42	61.92
27	4000	24	24	69.92	72.25	78.42	72.37	69.17	86.07	6.8	40.42	65.7

Statistical analysis

The independent value (Variables A and B) and 27 experimental data runs are presented in[Table 3]. In the present study Central composite design (CCD) was used to explore relationships between process variables and responses. Factors coded models as well as analysis of variance (ANOVA) for all responses are demonstrated in[Table 4]. In order to appraise fitting data the different polynomial models were used aimed at fitting the data from the experimental result to higher degree polynomial equation i.e. Quadratic vs 2FI for all the responses. To determine the significant models in each responses the significant (P-value) was assessed that is shown in [Table 4]. (P-value) was obtained for the removal of COD, BOD5 and color as well as significant equations for the responses which are presented in [Table 4]. The P-value less than 0.05 show the higher significance of corresponding model and based on obtained result of statiscally analysis, in this study P-value was greatly less than 0.05 results for all responses. Additionally for validating the fitted model the predicted Model via R2, Adjusted R2 and Pred R-Squared between the experimental and model predicted values were used. R2, Adjusted R2 and Pred R-Squared are nearby to each other and nearly close to 1 except in O3/GAC for COD, BOD5 and color removal.The value of 4 and more in Adequate precious indicate the validity and reliability of analysis result. Based on [Table 4], the value of Adequate precious for all responses were significantly than desired values and were between the varying amounts of 5.830-52.232, it implied the proper values in analysis validated. Base on Design Expert software it was revealed that COD and BOD5 removal were significantly influenced by initial COD although color removal, influenced by HRT in SBR1 and SBR2, respectively.

Response	Modified equations (A: initial COD. B: HRT in SBR1. C: HRT in SBR2)	Model type	R2	Precision	Adj R2	Pred R2	P-value
BOD by SBR1	+63.94+0.82A+11.20B-7.04AB+4.76A2-4.98B2	Quadratic vs 2FI	0.8280	14.068	0.7871	0.7217	0.0001
Color by SBR1	+6.00+0.35A+2.27B+0.50AB-1.46A2-0.79B2	Quadratic vs 2FI	0.9432	23.177	0.9297	0.9093	0.0069
COD by SBR1	+62.61-2.49A+7.24B-0.8AB+8.02A2-4.62B2	Quadratic vs 2FI	0.9845	52.232	0.9808	0.9748	0.0001
BOD by Ozonation/GAC	+76.49-2.72A-0.15B-6.12AB+4.86A2-6.81B2	Quadratic vs 2FI	0.5108	5.830	0.3943	0.2133	0.0001
Color by Ozonation/GAC	+36.21+0.18A+3.60B	Linear vs Mean	0.7554	12.539	0.7350	0.6894	0.0001
COD by Ozonation/GAC	+81.64-2.25A+0.8B-6.30AB+3.44A2-8.05B2	Quadratic vs 2FI	0.6040	6.830	0.5097	0.3634	0.0009
BOD by SBR2	+89.54-3.82A-2.18B+2.84C-4.02AB+1.32AC+0.1BC+ 3.58A2+0.37B2 -1.81C2	Quadratic vs 2FI	0.9208	18.091	0.8788	0.7993	0.0001
Color by SBR2	+59.02-0.56A+3.36B+5.82C+0.11AB+0.022AC+0.18BC+ 3.23A2 -1.70B2 -4.44C2	Quadratic vs 2FI	0.9520	22.128	0.9266	0.8698	0.0001
COD by SBR2	+85.75-4.73A-2.62B+3.38C-5.92AB+0.93AC-0.59BC+ 4.31A2 +0.35B2 -1.59C2	Quadratic vs 2FI	0.8966	15.427	0.8419	0.7489	0.0001

Performance of first SBR

It should be noted that collective removal efficiency was reported. Based on three dimensional plots, there is an improving trend of decolorization with increase of HTR in SBR1 in [Fig. 2]. But by increasing the initial COD concentration of 4000 mg/L, the efficiency was reduced. The maximum removal efficiency was observed in HRT of 24h and initial COD of 3000 mg/L that efficiency equal to %7.9. The low decolorization of SBR may be attributed to melanoidin which is high molecular weight polymer that is known as non-biodegradable substance consider as the origin of molasses wastewater. [36]. Therefore it was suggested the combination of processes aim to operative and sufficient that was not achieved by individual usage of SBR in terms of the high strength of baker's yeast wastewater. [37]. It means that, first SBR could not bring expectation and necessity of another processes to promote decolorization of system in term to getting the stringent standard regulation to aquatic environment due to declared difficulties should be considered in series of combined system.

3D plot of COD removal with respect to HRT in SBR1 and initial COD concentration is presented in Fig 2. By increasing HRT in SBR1, the COD removal efficiency was enhanced in different initial COD concentration. And by increment of initial COD, the efficiency of system for COD removal was reduced in 3000 mg/L, but during the conducting of different initial COD concentration in SBR1, the removal efficiency was at nearly constant rate varied 56%- 77.41%. The highest performance for COD removal was happened in HRT of 24h and initial COD concentration of 2000 mg/L, which achieved to 452 mg/L that reflected the COD removal efficiency up to 77.41%. Based on obtained result likely the low rate of system for reducing of organic load arisen to getting endogens phase.

Three dimensional plot of BOD5 removal with respect to HRT and initial COD concentration is presented in [Fig. 2]. By increasing HRT in SBR1 and initial COD of 2000 mg/L the BOD5 removal efficiency dramatically improved, but increment of initial COD concentration has pose to the slightly decrease of BOD5 removal rate. The maximum of BOD5 removal efficiency in SBR1 reach to 420 mg/L in HRT of 24h. The optimal result for BOD5 was shown in initial COD of 2000 mg/L which was reflected 79.87%.

Table 4: The ANOVA results for equation base on design expert 6.0.6 for all responses

Response	Modified equations (A: initial COD. B: HRT in SBR1. C: HRT in SBR2)	Model type	R2	Precision	Adj R2	Pred R2	P-value
BOD by SBR1	+63.94+0.82A+11.20B-7.04AB+4.76A2-4.98B2	Quadratic vs 2FI	0.8280	14.068	0.7871	0.7217	0.0001
Color by SBR1	+6.00+0.35A+2.27B+0.50AB-1.46A2-0.79B2	Quadratic vs 2FI	0.9432	23.177	0.9297	0.9093	0.0069
COD by SBR1	+62.61-2.49A+7.24B-0.8AB+8.02A2-4.62B2	Quadratic vs 2FI	0.9845	52.232	0.9808	0.9748	0.0001
BOD by Ozonation/GAC	+76.49-2.72A-0.15B-6.12AB+4.86A2-6.81B2	Quadratic vs 2FI	0.5108	5.830	0.3943	0.2133	0.0001
Color by Ozonation/GAC	+36.21+0.18A+3.60B	Linear vs Mean	0.7554	12.539	0.7350	0.6894	0.0001
COD by Ozonation/GAC	+81.64-2.25A+0.8B-6.30AB+3.44A2-8.05B2	Quadratic vs 2FI	0.6040	6.830	0.5097	0.3634	0.0009
BOD by SBR2	+89.54-3.82A-2.18B+2.84C-4.02AB+1.32AC+0.1BC+ 3.58A2+0.37B2 -1.81C2	Quadratic vs 2FI	0.9208	18.091	0.8788	0.7993	0.0001
Color by SBR2	+59.02-0.56A+3.36B+5.82C+0.11AB+0.022AC+0.18BC+ 3.23A2 -1.70B2 -4.44C2	Quadratic vs 2FI	0.9520	22.128	0.9266	0.8698	0.0001
COD by SBR2	+85.75-4.73A-2.62B+3.38C-5.92AB+0.93AC-0.59BC+ 4.31A2 +0.35B2 -1.59C2	Quadratic vs 2FI	0.8966	15.427	0.8419	0.7489	0.0001

Performance of O3/GAC

it was evident the Simultaneous effect of initial COD and HRT on color removal efficiency has been shown on 3D plot In[Fig .3], that by increasing HRT in SBR1, the color removal efficiency in O3/GAC was increased in different initial COD, but in the COD concentration of 3000 and 4000 mg/L, the color removal was reduced slightly. It was found that the optimal decolorization was shown in HRT of 24h which the efficiency reach to up than %41.2, while the initial COD concentration of 2000 mg/L. a constant trend of decolorization in O3/GAC during the different initial COD concentration was seen, and it was the range between 31.41 -41.29 percent.

The simultaneous effect of two factors on COD removal efficiency obtained from equation Y1. So by considering the O3 /GAC has been placed after the first SBR reactor, HRT in that reactor can be affected the O3/GAC removal efficiency. It depicted an enhancing trend that by increasing of HRT in SBR1 in the initial COD of 2000 mg/L, but further HRT from 6 to 12 h have positive effect on COD removal efficiency, but poor reduction of COD removal was seen in HRT of 24h. The maximum removal efficiency was observed in HRT of 12h and initial COD of 2000 mg/L which COD concentration reach to 150 mg/L that reflected efficiency of 92.47%. [Fig. 3].

In another study a combination of ozonation with conventional aerobic oxidation for distillery wastewater treatment showed the integrated process (ozone-aerobic oxidation-ozone) accomplished 79% for COD removal, along with Decoloration of the effluent sample when compared to 34.9% of COD reduction for non-ozonated samples, by considering similar treatment period. [32].

The optimal result for BOD5 removal was observed in HRT of 12h in SBR1 that the BOD5 reach to 85 mg/L, while the initial COD concentration of 2000 mg/L, which reflected the efficiency up to 91.4%. Initial COD concentration does not positive effect for BOD removal efficiency. As it can be seen by increment of initial COD concentration, a reduction removal trend of BOD5 was showed and in the initial COD of 4000 mg/L, the lowest removal efficiency was observed that reach to 69.17% in HRT of 24h in SBR1. [Fig. 3]
It should be mentioned that different ozone dosage of 25, 50 and 75 mg/h were conducted in pretesting, and finally 50 mg/h was determined as optimum time, and by increasing the further ozone dosage of 75 g/h, the drastic removal rate was not showed. As stated by Wu et al a slight enhancement of COD removal showed by increasing of dose of ozone, that may be attributed to two possibilities that including, the optimum ozone dosage was sufficient aim to operative oxidation of the existing organic compound and second relate to remaining fraction of the organic compound which has not been oxidized in the ozonation processes. [38].

Based on studies, increasing of ozonation time has not showed positive effect but also decreased the COD reduction that it assigned to oxidization of dye molecules to smaller organic fragments including aldehydes, acetic acid, and ketones which cannot be completely removed by Ozonation process [39,36]. As stated by another result the integrated process which combines of adsorption and biological process in recycled paper mill wastewater showed the combination system could remove COD in the range of 53-92 percent, and maximum removal efficiency was recorded in the longest HRT of 48 h. [40]. Application of ozonation subsequently the biological treatment due to non-biodegradable material provided change the molecules structure of compound by ozonation as chemical oxidation which are biodegradable and breakdown theses compound to smaller molecules [41].The combination of ozonation and activated carbon adsorption has revealed that GAC acts as an adsorbent and catalyst in promoting ozone oxidation, and the combination system adsorption provide strong synergistic effects on the textile wastewater treatment [28]. It was logical to location SBR in first step owing to treating the wastewater contribute to biological treatment that led to reducing of organic compound and the ozonation/GAC as middle processes for reducing the ozonation value which required, indeed significantly decrease and finally placing second SBR that led to satisfy reducing of organic compound.

Performance of second SBR

In this study the second SBR was located as final stage aim to eliminated the nonbiodegradable compound that are changed to smaller molecules and incomplete treatment due to the biodegradable compound treated the effluent of O3/GAC as middle step. Three dimensional plot of the model for 2 independent factor for decolorization of system is shown in [Fig 4]. Based on response surface for color removal, the increment of HRT in SBR2 in COD of 2000 mg/L was positive and significantly trend of increment for the decolorization of combined system was observed, the increment of the initial COD makes decrease the efficiency of system in initial COD of 3000 mg/L and the optimal result reach to 66.3% in HRT of 24 in SBR1 and 2, and initial COD of 2000 mg/L, the enhancement of decolorization was occurred until the initial COD value reach to 3000 mg/L and afterward the performance of system was prompted again in COD of 4000 mg/L. By increasing HRT of SBR1 in combined system, a significantly positive effect was showed.

Correspond on simultaneous effect of two independent factor obtained from equation in [Table 3] for COD removal a progressively increment with increasing HRT in SBR2 was seen. The increment of initial COD operation was assessed and was not effective in the initial COD of 3000 and 4000 mg/L. The maximum reduction of COD reach to 60 mg/L in HRT of 24h in SBR2 and initial COD of 2000 mg/L which reflected up to 97.74% of COD removal. During the conducting of different HRT and initial COD concentration the trend of COD removal efficiency were not dramatically different and the lowest COD removal was in HTR of 6 h and initial COD of 4000 mg/L that the efficiency was 72.81%.

The simultaneous effect of HRT in SBR1, 2 and initial COD concentration are shown in [Fig. 4]. The BOD5 removal efficiency was promoted gradually by increment of HRT in initial COD concentration to 2000 mg/l, and finally a fairly decrease was observed. It should be noted that the maximum removal efficiency was found in series collective result of system. The maximum of BOD5 removal reach to %98.34 in HRT of 24 h and initial COD of 2000 mg/L, the lowest efficiency reach to 79.28% in initial COD of 4000 mg/L and HRT of 6 h in combined system.

Corresponding on soft drink factory effluent the combined of SBR contribute to advanced oxidative processes (AOPs) has confirmed the maximum COD removal efficiency reached to more than 95% [42].The application of combined ozonation and biological treatment verified the ozonation process as postteratment increases the dye degradation rate. And increment of ozonation time led to dye concentration reduction in hydrolysed dye synthetic effluent. Pre-treatments with ozonation is economically point of view, due to decrease the ozone required in terms of mineralization of compound and the usage of biologically process subsequently would be effective in terms of complete mineralization with lower cost of operation in compare to chemical process [39].

CONCLUSION

In the current study a combination process of two stage SBRs with intermediate O3/GAC for simultaneous removal of COD and brownish color of baker's yeast industries wastewater was assessed as post-treatment after an anaerobic digestion of effluent that treated through the ABR-BioGAC. Series reactors has been established to fulfil the expectation in terms of meet the environmental standard discharge. Due to that fact that ozonation process make to poisonous by product it was logical to placing subsequently biological system. RSM was used to evaluate the interactive effect of two independent variables on the responses to optimization of the experiments. From the experiment which has been conducted, the maximum removal efficiency in SBR1-O3/GAC-SBR2 for COD and color removal reach to up 97.4 %, and 66.3% in optimal operating condition in HRT of 24 h in both SBR and initial COD concentration of 2000 mg/L, respectively. The result indicated that combination of biological system with and O3/GAC as intermediate stepwise was considered as satisfy pre-treatment option for treating of baker's yeast wastewater

CONFLICT OF INTEREST

There is no conflict of interest.

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FINANCIAL DISCLOSURE

None

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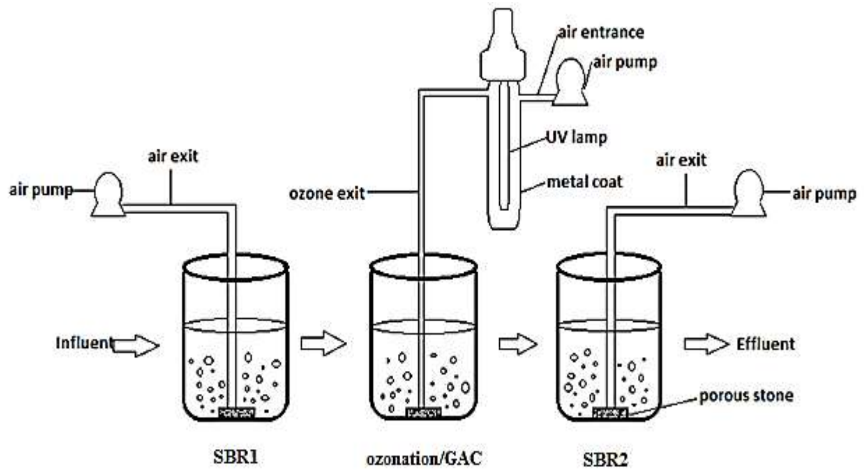

Fig .1: The schematic diagram of SBR1-O3/GAC-SBR2 was used in this study.

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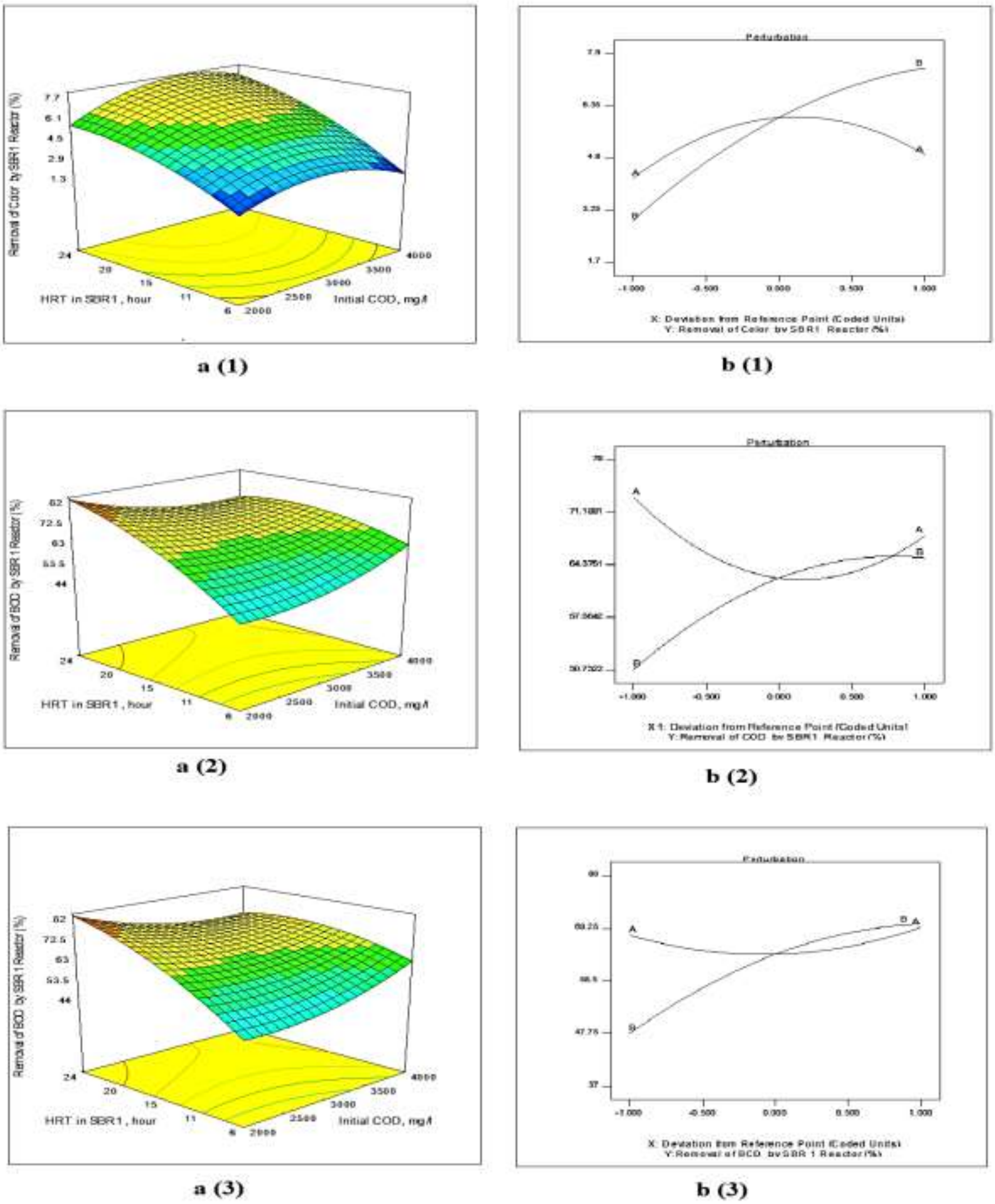
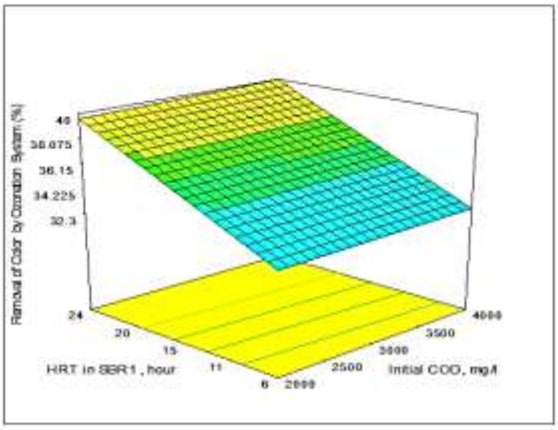
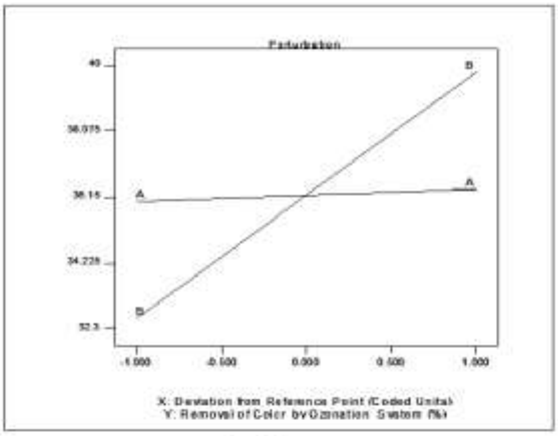


Fig. 2 (a1): Response surface for color removal in SBR1 with respect to HRT in SBR1 and initial COD. **Fig. 2 (a2):** Response surface for COD removal. **Fig. 2(a3):** Response surface for BOD5 removal.
Fig. 2 (b1): Perturbation plot for color removal. **Fig. 2(b2):** Perturbation plot for COD removal. **Fig. 2(b3):** Point perturbation plot for BOD5 removal.



a (1)



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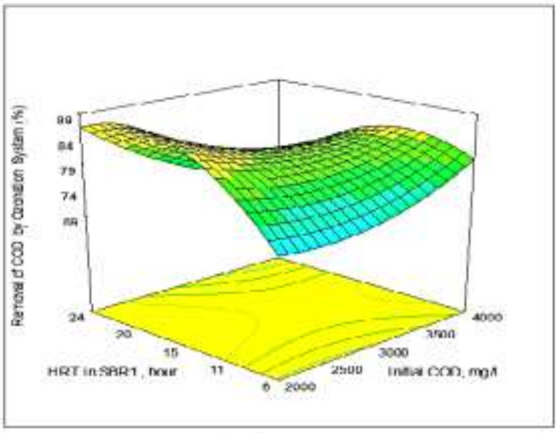
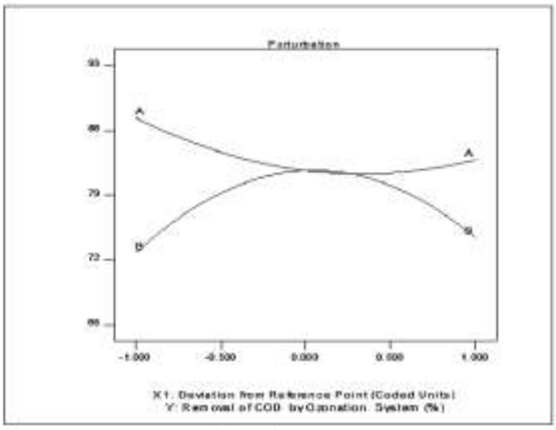
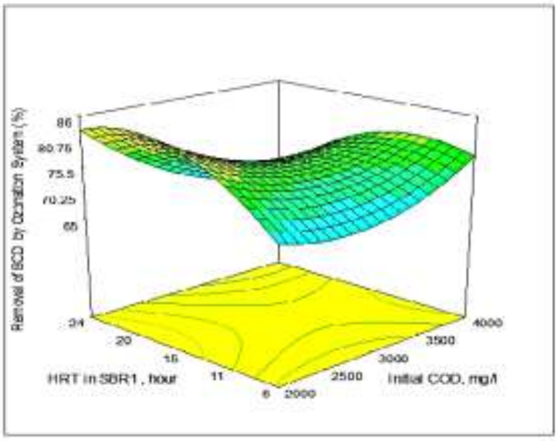


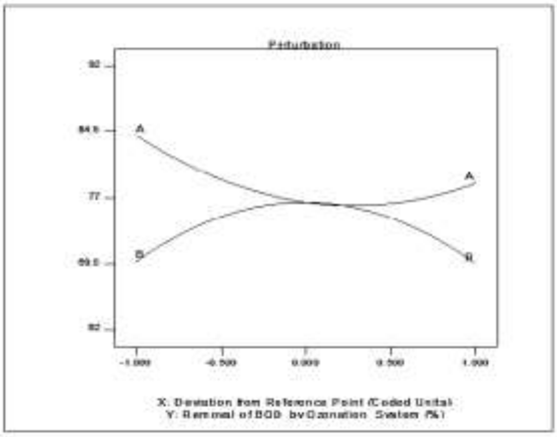
a (2)



b (2)



a (3)



b (3)

Fig. 3. (a1) :Response surface for color removal in O3/GAC system with respect to HRT in SBR1 and initial COD. **Fig. 3 (a2)** :Response surface for COD removal. **Fig. 3 (a3)** :Response surface for BOD5 removal. **Fig. 3 (b1)** :perturbation plot for color removal. **Fig. 3(b2)** : Deviation reference point for COD removal. **Fig. 3(b3)** :Deviation reference point for BOD5 removal.

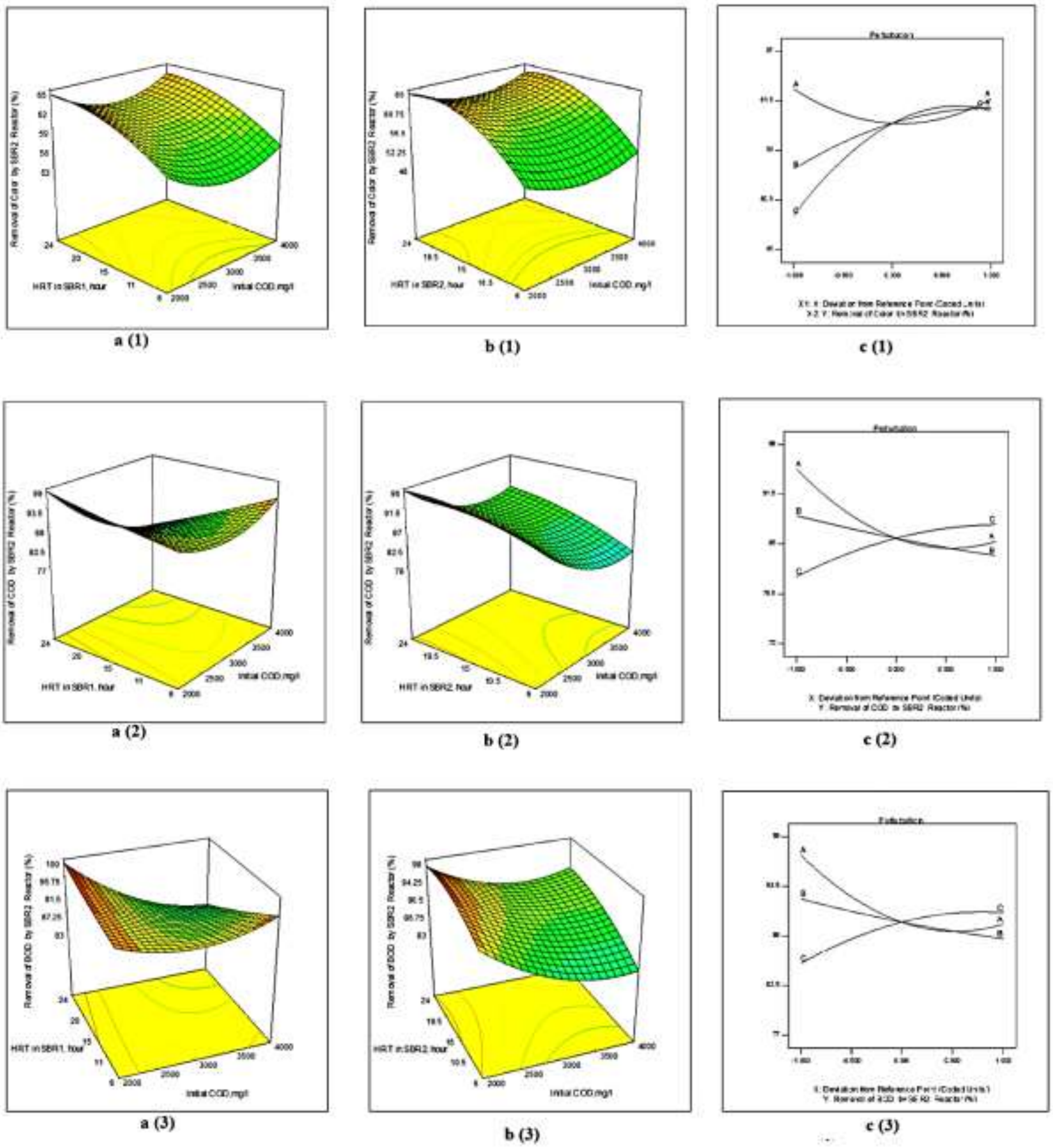


Fig. 4(a1): Response surface for color removal in SBR2 with respect to HRT in SBR1 and initial COD. **Fig. 4 (a2):** Response surface for COD removal. **Fig. 4 (a3):** Response surface for BOD5 removal.
Fig. 4(b1): Response surface for color removal in SBR2 with respect to HRT in SBR2 and initial COD. **Fig. 4 (b2):** Response surface for COD removal. **Fig. 4 (b3):** Response surface for BOD5 removal.
Fig. 4(c1): perturbation plot for color removal. **Fig. 4(c2):** Perturbation plot for COD removal. **Fig. 4 (c3):** Perturbation plot for BOD5 removal.