International Research Journal of Biological Sciences ISSN 2278-3202
Vol. **4(3),** 66-75, March **(2015)** *Int. Res. J. Biological Sci.*

Biological Treatment of Meat Processing Wastewater using Anaerobic Sequencing Batch Reactor (ASBR)

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Available online at: www.isca.in, www.isca.me
Received 12th January 2015, revised 20th February 2015, accepted 20th March 2015

Abstract

Effluents from meat processing industries contain high organic compounds and other contaminants that can cause harmful effects to the environment. Treatment of this wastewater to produce acceptable quality of effluent is therefore needed. This study aimed to determine the feasibility of using anaerobic sequencing batch reactor (ASBR) for treatment of meat processing wastewater and for biogas production. A laboratory-scale ASBR was designed and fabricated with an active volume of 10 liters (L) consisting of 60% wastewater and 40% sludge inoculum. The effects of different ASBR reaction durations were examined to determine the appropriate reaction time needed to achieve high organic removal in meat processing wastewater. Actual batch ASBR operation composed of four phases per cycle (24 hours): wastewater filling - 0.5 h, reaction -16 h, settling -7 h, and decantation -0.5 h. Post-treatment of effluent was done using granulated activated carbon. During biomethanation process in ASBR, pollutant removal was: 94% chemical oxygen demand (COD), 93% biochemical oxygen demand (BOD), 54% suspended solids, 58% turbidity, and 53% color. The concentration of COD and BOD in treated effluent was 116 mg/L and 78 mg/L, respectively. Biogas generated during the ASBR reaction was 2.7 L/day with 61% methane content. Post-treatment of effluent further reduced the concentrations of pollutants to acceptable level with 76 mg/L COD and 20 mg/L BOD. Biological treatment using ASBR and post-treatment with activated carbon was proven effective in reducing organic pollutants in meat processing wastewater.

Keywords: Anaerobic sequencing batch reactor, ASBR, meat processing wastewater, biological wastewater treatment, biogas, anaerobic wastewater treatment, anaerobic digestion.

Introduction

Meat processing wastewater constitutes one of the major concerns of the agro-industries. Generally, meat processing wastewater contains high levels of various contaminants such as fat, suspended solids, chemical oxygen demand, biological oxygen demand, chlorides, and nitrogen[1]. Considering the standard allowable limit for effluent discharge, pollutants must be removed from these food industry wastewaters before discharging to the environment. Anaerobic digestion in high-rate reactors such as anaerobic sequencing batch reactor (ASBR) can be applied for meat processing wastewater for its high amount of organic material and it provides high chemical oxygen demand (COD) and suspended solid removal[2]. The ASBR treatment method is relatively simple to operate, economical, with flexible control, required limited manpower, generates low quantity of sludge, and produce alternative energy in the form of methane[3-7]. The technique is efficient in reducing organic matter in low to high strength wastes. An ASBR operates in a single reactor vessel with four (4) phases of operation that allows for a high throughput of material while retaining microorganisms in reactor. The four steps of a typical ASBR cycle consist of the following: i. feeding or filling, ii. reaction, iii. settling or sedimentation, and iv. decantation or withdrawal of treated effluent[3,8,9]. During the feeding and reaction steps, the reactor content is slowly stirred to allow close contact between organics and bacteria[5,10]. Biogas produced during ASBR treatment of wastewater can be utilized for cooking or heating. On the other hand, sludge by-product from the digester can serve as soil conditioner or fertilizer.

The feasibility of ASBR technique for wastewater treatment was examined at laboratory-scale[6,8,11] and at the farm-scale[12]. ASBR has been used for treatment of wastewaters with high amounts of particulate organic matter such as swine manure[3,8,9], leachate, and dairy[13]. ASBR has also been applied to treat various wastewaters such as those from abattoir/slaughterhouse[4,5,14], meat industry[15], olive mill plant[16], distillery[17], and winery plant[18]. Some studies using low strength wastewaters have also been done using ASBR[10], as well as in decolorization of Azo dyes[19]. In the Philippines, there are no reports yet in literature on the application of ASBR in wastewater treatment. In this study, we examined the feasibility of using a lab-scale ASBR for biological treatment of meat processing wastewater and for biogas production.

Material and Methods

Characterization of wastewater and sludge inoculum: Wastewater was collected from Sirloin Foods Industries Corporation at Novaliches, Quezon City. Composite wastewater was obtained from the final effluent tank. All wastewater sampling was done between 10 A.M. to 1 P.M.. Samples were transferred to plastic containers, kept at $4^{o}C$ and analyzed within 24-48 hours (h). Collected wastewater samples were characterized based on the following physico-chemical parameters: pH, turbidity, salinity, total solids (TS), total suspended solids (TSS), volatile solids (VS), settleable solids, ash, and oil and grease. Microbial population (total coliform count), organic load (COD and biological oxygen demand [BOD]), and nutrient content (total nitrogen and total phosphorus) were also determined. Seed sludge for ASBR treatment was collected from a brewery wastewater treatment plant with existing anaerobic reactor. The sludge inoculum was characterized for its COD and BOD contents, pH, settleable solids, total solids, and volatile solids.

Design and fabrication of laboratory-scale ASBR: Figure-1 shows the schematic diagram of the laboratory-scale ASBR treatment system. The reactors were made up of clear plastic containers with a total capacity of 10 L. Gas outlet was connected to a graduated cylinder by rubber tubing and served as gas holder. PVC pipe (1/2" diameter) was attached to the cover of container for inlet port. Mixing of wastewater and sludge inoculum was carried out using a stainless steel plate (3 cm x 9 cm) connected to an electronic speed control (Fine FBL12000). The reactors have two outlet ports (155 and 175 mm from the base) to draw off treated effluent. The ASBR set-up was placed in a room with ambient condition.

Acclimatization of sludge inoculum: Sludge inoculum obtained from an existing wastewater treatment was acclimatized by feeding with meat processing wastewater. Fresh wastewater was mixed with inoculum for 8 hours with gentle mixing (85 $\pm$1 revolution per minute [rpm]). After settling overnight, treated effluent was removed and the reactor was re-filled with fresh meat processing wastewater. Biogas production was monitored daily during acclimatization to determine the activity of the inoculum. Acclimatization is complete when sustained biogas production is observed and COD reduction is at least 70% for six continuous days[9,11].

ASBR treatment at different reaction time: Meat processing wastewater was first filtered with cheesecloth to remove solid particles. Before ASBR treatment,

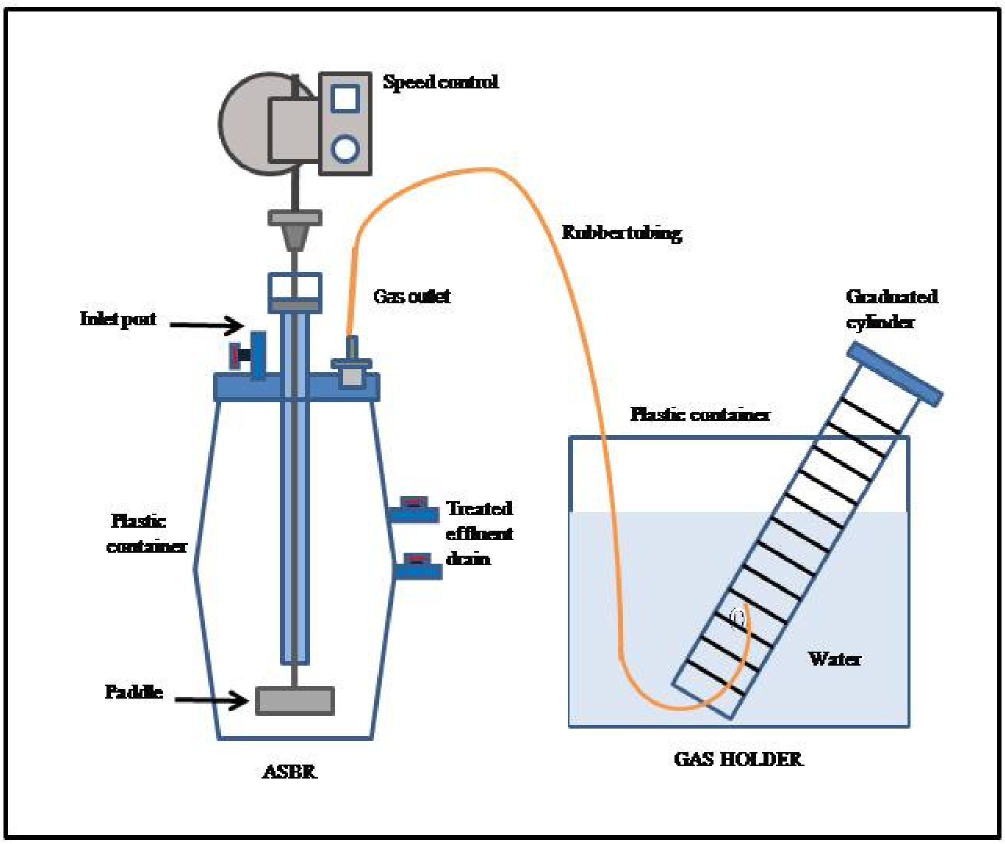

Figure-1
Schematic diagram of the lab-scale anaerobic sequencing batch reactor (ASBR) treatment set-up

pH of raw wastewater was adjusted to nearly neutral pH (7.0 – 7.5) using 5 normal (N) sodium hydroxide (NaOH). Wastewater was then mixed with the acclimatized sludge inoculum at a ratio of 60% wastewater and 40% sludge inoculum. Each ASBR treatment cycle lasted for 24 h, which consisted of the following steps: refill, reaction, settling, and decantation. The effect of different ASBR reaction durations (8, 12, and 16 h) on COD and BOD removal was examined during ASBR treatment. Feeding of wastewater was done manually using the inlet port. ASBR reaction was gently mixed at 85 $\pm$1 rpm. Treated effluent was collected at the port situated 155 mm from the bottom of the container. About 200 to 300 milliliter (mL) effluent was allowed to flow out from the port before sampling. Representative effluent sample was taken from the decant bucket after each cycle. Parameters such as COD, BOD, pH, suspended solids, turbidity, and color were examined before and after each ASBR treatment cycle. Biogas production was monitored in each cycle by water displacement technique[20], where the amount of water displaced equals the amount of biogas produced.

ASBR and post-treatment with activated carbon: ASBR-treated effluent was passed through a column with granulated activated carbon as post-treatment. Meat processing wastewater was anaerobically treated by ASBR with 16 h reaction. The react time was programmed using an automatic timer and continuously mixed at 85 $\pm$1 rpm. The 10 L reactor contains 60% wastewater and 40% sludge inoculum. pH of wastewater was adjusted to neutral pH before loading to the reactor. After 24-h ASBR cycle, treated effluent was collected and passed through an acrylic column (2.5 cm width X 50 cm length) containing 50 g acidified granulated activated carbon (20 x 40 mesh; MAPECON, Malate, Manila). Pebbles (200 g) were uniformly mixed with activated carbon to avoid compaction of materials. The bottom and top portions of the post-treatment column were also filled with pebbles (5 g each). Wastewater was characterized before and after each ASBR treatment, and after post-treatment.

Biogas production and methane analysis: Biogas production was monitored daily during the ASBR run. Water displacement was used to quantify the amount of gas produced. Volume of gas was measured by the volume of water displaced from the reactor into the other container as a result of gas pressure build up inside the vessel[20]. Flame test was done for qualitative analysis of the gas produced from the ASBR. Pipe connected from the gas holder was lighted with a Bunsen burner. Methane content was analyzed using a gas chromatograph (Shimadzu GC-2014) with thermal conductivity detector.

Analytical procedures: COD, color, and turbidity were analyzed using Hach DR/870 colorimeter (USA). BOD was determined after five days incubation using Oxi-Top system (WTW, Germany). The pH of wastewater was checked using a portable digital pH meter (pH 600, Milwaukee, Romania), and temperature at the working area was monitored by a digital thermometer (AZ-MT-09). Salinity was determined by a hand refractometer (Alla France). Settleable solids, TS, VS, TSS, and ash were determined following the APHA method[21]. Wastewater sample was submitted to accredited laboratories, i.e., ELARSI, Inc. (Quezon Avenue, Quezon City) for total coliform count and for oil and grease content; and Bureau of Soils and Water Management - Department of Agriculture (Diliman, Quezon City) for analysis of total nitrogen and phosphorus.

Data analyses: The mean percent reductions in concentration of COD, BOD, TSS, turbidity, and color were computed based on the differences between influent and effluent values[11]. Mean and standard deviation were used in data comparison.

Results and Discussion

Characteristics of meat processing wastewater: Table-1 shows the characteristics of meat processing wastewater without any treatment, except for screening of coarse solids (mainly fats) and passing thru series of settling tanks. Considering the Philippine effluent standard set by the Department of Environment and Natural Resources (DENR)[22], the collected meat processing wastewater exceeded the allowable level of COD (100 mg/L) and BOD (50 mg/L) for discharge to Class C receiving body of water. The effluent sample has an average COD and BOD of 1,504 and 1,242 mg/L, respectively. The COD/BOD ratio values of the wastewater during four (4) sampling period are shown in Table-2. The COD/BOD ratios were all below 10 (1.0 to 1.6) indicating that the compounds in the effluent were relatively degradable. Effluent from this industry can therefore cause possible oxygen depletion in the receiving river and can affect aquatic life[23].

The organic fraction (volatile solids) of the effluent was 38% while the inorganic fraction (ash) was 62%. The pH of effluent sample is acidic ranging from pH 3.1 to 4.4 (average pH 3.95) during the sampling period. Settleable solids in the sample averaged to 0.3 mg/L, which was below the effluent standard (0.5 mg/L) set by the DENR[22]. Also, the meat processing wastewater has low salinity (3.25 parts per thousand [ppt]), and oil and grease content (2.53 mg/L). However, total suspended solids (TSS) of the effluent averaged to 169 mg/L and exceeded the 70 mg/L effluent limit. In addition, very high total coliform count was observed in the effluent ranging from 3,300 to 110,000,000 most probable number (MPN)/100 mL.

The meat processing wastewater used in this study is considered as medium strength wastewater, i.e. ranging from 1,000 to 10,000 mg/L, based from the BOD value[24]. High BOD values in wastewater sample might be obtained when fats and vegetable trimmings are discharged together with the processing wastewater. This condition was observed in the meat processing plant during the site visit where some meat and vegetable trimmings were washed out along with the wastewater. The high organic load (COD and BOD) and low COD/BOD ratio (tables-1 and 2) suggest that the effluent is relatively degradable and thus can be utilized for anaerobic digestion.

Table-1
Characteristics of meat processing wastewater

Parameter	**Meat processing wastewater**		**Standard (DENR DAO 35)**
	Range	Average*	
pH	3.1 - 4.4	3.95 $\pm$0.61	6.5 – 9.0
COD (mg/L)	1317 - 1577	1504 $\pm$126	100
BOD (mg/L)	960 - 1520	1242 $\pm$273	50
Settleable Solids (mg/L)	0.01 - 0.05	0.3 $\pm$0.02	0.5
Total Suspended Solids (mg/L)	113 - 322	169 $\pm$102	70
Total Solids (%)	0.16 - 0.22	0.23 $\pm$0.06	-
Volatile solids (%)	32.60 - 52.00	38.29 $\pm$9	-
Ash (%)	48.00 - 67.40	61.71 $\pm$9	-
Turbidity (NTU)	181 - 253	218 $\pm$34	-
Salinity (ppt)	3 - 4	3.25 $\pm$0.5	-
Oil and Grease (mg/L)	1.8 - 3.8	2.53 $\pm$1	5
Total Coliform (MPN/100 mL)	$3.3 \times 10^3 – 1.1 \times 10^8$	3.7×10^7 $\pm$50.8	10,000
NH_3-N (ppm)	1.19 - 5.78	3.37 $\pm$2	-
Total Nitrogen (ppm)	15.36 - 32.16	25.57 $\pm$8	-
Total Phosphorus (ppm)	1.56 - 18.36	9.22 $\pm$7	-

*Average data from four sampling periods

Table-2
COD and BOD values of meat processing wastewater

Parameter	Wastewater samples			
	I	II	III	IV
COD (mg/L)	1577	1577	1547	1317
BOD (mg/L)	1520	1427	960	1060
COD/BOD	1.04	1.10	1.61	1.24

Levels of COD, BOD, pH, TSS, and coliform count in the untreated meat processing effluent were all beyond the allowable discharge limit set by DENR[22]. This wastewater, therefore, needs further treatment before being discharged into drainage canal.

Inoculum acclimatization: Sludge inoculum collected from an existing wastewater treatment plant was blackish, slightly syrupy, and with some granules. It has a COD of 54,700 mg/L, BOD of 9,667 mg/L, pH of 6.1, total solids of 9.81%, ash content of 51.1%, volatile solids of 48.9%, and settleable solids of 620 mg/L. Start-up was done before actual ASBR treatment to acclimatize the seed sludge to the substrate, meat processing wastewater. Masse and Masse[4] noted that start-up is a period when anaerobic bacteria are allowed to adapt to new environmental conditions. In our study, sludge inoculum was acclimatized in the laboratory by daily feeding of meat processing wastewater for about one month. COD removal of at least 70% (70 to 79%) was noted during the 4th week indicating that acclimatization was already complete[11]. Sustained biogas production was also observed during the same period suggesting the activity of methanogenic bacteria.

ASBR treatment at different reaction time: The effect of different reaction durations (8, 12, and 16 h) was examined to determine the appropriate reaction time needed to achieve high organic removal in meat processing wastewater. A total of 29 cycles were conducted that composed of 11 cycles of 8 h-reaction, 5 cycles of 12-h reaction, and 13 cycles of 16-h reaction. Ambient temperature condition during ASBR treatment was between 27 to 32^{o}C. Raw wastewater pH was acidic ranging from 4.0 to 4.7. Influent pH was adjusted to neutral pH before loading into the reactor. After each ASBR run, effluent pH was nearly neutral ranging from pH 6.8 to 7.4, indicating that the process remained stable. The allowable pH of effluent is between 6 to 9 (DENR-DAO 35)[22]. Figure-2 shows the percent COD removal during ASBR treatment runs. Highest COD removal was observed with longer reaction time. COD removal averaged to 81% for 8 h reaction, 93% for 12 h reaction, and 96% for 16 h reaction. Maximum COD removal was 90%, 95%, and 97% for 8-, 12-, and 16-h reactions, respectively. COD values of influent and treated effluent are shown in figure-3. Treated effluent after 16-h ASBR reaction showed acceptable COD limit while effluent after 8- and 12-h reactions did not pass the required discharged guideline of 100 mg/L specified by the DENR[22]. COD value of effluent after 16-h reaction ranged from 60 to 99 mg/L with an average of 83 mg/L. For 12-h reaction, COD range from 90 to 170 mg/L with an average of 125 mg/L. For 8-h ASBR reaction, COD of treated effluent ranged from 210 to 430 mg/L with an average of 346 mg/L. Influent COD range from 1,316 to 2,080 mg/L.

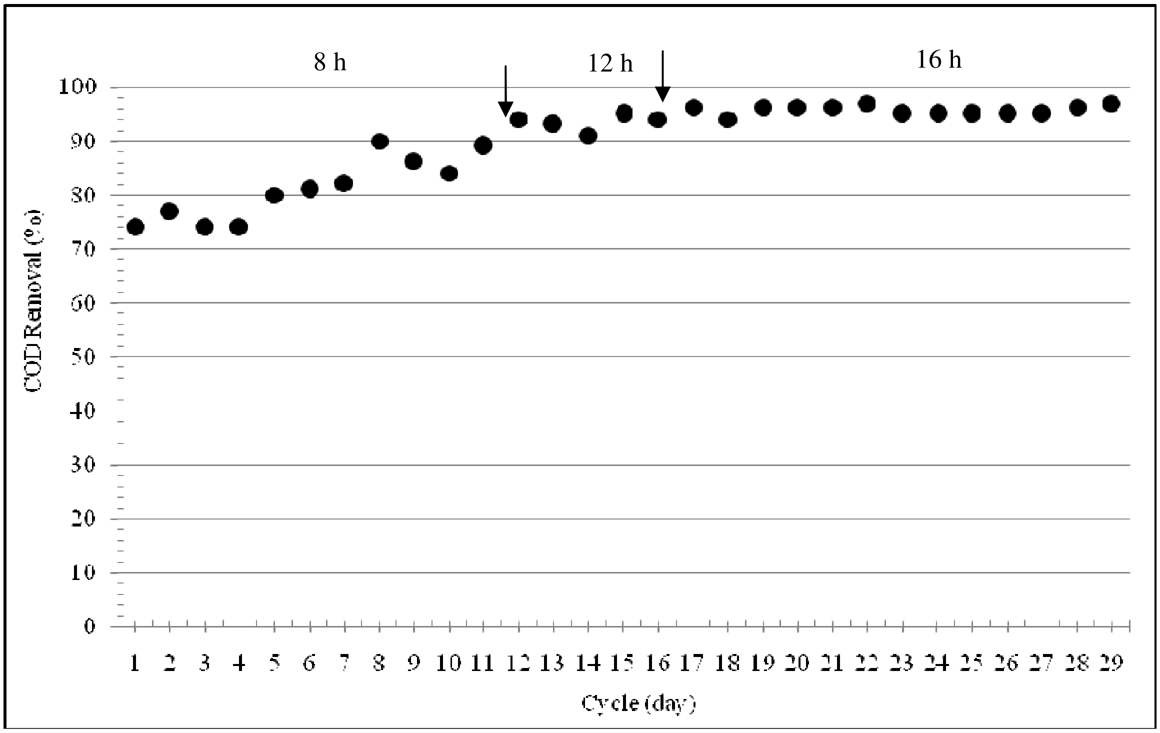

Figure-2
Percent COD removal during ASBR treatment of meat processing wastewater at different reaction durations (8, 12, or 16 h) (Arrows indicate points of change in reaction time)

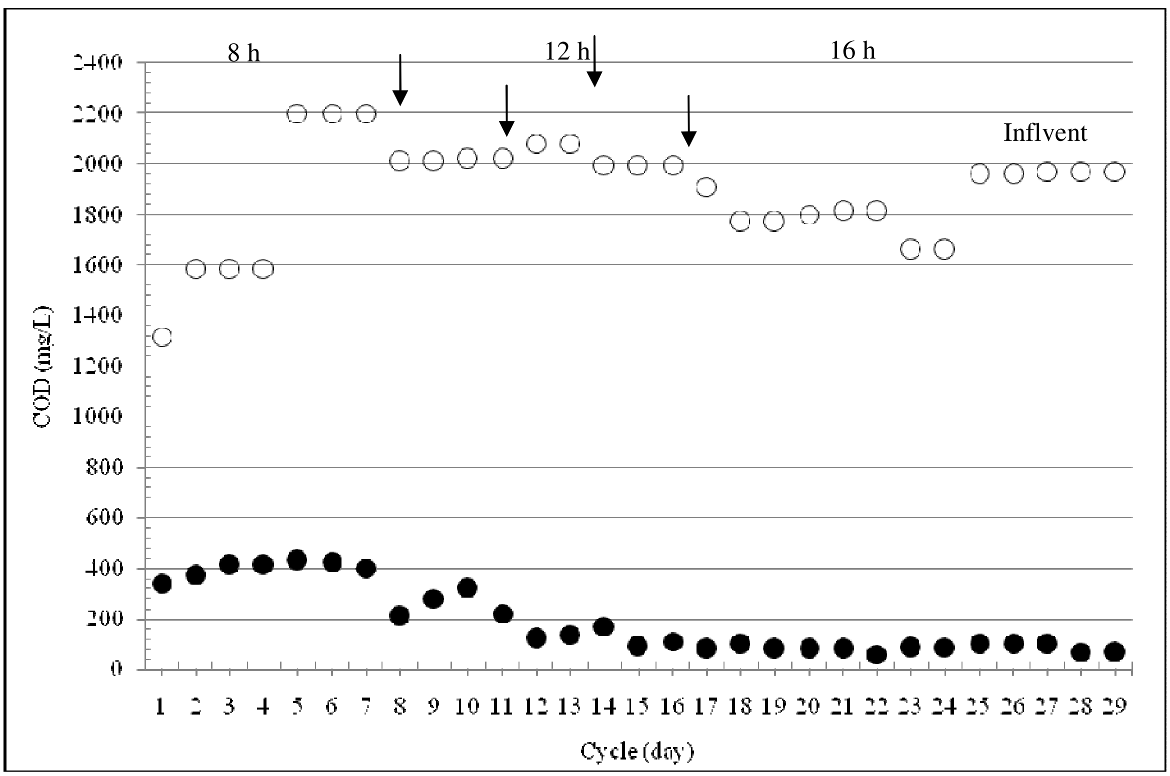

Figure-3
COD of influent and treated effluent during ASBR treatment of meat processing wastewater at different reaction durations (8, 12, or 16 h) (Arrows indicate points of change in reaction time)

Figure-4 shows the percent BOD removal during ASBR treatment runs. Highest percent BOD removal was also observed in reactor with longer ASBR reaction time. BOD removal averaged to 82% for 8-h reaction, 93% for 12-h reaction, and 94% for 16-h reaction. Maximum BOD removal was 88%, 95%, and 96% for 8-, 12-, and 16-h reactions, respectively. Influent BOD ranged from 1,060 to 1,900 mg/L (Figure-5). BOD of treated effluent in 8-h reaction ranged from 170 to 400 mg/L with an average of 257 mg/L. In 12-h ASBR reaction, BOD of treated effluent range from 80 to 120 mg/L with an average of 101 mg/L. Treated effluent in 16-h ASBR reaction showed the lowest BOD value, which range from 50 to 98 mg/L with an average of 80 mg/L. The allowable BOD limit for effluent is 50 mg/L[22]. Therefore, post-treatment of anaerobically-treated effluent is necessary to meet the required standard limit.

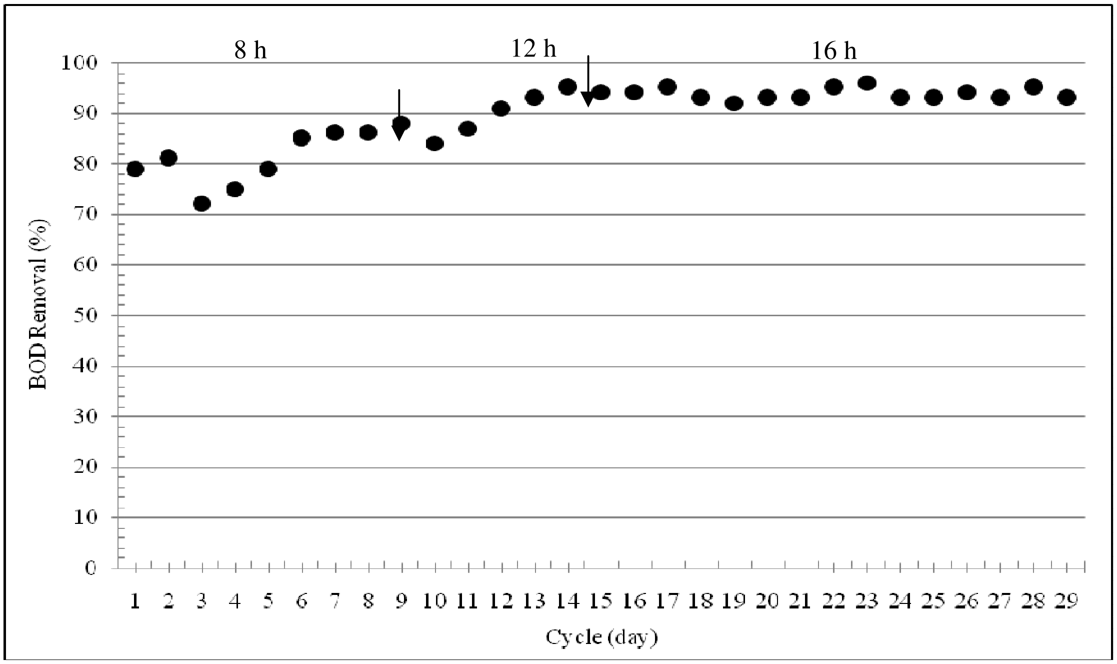

Figure-4
Percent BOD removal during ASBR treatment of meat processing wastewater at different reaction durations (8, 12, or 16 h) (Arrows indicate points of change in reaction time)

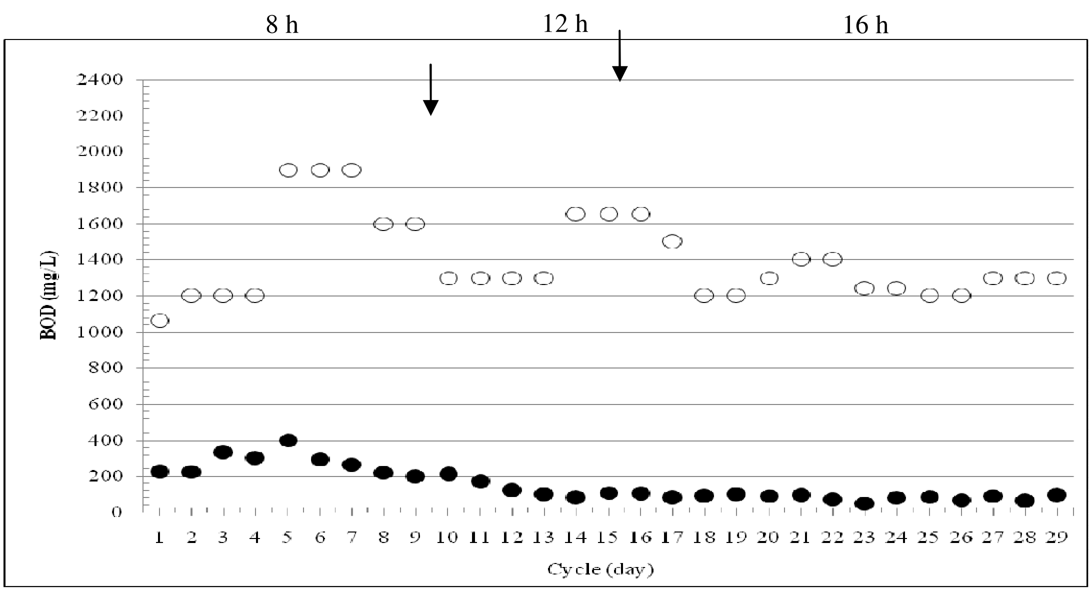

Figure-5
BOD of influent and treated effluent during ASBR treatment of meat processing wastewater at different reaction durations (8, 12, or 16 h) (Arrows indicate points of change in reaction time)

As expected, highest organic load (COD and BOD) removal was observed in 16 h reaction compared to 8 and 12 h reactions. In one study, the long reaction period is preferred for it provides longer reaction time and much complete degradation of organic material[1]. Setting the ASBR reaction time for longer period can be done to further increase the removal efficiency but this depends on the operation needs of the treatment facility. Farina et al.[17] noted that in batch ASBR operation, quality of effluent can be controlled since removal of treated effluent can be done once standard limit has been achieved. Figure-6 shows the scatter plot diagram of the BOD and COD values of effluent after each ASBR treatment. A strong positive correlation (0.95) was observed between COD and BOD values. High correlation of COD and BOD means that as COD value increases, BOD value increases in a linear fashion. This correlation can be used to estimate the BOD value once the COD value is measured and thus, facilitate rapid effluent quality assessment[23].

Figure-7 shows the biogas production and ambient temperature profile during ASBR treatment cycles. Results showed that biogas production is not dependent on ASBR reaction time. Maximum biogas yield was observed during 12-h ASBR reaction with 3,300 mL/cycle. Biogas produced in 8-h reaction range from 1,540 to 2,960 mL/cycle with an average of 2,276 mL/cycle. For 12-h reaction, biogas ranged from 2,450 to 3,300 mL/cycle with an average of 2,922 mL/cycle. For 16-h reaction, biogas ranged from 2,440 to 3,100 mL/cycle with an average of 2,763 mL/cycle. Based from the average 2.76 L biogas produced per day in 16-h ASBR reaction, and 4 L wastewater loaded per day, this translates to 0.69 L biogas production/L of wastewater loaded. Temperature somewhat affects biogas yield during ASBR treatment. Ambient temperature ranged from 28 to 31^{o}C during the treatment duration. As shown in figure-7, drop in daily temperature also produced low biogas yield on that particular day. Theoretically, increase in temperature will result to higher degradation of organic materials due to rapid microbial activity[6]. Regardless of reaction time, TSS of all treated effluents were within the allowable level, which is 70 mg/L. Percent turbidity removal was almost the same in 8-, 12-, and 16-h reaction time with 68%, 69% and 70%, respectively. Color reduction was examined in ASBR-treated effluent with 16-h reaction time and showed an average of 68% color reduction. Effluent color ranged from 490 to 700 platinum-cobalt units (PCU) with an average of 588 PCU. Standard allowable limit for effluent color is 150 PCU[22]. Post treatment of effluent is therefore needed to reach the acceptable color value.

ASBR and post-treatment with activated carbon: Two trials were conducted to examine the efficiency of ASBR treatment followed by post-treatment of effluent with activated carbon. ASBR was done following the one cycle per day operation which consisted of 30 min refill, 16 h reaction, 7 h settling, and 30 min removal of treated effluent. This schedule was followed as 16 h reaction showed the highest organic matter removal and overnight settling is practical for normal industry operation. Results showed that after ASBR treatment (table-3), percent removal was 94% in COD, 93% in BOD, 54% in TSS, 58% in turbidity, and 53% in color. In other reports using ASBR, greater than 90% organic removal efficiency was also obtained such as those in treatment of winery wastewater (98%)[18], and of dairy plant wastewater (91%)[13].

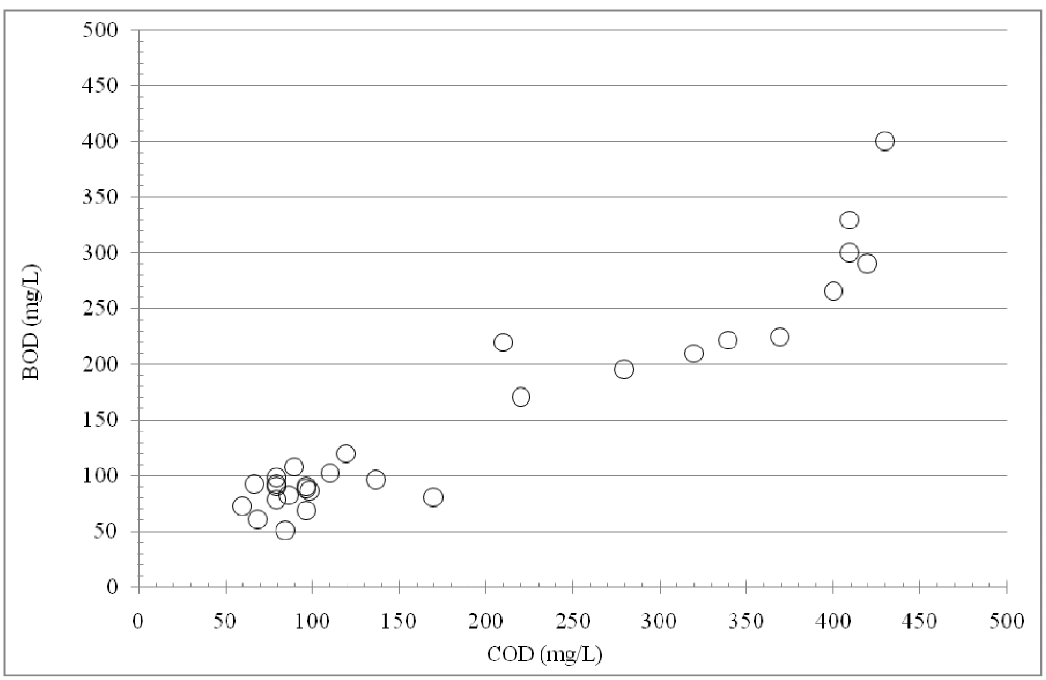

Figure-6
Correlation between COD and BOD values of treated effluent after ASBR treatment of meat processing wastewater

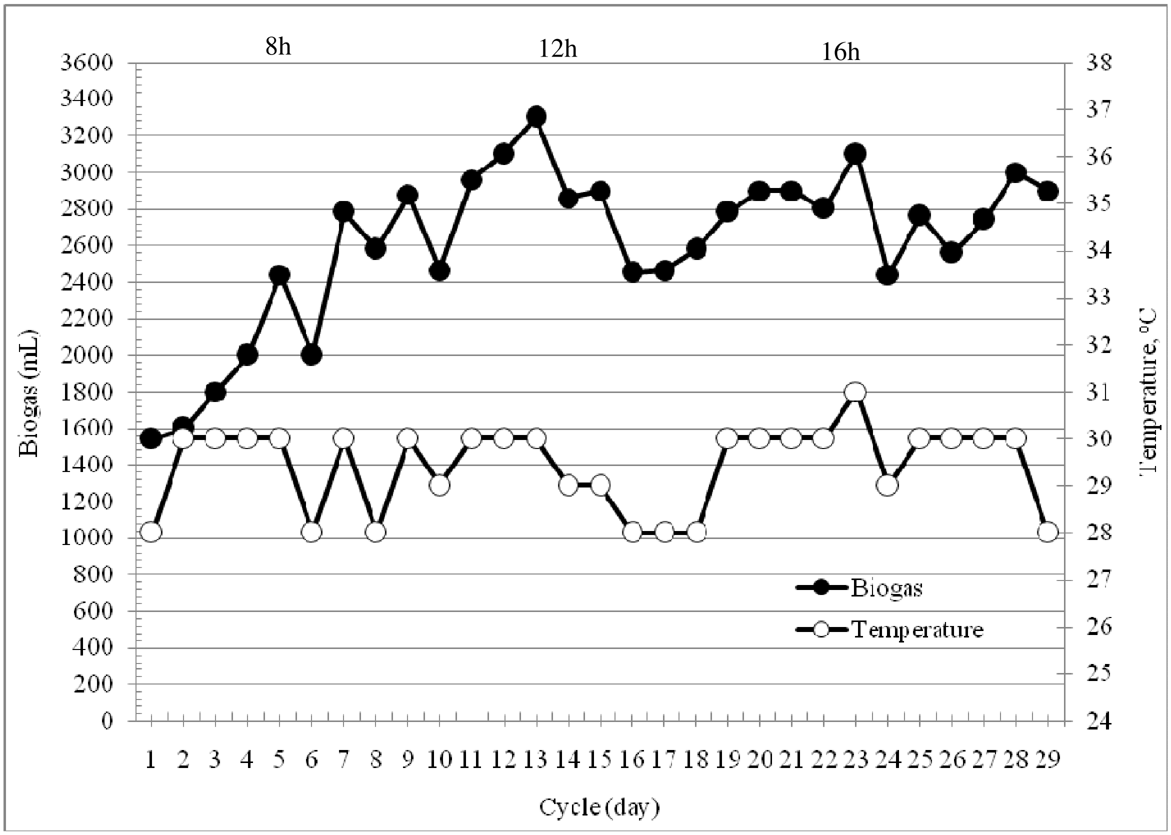

Figure-7
Biogas production and temperature profile during ASBR treatment of meat processing wastewater at different reaction durations (8, 12, or 16 h) (Arrows indicate points of change in reaction time)

Table-3
Characteristics of wastewater before and after ASBR treatment and post-treatment with activated carbon

	ASBR Influent	ASBR Effluent	Post Treatment (activated carbon)	Standard (DENR DAO 35)
COD (mg/L)	1740 ±110	116 ±3	76 ±0.5	100
BOD (mg/L)	1100 ±100	78 ±10	20 ±10	50
TSS (mg/L)	146 ±0.5	66 ±2	53 ±0	70
pH	7.6 ±0.05	7.3 ±0.1	7.8 ±0.15	6 - 9
Color (PCU)	1885 ±90	880 ±8.5	641 ±22	150
Turbidity (NTU)	233 ±13	100 ±1.5	83 ±0	-

* Values are means ±SD from two independent experiments.

Treated effluent was then passed through a column with granulated activated carbon (AC) for post-treatment. The flow rate of wastewater in the column averaged to 10 min/L. Post-treatment process resulted to reduction of 35% in COD, 76% in BOD, 20% in TSS, 18% in turbidity, and 27% in color (Table-3). Values of COD, BOD, TSS and pH after post-treatment with AC were all below the standard limit[22] set for effluent. The overall efficiency in organic matter removal of the ASBR with AC post-treatment system was 96% and 98% of the total COD and BOD, respectively. For other parameters, the overall removal of ASBR-AC post treatment system was 64% for both TSS and turbidity, and 66% for color. Post-treatment of effluent from ASBR contributes in further reduction of various parameters in wastewater and in achieving acceptable effluent limit. As mentioned in literature, effluents from anaerobic treatment are often not suitable for direct discharge into receiving waters without further treatment scheme[24].

Biogas production and Methane analysis: Flame test showed that the biogas yield from the ASBR reactor is flammable with bluish and yellowish flames. Average biogas production after 16-h ASBR reaction was 2.704 ±4.9 L/d or 676 ±1.4 mL biogas/L of wastewater. From the initial COD of 1,740 mg/L, the average biogas yield was 0.39 ±0.04 mL/mg COD. This biogas yield was higher compared to that reported by Ndegwa et al.[6] using ASBR for low-strength swine waste with 0.14 mg/L and 0.16 mg/L COD at 20°C and 35°C, respectively.

Methane content of biogas based from gas chromatographic analysis was 61±1.1%, which is in accordance to other reported ASBR studies. In literature, methane content in ASBR operation was 40-60% in food processing industrial wastes[25], 50-80% in distillery wastewaters[17], 65-75% in dilute swine slurries[6], and 75% in slaughterhouse wastewater[4]. High methane production during anaerobic process indicates degradation of organic materials[4].

Characteristics of sludge by-product: Sludge by-product taken from the anaerobic reactor after treatment of meat processing wastewater has the following characteristics: 1.40% organic carbon, 0.04% total phosphorus, 0.09% total potassium, 7% total solids, 48% volatile solids, 52% ash, and neutral (7) pH. Sludge by-product showed the same volatile solid content as in the initial sludge inoculum. Previous reports on anaerobic digestion have indicated the conservation of nutrients in most operations[11,26].

Conclusion

Meat processing wastewater containing 1,317 to 1,577 mg/L of COD was treated in 10-L ASBR. The fabricated anaerobic digester was proven effective for lab-scale ASBR treatment. Specifically, the ASBR was effective in reducing COD, BOD, turbidity, suspended solids, and color in meat processing wastewater. ASBR treatment at different reaction durations (8, 12, and 16 h) showed highest COD and BOD removal in 16-h ASBR reaction. This ASBR react time allowed high organic matter removal of 94% COD and 93% BOD. Biogas was produced during anaerobic treatment with methane content of 61%. Post-treatment of ASBR-treated effluent using activated carbon was also effective to further reduce the organics and other contaminants in the effluent to acceptable limit. Activated carbon greatly reduced the BOD value of the ASBR-treated effluent. The resulting sludge in the anaerobic digester can be used as material for composting for it contains nutrients that can be utilized by plants. Data from this lab-scale experiment will be useful in the succeeding pilot-scale ASBR project and in planning for treatment application to other types of wastewater. We also recommend to utilize the solid fat waste generated from the meat processing plant for biogas production.

Acknowledgement

Authors are very thankful to Sirloin Foods Industries Corporation (Quezon City) for their support and assistance during the conduct of this research, and for their continued interest and collaboration in pursuing application of this technology.

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