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EVALUATION OF AN UPFLOW ANAEROBIC SLUDGE BLANKET BIOREACTOR FOR THE TREATMENT OF STILLAGE

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— Abstract—

In this research the evaluation of a type bioreactor "upflow anaerobic sludge blanket" (UASB) of 4.4 L occurs during a period of 90 days, which was fed with wastewater (vinasse) of a fermented beverage company from Comitan, Chiapas. The removal efficiency of chemical oxygen demand (COD), stability with respect to reactor factor alpha (α) and hydrogen potential (pH) were mainly investigated. The COD removal efficiency of was 90 %. During the study, the α factor (0.28) and pH (7.1) remained stable in the system.

Keywords

Wastewater, Vinasse, UASB, COD.

Technology for anaerobic wastewater treatment has been applied in the treatment of wastewater from different industries such as: Distilleries, tanneries, textile, pulp and paper and food processing (Buzzini et al, 2002; Kasum et al . , 2002, Ramasamy et al . , 2004 Chavez et al, 2005). For this purpose, various configurations of reactors such as the contact anaerobic reactor (Nahale, 1991), fluidized bed reactor (IZA, 1991) anaerobic fixed film reactor (FFR) (Rao et al., 2005) and mantle up flow anaerobic sludge reactor, commonly known as UASB have been developed between the years 1976-1980 by Professor Gae Lettinga from Wageningen University in the Netherlands (Iñiguez-Covarrubias and Camacho-Lopez, 2011). The first UASB reactor was applied for the waste water treatment of a beet sugar refinery in the Netherlands (Lettinga, 1980). After the first pilot scale UASB reactor was successfully operated, many reactors of this type were used on a real scale to treat different types of industrial wastewater. This reactor is currently applied extensively because of their effectiveness in wastewater with a high organic load and for its economic advantages (Lettinga et al . , 1997; Buzzini et al . , 2002; Kusum et al . , 2002, Mahmoud et al. , 2003; Chavez et al, 2005)..

In the state of Chiapas, particularly in the region of the Comitan plateau, there can be found crops which include the *Agave americana L*. and *Agave salmiana Otto ex Salm-Dyck*, which are used for a typical alcoholic beverage (spirit) of the region called are Comiteco (Reynoso-Santos et al., 2012). Currently, the preparation process is carried out using traditional methods where 0.85 L of waste/L must is obtained from the distillation process, which is dumped into surface water or used as irrigation water causing eutrophication of surface water bodies and result in nitrate leaching to groundwater and reduced levels of dissolved oxygen (Vlyssides et al., 1997). In soil, it can be a threat to fertility due to an imbalance of nutrients or even harmful concentrations of nutrients (Kannabiran and Pragasam, 1993). For this reason the objective of this investigation was to evaluate a UASB bioreactor to treat stillage from the alcoholic distillation process of Comiteco.

METHODOLOGY

Obtaining the raw material

The stillage used was provided by the Company Balun Canan, SA de CV established in the city of Comitan, Chiapas, as a product of batch distillation, which were stored at 4 ° C until use.

Physicochemical analysis

The sediment solids (SS, mg / L) were determined according to the Mexican standard NMX-004 (2000). The total volatile solids (TVS, mg / L) and total dissolved solids (TDS, mg / L) were carried out following the Mexican standard NMX-034 (2001). The pH of the samples was determined using a HACH model SenSion 3 (influent and effluent) potentiometer, and the acidity was determined according to the norm NMX-036 (2001). The analysis of the chemical oxygen demand (COD, mg O2/L) was performed according to the Mexican standard NMX-030 (2001) using the technique of closed / spectrophotometric reflux (influent and effluent). The biochemical oxygen demand (BOD 5) was performed according to the Mexican standard NMX-028 (2001).

Description and preparation of the bioreactor

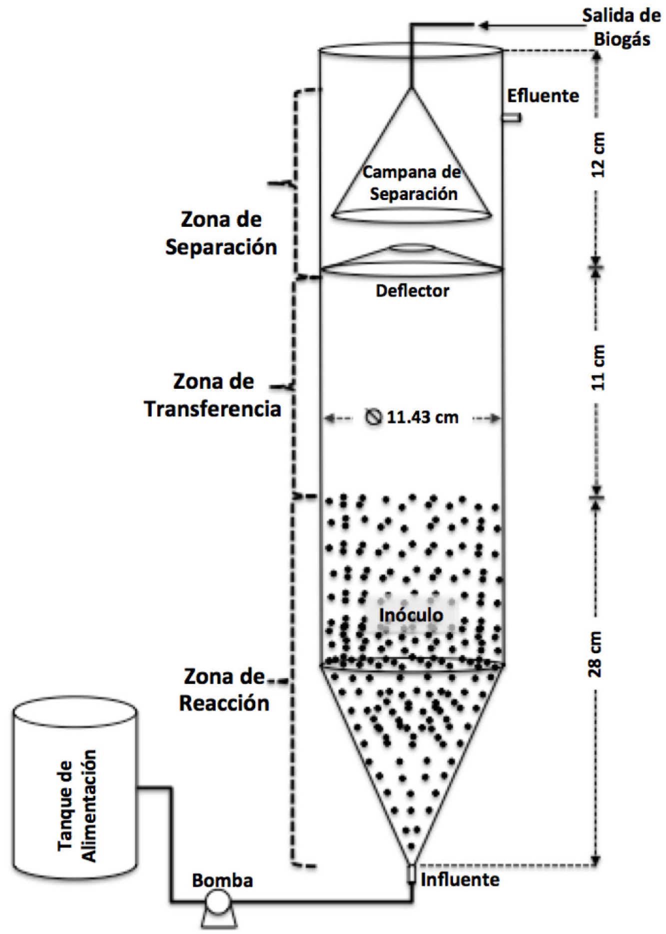
In Figure 1 you can see the design conditions of the bioreactor which was built in fiberglass with a volume of 4.4 L, with a cylindrical shape due to its hydrodynamic advantages and the least possibility of the formation of dead zones. The bioreactor was operated at a 24h hydraulic retention time (HRT) and inoculated with 2 L of anaerobic microbial complex (obtained from a bottled water treatment plant of a bottling plant), with a content of 2.5 gST / mL .

Bioreactor Monitoring

During the evaluation period of the bioreactor the COD was monitored. The control parameters were temperature, pH and alpha factor (α) which is obtained according to the following procedure (Speece, 1996): 10 mL of sample was taken and acidified with 0.1N HCl until a pH of 5.75 was recorded of the mL of HCl required (V1) . This volume corresponds to the bi-carbonic alkalinity. Subsequently, this sample was brought to pH 4.3 (V2). The alpha factor was calculated by the following equation:

$$\alpha = \frac{V_2}{V_1 + V_2}$$

Figura 1. Upflow anaerobic sludge blanket bioreactor.



Source: This investigation.

RESULTS AND DISCUSSION

The physicochemical characteristics of stillage (influent) in terms of COD, BOD5, TDS, TSS, TVS, and SS as well as temperature and pH are shown in Table 1.

Table 1. Physicochemical characterization of stillage.

Parámetro	Valores obtenidos
pH	3.9 ± 0.013
Acidez (mg CaCO3/L)	79.3 ± 4.9
DQO (mg O2/L)	120,221±18,447
DBO5 (mg O2/L)	102,180 ± 15,320
SS (mL/L)	100 ± 14.1
ST (mg/L)	71,691.42 ±186.6
SVT (mg/L)	62,890.47±172.6
SST(mg/L)	9,190 ± 95.8
SDT (mg/L)	62,501.42 ± 93

Source: This investigation

As seen in Table 1, the stillage had a pH below permissible range indicated by the NOM-001-ECOL-1996 (5-10 units), for this reason the stillage discharged into a body of surface water is considered to be a pollutant due to its low pH which can cause acidification (Lükewille et al., 1997). On the other hand, the concentration of organic matter measured as BOD5 and COD present in the stillage are 1000 times greater than the maximum extent permitted by NOM-001-ECOL-1996 (30-200 mg O 2 / L). This organic load is due to the presence of dissolved solids and reducing sugars, non - volatile compounds from the fermentation broth (alcohol), acetic acid, glycerol, melanoidins and phenolic and polyphenolic compounds (Capasso et al . , 1992; Sangave et al, 2007;. Robles-Gonzalez et al, 2010). For this reason it is vitally important to give treatment to these agro - industrial effluents, which by its level of biodegradability (0.85, obtained from the BOD5 / COD ratio) and organic matter, anaerobic biological treatment is feasible as it is carried out in the UASB reactors.

In Figure 2, the behavior of the bioreactor based on control parameters (pH and α) is observed during the 90 day evaluation. As can be observed, the pH in the bioreactor remained stable in the optimum range (6.8-7.4) for the methanogenic Archaea reported by Speece, (1996). On the other hand, the alpha factor is usually used to control the stability of the anaerobic process (Speece, 1996) and to measure the buffer capacity of the bioreactor. As we can see, the bioreactor operated properly due to its alpha index was found to be within the optimal operating range (0.2-0.4) reported by Rojas, (2004).

Figure 2. Control Parameters of the UASB

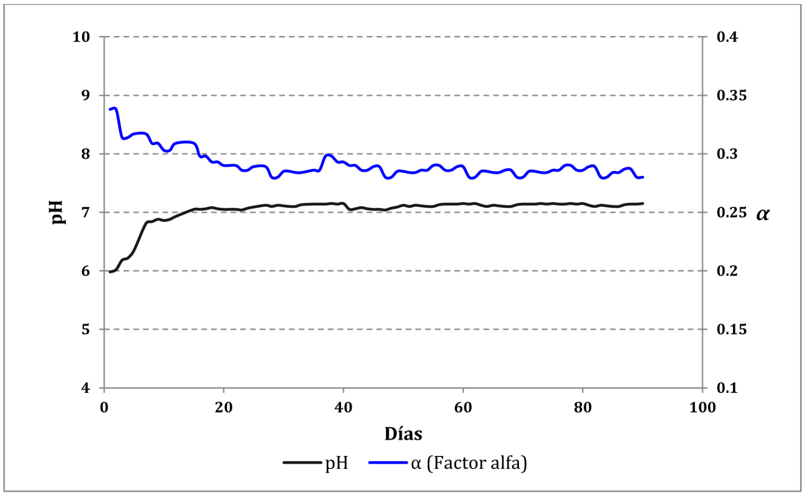
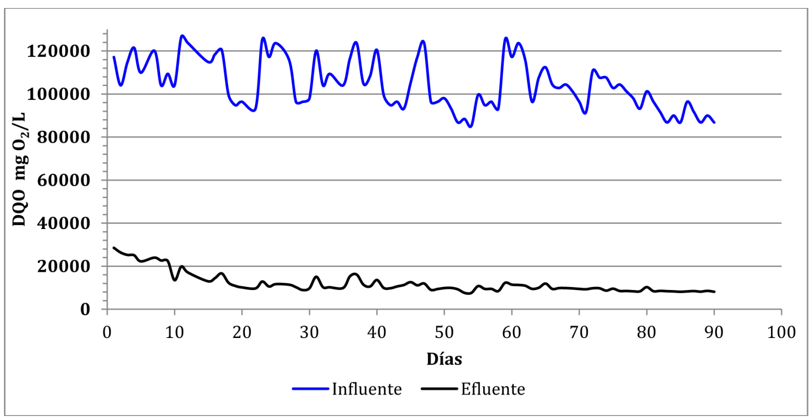
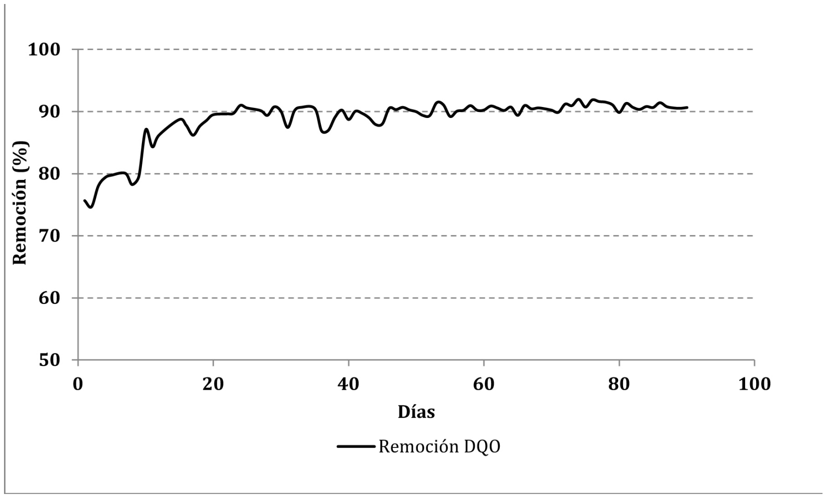


Figure 3. Evaluation of the UASB bioreactor.



Analysis of COD in **Figure 3 and Figure 4** shows the behavior of the UASB bioreactor during the evaluation period of 90 days, where one can observe that the bioreactor operated stably throughout the evaluation period, reaching a percentage of removal greater than 90%. However , even if the removal percentage was high, effluents were generated with a COD of 6500 mg O2/L, which still have large amounts of biodegradable organic matter which can be used as raw material of advanced oxidation processes, trickling filters , biodiscs or a second anaerobic treatment as reported by Robles-Gonzales et al. (2010).

Figure 4. Percent Removal..



CONCLUSIONS

According to the results of this study we concluded that an anaerobic biological treatment as provided by the up flow anaerobic sludge blanket reactor is an effective technology to carry out the treatment of stillage of the fermented drink produced in Comitan, Chiapas, because of its high performance measured in terms of COD removal with a percentage greater than 90%, reaching a profile similar to aerobic treatments. For this reason the use of such bioreactors is recommended due to the economic savings in energy costs compared to the operation of aeration is aerobic processes.

REFERENCES

Buzzini A.P., Pires E.C. (2002). Cellulose Pulp Mill Effluent Treatment in an Up flow Anaerobic Sludge Blanket Reactor. Process Biochem. (38): 707-713.

Capasso, R.; Cristinzio, G.; Evidente, A. (1992). Isolation, spectroscopy and selective phytotoxic effects of polyphenols from vegetable wastewaters. Phytochemistry. (31): 4125–4128.

Chavez P.C., Castillo L.R., Dendooven L., Escamilla-Silva E.M. (2005). Poultry Slaughter Wastewater Treatment with an up Flow Anaerobic Sludge Blanket (uasb) Reactor. Bioresour. Technol. (96):1730-1736.

Iñiguez-Covarrubias G. y Camacho-López A. (2011). Evaluation of an Upflow Anaerobic Sludge Blanket Reactor (uasb) with Changes in the Upflow Velocity. Ingeniería Investigación y Tecnología. Vol. XII, Núm. 1, 199-208.

Iza J. (1991). Fluidized-Bed Reactors for Wastewater Treatment. Water Sci. Technol. (24): 109-132.

Kannabiran, B. y Pragasam, A. (1993). Effect of distillery effluent on seed germination, seedling growth and pigment content of Vigna mungo (L.) Hepper (cvt9). Geobioscience *20, 108–112*.

Kasum L., Kansal A., Balakrishnan M. Rajeswari K.V., Kishore V.V.N. (2002). Assessment of Biomethanation Potential of Selected Industrial Organic Efluents in India. Resour. Conserv. Recycl. (35): 141-161.

Lettinga G, van Nelsen AFM, Hobma SW, de Zeeuw W, Klapwijk A. (1980). Use of the upflow sludge blanket (usb) reactor concept for biological wastewater treatment, especially for anaerobic treatment. Biotechnol Bioeng. 22(4): 699-734.

Lettinga G., Field J., Vanlier J., Zeeman G., Hulshoff-Pol L.W. (1997). Advanced Anaerobic Wastewater Treatment in the Near Future. Water Sci. Technol. 35(10): 5-12.

Lim S.J., Tak-Hyun, K. (2014). Applicability and trends of anaerobic granular sludge treatment processes, a Review. Biomass and bioenergy. 60:189-202.

Lükewille A.; D. Jeffries, M.; Johannessen, G.; Raddum, J.; Stoddard y T. Traaen. (1997). Transboundary Air Pollution. International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes. The nine year report: acidification of surface water in Europe and North America – Long-term developments (1980s and 1990s). NIVA-report n° 3637-97:168.

Mahmoud N., Zeeman G., Gijzen H., Lettinga G. (2003). Solids Removal in Upflow Anaerobic Reactors, a Review. Bioresour. Technol. (90):1-19.

Nahale C. (1991). The Contact Process for the Anaerobic Treatment of Wastewater: Technology, Design and Experience. Water Sci. Technol. (24):179-191.

Norma Mexicana NMX-AA-004-SCFI. Análisis de agua-determinación de sólidos sedimentables en aguas naturales, residuales y residuales tratadas-método de prueba. Diario Oficial de la Federación. 18 de diciembre del 2000. México, DF.

Norma Mexicana NMX-AA-034-SCFI. Análisis de agua–determinación de sólidos y sales disueltas en aguas naturales, residuales y residuales tratadas–método de prueba. Diario Oficial de la Federación. 1 de agosto del 2001. México, DF.

Norma Mexicana. NMX-AA-030-SCFI. Análisis de agua- determinación de la demanda química de oxígeno en aguas naturales, residuales y residuales tratadas-método de prueba. Diario Oficial de la Federación. 17 de abril del 2001. México, DF.

Ramasamy E.V., Gajalakshmi S., Sanjeevi R., Jithesh M.N., Abbasi S.A. (2004). Feasibility Studies on the Treatment of Dairy Wastewaters with up Flow Anaerobic Sludge Blanket Reactors. Bioresour. Technol. (93):209-212.

Rao G.A., Venkata-Naidu G., Krishna-Prasad K., Chandrasekhar- Rao N., Venkata- Mohan S., Annapurna J., Sarna P.N. (2005). Anaerobic Treatment of Wastewater with High Suspended Solids from a Bulk Drug Industry Using Fixed Film Reactor (AFFR). Bioresour. Technol. (96): 87-93.

Reynoso-Santos, R.; García-Mendoza, J.A.; López-Báez, W. Y López-Luna, A. (2012). Identificación taxonómica de las especies agave utilizadas para la elaboración del licos comiteco en Chiapas, México. Agroproductividad 5(4):9-17.

Robles-González, V.; López-López, E.; Martínez-Jerónimo, F.; Ortega-Clemente, A.; Ruiz-Ordaz, N.; Galíndez-Mayer, J.; Rinderknecht- Seijas, N.; Poggi-Varaldo, H. (2010). Combined treatment of mezcal vinasses by ozonation and aerobic biological post-treatment. Procedings of 14th International Biotechnology Symposium. Rimini, Italy, 14–18 September 2010 in CD ROM.

Rojas, CH. O. (2004). La alcalinidad como parámetro de control de los ácidos grasos volátiles en digestores UASB. 101-105.

Sangave, P.C.; Gogatea, P.R.; Pandit, A.B. (2007). Ultrasound and ozone assisted biological degradation of thermally pretreated and anaerobically pretreated distillery wastewater. Chemosphere 68 (1): 42–50.

Speece, R.E. (1996). Anaerobic biotechjology for industrial wastewater tretments. Archae Press. Nashvillee. TN, USA.

Vlyssides, A.G., Israilides, C.J., Loizidou, M., Karvouni, G., Mourafeti, V., 1997. Electrochemical treatment of vinasse from beet molasses. Water Sci. Technol. 36 (2–3), 271–278.