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Anaerobic Degradation of Textile Mill Effluent

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Abstract

This study was designed to evaluate the treatability performance of a single-stage UASBR at neutral pH and constant mesophilic temperature, and to investigate the biogas yield of a single-stage UASBR using textile mill. For this purpose sixty five percent of UASB reactor was seeded with anaerobic digester and activated sludge the nearby wastewater treatment plant. The acclimatization process continued for about 28-29 days in the laboratory. The seed sludge provided 41 grams of volatile suspended solids (VSS). The organic loading rate of 0.6kg-COD/m^3.day and a HRT of 22hours are the conservative figures that warrant a removal efficiency of more than 80%.Since, Pakistan is facing a shortage of energy; therefore, encouraging such technologies can help to tackle the problem of energy crises.

Keywords

Textile Mill, Effluent, COD, UASBR, Biogas

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1. Introduction

The available water in our country is being polluted at an alarming rate. The pollution mainly occurs due to untreated domestic and industrial effluents and agricultural/surface runoffs etc, the domestic effluent includes sewage as well as sullage while industrial effluents only include waste sewage. The runoffs may include garbage and sediments. Due to all these effects of pollution, the only clean and potable water available is 18% and the rest 82% is unfit for drinking purpose [1]. Besides water deficiency it is an admitted fact that Pakistan is deficient in energy though it has a substantial potential of energy. The energy is not only confined to electrical energy but the bio-gas has also a significant share in this sector. However bio-gas has not been given attention as it deserves.

Biomass is the most important sources in Pakistan as it is about 37% of its total primary energy supply. The growing acceptance of anaerobic digestion as a simple, low-cost high rate and effective waste treatment technology makes it a viable solution for pollution control, in addition to give support to energy resources sector [2].

For the treatment of textile mill wastes the anaerobic technology seems to be more reliable, effective and economical. Hence, a long-term comprehensive study is required to investigate the treatment feasibility of the actual textile mill effluent using single-stage UASB reactor [3,4]. Therefore, this study was design to evaluate the treatability performance of a single-stage UASBR at neutral pH and constant mesophilic temperature and to investigate the biogas yield of a single-stage UASBR using textile mill effluent.

2. Materials and Methodology

Due to the advantages and high application potential of UASB reactor for the developing countries, therefore, it was

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decided to employ UASB reactor for this study. An UASB reactor made up of acryl resin material each with a total effective volume of 6.0liters was employed in this study. The internal diameter of the reactor was 10.5cm and the thickness of the water jacket was 1.5cm centimeter. The reactor had a water jacket to maintain a constant temperature. The reactor was also equipped with a gas solid separator (GSS) and a mixer [5, 6]. The stem diagram of the typical UASB reactor is shown below. Actual textile mill effluent was used as the sole carbon source in the feed (influent). Nitrogen and Phosphorous were added in the form of $(NH_4)_2SO_4$ and KH_2PO_4 in accordance with the COD:N:P ratio of 650:7:1 [7]. Trace nutrients were added at a concentration of 1.0 milliliter/liter after making a stock solution of nutrients in the following concentration. The typical layout of the UASBR is shown in the Figure 1.

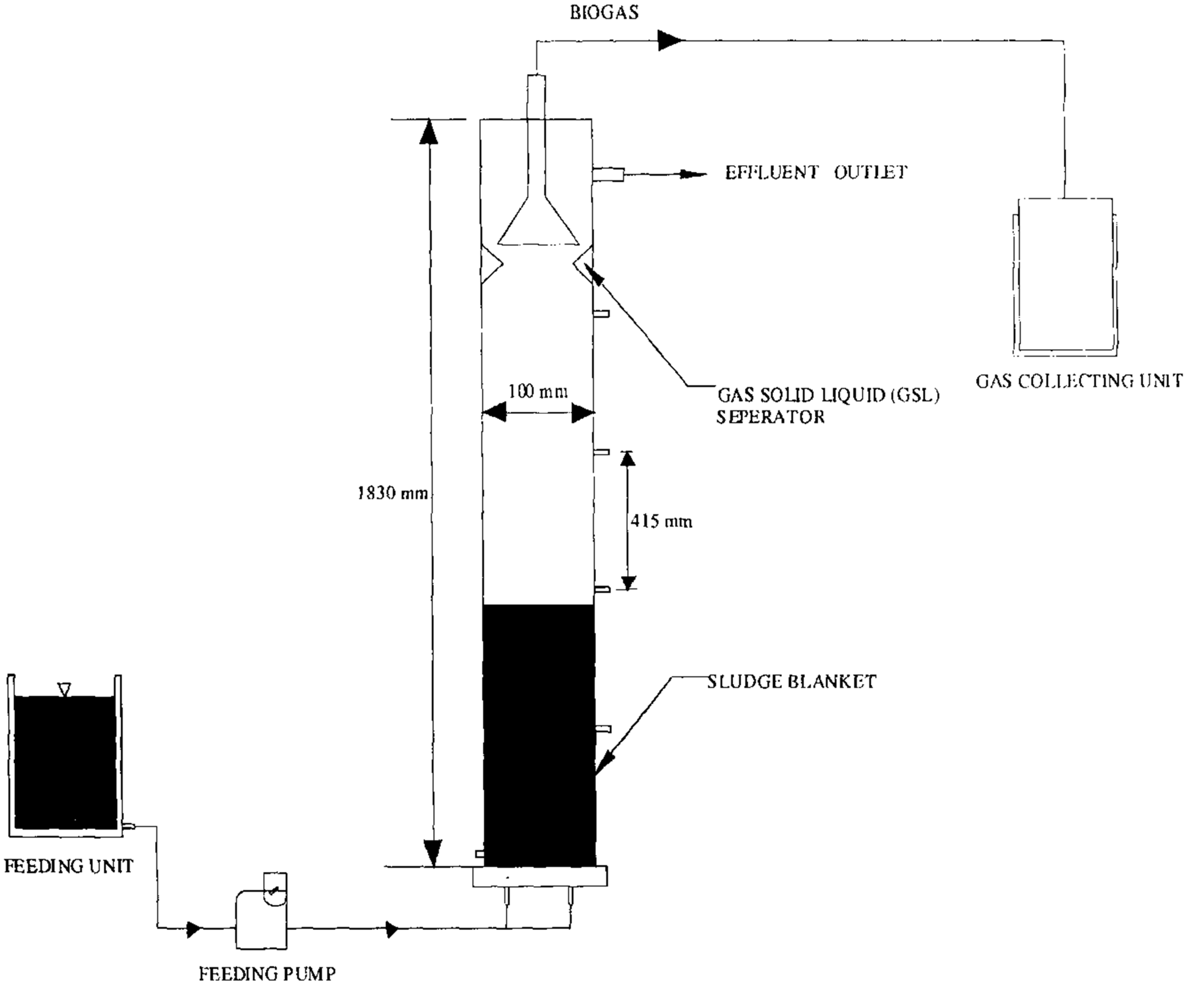

Fig 1. Typical layout of the UASB Reactor

3. Results and Discussion

PH is the most important and principle operational parameter of an anaerobic digestion. An optimum pH of “5.5 to 6.0” was reported for the process of anaerobic digestion in UASB. Since, the methanolic bacteria are highly sensitive to pH and requires neutral pH conditions, therefore, this ranges seems to be unsuitable for the optimum growth of this kind of bacteria. It was concluded that the 7.8 to be the optimum pH, with no activity occurring below pH 6.8 [8]. These results suggested that optimum pH should lie within neutral condition pH. This concept was also supported by various researchers, and concluded from this study, too.

Therefore, in this study the pH of the reactor was tried to maintain near to neutral, by adding an external buffer in the form of $NaHCO_3$ addition to the feed solution. The organic loading rate (OLR) was gradually increases from 0.2kg-COD/m^3-d to 2.2kg-COD/m^3-d, in order to avoid any volumetric shocks to the reactor. Similarly, the hydraulic retention time (HRT) was also decrease slowly from 38hrs to 09hrs to prevent any washout of sludge from reactor. The time course of reactor pH during the experimental period, the effect of reactor pH on COD removal efficiency of the UASB, formation of VAFs in the effluent and amount of biogas yield is shown the Figures 2-6.

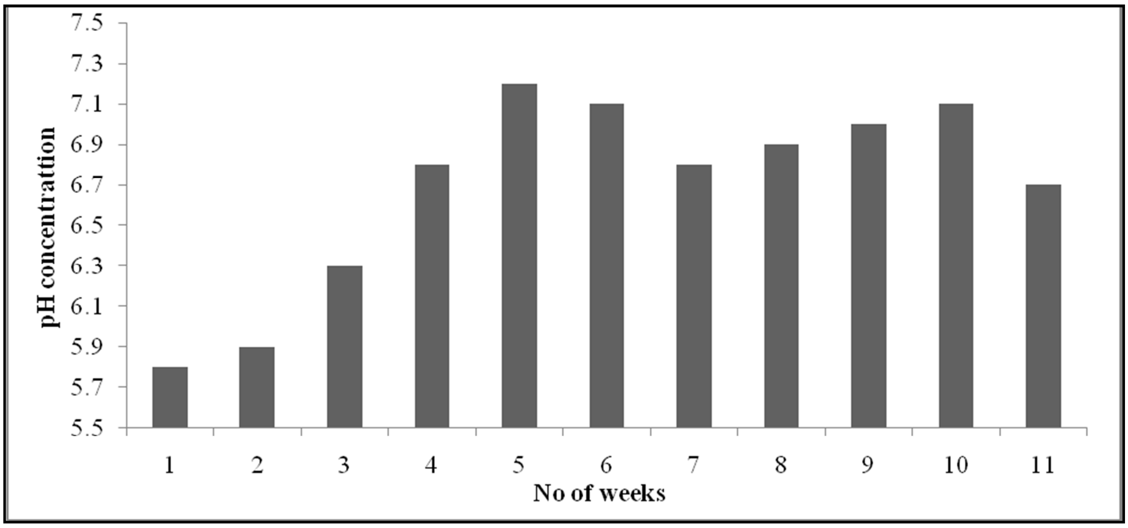

Fig 2. pH observation during the process

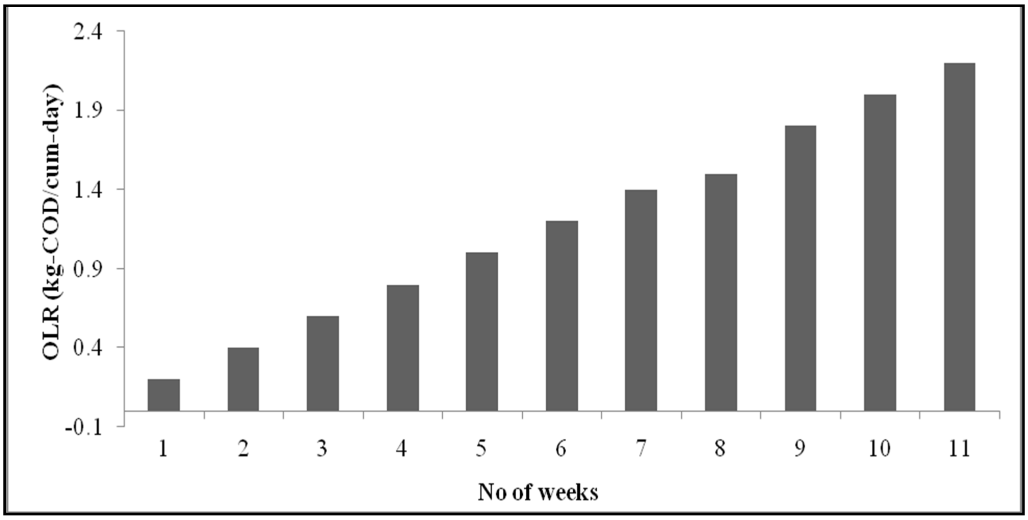

Fig 3. Organic loading rate during the process

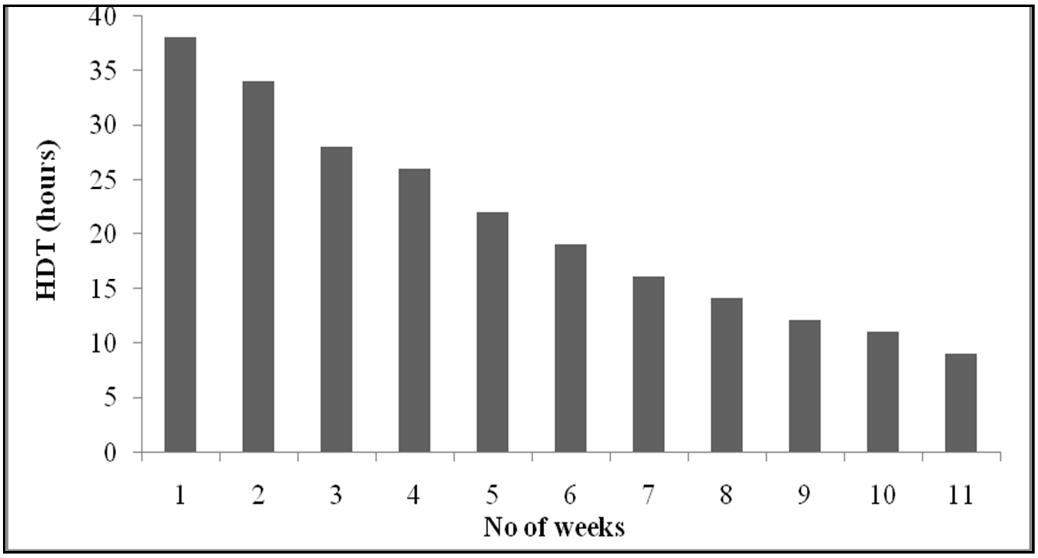

Fig 4. Hydraulic detention time during the process

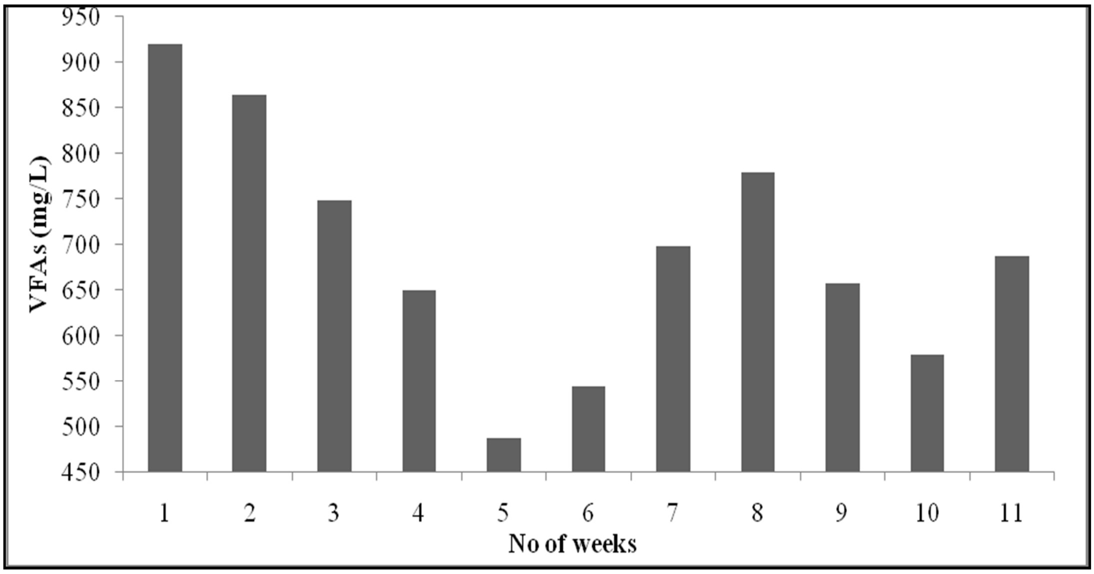

Fig 5. VFAs concentration during the process

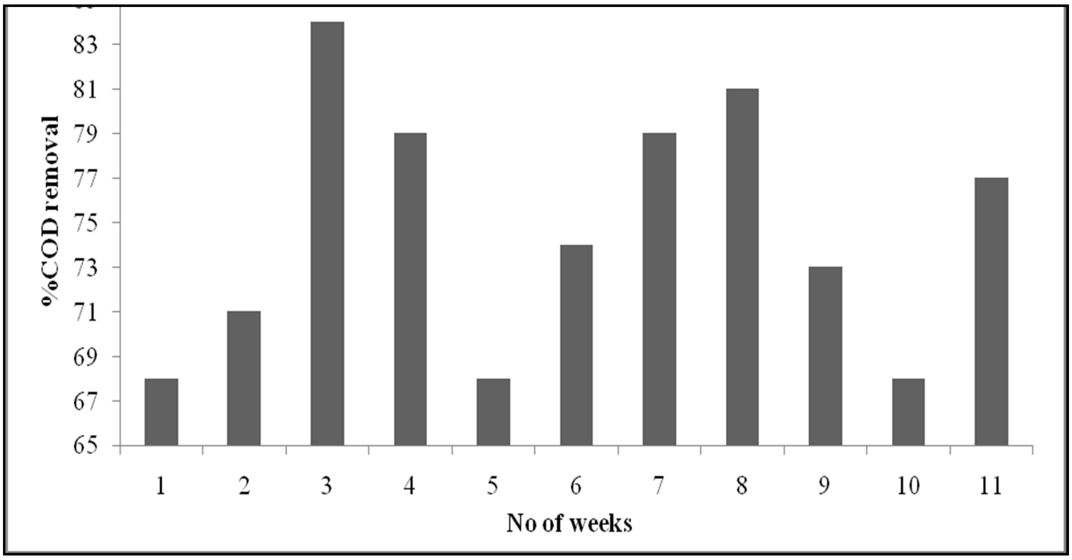

Fig 6. COD removal during the process

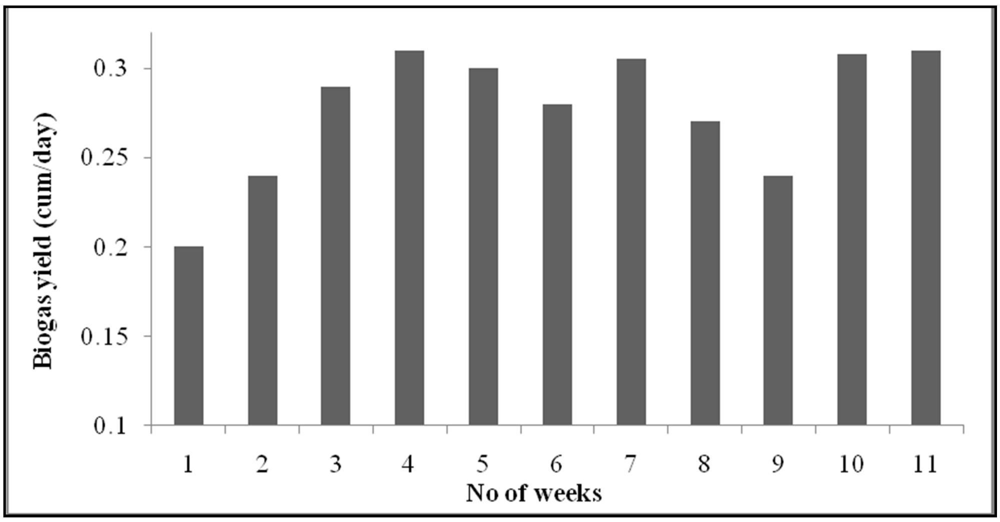

Fig 7. Biogas yield during the process

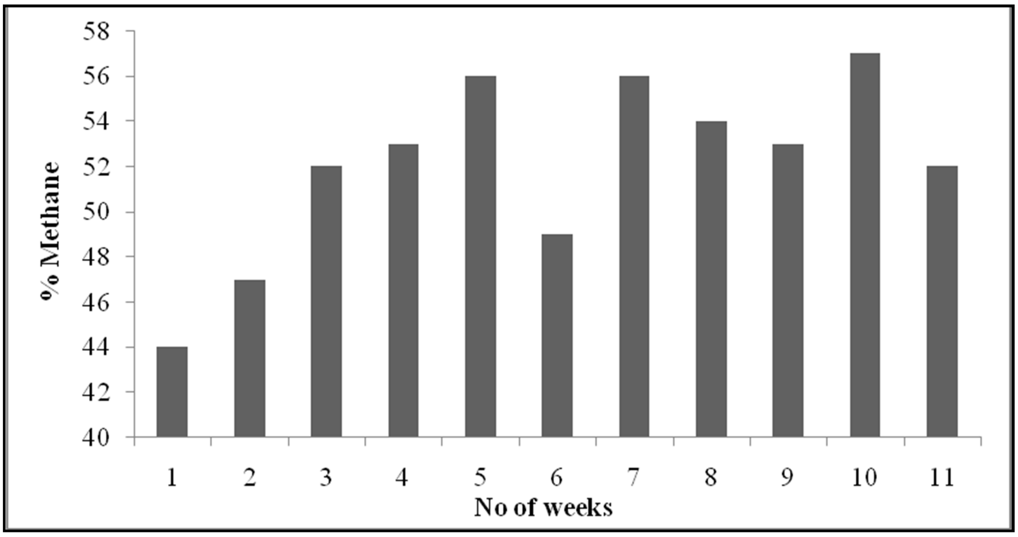

Fig 8. Methane contents of the biogas

The pH of the reactor was initially acidic varying from 5.8 to 5.9, but it was later on controlled at around neutral pH (7.07, average pH value after the 4th week) by the addition 60 ml of 0.5 M $NaHCO_3$ per liter of the feed solution, after 28th days of operation.

The effect of pH on the COD removal efficiency shows that about 80% of the COD can be removed, if the pH of the reactor is kept neutral. Thus by keeping the pH of the reactor at neutral, the effluent COD can be easily dropped down to the limits set by NEQS. VFAs are one of the important parameter that shows the inefficiency of the reactor to convert acetic acid into methane. In this study the formation of mean VFAs was observed to be 690mg/L. The maximum formation of VFAs, i.e. 920mg/L was observed when the pH of the reactor was about 5.8. Corresponding to this pH only 68% of the COD was observed to be removed.

The results illustrates that corresponding to neutral pH after maintaining a buffering capacity within the reactor, the optimum COD removal efficiency, effluent VFAs concentration and the biogas yield was observed as 80%, 680mg/L and $0.31m^3/kg\text{-}COD_{rem}$, respectively. These results show the smooth functioning of the reactor under optimum operating conditions.

The treatment COD removal efficiency of the UASB was observed to be greatly dependent on HRT and OLR, at constant pH and temperature. The longer retention time seems to be more favorable in terms of COD reduction [9]. During earlier stage of the experiment when the HRT was high the COD reduction was observed to be more than 74-82%. At 5th week the COD observed was the least, about 66% at an average HRT of 22hours. The concentration of VFAs was observed to be 340mg/L, corresponding to the pH value of 7.1. Whereas, the maximum COD removal of 84% was observed during the 3rd week, when the average HRT was 22hours and the OLR was observed to be $0.6kg\text{-}COD/m^3$-day, and the pH of the reactor was about 6.3, indicating that pH greatly influences the performance of UASB reactor. This might be due to the very low OLR at the start of the study period.

It was observed that for every step there was an increase in the COD removal efficiency of the reactor after establishing a steady state conditions under a given OLR. And in every step of increasing the OLR, it was observed that there was an abrupt decrease in the COD removal efficiency due to the increase in the concentration of VFAs in the reactor.

The removal efficiencies of total chemical oxygen demand COD achieved are in the range of 54–80%. The reactors are operated at ambient temperatures (26–30°C) and organic loading rates (OLRs) in the range of $0.2–3.1kg\text{-}COD/m^3$-d. The study shows a close resemble in the results, i.e. the optimum COD removal was observed to be 82%, corresponding to an organic loading rate of $0.6kg\text{-}COD/m^3$-d and HRT of 22hrs [10,11]. The low peaks of efficiency observed during the last days of operation beginning could be attributed to the variation in flow and acclimatization of seed sludge to the waste, or wash-out of seeded sludge from the reactors on account of high HRT. For fulfilling the requirement of NEQS (National Environmental Quality Standards, Pakistan) 80% of COD can be easily achieved at an HRT of about 20hours and an OLR of $0.6\text{-}0.8kg\text{-}COD/m^3$-day, at neutral pH. But still, a post-treatment facility would be required to polish the results.

Small gas bubbles were observed from the start of the experiment. The gas was collected in a smaller system saturated with NaCl solution. However, because of low gas pressure the gas production rates and deficiency in the gas collection system, appreciable amount of gas could not be collected during initial days of operation. Methane (CH_4) content of 75-80% of the gas is reported by researcher, and a study on dairy waste has shown to be 75%. The rest of the gas content will be mainly CO_2, because these two gases are produced in the anaerobic digestion process. A portion of the gas cold is H_2, if the system is not working properly due to the presence of hydrogen-producing acetogens, which will provide unfavorable conditions for the conversion of VFAs to acetate then to methane. In this study on the percentages of methane and carbon dioxide were observed. The results are shown in the Figures 7-8.

The low biogas yield was observed during the early days, when the pH was alkaline, and the concentration of VFAs were found to be more than 560mg/L, indicating that population of methanogenic bacteria had not grown appreciably and that facultative microbes may be competing for the substrate with the methane producing organisms. The average gas conversation rate was calculated to be $0.28m^3/kg\text{-}COD_{rem}$. And the average concentration of methane was noticed to be 53%. Corresponding to the optimum operating conditions the biogas yield and the methane content of the biogas was observed as $0.31m^3/kg\text{-}COD_{rem}$ and 56%, respectively. The same methane composition was also observed by Cherncharo, 1999 to be 69% for treating domestic wastewater.

4. Conclusion and Recommendation

1. Treatment of high-ranged kitchen effluent is technically feasible provided that the pH of the system is kept near to neutral. This can be achieved by adding $NaHCO_3$ to the feed solution.
2. The volumetric loading rate of $0.6kg\text{-}COD/m^3$.day and a HRT of 22hours are the conservative figures that warrant a removal efficiency of more than 80% and thus textile mill effluent quality can be brought within the limits of Pak-NEQS.
3. The UASB reactor seems to be a viable option not only in terms of pollution reduction, but it too helps in the conversation of wastes into energy (biogas).
4. The amount of biogas yield from the UASB reactor, using textile mill effluent is $0.31m^3/kg\text{-}COD_{rem}$ at optimum operating conditions, with 56% methane contents.
5. Since, Pakistan is facing a shortage of energy; therefore, encouraging such technologies can help to tackle the problem of energy crises.

However, it is recommended to study the cost of developing the UASB technology for the on larger basis needs to be focused.

References

[1] Bryant, M.P. (1979). Microbial methane production – theoretical aspects. J. Animal Sci., 48: 193-201.

[2] Chernicharo A, (2001). An innovation conversion of full scale extended aeration activated sludge plant by UASB reactor as a first step treatment: case study of Botucatu city, Brazil. In: Proceedings of ninth world congress on Anaerobic Digestion/Anaerobic conversion for sustainability, Antwerpen, Belgium, 2-6 September, pp, 531-534.

[3] Freire, C.S.R., Silvestre, A.J.D., Neto, C.P., (2003). Carbohydrate derived chlorinated compounds in ECF bleaching of hardwood pulp: Formation, degradation and contribution to AOX in a bleached kraft pulp mill. Environ. Sci. Technol. 37: 811-814.

[4] Environmental Report Draft, March (1999). Environmental Technology Programme for Industries, Pak-EPA Pakistan.

[5] Bajpai, P., (2000). Microbial degradation of pollutants in pulp mill effluent. Adv. Appl. Microbiol. 48: 9-134.

[6] Driessen, W.J.B.M., Tielbaard, M.H., Vereijken, T.L.F.M. (1994). Experiences on anaerobic treatment of distillery effluent with the UASB process. Water Science Technology 30:12.

[7] Bhatti, Z.I. (1995). Studies on the biological treatment of methanolic waste in UASB reactor, PhD Thesis, Osaka University, Japan.

[8] Francis, D.W., Turner, P.A., Wearing, J.T., (1997). AOX reductions of kraft bleach plant effluent by chemical pre-treatment, pilot-scale trials. Water Res. 31:10, 2397-2404

[9] Schellinkhout A (1993). UASB technology for sewage treatment: experience with a full scale plant and its applicability in Egypt. Water Sci. Technol.27**:**9, pp. 173–180.

[10] Hall, E.R., Onysko, K.A., Parker, W.J., (1995). Enhancement of bleach kraftorganochloride removal by coupling membrane filtration and anaerobic treatment. Environ. Technol. 16: 115-126.

[11] Khallas, J. Munter, R., (1994). Post-treatment of pulp and paper industry wastewater using oxidation and adsorption process. Water Sci. Technol. 29: 259-272.