INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES
Volume-6, Issue-3, July-Sept-2016 Coden: IJPAJX-CAS-USA, Copyrights@2016 ISSN-2231-4490
Received: 28th June 2016 Revised: 24th July 2016 Accepted: 27th July 2016
DOI: 10.21276/Ijpaes http://dx.doi.org/10.21276/ijpaes ***Research article***

RICE MILL WASTEWATER TREATMENT BY UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR

Jitender Kumar Saini [1] Anju Saini[2] and Rajesh Kumar Lohchab[3]

[1,2,3]Department of Environmental Science & Engineering, Guru Jambheshwar University of Science & Technology, Hisar Haryana

ABSTRACT: Population growth creates demand of food industry. Rice mills are the important food industry generating effluents of medium COD mainly containing organic content generate biological oxygen demand. Anaerobic treatment like UASB is one of the important technology to treat rice mill wastewater. Present study was carried out in UASB reactor having volume of 2.4 litre. The study was divided into three phases i.e. Phase I, II and III operated at 50%, 100% and 100% rice mill wastewater feed concentration at HRT of 20 hrs, 14 hrs and 10 hrs, respectively. The pH of the reactor in phase I, II and III varied from 7.18 to 8.21, 6.1 to 7.22 and 6.52 to 8.04, respectively. The Volatile fatty acid (VFA) shows a good reduction of 93%, 78% and 75% in phase I, II and III, respectively. Whereas sludge profile varied from 1.14 to 0.75, 1.25 to 1 and 0.50 to 0.1 in phase I, II and III, respectively. This study shows COD reduction 97%, 89% and 86% in phase I, II and III, respectively. The COD reduction shows a decreasing trend with increase in feed concentration and decrease in HRT. The pH and VFA Alkalinity ratio were within the optimum range of anaerobic treatment. The optimum operating conditions results in 86% COD reduction even at lower HRT of 10 hrs and higher organic loading rate. The results clearly indicate that organic loading rate applied significantly affects the COD removal efficiency of the reactor.
Key Words: Chemical oxygen demand, rice mill wastewater, concentration

*Corresponding author: Jitender Kumar Saini. [3]Department of Environmental Science & Engineering, Guru Jambheshwar University of Science & Technology, Hisar Haryana, India Email: sainijitender5@gmail.com

INTRODUCTION

In recent past, due to growth of population the demand of agro based products was increased, which leads to increase in Agro-industries. Rice is an important part of our diet. Food security is a critical issue in the developing world. It is estimated that the 80% of world population uses rice as major source of calories [1]. India is second largest producer of rice in the world. Being the prime cereal crop in India, rice occupies an area of 42 million ha with an annual production of 76 million tons and contributing to nearly 42% of the total food grain production [2]. The mechanized sector of rice milling industry handles more than 45 millions tonnes of paddy annually. Few decades ago food grains were processed at family level before cooking but due to industrialization and global competitive market trends, it has emerged as major industrial activity in small medium sector to cater the needs of increasing population. There are large number of mills engaged in processing/milling of rice and are spread over in almost all state across the country. Rice is life to more than half of world's population [3].

Rice milling is the process of removing the husk and part of the bran from paddy in order to produce edible rice. A major part of total rice product is converted into sella or parboiled rice (partially boiled at temperature 70 °C to 100 °C). Parboiled rice production generally requires a large amount of water for soaking of the paddy. It has two simple steps i.e. soaking in hot water at 60-70°C for 3- 3.5 hrs and steaming for 15-30 min [4]. Approximately 1.0 to 1.2 liters of wastewater per kg of paddy is generated during soaking process [5]. The volume of effluent generated from sella-rice mill is approximately 0.9 to 1 L per kg of paddy processed [4]. So a huge amount of wastewater is produced in rice mill during its processing. Water pollution caused by rice mill having high levels of organic material [6]. This wastewater can cause water pollution and odour nuisance if not treated properly.

Since many years, biological treatment has been established as a cost effective method for treatment of industrial effluent containing organic materials. Anaerobic treatment processes are mostly preferred because of their low energy consumption, low nutrient requirement and energy recovery in the form of methane. Among the high rate anaerobic reactors, the UASB bioreactors are found to be much effective for treatment of wastewaters [7].The UASB bioreactor has been applied effectively for the treatment of a variety of industrial wastewaters such as dairy effluents [8], brewey effluents [9], solid food wastes [10] and rice mill wastewater [5].

The purpose of present study was to investigate the performance of UASB reactor for the treatment of rice mill wastewater having medium COD/BOD at increasing organic loading rate (OLR) and decreasing hydraulic retention time (HRT).

MATERIALS AND METHODS

Wastewater samples for present study were collected from a rice mill and preserved at 4^{o}C. The study was carried out at room temperature in glass UASB reactor having reactor volume of 2.4 litre with length 60 cms and diameter 24 cms. Initially UASB reactor was started by adding 500 ml filtrate of biogas plant sludge, 1000 ml of rice mill wastewater and remaining volume was filled with distilled water. The reactor was then kept steady state condition for two weeks to acclimatize the bacterial incolumn with substrate. After two weeks, 500 ml rice mill effluent were added to the reactor on weekly basis until more than 88.46% COD reduction was achieved. When steady state condition reached, the reactor was run in continuous mode. The study was divided into three phase i.e phase I, II and III based on increasing feed concentration i.e OLR and decreasing HRT. In phase I, II and III, influent feed concentration and HRT were 50% and 20hrs, 100% and 14 hrs and 100% and 10 hrs, respectively. The ineffluent and effluent of UASB reactor were analysed daily for their physico-chemical characteristics as per standard method of APHA [11].

RESULTS AND DISCUSION

The rice mill effluents used in UASB reactor were yellow brownish in colour having 2080 mg/L COD, 2570 mg/L total solid and 840 mg/L of VFA (Table 1). The pH of rice mill wastewater was near to neutral with abundant nutrients like nitrogen and phosphorus.

pH

As pH of rice mill effluent was 7.1, thus doesn’t require adjustment before feeding to the UASB reactor. The optimum pH range required for anaerobic degradation is 6.5 to 8.0 [12]. Figure 1 and table 2 shows pH variation of rice-mill wastewater after UASB treatment. The pH of the reactor in phase I, II and III varied from 7.18 to 8.21, 6.1 to 7.22 and 6.52 to 8.04, respectively. Initially the reactor pH was slightly acidic but it gradually reaches to optimum value in all phases of the study. The rise in the pH in the reactor might be due to utilization of VFA by methanogens [13].

Total Kjeldhal Nitrogen (TKN)

Presence of nitrogen in appropriate amount in wastewater is necessary for its treatment through biological processes. Figure 2 and table 2 shows the variation in concentration of total nitrogen. Total nitrogen of the reactor in phase I, II and III was varied from 32.2 mg/L to 3.2 mg/L, 50.4 mg/L to 14 mg/L and 57.4 mg/L to 19.6 mg/L, respectively. The result shows a progressive decrease in TKN with increase in feed concentration.

Phosphate

Figure 3 and table 2 shows the variation in phosphate concentration. The concentration of phosphate was varied from 12 mg/L to 2.46 mg/L in phase I, 20.11 mg/L to 6.51 mg/L in phase II, and 10.72 mg/L to 0.44 mg/L in phase III. Results clearly shows that HRT has no significant effects on phosphate removal as there was negligible difference in removal of phosphorus from phase II to III. Phosphate is a nutrient used by micro organism for its growth. High phosphate removal may be due to the presence of the phosphate accumulating organism (PAOs) which utilize phosphorus polyhydroxy butyrates under anaerobic condition leading to depletion in phosphate content from rice mill wastewater [14].

Sludge Profile

The VSS/TSS ratio shows the sludge profile of UASB reactor. The VSS concentration varied from 400 mg/L to 60 mg/L (85% reduction), 200 mg/L to 40 mg/L (80% reduction) and 120 mg/L to 40 mg/L (67% reduction) in phase I, II and III, respectively (Table 2). A decrease in VSS reduction was observed with increase OLR and decreasing HRT. The decrease in concentration of VSS was observed when process moved from acidogenic to methanogenic stage [15].

TSS was varied from 350 mg/L to 80 mg/L (77% reduction), 160 mg/L to 40 mg/L (75% reduction) and 240 mg/L to 40 mg/L (83% reduction) in phase I, II and III, respectively (Table 2). The VSS TSS ratio varied from 1.14 to 0.75, 1.25 to 1.0, and 0.50 to 1.0 in phase I, II and III respectively. From figure 4, it is clear that VSS TSS ratio was observed decrease with time but in phase III it increased. Less the VSS TSS ratio results in higher COD reduction [16].

VFA Alkalinity Ratio

The VFA varied from 480 mg/L to 34 mg/L (92% reduction) in phase I, 454 mg/L to 102 mg/L (77% reduction) in phase II and 514 mg/L to 128 mg/L (75% reduction) in phase III (Table 2). From phase I to III gradual decrease in VFA concentration was observed during the study period.

The total alkalinity of the rice-mill waste water was 1300 mg/L. Table 2 shows alkalinity variation during the study period. The alkalinity of the reactor in phase I, II and III varied from 1150 mg/L to 350 mg/L, 1600 mg/L to 450 mg/L and 1300 mg/L to 400 mg/L, respectively. The total alkalinity of the reactor shows regular slight decrease with time. This may be due to acidogenesis followed by methanogenesis. Same pattern of alkalinity reduction was observed by Mohan et al. [17]. It is essential that the reactor contents provide enough buffering capacity to neutralize any eventual VFA accumulation and thus prevent build-up of localized acid zones in the digester [18]. In this process, the degradation of proteins in the waste water by anaerobic treatment results in generation of alkalinity due to the reaction of ammonia with carbon dioxide and water [19].

The VFA Alk ratio is shown in figure 5. It was varied from 0.41 to 0.09, 0.28 to 0.22 and 0.39 to 0.32 in phase I, II and III, respectively. VFA alkalinity ratio in all the three phases of UASB treatment was observed within limits of operational conditions i.e less than 0.8 [20]. Result clearly shows that the performance of reactor was excellent as VFA/ALK ratio in all the three phases of study was less than 0.4 [21].

Chemical Oxygen Demand (COD)

The COD in phase I, II and III was decreased from 620 to 20 mg/L, 1260 to 140 mg/L and 1280 to 180 mg/L, respectively (Figure 6 and Table 2). The maximum COD reduction observed during the study was 97%, 88% and 86% in phase I, II and III, respectively. Results shows that a decrease in COD reduction was observed with increase in influent concentration i.e OLR and decrease in HRT. Same pattern of COD reduction was observed by Sponza et al. [22]. The decrease in COD reduction from phase II to III was very insignificant thus rice mill wastewater can be treated at higher organic load i.e influent COD 1280 mg/L and low HRT of 10 hrs.

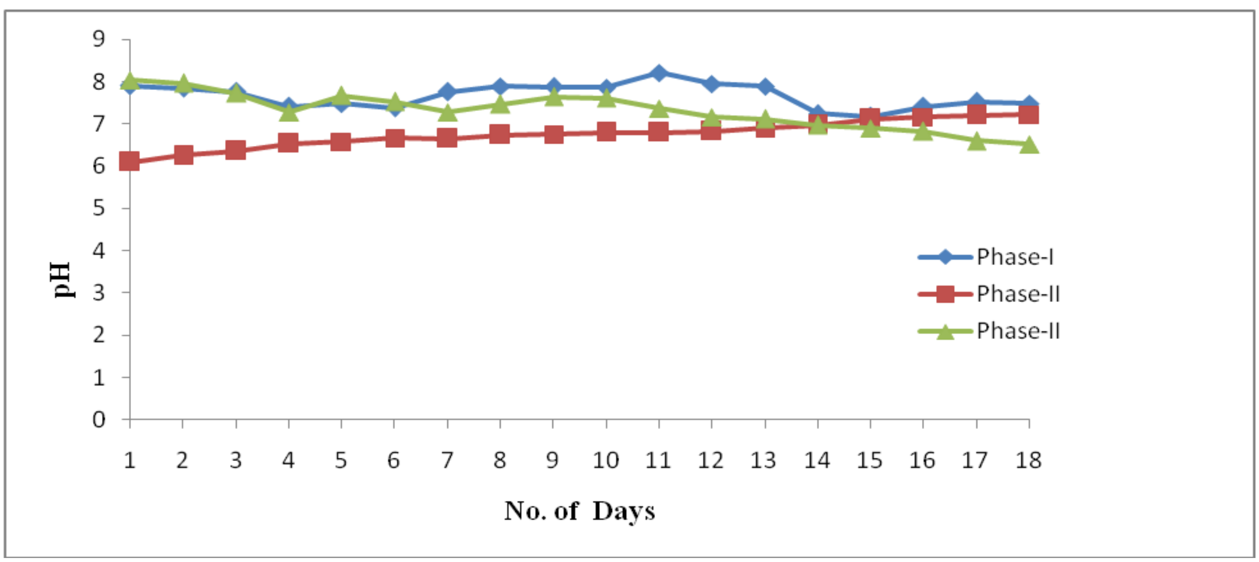

Figure-1: pH variation during the study period

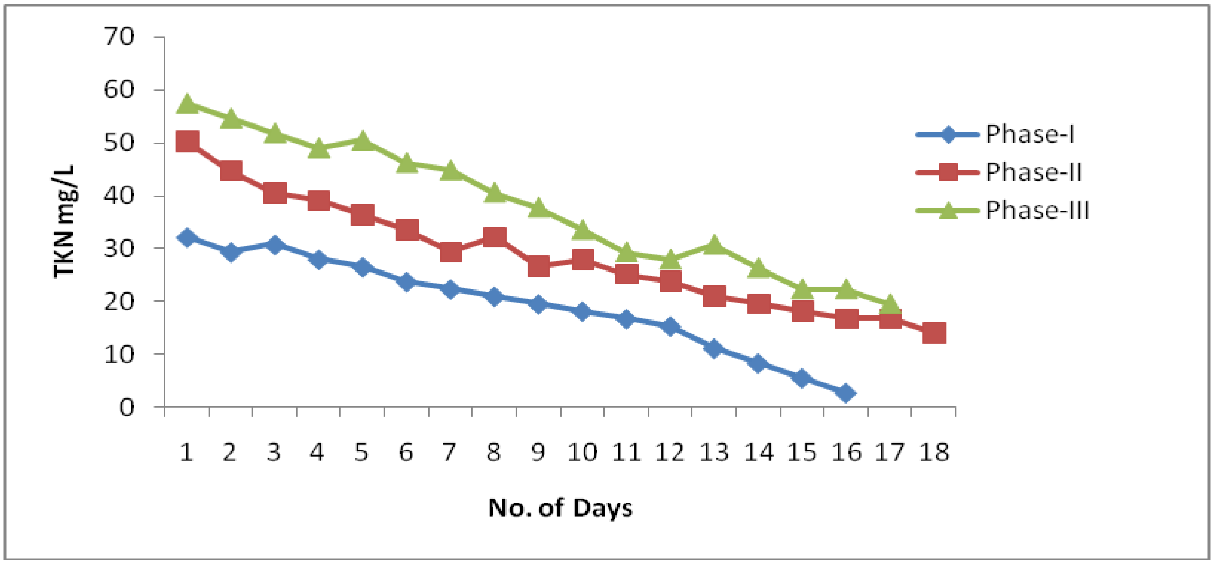

Figure-2: TKN variation during the study period

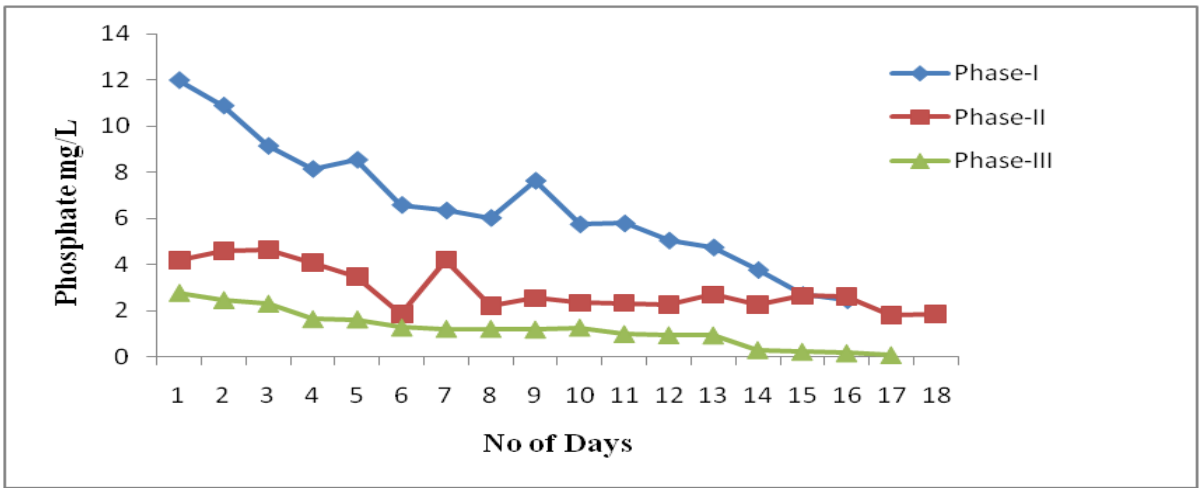

Figure-3: Phosphate variation during the study period

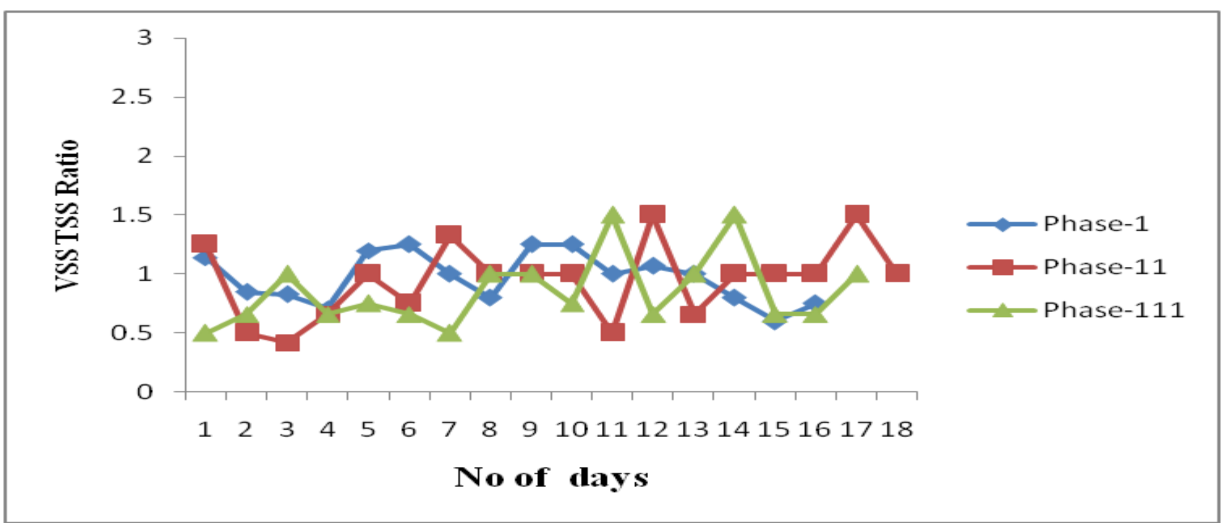

Figure-4: Sludge profile variation during the study period

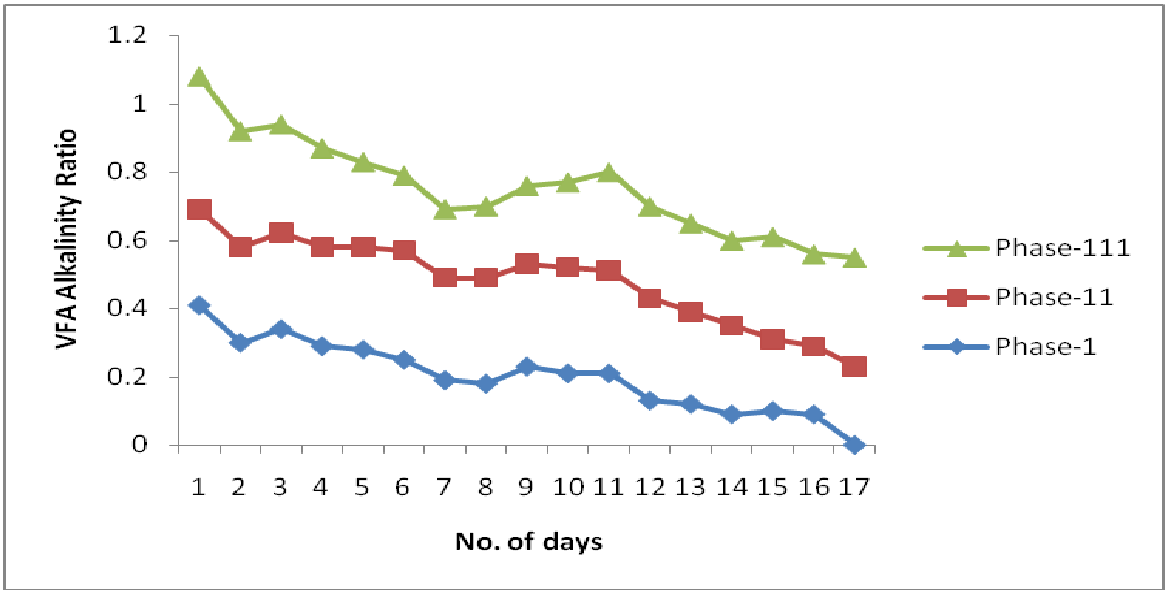

Figure-5: VFA Alkalinity ratio variation during the study period

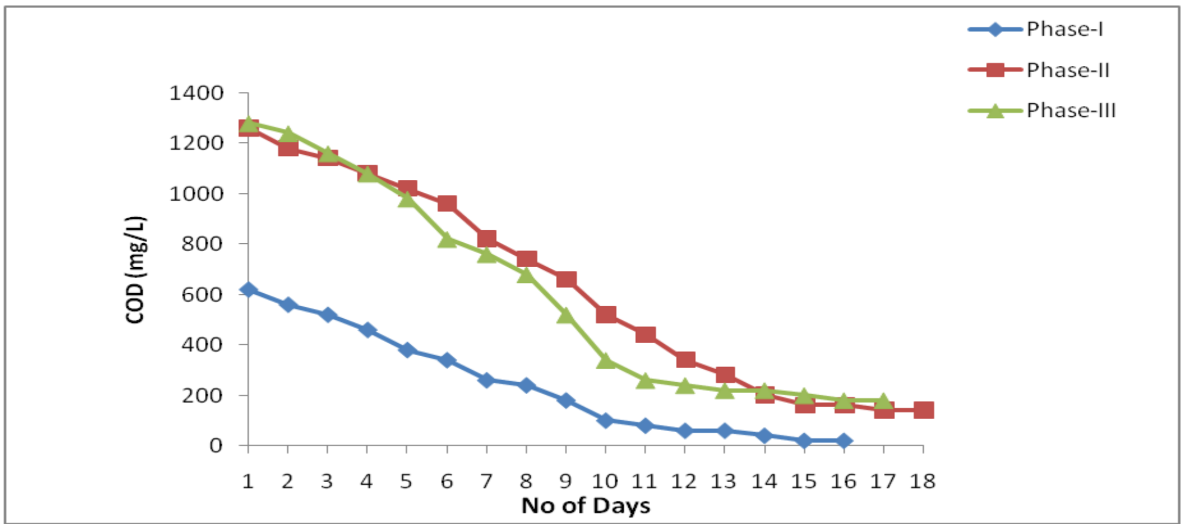

Figure-6: COD variation during the study period

Table-1: Characteristics of Rice Mill Waste Water

S. No	Parameter	Value (mg/l)
1	Color	Yellow brownish
2	Temp.	35ºC
3	pH	7.1
4	COD	2080
5	TS	2570
6	TDS	1950
7	TSS	620
8	VSS	760
9	VFA	840
10	Alkalinity	500
11	Total phosphate (PO_4)	1.9
12	TKN	7.9
13	Sodium (Na)	17.1
14	Potassium (K)	5.4
15	Sulphate	.76

Table 2: Vriation in Physico-Chemical Characteristics of Treated Rice Mill Wastewater at different HRT in phase I, II and III.

S.No	Parameters	Phase-I	Phase-II	Phase-III
1	pH	7.18 – 8.21	6.1 – 7.22	6.0- 8.04
2	COD	620- 20	1260-140	1280- 180
3	Alkalinity	1150-350	1600- 450	1300- 400
4	Volatile fatty Acid	480- 34	454- 102	514- 128
6	Total Suspended Solid	350- 80	160- 40	240- 40
7	Volatile Suspended Solid	400-60	200- 40	120- 40
8	Total Kjhedhal Nitrogen	32.2- 2.8	50.4- 14	57.4- 19.6
9	Phosphate	12 – 2.46	4.16- 1.8	2.8- .10

All the values are expressed in mg/l except pH

CONCLUSION

Anaerobic treatment by UASB reactor has enormous potential for stabilization of rice mill wastewater. The COD removal efficiencies were more than 97%, 89% and 86% respectively in phase I, II and III, respectively. Present study reveals that anaerobic treatment is good option of treatment of rice mill wastewater treatment as COD removal of 86% was achieved even at higher organic loading rate i.e 100% influent concentration and HRT of 10 hrs. VFA and COD reduction shows same pattern during rice mill effluent treatment. The UASB reactor is highly efficient and can successfully be employed for the treatment of rice mill wastewater.

REFERENCES

[1] Pooja, V.S. and Anupam, B.S. 2011. Treatment of rice mill effluent for pollution control by Electrocoagulation. Journal of Chemical, Biological and Physical Sciences, 2(1), 480-483.

[2] Rao, C.P. 2003. Nutrient utilization efficiency of rice influenced by different sources and levels of phosphorus and rates of zinc. Annals Agriculture Resources, 24, 7- 11.

[3] Ali, N. and Pandya, A.C. 1974. Basicconcept of parboiling of paddy. Journal of Agricultural Engineering Research, 19, 111–115.

[4] Paspia, H.A. and Desikachar, H.S.R. 1980. Modern process for parboiling of rice. Journal of Federation Science and Technology, 18, 84-89.

[5] Behera, M., Jana, P.S. and Ghangrekar, M.M. 2010. Performance evaluationof low cost microbial fuel cell fabricated using earthen pot with biotic and abiotic cathode. Bioresource technology, 101, 1183-1189.

[6] Manogari R. D. Daniel and A. Krastanov 2008. Biodegradation of rice mill effluent by immobilized Pseudomonas sp. Cells. Ecol. Engine. Environ. Protect. 1, 30-35.

[7] Lettinga, G., Van Velsen, A.F.M., Hobma, S.W., Zeeuw, W and Klapwijk, A 1980. Use of up-flow sludge blanket (UASB) reactor concept for biological wastewater treatment, especially for anaerobic treatment. Biotechnol. Bioeng, 22 699±734

[8] Dhabadgaonkar, S.M. and Mhaisalkar, V.A. 1995 Application of UASB process for treatment of dairy wastewaters. J. Instn. Eng. (I). 75 33±40

[9] Fang, H.H.P., Jinfu, L.G.Z., Bute, C and Guowei, G. 1990. Treatment of brewery effluent by UASB process. J. Environ. Eng. ASCE 116 454±460.

[10] Argelier, S., Delgenes, J.P., Moletta, R. 1998. Design of acidogenic reactors for anaerobic treatment of the organic fraction of solid food waste. Bioprocess Engg. 18 309±315

[11] APHA, AWWA, WEF, 2005. Standard methods for the examination of water and wastewater, 21st ed., Washington, DC, USA, ISBN: 0-87553-235-7.

[12] Shefali,V. 2002. Anaerobic digestion of biodegradable organics in municipal solid wastes. Department of Earth and Environmental Engineering, Foundation School of Engineering & Applied Science, Columbia University.

[13] Foresti, E., Zaiat, M. and Vallero, M. 2006. Anaerobic processes as the core technology for sustainable domestic wastewater treatment consolidated applications, new trends, perspectives and challenges. Environmental Science and Biotechnology, 5, 3–19.

[14] Metcalf, L. and Eddy, H. P. 2003. Wastewater Engg. Tata McGraw Hill Pub.Co. New Delhi.
[15] Ruiz, I., Soto, M., Veiga, M.C., Ligero, P., Vega, A. and Blazquez, R. 1998. Performance of and biomass characterization in a UASB reactor treating domestic wastewater at ambient temperature. Water S.A, 24, 215-222.
[16] Movahedyan., Assadi, H. A. and Parvaresh, A. 2007. Performance evaluation of an anaerobic baffled reactor treating wheat flour starch industry wastewater. Iran. Journal of Environmental Health and Science Enggineering, 4(2), 77-84.
[17] Mohan, S.V., V. Lalit Babu. and Sharma, P.N. 2007. Anaerobic biohydrogen production from dairy wastewater treatment in sequencing batch reactor (AnSBR). Enzyme and Microbial Technology, 41, 506-515.
[18] Kanat, G. and Saral, A.(2009. Estimation of biogas production rate in thermophilic UASB reactor using artificial neural networks. Environmental Model Assess, 14, 607–614.
[19] Gohil, A. and George, N. (2006). Treatment of tomato processing wastewater by an upflow anaerobic sludge blanket system. Bioresources and Technology, 97 (16), 2141- 2152.
[20] Vlissidis, A. and Zouboulis, A. L. 1993. Thermophillic anaerobic digestion of alcohol distillery wastewater. Bioresource Technology, 43, 131-140.
[21] Grady , C.P.L., Daigger, G.T. and Lim, H.C. 1980. Biological Waste Water Treatment. Marcel Dekker, New York.
[22] Sponza, D.T. 2002. Simultaneous granulation biomass retainment and carbon tetraohloride(CT) removal in an upflow anaerobic sludge blanket (UASB)reactor, Process Biochemistry, 37, 1091-1101.

INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

ISSN 2231-4490

International Journal of Plant, Animal and Environmental Sciences