"Performance Evalution Of Anaerobic Digester at Rajaram Bapu Patil Sahakari Dudh Sangh Ltd, Islampur "

Pratiksha S. Desai[1]
Asso. Prof. S.V. Kulkarni [2]
KIT's college of Engineering (Autonomous),
Kolhapur 416234, Maharashtra, INDIA.

Abstract- *With the aim of improving knowledge, about well-balanced anaerobic digestion process. All the products of a previous metabolic stage are converted into the next one without significant buildup of intermediary products. The overall result is a nearly complete conversion of the anaerobically biodegradable organic material into end products like methane, carbon dioxide, hydrogen sulfide, and ammonia. Hence, for balancing the digestion process in a proper way after studying the anaerobic digester at Rajaram Bapu Patil Sahakari Dudh sangh ltd, islampur . Found some issues regarding anaerobic digester, the study of the effect of organic loading rate (OLR) and hydraulic retention time (HRT) on the performance, stability and microbial community of the anaerobic digester. The main aim of the project for proper working of anaerobic digestion process is, The variations in the organic loading rate (OLR) and hydraulic retention time (HRT) by maintaining the flow rates/ hydraulic loading rate (HLR).*

Keyword: *organic loading rates (OLR), Hydraulic retention time (HRT), hydraulic loading rates (HLR).*

1. Introduction: In order to operate the continuous Anaerobic Digester plant, organic loading rate (OLR) and the hydraulic retention time (HRT) are principal parameters. OLR is the quantity of organic material added per unit volume of the Anaerobic Digester in a day. The mass of organic material can be expressed as volatile solids, or biological or chemical oxygen demand. Rate of methane generation is enormously dependent on the OLR. So as to get maximum yield from the specified size of the anaerobic digester plant, the OLR is to be kept as maximum, but at the greater concentration of OLR, the Anaerobic Digestion process may be inhibited because of the accumulation of volatile fatty acids that may cause a decrease of pH within the digester.

HRT is an average time to which the feedstock remained inside the anaerobic digester. Decrease in the HRT, upsurges the hazard of washout of the active bacterial population. On the contrary, the increase in the HRT increases the capital cost of the reactor. In a similar way to the OLR, there should be an optimum HRT to keep the efficient operation of the anaerobic digestion plant. The various organic loads were added in the particular range, whereas various HRTs were kept from 20-35 days. Results reveal that on the increase of the OLR, the volumetric methane production increases, without significantly compromising methane yield. On the contrary, by increasing the HRT, the volumetric methane production decreases, whereas the specific methane production increases. The optimum OLR and HRT were observed after the particular hydraulic loading rate.

- OLR fluctuations can be used to produce stability and increase performance of the anaerobic digester.
- Changes in the OLR can be used to control microbial community structure.

Digesters were exposed to one or two changes in OLR using the same or different co-substrates (Fat Oil and Grease waste (FOG) and/or glycerol). Although all the OLR fluctuations produced a decrease in biogas and methane production, the digesters exposed twice to glycerol showed faster recovery towards stable conditions after the second OLR change. The response of digesters exposed to variations in OLR depends on the past operation of the reactor and that digesters previously exposed to OLR increase recover to initial values of biogas quantity and quality faster when exposed to new OLR increase with the same influent. They also show that tolerance to increased OLR can be built in the anaerobic digesters and generate an increase in AD performance in terms of biogas quantity and quality, and most likely reducing biogas fluctuations correlated with influent variability. AD process stability is linked to the quality of the influent material entered in the system. Tolerance to increased OLR can be built in the digester.

2. Effect of environmental variations on anaerobic digester:

Generally, effluent treatment plants are subjected to variations in one or more parameters that affects the performance of digesters viz. flow rate, hydraulic retention time (HRT), temperature, pH, organic loading rate (OLR) as well as others. Some of these variations can be controlled, and digester can be designed to accommodate them.

2.1 Effect of organic and hydraulic load variations

In anaerobic digester, organic matter is converted into acid and further acids are converted into methanogenic bacteria which produces the methane gas (hydrolysis,acidogenesis, methanognesis).Making variationsin flow and concentration may affect the efficiency of anaerobic digester. Effect of fluctuations in hydraulic and organic loading rates are dependent on hydraulic retention time (HRT), solid retention time (SRT), sludge properties and digester design. Due to sudden variation in organic loading rate and hydraulic loading rate may affect the volatile fatty acids (VFA).

2.2 Effect of variations in temperature

Effect of temperature on anaerobic digester depends upon duration and sludge characteristics and sludge load. When an anaerobic digester is operated under steady state conditions, the activities of different metabolic groups are in balance. When the process is exposed to sudden temperature change, digestion process conditions can become unbalanced, due to various metabolic groups of microorganisms.

2.3 Effect of pH variations

The pH value in methanogenic phase is generally lies in between 6.3 to 7.8. the effect of drastic pH change in influents depend on available alkalinity in digester. During the experimentation there were difficulties related to pH and faced the sudden changes in pH range, so as to lower the pH we added HCL to the digester then pH resulted in between 6.60 to 6.80. further we found the gas production is increased by almost 30%-40%. But the hydrogen content remained unchanged. So that,we tested the digester after adding the NaOH to increase the pH. And observed that as pH increased gas production also increased. Based on the experimental results obtained with dairy wastewater, process efficiency recovers pH to the optimal range.

3. Objectives:

To the proposed research work there is a path of studies is finalized as per following stages:

1. To evaluate the influent, effluent characteristics of the anaerobic digester.
2. To study the removal efficiency of COD, BOD, in the digester.
3. To study the effect of variation in operational parameters such as HLR, OLR on the removal efficiencies of anaerobic digester.
4. To determine appropriate flow rates for existing system.

These objectives were followed to carried out the research work effectively.

4. Methodology:

As per the proposed research work we carried out our work in stages – Preliminary laboratory analysis, Setup at existing plant and laboratory analysis, outcomes.

5.1 Collection of the dairy wastewater samples from the Rajaram Bapu Patil sahakari dudh sangh ltd, Islampur for analysis on weekly basis.

5.2 To carry out the experimental analysis for wastewater from anaerobic digester for parameters such as pH, BOD,COD, volatile solids, VFA.

5.3 To finalize operational parameters- organic loading rate(OLR), hydraulic retention time (HRT), hydraulic loading rates (HLR)/ flow rates for digester.

5. Results and Discussion:

The samples have been collected per month during December, January, February and March. 2017-18. The samples from dairy industry are collected and analysis has carried out for better knowing the existing system.

Table 1: Influent characteristics of Anaerobic Digester

Sr. No	pH	COD	BOD	Flow
1	7.1	2960	1440	150
2	7.13	3520	1520	200
3	8.4	3600	1600	220
4	8.2	2080	1020	100
5	6.9	2640	1200	120
6	7.2	3120	1300	120
7	6.9	3500	1510	170
8	6.98	3260	1640	190
9	7.2	3340	1650	180
10	6.85	3340	1720	180

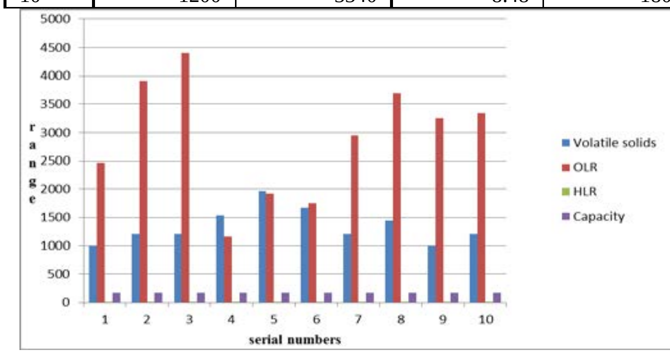
Table 2: Effluent characteristics of Anaerobic Digester

Sr. No	pH	COD	BOD	Flow
1	7.5	2420	1000	150
2	7.5	2900	1200	200
3	8.6	3000	1260	220
4	8.8	1440	950	100
5	7.6	1560	900	120
6	7.21	1700	870	120
7	7.45	1700	1200	170
8	7.21	1520	1200	190
9	7.21	1500	1260	180
10	7.10	1500	1300	180

The experimental analysis of anaerobic digester during month January for parameters like OLR, HLR, volatile solids:

Table 3: Operational Parameters of Existing Anaerobic Digester

Sr. No	Volatile solids	OLR	HLR	Capacity
1	1000	2466.7	7.06	180
2	1200	3911.1	9.425	180
3	1200	4400	10.36	180
4	1540	1155.6	4.71	180
5	1966	1920	5.65	180
6	1680	1760	5.65	180
7	1200	2946.7	8.01	180
8	1450	3694.4	8.95	180
9	1000	3260	8.48	180
10	1200	3340	8.48	180



Graph 1: Graphical representation of Operational Parameters of Existing AD.

For knowing the role of pH values in digestion process pH calculated at three stages of digestion, at Digester (top), Digester (bottom), Digester (middle). The variation of pH with digestion period is indicated in *table. 4.*

Table 4: pH values for Anaerobic Digester

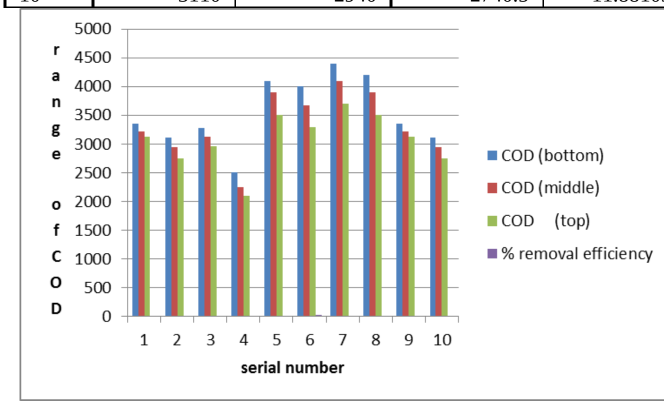
Sr. No	pH (bottom)	pH (middle)	pH(top)
1	6.85	6.98	6.57
2	6.36	7.2	7.8
3	6.4	6.85	6.9
4	6.12	6.85	7.1
5	7.2	8.12	8.48
6	7.9	9.12	7.23
7	7.67	9.2	7.8
8	6.3	6.87	7.21
9	6.69	7.67	8.48
10	6.3	6.9	8.2

From the initial pH, it decreased to 6.12 for control and 7.23 on an average at the end of the operational period. So, from the above, it can be concluded that the fluctuations observed in the present study was well within the methanogenic range, which proved that the digester could maintain the pH within a neutral range.

Graph 2: Graphical representation of pH for AD.

Table 5: COD % of removal efficiency of existing AD

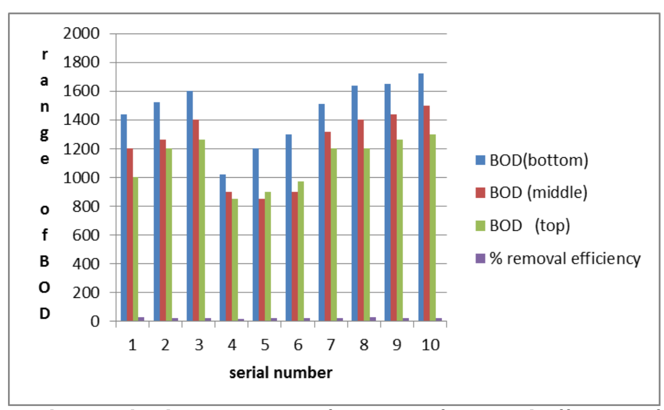
Sr. No	COD (bottom)	COD (middle)	COD (top)	% removal efficiency
1	3350	3220.86	3120.32	6.856119
2	3110	2940	2740.5	11.88103
3	3280	3120	2960.67	9.735671
4	2500	2250	2100.4	15.984
5	4100	3900	3500	14.63415
6	4000	3670	3300	17.5
7	4400	4100	3700	15.90909
8	4200	3900	3500	16.66667
9	3350	3220.86	3120.32	6.856119
10	3110	2940	2740.5	11.88103



Graph 3: Graphical representation of COD % of removal efficiency of existing AD.

Table 6: BOD % of removal efficiency of existing AD

Sr. No	BOD(bottom)	BOD (middle)	BOD (top)	% removal efficiency
1	1440	1200	1000	30.412
2	1520	1260	1200	21.052
3	1600	1400	1260	21.250
4	1020	900	850	16.666
5	1200	850	900	25.000
6	1300	900	970	23.007
7	1510	1320	1200	20.529
8	1640	1400	1200	26.829
9	1650	1440	1260	23.636
10	1720	1500	1300	24.418



Graph 4:Graphical representation of BOD % of removal efficiency of existing AD.

For finalization of operational parameters flow rates are being maintained during month February and March. The flow rates are varied 8m^3/hr., 10 m^3/hr. 12 m^3/hr. and the removal efficiencies were checked. Also the variations in organic loading rates were recorded for both the flow rates at Anaerobic Digester.

When the flow rate is maintained in between 8m^3/hr. the following are the results obtained during month of February.

Table 7: Operational parameters with flow rate of 8m^3/hr.

Sr. No	pH	COD	OLR
1	6.82	3500	3305.6
2	6.9	3770	3560.6
3	7.11	3420	3230
4	6.9	4000	3777.8
5	6.79	3300	3116.7
6	6.4	4100	3872.2
7	7.12	4200	3966.7
8	6.82	3500	3305.6
9	6.98	3770	3560
10	7.12	3300	3116.7

Table 8: COD % removal efficiency of AD for flow rate 8m^3/hr

Sr. No	COD(bottom)	COD (middle)	COD (top)	% removal efficiency
1	3960	3500	2800	29.29293
2	4100	3770	3000	26.82927
3	3700	3420	2920	21.08108
4	4400	4000	3300	25
5	3900	3300	2800	28.20513
6	4500	4100	3300	26.66667
7	4400	4200	3500	20.45455
8	3960	3500	2800	29.29293
9	3110	2940	2440.5	22. 273
10	3280	3020	2560.67	21.951

Graph 5:Graphical representation of COD % of removal efficiency of AD for flow rate 8m^3/hr.

For determining BOD^3 samples were immediately processed after Collection for the determination of initial oxygen and incubated at 27 °C for 3 days for the determination of BOD^3.

Table 9: BOD % removal efficiency of AD for flow rate 8m^3/hr.

Sr. No	BOD (bottom)	BOD (middle)	BOD (top)	% removal efficiency
1	1600	1500	1240	22.50
2	1900	1660	1400	26.31
3	1500	1440	1300	13.33
4	2020	1900	1860	8.92
5	1400	1300	1100	21.42
6	1800	1700	1660	8.77
7	1600	1460	1320	17.50
8	1620	1500	1400	14.75
9	1200	1080	950	20.83
10	1600	1460	1300	18.75

Graph 6:Graphical representation of BOD % of removal efficiency of existing AD.

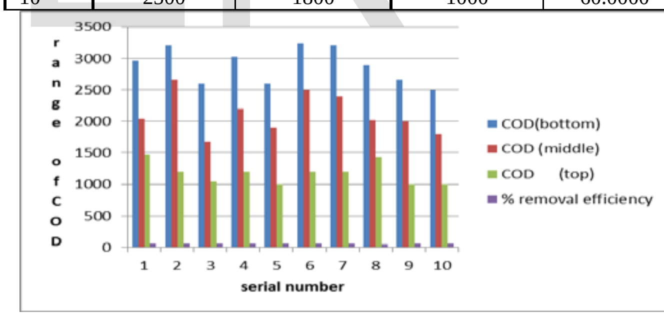
When the flow rate is maintained in between 10 m^3/hr. the following are the results obtained during month of February and some in March.

Table 10: Operational parameters with flow rate of 10m^3/hr.

Sr. No	pH	COD	OLR
1	6.9	2960	3288.88
2	5.8	3200	3555.55
3	6.66	2600	2888.88
4	6.98	3020	3355.56
5	5.70	2600	2888.88
6	5.90	3240	3600
7	7.12	3200	3555.55
8	6.58	2900	3222.23
9	5.87	2660	2955.56
10	6.24	2500	2777.78

Table 11: COD % removal efficiency of AD for flow rate 10m^3/hr

Sr. No	COD(bottom)	COD (middle)	COD (top)	% removal efficiency
1	2960	2040	1480	55.2238
2	3200	2660	1200	62.7634
3	2600	1680	1040	60.0000
4	3020	2200	1200	56.8750
5	2600	1900	1000	61.5384
6	3240	2500	1200	62.9629
7	3200	2400	1200	62.5000
8	2900	2020	1440	50.3448
9	2660	2000	1000	62.4060
10	2500	1800	1000	60.0000



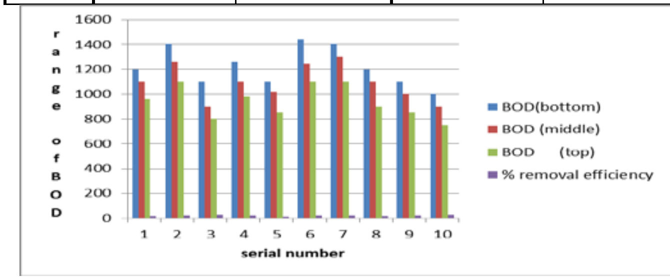
Graph 7:Graphical representation of COD % of removal efficiency of AD for flow rate 10m^3/hr.

Table 12: BOD % removal efficiency of AD for flow rate 10m^3/hr

Sr. No	BOD(bottom)	BOD (middle)	BOD (top)	% removal efficiency
1	1200	1100	960	20.00
2	1400	1260	1100	21.42
3	1100	900	800	27.27
4	1260	1100	980	22.22
5	1100	1020	850	13.72
6	1440	1240	1100	20.83
7	1400	1300	1100	21.42
8	1200	1100	900	16.67
9	1100	1000	850	22.27

ISSN 2229-5518

10	1000	900	750	25.00



Graph 8:Graphical representation of BOD % of removal efficiency of existing AD.

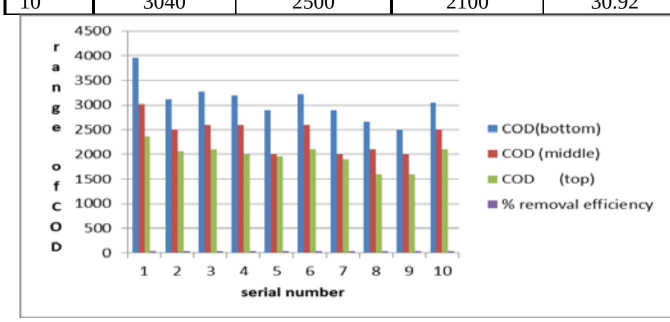
When the flow rate is maintained in between 12 m^3/hr. the following are the results obtained during month of March.

Table 13: Operational parameters with flow rate of 12m^3/hr.

Sr. No	pH	COD	OLR
1	6.70	3960	5280.00
2	6.00	3110	4116.67
3	5.90	3280	4373.33
4	7.12	3200	4266.67
5	6.24	2900	3866.66
6	6.90	3220	4293.33
7	5.97	2900	3866.00
8	6.75	2660	3546.66
9	6.70	2500	3333.33
10	6.54	3040	4053.33

Table 14: COD % removal efficiency of AD for flow rate 12m^3/hr

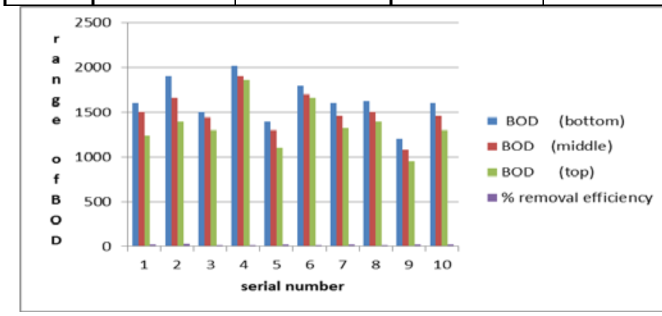
Sr. No	COD(bottom)	COD (middle)	COD (top)	% removal efficiency
1	3960	3020	2370	40.03
2	3110	2500	2060	33.76
3	3280	2600	2100	35.97
4	3200	2600	2000	37.50
5	2900	2000	1960	32.41
6	3220	2600	2100	34.78
7	2900	2000	1900	34.48
8	2660	2100	1600	39.84
9	2500	2000	1600	36.00
10	3040	2500	2100	30.92



Graph 9:Graphical representation of COD % of removal efficiency of AD for flow rate 10m^3/hr.

Table 15: BOD % removal efficiency of AD for flow rate 12m^3/hr

Sr. No	BOD (bottom)	BOD (middle)	BOD (top)	% removal efficiency
1	1600	1400	1260	21.25
2	1320	1100	1000	24.24
3	1300	1260	1000	23.07
4	1300	1140	1000	23.07
5	1000	1000	900	10.00
6	1300	1100	1000	23.07
7	1100	1000	950	13.63
8	1000	900	900	10.00
9	1060	1000	900	15.09
10	1200	1160	1000	16.67

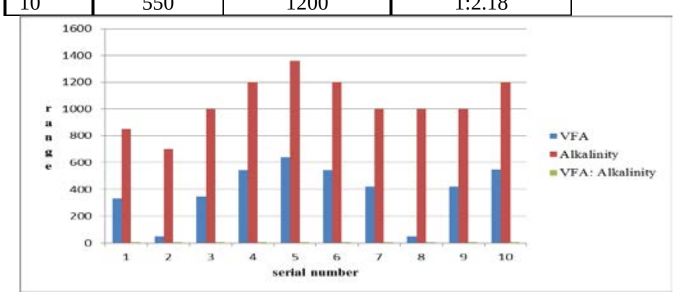


Graph 10:Graphical representation of BOD % of removal efficiency of existing AD.

Another aim of the project is to observe the volatile fatty acids (VFA) and Alkalinity ratio. Ideally this ratio is about 1:2 (i.e. 1 is VFA and 2 is alkalinity) Generally, VFAs are the useful indicators of Anaerobic Digestion process performance and stability or imbalance. The presence of higher quantities of VFAs has been reported to be inhibitory to methanogenic activity. The profile of VFA production during AD is depicted in following table. The alkalinity of a balanced process is between 1,000 and 5,000 mg CaCO3/L. The variation of alkalinity throughout the digestion period with increase in OLR values is indicated in following *table.* .

Table 16: VFA and Alkalinity ratio

Sr. No	VFA	Alkalinity	VFA: Alkalinity
1	333.33	850	1:2.5
2	47.60	700	1:14
3	345.30	1000	1:28
4	546	1200	1:2.19
5	640	1360	1:2.12
6	546	1200	1:2.19
7	420	1000	1:2.30
8	50	1000	1:20
9	420	1000	1:2.3
10	550	1200	1:2.18



Graph 11. Graphical representation of VFA and Alkalinity ratio

ISSN 2229-5518

6. Conclusion:

The performance studies on the anaerobic digester of dairy wastewater will be evaluated after analysis of the extensive experimentation will provide information about the efficiency of the anaerobic digester for effluent treatment plant for dairy wastewater, Study will be able to:

1. Examined the initial conditions of the anaerobic digestion system at ETP of Rajaram Bapu Patil Shakari Dudh Sangh ltd. Islampur.
2. Demonstrated the change in the anaerobic digester by varying the operational parameters such as, organic loading rate (OLR), hydraulic loading rate (HLR).
3. Investigated the appropriate flow rate for effective removal efficiency in digestion process.
4. Also, analyzed the correlation between the volatile fatty acids (VFA) and Alkalinity.

As per the research carried out over Anaerobic Digester, it proved that digester will work effectively at the flow rate of 10 m^3/hr. Hence, the ideal anaerobic digestion condition is totally dependent on the operational as well as the system parameters.

8. References:

1. Robert M.W. Ferguson et al. , (2016)"Organic loading rate: A promising microbial management tool in anaerobic digestion" . *journal science direct*:

2. L. Guerrero a et al, (2015) "Performance evaluation of a two-phase anaerobic digestion process" *Journal of Environmental Science and Health*

3. A. R. Sahito, et al(2015) "optimization of organic loading rate and hydraulic retention time for maximum production of methane through anaerobic codigestion" *Journal of Animal & Plant Sciences*

4. Yuling Chen ,et al (2014) "Effects of Organic Loading Rate on the Performance of a Pressurized Anaerobic Filter in Two-Phase Anaerobic Digestion" *Energies 2014*

5. M. Cornell , et al.,(2012) "Effect of increasing the organic loading rate on the co-digestion and mono-digestion of cattle slurry and maize" *Water Science & Technology*

6. Burak Demirel et al.,(2004) "Anaerobic acidogenesis of dairy wastewater: the effects of variations in hydraulic retention time with no pH control" *Journal of Chemical Technology and Biotechnology*

7. GN Demirer et al.,(2004) "Effect of retention time and organic loading rate on anaerobic acidification and biogasification of dairy manure" *Journal of Chemical Technology and Biotechnology*

8. Mariana Chavez-Vazquez et al.,(2002) "evaluation of the performance of different anaerobic digestion technologies for solid waste treatment" *Environmental Engineering.*

9. Sameer Saxena, et al.,(2017) "Performance Evaluation of Dairy Wastewater Treatment Plant" *International Research Journal of Engineering and Technology (IRJET)*

10. shiva kumar, et al.,(2014) "performance evaluation and biological treatment of dairy wastewater treatment plant by upflow anaerobic sludge blanket" *IJSRD - International Journal for Scientific Research & Development.*

11. Bharati S. Shetea et al.,(2013) "Anaerobic Reactor to Treat Dairy Industry Wastewater" *International Journal of Current Engineering and Technology*

12. Priyanka Purohit et. Al.,(2013) "Performance Evaluation of Anaerobic Digesters" *International Journal of Chemical & Petrochemical Technology (IJCPT*

13.R.Thenmozhi et al.,(2012) "Treatability Studies of Dairy Wastewater by Upflow Anaerobic Sludge Blanket Reactor" *Civil and Environmental Research.*

14. Sihuang Xie et al., (2016) "Anaerobic co-digestion: a critical review of mathematical modelling for performance optimization" *Bioresource Technology.*

15. S. Gopikumar et al.,(2015) "Evaluation of operational parameters for semicontinuous anaerobic digester treating pretreated waste activated sludge" *Desalination and Water Treatment.*

16. Dairy wastewater Handbook.

17. Metcalf and eddies "Wastewater Engineering".