BIOLOGICAL APPROACHES FOR TREATMENT OF HIGH STRENGTH INDUSTRIAL EFFLUENT

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ABSTRACT

Effluent generated from various activities of industries contains pollutants mainly biodegradable constituents (deplete DO and kill aquatic life) can be treated biologically. Biological processes (Aerobic and anaerobic processes) are useful for the degradation of biodegradable constituents into acceptable end products and also cost effective wastewater treatment as compared to physical and chemical methods. High strength effluent generally having chemical oxygen demand (COD) more than 1300mg/L preferably treated anaerobically. Anaerobic treatment is most useful (produce biogas by degradation of organic matter) and cost effective as compared to aerobic treatment for treating high strength industrial effluent. Food processing industry (milk and milk products, alcoholic beverages, grain processing etc), tannery industry are listed as highly water polluting industry.

Attached growth anaerobic biological processes are beneficial as compared to suspended growth anaerobic biological processes because they are able to withstand at high organic loading rate and shock loading, low solid retention time, low hydraulic retention time etc. Distillery industry is one of the highly water polluting industry having 5-Day BOD at 20˚C is 45,000 to 60,000 mg/L, COD 70,000 to 98,000 mg/L, Total Solids 60,000 to 90,000 mg/L, Total Dissolved Solids 67,000 to 73,000 mg/L and Total Suspended Solids 2,000 to 14,000 mg/L . Anaerobic treatment is preferably used as pretreatment step for treating high strength industrial effluent; effluent treated anaerobically may require some kind of post treatment in order to comply with the prescribed standards for disposal in inland and surface water bodies. In the present study an attempt has been made to compare the various advantages and disadvantages of suspended and attached growth anaerobic biological processes; and which should be preferably used for treating high strength industrial effluent.

Keywords: *Biological processes, high strength industrial effluent, effluent treatment, Distillery Industry, Pulp & Paper Industry, Tannery Industry*

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INTRODUCTION

Effluent generated from various industrial activities contain numerous pollutants such as pH, BOD (Biochemical Oxygen Demand),COD (Chemical Oxygen Demand), Chloride, Total Nitrogen, Total Phosphorus, Color, Sulfates, Oil & grease, Total Solids, Organic acids etc. The disposal of untreated industrial wastewater causes environmental pollution. Hence the effluent generated from various industrial activities contains high organic and inorganic substances so comprehensive treatment should be required to meet the prescribed standard prior to disposal into inland and surface water bodies. Sometimes industrial effluent is treated along with sewage but pretreatment should be required before disposal into municipal collection system e.g., distillery effluent is highly acidic in nature pH 4.5, pretreatment should be required for pH adjustment otherwise if directly dispose in municipal collection system effects on biological activity which degrade biodegradable organic compounds. In the present work we are concerned with high strength effluents generated from industries such as distillery, tannery, fertilizer, cane sugar etc, the effluent generated is highly polluted and highly organic in nature, anaerobic treatment is required as pretreatment step for degradation of organic compounds followed by aerobic treatment.

COMPARISON BETWEEN AEROBIC AND ANAEROBIC TREATMENT

Biological treatment is classified into aerobic process (micro-organism degrade biodegradable constituents in the presence of oxygen) and anaerobic processes (micro-organism degrade organic matter in the absence of oxygen). Aerobic and anaerobic treatment processes are further classified into suspended and attached growth biological treatment processes. If wastewater Chemical Oxygen Demand (COD) greater than 1500-2000 mg/L than anaerobic treatment is preferred for the degradation of organic matter. After anaerobic treatment some kind of post treatment should be required prior to disposal because effluent quality is not as good as treated with aerobic.[8]

Anaerobic treatment process is highly efficient as compare to aerobic

- Production of useful product methane from the biodegradation of organic matter
- High removal efficiency
- For high pathogen kill
- Low energy consumption
- Low nutrient requirement

- Low reactor volume
- Low biomass yield

If we treat high strength industrial effluent with aerobic treatment results into high reactor volume, high energy requirement (for aeration), high nutrient requirement and also high sludge generation and also increase the overall cost due to facility required for sludge stabilization.

Table1: Comparison of aerobic and anaerobic treatment [2]

Feature	Aerobic	Anaerobic
Organic removal efficiency	High	High
Effluent quality	Excellent	Moderate to poor
Organic loading rate	Moderate	High
Sludge production	High	Low
Nutrient requirement	High	Low
Alkalinity requirement	Low	High for certain industrial waste
Energy requirement	High	Low to moderate
Temperature sensitivity	Low	High
Start up time	2-4 weeks	2-4 months
Odor	less opportunity for odor	Potential odor problem
Bioenergy and nutrient recovery	No	Yes
Mode of treatment	total(depending on feedstock characteristics)	essentially pretreatment

Source: Chan Y.J. *et al*.(2009)

SUSPENDED AND ATTACHED GROWTH ANAEROBIC BIOLOGICAL WASTEWATER TREATMENT PROCESSES

Anaerobic processes basically involve three steps

1 Hydrolysis: that involve breakdown of complex organic material into simple monomeric unit that can be easily fermented by acidogens

2 Fermentation: In this step solubilised organic material is fermented to acetate, hydrogen and carbon dioxide, which are precursor of methane formation

3. Methanogensis: In this steps acetate split in to methane and carbon dioxide by aceticlastic methanogens and acetogens use carbon dioxide to oxidize hydrogen to form acetic acid. Acetic acid is further converted to methane**.** [8]

In the Suspended attached growth biological treatment process microorganisms remain in suspension either by mixing or some other mechanism to remain in suspension. Mixing is provided so that organic matter become properly in contact with micro-organisms, also uniformity of the proper conditions (temperature) for microbial survival. Whereas in attached growth biological treatment processes micro-organisms or biofilm is attached to some inert medium, wastewater is uniformly distributed above the surface of the biofilm so that organic matter properly gets in contact with micro-organisms.

CLASSIFICATION OF ANAEROBIC BIOLOGICAL TREATMENT PROCESSES [8]

Suspended Growth Anaerobic Biological Wastewater Treatment Processes

Complete Mix Suspended Growth Anaerobic Digester, Anaerobic Contact Process, Anaerobic Sequencing Batch Reactor, Continuous Stirred Tank Reactor (CSTR)

Attached Growth Anaerobic Biological Wastewater Treatment Processes

Upflow Packed Bed Attached Growth Reactor, Upflow Attached Growth Anaerobic Expanded Bed Reactor, Attached Growth Anaerobic Fluidized Bed Reactor, Downflow Attached Growth Anaerobic Processes

Anaerobic Sludge Blanket Processes

Upflow Sludge Blanket Reactor Process (UASB), Anaerobic Baffled Reactor, Anaerobic Migrating Blanket Reactor

Other Anaerobic Treatment Processes

Covered Anaerobic Lagoon Process, Membrane Separation Anaerobic Treatment Process

Attached growth anaerobic biological wastewater treatment processes are advantageous as compare to suspended growth anaerobic biological wastewater treatment processes

- Because it is able to withstand at high organic loading rates
- Resistance to shock loadings
- Low HRT
- Less energy required

In the suspended growth anaerobic biological wastewater treatment processes , the process is operated for several day as compare to attached growth hence high Hydraulic Retention time (HRT) & Solid Retention time (SRT), Process failure is observed under transient conditions,

Sludge wastage along effluent is observed, and also expensive due to aeration and also long residence time. These are the main disadvantages of suspended growth biological wastewater treatment process over attached growth anaerobic processes.

For the treatment of high strength industrial effluent integrated anaerobic – aerobic bioreactors are used they are cost effective and highly efficient (results in reduction of overall cost of process).

Table 2: Wastewater Characteristics of Untreated High Strength Industrial effluents

References	CPCB	Modi P.N.(2001)	Kongjo *et al.* (2008)
Characteristics	Distillery Industry	Cane sugar industry	Tannery Industry
pH	4.3-5.3	4.6-7.1	7-8.7
Total Solids (TS)	60,000-90,000	870-3500	-
Total Suspended Solids (TSS)	2,000-14,000	220-800	600-955
Total Dissolved Solids (TDS)	67,000-73,000	-	13300-19700
Total Volatile Solids (TVS)	45000- 65000	400-2200	-
COD	70000-98000	600-4380	4100-6700
BOD	45000-60000	300-2000	630-975
Total Nitrogen	1000-1200	10.0-40.0	-
Chloride	5000-8000	-	-
Sulphate	2000-5000	-	-
Acidity	8000-16000	-	-
Temperature	$70^{o}C$-$80^{o}C$	-	-

Table 3: Treatment efficiency of Integrated Anaerobic and aerobic units [2]

Type	**Type of wastewater**	**Influent COD (mg/L)**	**Total COD remov**	**Anaerobic COD removal**	**Aerobic COD remova**	**Reference**

			al (%)	**(%)**	**l (%)**	
UASB+ CSTR	Pulp & paper industry	5500-6600	91	85	-	**Tezel U. *et al.*(2001)**
UASB+ CSTR	Pharmaceutical industry wastewater	3000	97	68-89	71-85	**Sponza D.T. *et al.*(2007)**
UASB+ AS	Olive mill w/w+ municipal w/w	1800-4400	95-96	70-90	>60	**Gizgis N. *et al.*(2006)**
UASB+ AS	Starch industry w/w	20000	-	77-93	64	**Sklyar V. *et al.*(2003)**
CSTR+ Activated Sludge	Green olive debittering w/w	23500	83.5	37.4-48.9	73.6	**Aggelis G.G.*et al.*(2001)**

Source: Chan. Y.J.*et.al*.(2009)

CONCLUSIONS

Integrated anaerobic and aerobic units are highly cost effective and efficient for treating high strength industrial effluents and also comparison between suspended and attached growth processes shows that attached growth biological treatment processes are cost effective as compare to suspended growth biological wastewater treatment processes. However anaerobic processes are most suitable for treating high strength industrial effluent and also for sludges; and production of methane (useful fuel) by the degradation organic compounds and also for stabilization of sludges.

REFERENCES:

1. Aggelis G.G., Gavala H.N., and Lyberators G.,(2009),Combined, separate aerobic and anaerobic biotreatment of green olive debittering wastewater, Journal of Agricultural Engineering Research,80:283-292
2. Chan Y.J., Chong M.F., Law C.L., and Hassell D.G. (2009), A review on anaerobic aerobic treatment of industrial and municipal wastewater, Chemical Engineering Journal, 155:1-18.
3. Gizgis N., Georgious M., and Diamadopoulos E., (2006), Sequential anaerobic/aerobic biological treatment of olive mill wastewater and municipal wastewater, Journal of Chemical Technology and Biotechnology, 81, 1563-1569.
4. Kongjao S., Damronglerd S., and Hunsom M., 2008. Simultaneous removal of organic and inorganic pollutants in tannery wastewater using electrocoagulation technique, Korean Journal of Chemical Engineering, 25: 703-709.
5. Modi P.N., (2001) Sewage treatment & Disposal and Wastewater Engineering, Environmental Engineering Volume II.
6. Sponza D.T., and Demirden P., (2007), Treatability of sulfamerazine in sequential upflow anaerobic sludge blanket reactor (UASB)/ completely stirred tank reactor (CSTR) processes, Separation and purification Technology, 56,108-117.
7. Sklyar V., Epov A., Gladchenko, M., Danilovich, D., and Kalyuzhnyi, S.,(2003), Combined biological (anaerobic-aerobic) chemical treatment of starch industry wastewater, Applied Biochemistry and Biotechnology,109, 253-262
8. Tchobanoglous G., Burton F.L., and Stensel H.D., Wastewater Engineering: Treatment and Reuse, Tata, McGraw-Hill Edition.
9. Tezel U., Guven E., Erguder T.H., and Demirer G.N. (2001), Sequential (anaerobic/aerobic) biological treatment of dalaman SEKA pulp & paper industry effluent, Waste Management, 21: 717-724.