Validation of Slaughterhouse Wastewater Using Expanded Granular Sludge Bed Reactor

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Abstract

Poultry butcher houses produce enormous volumes of wastewater with astoundingly charged in dissolvable and insoluble organics. These wastewater contains huge degrees of organics, for instance, Biochemical Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), Nitrogen and Phosphorus from, for instance, blood, fat, oil, and proteins. Adequate treatment of this wastewater is fundamental before discharge as a result of the development of common issue. Poultry definition, prepared foul taking everything into account and especially those regarded for their meat and egg, as chickens, turkeys, ducks, geese and guinea foul. Anaerobic wastewater treatment offers different focal points including low ooze yield, energy recovery, slop amassing capacities, and low enhancement need. The goal is to diminish the proportion of sludge that ought to be masterminded. The most extensively used procedure for overflow treatment is anaerobic ingestion. In this cycle, a tremendous division of the characteristic issue (cells) is isolated into carbon dioxide (CO2) and methane (CH4), and this is developed without oxygen. About segment of the entirety is then changed over into gases, while the remainder of dried and transforms into an excess soil-like material. The purpose of this work is to endorse the display of Expended Granular Sludge Bed Reactor (EGSB) to treat the butcher house wastewater in a clear up stream way, expected to take out high COD capability coming about as a result of high biomass upkeep in the structure.

Keywords: Slaughterhouse granular slop bed reactor, waste water, etc.

I. Introduction

In India, there are around 4,000 selected butcher houses with the close by bodies and more than 25,000 unregistered premises, where animals are butchered to fulfill the solicitations of local buyers. Around 45-portion of the animals can be changed into edible things (MEAT). About 15% waste and the overabundance 40-45% of the animal is changed into by things, for instance, Leather, Soaps, Candles (fat) and pastes. Wastewater from slaughterhouse is a blend of the getting ready water from both the butchering line and the cleaning of the guts, which causes a gigantic assortment in the centralization of common issue. The principal poison in slaughterhouse discharge is normal issue. The dedication of characteristic weight to these effluents are gut, crap, oil, fat, and undigested sustenances, blood, suspended material, pee, free meat, dissolvable proteins, squander, waste, coarseness and colloidal particles (Bazrafshan et al., 2012). The consumed water per butchered animal is unmistakable as demonstrated by animal kind and the butchering cycle, and ranges from 1 to 8.3 m³. A critical segment of this value is discarded as wastewater, with values going from 0.4 to 3.1 m³ per butchered anima.. Metcalf and Eddy, (2003), declared wastewater age rates can be as high as 80% of the hard and fast ate up water..

II. Objectives of the Study

The destinations of the examination are portrayed underneath:

- To create trial conventions for the evaluation of high quality slaughterhouse wastewater for treatment in an Anaerobic Expanded Granular Sludge Bed Reactor.
- To create Laboratory scale AEGSBR for the evaluation of the slaughterhouse gushing.
- To gather and portray the slaughterhouse wastewater test.
- To lead a trial concentrate under fluctuating operational conditions, for example, Hydraulic Retention Time and Organic Loading Rate.
- To assess the treatment execution of the model concerning rate expulsion of COD.
- To screen the Bio-gas assortment all through the activity of the reactor.
Slaughtering Process and Techniques

- The Humane Method and Conventional Technique of Slaughter.
- Traditional and Ritualistic Slaughter
- African Traditional Slaughter
- Jewish Method/Schechita
- Muslim Method (Halal) of Slaughter
- Jhakta (Sikh) Method

Current Scenario on Indian Slaughter House

- Most of the Slaughter house are inadequate concerning fundamental workplaces like water, power, ventilation, drainage, terminated ground surface, overhead rails and trash evacuation.
- Animals are butcher in ordinary way on the open ground with/less any extra planning.

Meat Processing Plants

- Lair age
- Slaughter and Bleeding
- Dressing
- Paunch Handling
- Rendering
- Processing and Cleaning

Pollution Parameter

- Biochemical oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Chloride (Cl)
- Dry matter or Total Solids (TS)
- Grease fat and oil (FOG)
- pH
- Nitrogen (N)
- Temperature
- Turbidity and Colour
- Volatile Solids

Table - I General Biochemical Oxygen Demand (BOD)

| Source                  | BOD mg/ltr |
|-------------------------|------------|
| Poultry meat plant      | 1000 – 1200|
| Pig meat plant          | 15000 – 2000|
| Cattle/sheep meat plant | 1400 – 3200|
| Fish processing         | 1000 – 3000|
| Dairy (washing)         | 600 – 1300  |
| Natural Domestic Sewage | 250 – 300   |

Slaughterhouse Wastewater Treatment

Primary Treatment
Crucial and basic treatment before natural cycles is used to avoid sludge lightness and unit over-troubling. For starter and fundamental treatment, coarseness chambers, screens, settling tanks and separated air lightness units (DAF) are commonly used. Coarseness chambers and screen can kill particles while settling tanks dispense with fat, oil and oil (FOGs) and fine solid particles by gravity (del Nery et al., 2007; de Nardi et al., 2008). In slaughterhouse wastewater, fats add to 40% of TCOD while lipids address under 1% of SCOD anyway over 67% of particulate COD (Masse et al., 2003). Engineered coagulation and flocculation is commonly used as pre-treatment by adding ferric and aluminum salts and
aluminum-polymerised blends to dispense with turbidity, COD, and SS from slaughterhouse wastewater (Masse et al., 2003; Al-Mutairi et al., 2004). By applying different coagulants and flocculants, past what 90% of SS can be profitably dispensed with while gigantic assortments in COD and Oil and Grease 10 departures have been seen (Table 2.2). Other basic/pre-treatment headways have similarly been assessed, for instance, hydrolysis pretreatment (Masse et al., 2001 and 2003), and electrocoagulation (Bayramoglu et al., 2006; Bayar et al., 2011). Basic and basic treatment of slaughterhouse wastewater is summarised in Table 2.2. Powerful SS and COD departures are cultivated by using DAF and coagulation.

**Secondary Treatment**
Basic or potentially substance pretreatment isn’t sufficient to diminish poisons to satisfy discharge rules. Given the high biodegradability of slaughterhouse wastewater, natural cycles are seen as sensible for slaughterhouse wastewater treatment. Couillard et al. (1989) investigated the thermophilic lively cycle treating slaughterhouse wastewater at 52 - 58 °C in a semi-reliably dealt with bioreactor and achieved over 93% of COD departure and 72 - 90% of orthophosphate ejection. High operational temperature and short SRT are the musings behind the thermophilic oxygen devouring cycle, anyway limit its application basically. Anaerobic assimilation has been represented to vanish above issues, for instance, upflow anaerobic sludge cover reactor (UASB) (Sayed et al., 1987; Manjunath et al., 2000; Nery et al., 2001; Caixeta et al., 2002), anaerobic channels (Campos et al., 1986; Ruiz et al., 1997), fluidized-bed reactors (Borja et al., 1989), fixed-bed reactors (Tritt et al., 1992; Saddoud et al., 2007), and anaerobic baffled reactors (ABR) (Barber and Stuckey, 1999). Differentiated and the oxygen devouring cycle, anaerobic systems were found to have high characteristic clearing efficiencies with lower costs. 70% - 95% of COD ejection can be cultivated by using UABR developments anyway with low N and P clearings (Table 2.3). Due to issues of high assortment of SS, low slop quality and floating fats, anaerobic osmosis structures anticipate that progression should avoid those detriments. Masse et al. (2003) got hydrolysis pretreatment for fat degradation during the anaerobic absorption measure. Manjunath et al. (2000) used a DAF cycle as pretreatment for UASB structures.

**Slaughterhouse Wastewater**
Rough slaughterhouse wastewater was assembled from the chidambaram market of a local slaughterhouse and set aside in the exploration community at for test use. The credits of the slaughterhouse wastewater are showed up in Table.

![FIG 1.1 Slaughterhouse Process Flow Diagram](image)

**III. Methodology**
The present exploratory work was done to evaluate the introduction of anaerobic expanded granular slime bed reactor for the clearing of organics in the butcher wastewater. A schematic outline of an EGSB reactor is showed up in Figure 3.1. The preliminary examination office model was included plexiglass. The reactor includes a segment partition 9.54 liters and a gas-solid separators (GSS) package 4.93 liters. The height and inside estimation of the chamber section segment are 121.5 cm and 10 cm. The working volume of the reactor is 14.47 liters including GSS. The real component of the exploratory plan is showed up in Table 3.1. A variable speed of peristaltic siphon (PP-10) was used to control the stream rate. The photographic point of view on the exploratory plan is showed up in Figure 3.3.
Figure 3.1 Flow Chart of Experimental Methodology

Fig. 3.2 Schematic of Anaerobic

Expanded Granular sludge bed reactor
- Influent tank
- Peristaltic Pump
- Sampling Ports
- Effluent tank
- Bio gas collecting jar
- EGSBR
Table 3.1 Physical features and process parameters of experimental model

| Specification                        | Dimensions |
|--------------------------------------|------------|
| Total height of the reactor          | 152.5 cm   |
| Column portion                       | 121.5 cm   |
| Diameter of the cylinder column      | 10 cm      |
| Triangle portion                     | 9 cm       |
| Total liquid volume                  | 14.47 liters |
| Peristaltic pump                     | PP – 10 model |
| Free board                           | 11 cm      |

Monitoring parameters
The lab model of an anaerobic expanded granular seepage bed reactor was endlessly worked all through the assessment time period and the going with limits were checked.

- Influent COD mg/l.
- Influent flow rate, l/day.
- Effluent COD mg/l.
- Hydraulic Retention Time, days.
- Organic Loading Rate, kg COD /m³.day.
- \( p^H \)
- Turbidity (NTU).
- Bio gas, ml/minute.

Characterization of Slaughterhouse Wastewater
The butcher house spouting was assembled from the market zone of Chidambaram Municipality. The models were depicted by the Standard philosophy (APHA 2005) which are presented in Table 3.2.

Table 3.2 Characterization of real time slaughterhouse wastewater

| Sl. No. | Parameters                             | Raw wastewater | Desirable limit of IS 10500 |
|---------|----------------------------------------|----------------|----------------------------|
| 1.      | \( p^H \)                              | 6.9            | 6.5 to 8.5                 |
| 2.      | Total solids, mg/l                     | 8820           | 500                        |
| 3.      | Total volatile solids, mg/l            | 2400           | -                          |
| 4.      | Suspended solids, mg/l                 | 2200           | 100                        |
| 5.      | Chemical oxygen demand(COD) ,mg/l      | 2080           | 250                        |
| 6.      | Biochemical oxygen demand(BOD₅),mg/l   | 1120           | 30                         |
| 7.      | Turbidity, NTU                         | 31.5           | 1                          |
| 8.      | Phosphorous, mg/l                      | 55             | -                          |
| 9.      | Sodium, mg/l                           | 680            | 200                        |
| 10.     | Potassium, mg/l                        | 90             | -                          |
| 11.     | TKN, mg/l                              | 480            | 100                        |
Results

Startup Process
The influent and gushing examples from the reactor were gathered once in three days and were broke down right away. At first, the influent was gathered from the treatment office at Annamalai University and feed to the reactor with a COD of 440mg/l with an OLR of 0.0085Kg COD/m³.d. The low introductory stacking rate was suggested for the effective beginning up of AEGSB. A low starting natural stacking rate was valuable for the development of anaerobic dynamic muck and the low COD natural stacking brought about low creation of gas rate and low wastewater up-stream speed. Brief beginning up is fundamental for the exceptionally proficient activity of AEGSB, because of moderate development paces of anaerobic microorganisms, particularly Methane delivering microbes.

Stabilization process
The start up period is considered as the period taken for stable movement to be refined. This is a vital development for the consistent movement of the AEGSB and other anaerobic reactors at an arranged normal stacking rate (OLR). One of the focal issues zeroed in on is the vaccination with phenomenal methanogenic overflow. Likewise, working temperature is unquestionable during fire up. In this work, the AEGSB reactor, ensuing to developing, was worked at a temperature some place in the scope of 24°C and 37°C (Mesophilic range). The COD removal rate, during first fifteenth day, was low in the extent of 10-20%. The low capability in departure close to the beginning of the cycle is inferable from the biomass change in the new atmosphere. The low removal adequacy during fire up stage, can be attributed to the presence of un changed seed slop. During the hour of 36 to 60 days, moderate departure of COD was cultivated. The reactor achieved a reliable state from 55 to 60 days with a COD removal efficiency of 76% was cultivated in (Figure 4.1).

![Figure 4.1 Time in days with Respect to % COD Removal Efficiency](image)

Performance of the AEGSB reactor
The continuous slaughterhouse wastewater was used during the preliminary examination time frame. The AEGSB reactor was guided with three plan of ordinary COD stacking with 1752, 1744, 1820 mg/l and the stream rates, for instance, 15.120, 12.240, 9.360, 6.480 and 3.600 l/day continually using peristaltic siphon. The influent COD of the slaughterhouse wastewater was going from 1520 to 2080 mg/l with HRT of 2.00, 2.18, 3.20, 4.13 and 8.16 days. The Performance of AEGSB reactor treating slaughterhouse wastewater for three ordinary influent COD obsession were presented in Table 4.1, 4.2 and 4.3.

| Sl. No. | Flow rate l/day | HRT, days | OLR,Kg COD/m³.day | pH | Influent COD, mg/l | Effluent COD, mg/l | %COD removal Efficiency | Gas Conversion, ml/minute |
|--------|-----------------|-----------|-------------------|----|-------------------|-------------------|------------------------|--------------------------|
| 1      | 15.120          | 2.00      | 0.017             | 6.75 | 1680              | 560               | 66.67                  | 76                       |
| 2      | 12.240          | 2.18      | 0.015             | 7.85 | 1840              | 568               | 69.13                  | 102                      |
| 3      | 9.360           | 3.20      | 0.011             | 8.40 | 1760              | 720               | 59.09                  | 98                       |
| 4      | 6.480           | 4.13      | 0.082             | 7.20 | 1840              | 728               | 60.43                  | 105                      |
| 5      | 3.600           | 8.16      | 0.039             | 7.86 | 1600              | 512               | 68.00                  | 121                      |
Table 4.2. Performance of AEGSBR treating slaughterhouse wastewater for an average influent COD of 1744 mg/l

| Sl. No. | Flow rate l/day | HRT, days | OLR, Kg COD/m³.day | pH | Influent COD, mg/l | Effluent COD, mg/l | %COD removal Efficiency | Gas Conversion, ml/ minute |
|---------|----------------|-----------|--------------------|----|-------------------|-------------------|------------------------|---------------------------|
| 1.      | 15.120         | 2.00      | 0.017              | 6.75 | 1680              | 560                | 66.67                  | 76                        |
| 2.      | 12.240         | 2.18      | 0.015              | 7.85 | 1840              | 568                | 69.13                  | 102                       |
| 3.      | 9.360          | 3.20      | 0.011              | 8.40 | 1760              | 720                | 59.09                  | 98                        |
| 4.      | 6.480          | 4.13      | 0.082              | 7.20 | 1840              | 728                | 60.43                  | 105                       |
| 5.      | 3.600          | 8.16      | 0.039              | 7.86 | 1600              | 512                | 68.00                  | 121                       |

Table 4.3. Performance of AEGSBR treating slaughterhouse wastewater for an average influent COD of 1820 mg/l

| Sl. No. | Flow rate l/day | HRT, days | OLR, Kg COD/m³.day | pH | Influent COD, mg/l | Effluent COD, mg/l | %COD removal Efficiency | Gas Conversion, ml/ minute |
|---------|----------------|-----------|--------------------|----|-------------------|-------------------|------------------------|---------------------------|
| 1.      | 15.120         | 2.00      | 0.015              | 7.86 | 1520              | 1120              | 70.00                  | 142                       |
| 2.      | 12.240         | 2.18      | 0.017              | 8.20 | 2080              | 680               | 67.00                  | 180                       |
| 3.      | 9.360          | 3.20      | 0.013              | 7.51 | 1750              | 500               | 64.04                  | 216                       |
| 4.      | 6.480          | 4.13      | 0.850              | 7.20 | 1900              | 450               | 78.03                  | 284                       |
| 5.      | 3.600          | 8.16      | 0.460              | 7.15 | 1850              | 290               | 84.32                  | 332                       |

**Effect of Hydraulic Retention Time**

The introduction ascribes of HRT in days with respect to rate COD departure viability is showed up in Figure. 4.3. The overall show of the EGSB reactor at room temperature 240 to 370°C between the upkeep time and COD clearing viability. The most extraordinary COD departure was cultivated at 84.32% with an OLR of 0.460 Kg COD/m³.day. As a result of the serious degree of organics is in suspended structure supports the higher capable degradation in the reactor. The Bio gas change with respect to HRT as showed up in Figure 4.5 focused the most extraordinary change was gotten at 8.16 days. The change was not progressive since it was fluctuating one, and it occurred considering the starvation of the living things and besides the pH and normal conditions inside the reactor. The credits twists were drawn for the effect of pH concerning Hydraulic Retention Time (HRT) as showed up in Figure 4.4. The exuding pH in Stage 1 dropped from 8.40 to 6.72 due to an extended methanogenic activity. During this period, there were slight changes in the pH. Further, the decline in the HRT caused liberal change in the pH profile of the reactor system with ordinary radiating pH in Stage 3 is being 7.86, 8.20, 7.51, 7.20 and 7.15 with the HRT of 2.0, 2.18, 3.20, 4.13 and 8.16 days. The assessment of pH insignificantly waver during this stage exhibits the power of destructive maturing over methanogens. It shows strong anaerobic atmosphere, which is incredible for methanogenic living things.

**Effect of Organic Loading Rate**

The most extraordinary change of biogas was refined at 332 ml of gas/minute with an OLR of 0.460 Kg COD/m³.day. The graphical depiction of OLR in Kg COD/m³ day concerning biogas change is showed up in Figure 4.7. The pH obsession was assessed for various extents of COD with contrasting OLR were spoken with in Figure 4.6. The OLR was gradually extended from 0.01353 to 0.850 Kg COD/m³.days. The COD clearing capability was cultivated at a constraint of 84.32% at an OLR of 0.460 Kg COD/m³.days Figure 4.8.
Figure 4.3 HRT in days Vs % COD removal efficiency

Figure 4.4 HRT in days Vs effluent pH

Figure 4.5 HRT in days Vs Bio-gas conversion, ml/minute

Figure 4.6 OLR in kg COD/m³.day Vs effluent pH
Scanning Electron Microscopy (SEM) analysis

The model was seen under various enhancements in a Scanning Electron Microscopy Figure 4.9. A huge bit of the examinations were based on the microbial people scattering in the AEGSBR, and the results showed midway contrast of microbial people apportionment under different preliminary conditions (Sallis P.J and Uyanik S, 2003). In this examination, the slop was light hearty shaded and was taken from the reactor for SEM evaluation.

IV. Conclusions

The discussions of slaughterhouse wastewater under changing working conditions were likely analyzed in the past parts. Considering the test outcomes and assessments, the presentation of the AEGSB structure is extraordinarily sensible for getting slaughterhouse wastewater wipe out great common toxins. The water fueled support time was satisfactory to think about degradation of organics in the reactor. The best COD ejection efficiency was refined at 84.32% with a HRT of 8.16 days. The better Organic Removal Efficiency in regards to level of COD ejection is most prominent with an OLR of 0.460 kg COD/m3.day. Keeping up a sensible and stable pH inside the reactor was a critical subject for methanogenic works out. Graph of anaerobic treatment is a result of different central focuses, for instance, low energy use, low compound use, low seepage creation, less equipment required. Finally according to the result of this examination, the AEGSB reactor developing with granular ooze shows extraordinary cycle execution for the treatment of butcher house wastewater at room temperature. The temperature was the determinant factor for achieving high efficiency. The AEGSB reactor can prepared to apply for the treatment of some other excellent wastewater as well.

V. References

1. Ameen Sarairah and Ahmad Jamrah (2008) “Characterization and Assessment of Treatability of Wastewater Generated in Amman Slaughterhouse”, Dirasat, Engineering Sciences, Volume 35, No. 2008
2. APHA (2005), “Standard Methods for Examination of Water and Waste Water. (20th edn)”, American Public Health Association, Washington DC.
3. Budiyono, Widiasa, and Seno Johari (2010) Study on Treatment of Slaughterhouse Wastewater by Electrocoagulation Technique. Internat. J. of Sci. and Eng. Vol. 1(1):25-28, July 2010, Budiyono et al. ISSN : 2086-5023 (online version)25
Biogas from Slaughterhouse Waste: Towards an Energy Self

Budiyono (2011) “Study on Slaughterhouse Wastes Potency and Characteristic for Biogas Production”, Internat. J. of Waste Resources, Vol. 1(2):4-7, Sept. 2011.

Ciro Bustillo-Lecompte, Mehrab Mehrvar, Edgar Quiñones-Bolaños (2016) “Slaughterhouse Wastewater Characterization and Treatment: An Economic and Public Health Necessity of the Meat Processing Industry in Ontario, Canada”, Journal of Geoscience and Environment Protection, 2016, 4, 175-186.

Dipti Giri (2015) “Slaughterhouse wastewater treatment by anaerobic fixed film fixed bed reactor packed with special media”, Volume-5, Copyrights@2015 ISSN-2231-4490.

Edris Bazrafshan (2012) “Slaughterhouse wastewater treatment by combined chemical coagulation and electro coagulation process, Plos One www.plosone.orgs. Volume 7

Gajender C Sunder and Shanta Satyanarayan(2013) “Efficient Treatment Of Slaughter House Wastewater By Anaerobic Hybrid Reactor Packed With Special Floating Media”, International Journal of Chemical and Physical Sciences|CPS Vol. 2, Special Issue - March 2013.

Gasca and López (2010), “Kinetics of Organic Matter Degradation in an Upflow Anaerobic Filter Using Slaughterhouse Wastewater”, Volume 1• Issue 2•1000106 Research Article open access Freely available

Hamdy Seif and Amal Moursy (2001) “Treatment Of Slaughterhouse Wastes Sanitary Eng”, Dept., Faculty Of Eng., Alexandria University, Egypt.

Javed Ahmad and Touseef A. Ansari . (2012) “Biogas from Slaughterhouse Waste: Towards an Energy Self-Sufficient Industry with Economical Analysis in India, ISSN:1948-5948 JMBT, an open access journal.

Kabdaşlı (2009), “Application of struvite precipitation coupled with biological treatment to slaughterhouse wastewaters”, Environmental Technology Vol. 30, No. 10, September 2009, 1095–1101 ISSN 0959-3330 print/ISSN 1479-487X online © 2009 Taylor & Francis

Manzanzi Maroneze (2014) “Treatment of cattle-slaughterhouse wastewater and the of sludge for biodiesel production by microalga heterotrophic bioreactors”, Sci. Agric. v.71, n.6, p.521-524.

Massé D.J and Masse L. (2000) “Characterization Of Wastewater From Hog Slaughterhouses In Eastern Canadand Evaluation Of Their In-Plant Wastewater Treatment Systems Agriculture and Agri-Food Canada”, P.O. Box 90, 2000 Route 108 East, Lennoxville, QC, Canada J1M 1Z3. Agriculture and Agri-Food Canada contribution No. 660.

Metcaf and Eddy(2003), “ Text book on Wastewater Engineering: Treatment and Reuse”.

Miranda L. A. S (2005) “A full-scale uasb reactor for treatment of pig and cattle slaughterhouse wastewater with a high oil and grease content”, Brazilian Journal of Chemical Engineering, Vol. 22, No. 04, pp. 601 - 610.

Natássia Jersak Cosman1*, Benedito Martins Gomes2, Simone Damasceno Gomes2, Ana Paula Resende Simiquel3 and Glauce Maria Pastore3 (2017) “Use of biosurfactant surfactin produced from cassava wastewater for anaerobic treat ment of effluent from a poultry slaughterhouse”, Vol. 16(5), pp. 224-231, 1 February, 2017

Vidhya, K., & Kandasamy, S. (2016). Experimental Investigations on the Properties of Coal-Ash Brick Units as Green Building Materials. International Journal of Coal Preparation and Utilization, 36(6), 318–325.

Sudharsan, N., & Grant, B. C. J. (2018). Comparison of static response of laced reinforced concrete beams with conventional reinforced concrete beams by numerical investigations. International Journal of Civil Engineering and Technology, 9(8), 700–704

Ping F. Wu and Gauri S. (2011) “Characterization of provincial inspected slaughterhouse wastewater in Ontario, Canada, School of Engineering, University of Guelph, Guelph, Ontario, Canada”, N1G 2W1, Volume 53.

Pradyut Kundu (2013) “Treatment of Slaughter House Wastewater in a Sequencing Batch Reactor: Performance Evaluation and Biodegradation Kinetics”, Hindawi Publishing Corporation BioMed Research International Volume 2013, Article ID 134872.

Rajakumar R. (2010) “Treatment of poultry slaughterhouse wastewater in upflow anaerobic filter under low upflowwelocity”, Int. J. Environ. Sci. Tech., 8 (1), 149-158, Winter 2011.

Seni Karnchanawong and Wachara Phajee(2009), “Effects of Upflow Liquid Velocity on Performance of Expanded Granular Sludge Bed (EGSB) System”, International Journal of Civil and Environmental Engineering 1:3 2009

Stets (2014), “Microbial community and performance of slaughterhouse wastewater treatment filters”, Genetics and Molecular Research 13 (2): 4444-4455 (2014).

Vidhya, K., & Kandasamy, S. (2013). Study on properties of bricks manufactured using fly ash and pond ash. Pollution Research, 32(2), 405–409.

Vidhya, K., & Kandasamy, S. (2014). Study on the flexural strength of coal ash brick masonry wall elements. Journal of Structural Engineering (India), 41(4), 410–419.

N. Sudharsan, T. Palanisamy, S. C. Yaragal, (2018), Environmental sustainability of waste glass as a valuable construction material - A critical review. Ecology, Environment and Conservation, 24 pp. S331–S338.

Sudharsan, N., & Saravanaganesh, S. (2019). Feasibility studies on waste glass powder. International Journal of Innovative Technology and Exploring Engineering, 8(8), 1644–1647.