# BIOLOGICAL LIQUEFACTION AND ANAEROBIC DIGESTION OF WASTE FLESHINGS INTEGRATED WITH SLUDGE AND BIO-ENERGY GENERATION – A NOVEL AND SUSTAINABLE DEVELOPMENT

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**ABSTRACT**

The safe disposal of large amount of solid wastes from tanneries such as unutilized fleshing and sludge from effluent treatment plants are major challenges and disposal of sludge in the Secure Land Fill (SLF) system is becoming prohibitive and environmentally challenging. The tanneries in Asia process 8 → 9 million tons of hides and skins per year and generate 3 to 4 million tons of solid waste and 2.5 to 3.5 million tons/year of dewatered sludge from effluent treatment plants. The disposal of sludge and solid waste especially about 1.0 million tons of fleshing are becoming a major environmental challenge.

The biological liquefaction of waste / unutilized fleshing in pilot scale by mixing with active bio-sludge / liquid from Anaerobic Digester could be achieved with a detention time of 7-8 days under atmosphere temperature of 20-35°C. Biologically liquefied fleshing is mixed with bio-sludge from effluent treatment plant with 4-6% solids concentration. Anaerobic Digestion is effective with a detention time of 30 days and generates 0.5m3 of bio-gas per kg of COD removal. Bio-gas is collected and stored in gas balloon and further converted into electricity using Gas Engine. The digested sludge is dewatered and converted into fertilizer by composting process.This unique and sustainable technological development will reduce the generation of hazardous category sludge and environmental issues in the disposal of unutilized fleshing.

*Key words : Biological liquefaction, Environmental issue, Anaerobic digester, Fleshing from Tanneries, Fertilizer.*

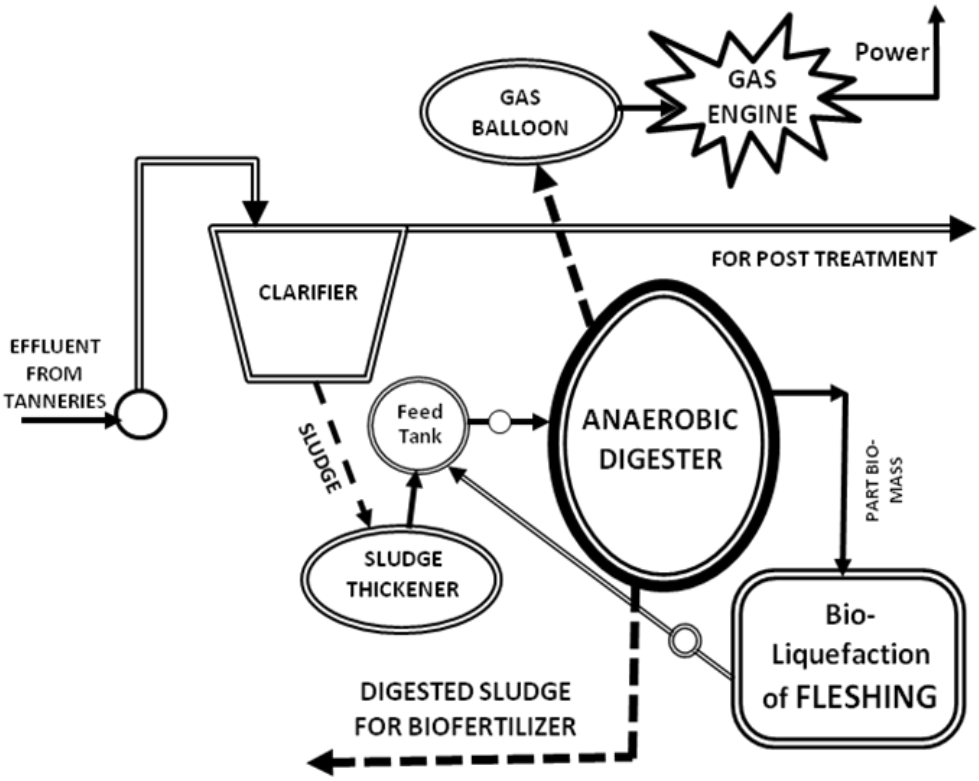
## 1. INTRODUCTION

The safe disposal of large amount of solid wastes from tanneries such as unutilized fleshing and sludge from effluent treatment plants are major challenges and disposal of sludge in the Secure Land Fill (SLF) system is becoming prohibitive and environmentally challenging. The tanneries in Asian countries process 8 → 9 million tons of hides and skins per year and generate 3 to 4 million tons of solid waste and 2.5 to 3.5 million tons/year of dewatered sludge from effluent treatment plants. The disposal of sludge and solid waste specifically waste fleshing are becoming a major environmental challenge. The tanneries processing raw hides and skins generate 10-15% of fleshing as wet solid waste. It is estimated annually on an average 1.0 million tons of fleshing are generated from Asian tanneries. The demand for conversion of fleshing into glue for wood works and other products are reducing due to the replacement by synthetic adhesives. Newenvironmental pollution control norms such as reduction in volatile organic matter in the sludge for disposal into Secured Land Fill (SLF) and lack of capacity requirement for establishment of organized unit for conversion into useful products, many small-scale unorganized units handling / processing waste fleshing vanished in many tannery clusters. Hence, it is becoming a necessary to develop and establish a viable environmental solution such as biological liquefaction, anaerobic digestion with bio-energy generation and bio-fertilizer to ensure safe disposal of waste fleshing and sludge.

## 2. METHODOLOGY OF BIOLOGICAL LIQUEFACTION

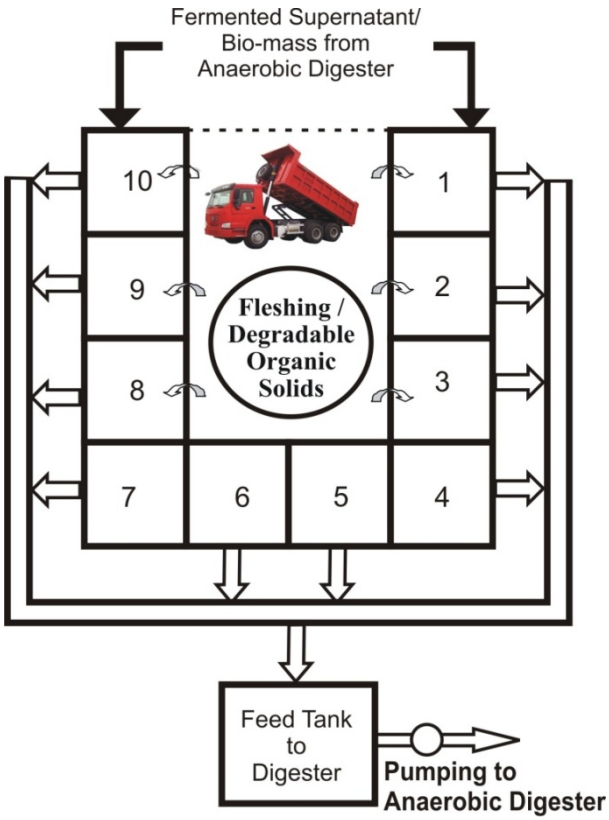
With a view to reduce the sludge generation from tannery effluent treatment plants and conversion into bio-energy and bio-fertilizer an anaerobic digestion system has been developed and applied on commercial scale under Indo-Dutch Technical Co-operation in the area of Environmental Protection to address the Leather industrial wastes. During the up-scaling of anaerobic digestion, an innovative development of biological liquefaction of waste fleshing by fermentation using part of bio-sludge from Anaerobic Digester was made and the liquefied fleshing successfully converted into bio-energy and bio-fertilizer.This innovation is separation of liquefaction process of the bio-mass mainly by enzymes and anaerobic digestion mainly by methane producing bacteria in different units. A part of active bio-mass from Anaerobic Digester is collected and slowly mixed with fleshing in serious of tanks for fermentation & liquefaction with a detention time of 7-10 days under atmosphere temperature of 18-35$^{o}$C. The biologically liquefied fleshing becomes a fine slurry with high concentration of COD in the range of 20000 - 30000mg/l.

The process of biological liquefaction and anaerobic digestion is shown in the following process flow diagram.




**ANAEROBIC DIGESTION OF SLUDGE WITH LIQUEFIED FLESHING**

The addition of Fermented Supernatant/Bio-mass from Anaerobic Digester, collection of waste fleshing from tanneries, making into small pieces / mincing by mechanical and mixing of fermented supernatant and fleshing in tanks are the main physical activities. Maintenance of detention time of 7-10 days for biological liquefaction by gentle intermittent stirring, collection of liquefied fleshing at the bottom of tanks and pumping the liquefied fleshing with high COD of 20000-30000 mg/l to the anaerobic reactor are shown in the following diagram.




BIOLOGICAL LIQUEFACTION OF FLESHING

## 3. FEED CHARACTERISTICS AND ANAEROBIC REACTION

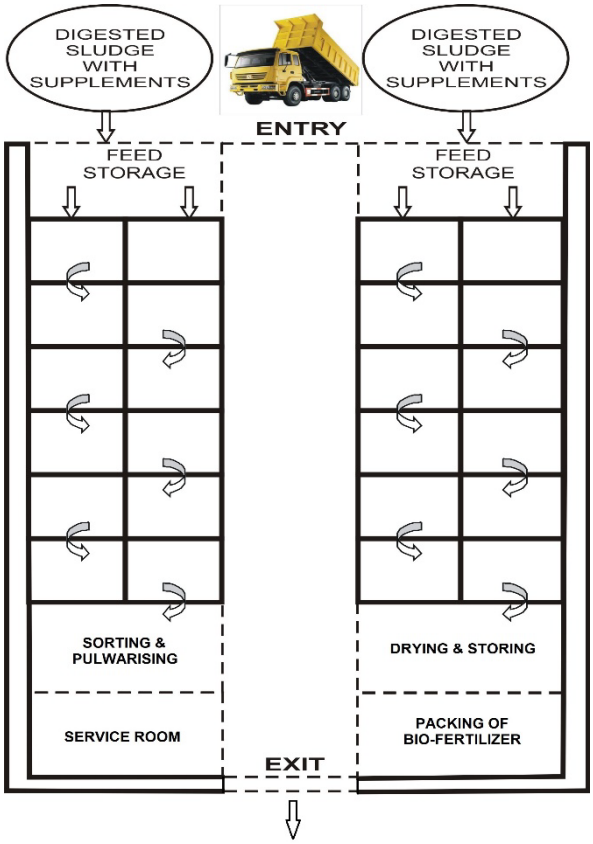
The liquefied fleshing is mixed with bio-sludge from effluent treatment plant with 3-6% solids and fed to the Anaerobic Reactor with COD load of 1900-2600kg/day. The characteristics of feed to Anaerobic Reactor are given in the following table.

**Characteristics of Feed to Anaerobic Reactor/Digester**

| Sl. No. | Source of Feed | Volume | Solids Concentration | COD load in Kg |
|---|---|---|---|---|
| 1. | From Biological Liquefaction System | 5-10m3/day | 3 – 5% | 400-600 |
| 2. | Sludge from Primary & Secondary Clarifier of Soak Stream | 20-25m3/day | 4– 5% | 800-1000 |
| 3. | Sludge from Primary & Secondary Clarifier of Composite Stream | 15-20m3/day | 4– 6% | 700-1000 |
| | **Total feed / Rated capacity of Anaerobic Reactor** | **Upto 55m3/day** | **3.5 – 5%** | **1900-2600** |

During Anaerobic Digestion process with detention time of 30 days about 0.5m3 of bio-gas is generated per kg of COD removal. The bio-gas is collected and stored in gas balloon and further converted into electricity using Gas Engine.

The digested sludge is dewatered to increase the solids concentration to the level of 20-25% and taken for bio-fertilizer plant by mixing with degradable organic solid wastes such as vegetable market waste, leaves, etc., and converted into bio-fertilizer.The composting process is shown in the following process flow diagram.




**BIO-FERTILIZER FROM BIO-SLUDGE AND DEGRADABLE SOLID WASTE**

## 4. RESULTS AND DISCUSSION

The rate of COD load, bio-gas generation per day and the corresponding electricity generation in kWh/day is given in the following table.

**Bio-gas Production and Potential Electricity Generation from 50-55m$^3$/day**

| Sludge dry weight in % | Degradable dry weight load in kg/day | COD load in kg/day | Biogas production in m$^3$/day | Electricity generation in kWh/day |
|---|---|---|---|---|
| 3 | 1500 | 1500 | 450 | 945 |
| 4 | 2000 | 2000 | 600 | 1260 |
| 5 | 2500 | 2500 | 750 | 1575 |
| 6 | 3000 | 3000 | 900 | 1890 |

- It is feasible to liquefy the waste fleshing biologically and increase the bio-mass feed to Anaerobic Reactor in terms of COD to more than 20000 mg/l.
- Optimum detention time for biological liquefaction is in the range of 7-10 days depending upon the fat content and atmospheric temperature.
- Optimum detention time for Anaerobic digestion is in the range of 25-30 days depending upon the COD load and atmospheric temperature.
- The bio-gas generation is in the range of 0.4-0.6m3 per kg of COD removal.
- Improved occupational health and safety measures in the context of COVID-19 pandemic situation had become a major threat not only for the technological development but also for sustainable operation and maintenance of the entire leather process and environmental management.

## 5. CONCLUSION

This unique and sustainable technological development of biological liquefaction of fleshing, anaerobic digestion by mixing with degradable sludge from effluent treatment plant and solid wastes and conversion into bio-fertilizer and energy will reduce the hazardous category sludge generation and minimize the disposal problem into SLF.The environmental issues in the disposal of unutilized fleshing and bio-sludge from effluent treatment plants are also minimized. Based on the pilot scale development, commercial scale anaerobic digesters are being implemented in Effluent Treatment Plants (ETPs) and CETPs in India, The Netherlands and other countries.

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