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Odor-Free Paper making by Anaerobic treatment in ETP

Abstract:

The Kraft paper industry faces significant challenges due to foul odours produced during paper processing, which leads to production constraints, decreased paper quality, and financial and environmental issues [1]. This paper presents a solution leveraging Effluent Treatment Plants (ETPs) with anaerobic digesters to produce Bio-CNG [2]. By utilizing this approach, kraft paper mills can mitigate odour issues, improve product quality, and enhance economic returns through an efficient, sustainable waste-to-energy conversion.

The paper industry is often associated with significant environmental challenges, particularly related to the generation of odorous wastewater during production processes. This study explores the implementation of anaerobic treatment in effluent treatment plants (ETPs) as a solution for achieving odor-free paper manufacturing. By utilizing anaerobic digestion, organic materials present in wastewater are effectively broken down in an oxygen-free environment, minimizing the formation of volatile compounds responsible for unpleasant odors [3]. The process not only reduces the biochemical oxygen demand (BOD) of the effluent but also generates biogas, a renewable energy source that can enhance the sustainability of paper production [5]. The study highlights the operational benefits, including reduced odor emissions, compliance with environmental regulations, and improved resource recovery. Additionally, it addresses potential challenges such as system complexity and initial investment costs. Overall, anaerobic treatment presents a viable pathway toward more environmentally friendly and socially responsible paper manufacturing, promoting a circular economy within the industry [4].

Keywords: *Kraft Paper Industry, Effluent Treatment Plant (ETP), Anaerobic Digestion, Bio-CNG, COD Reduction, Renewable Energy.*

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Introduction

The kraft paper production process generates high-COD effluent, contributing to odor and environmental challenges. Compliance with regulatory standards is often hindered by foul odors, which also negatively impact product perception in the market. This paper examines the implementation of anaerobic digestion within ETPs to reduce COD and produce Bio-CNG. The study emphasizes economic and environmental benefits while detailing the process's operational efficiency and potential challenges

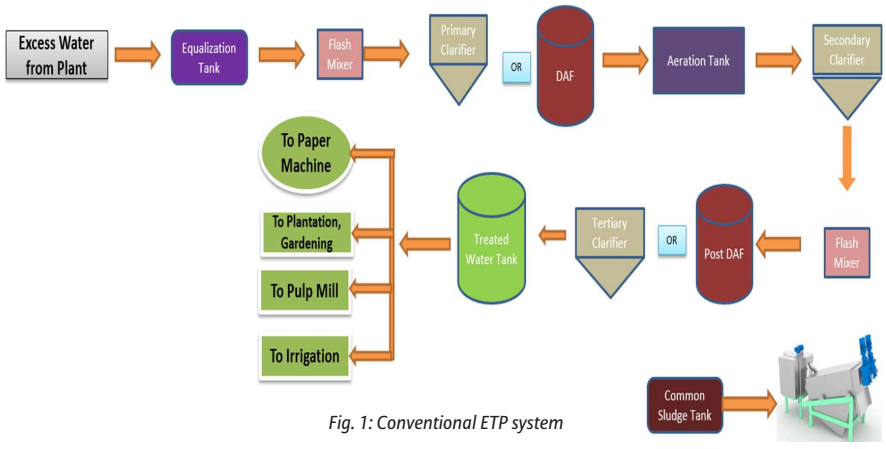

Fig. 1: Conventional ETP system

A. Effluent Treatment Process in Kraft Paper Mills

- Current ETP Setup: Traditionally involves primary (physio-chemical) treatment, secondary (biological) treatment, and tertiary (polishing) steps as shown in Fig. 1.
- Process Flow without CBG Plant: Begins with equalization, followed by primary and secondary clarifiers, and aeration, directing treated water for secondary applications (irrigation, gardening).

B. Enhanced ETP Process with Bio-CNG Production

- Anaerobic Digesters: Integrated to reduce COD by up to 70%, significantly mitigating Odour (Fig. 2).

Anaerobic Treatment: Organic waste from the effluent undergoes microbial action in an oxygen-free environment, producing biogas and reducing COD [2, 3].

- Process Flow with CBG Plant: Anaerobic digestion, H2S scrubber, and PSA (Pressure Swing Adsorption) for methane purification (Fig. 3).

Fig. 2

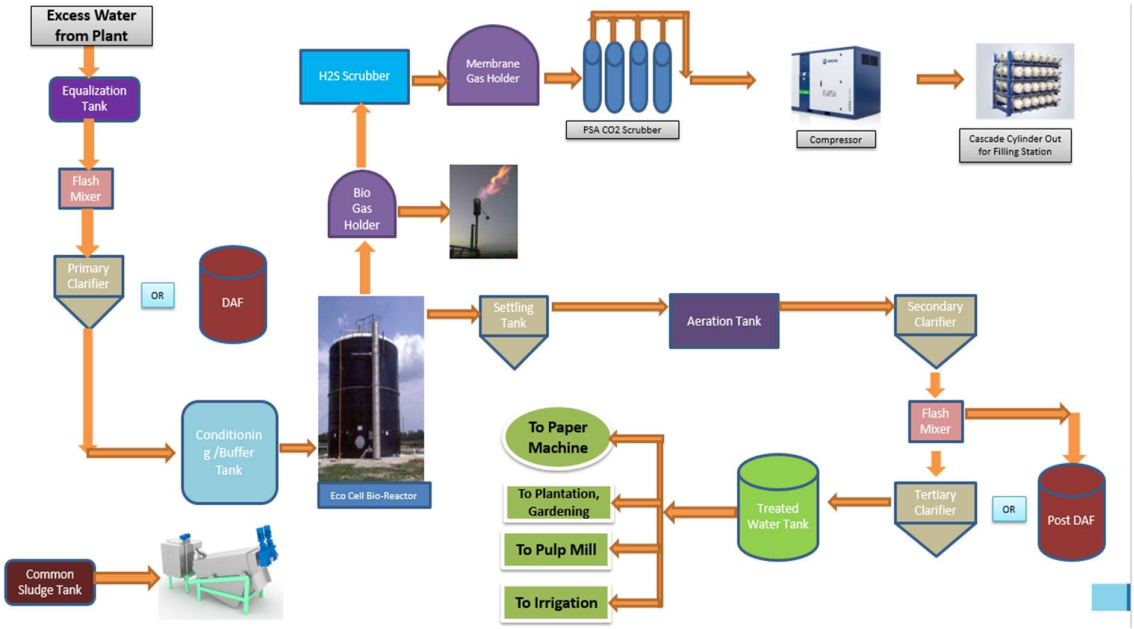

Fig. 3 Process flow diagram with CBG

- Bio-CNG Purification and Storage: Methane is purified to over 96% for use as transport fuel or power generation. Excess biogas is flared for safety.

Fig. 4 Bio-CNG production

C. Key Components in Bio-CNG Production

- H_2S Scrubber: Removes hydrogen sulphide to reduce gas odour and improve safety.
- Biogas Balloon and PSA System: Captures and purifies biogas to high methane concentrations suitable for various applications (Fig. 4).
- Compressor and Cylinder Cascades: Compresses purified CBG to high pressures for transportation to refuelling stations (Fig. 5).
- Filling Station: Final product dispensed as fuel, supporting transport industry sustainability.

Fig. 5 cylinder cascades

Materials and Methods

Materials

1. **Effluent from Kraft Paper Mills:** Characterized by high COD and Total Suspended Solids (TSS), the primary waste material treated in this process.
2. **Anaerobic Digestion Unit:** Reactor designed for breaking down organic matter in the absence of air, crucial in reducing COD and producing biogas [1].
3. **Scrubbing Equipment:**

- **H_2S Scrubber:** Removes hydrogen sulphide to reduce gas odour and improve safety.
- **Pressure Swing Adsorption (PSA) System:** Purifies methane by separating CO_2, ensuring high-purity Bio-CNG output.

4. **Biogas Balloon Storage and Compressor System:** Stores biogas post-scrubbing, compresses Bio-CNG, and fills transport cylinders for energy applications.

Methods

1. **Effluent Treatment Process:** Conducted in stages to progressively reduce contaminants [4].

- **Primary Treatment:** Physico-chemical treatment using a flash mixer and primary clarifier to remove large particulates.
- **Secondary Treatment:** Biological treatment includes aerobic and anaerobic processes, enhancing breakdown of organic waste.
- **Tertiary Treatment:** Involves polishing steps, such as sand and activated carbon filtration, for final effluent quality improvements.

2. **Anaerobic Digestion and Biogas Production:** Effluent is processed in an anaerobic digester, where microbial activity reduces COD by up to 70%.
3. **Bio-CNG Production:** Biogas from anaerobic digestion undergoes PSA to remove CO_2, with methane concentrations reaching 96%.
4. **Energy and Fuel Conversion:** Purified Bio-CNG is compressed and used as transport fuel or for power generation.

Results and Discussion

Results

Fig. 6 shows the complete layout of the treatment plant with CBG. Performance characteristics of the plant are given in Tables 1 and 2.

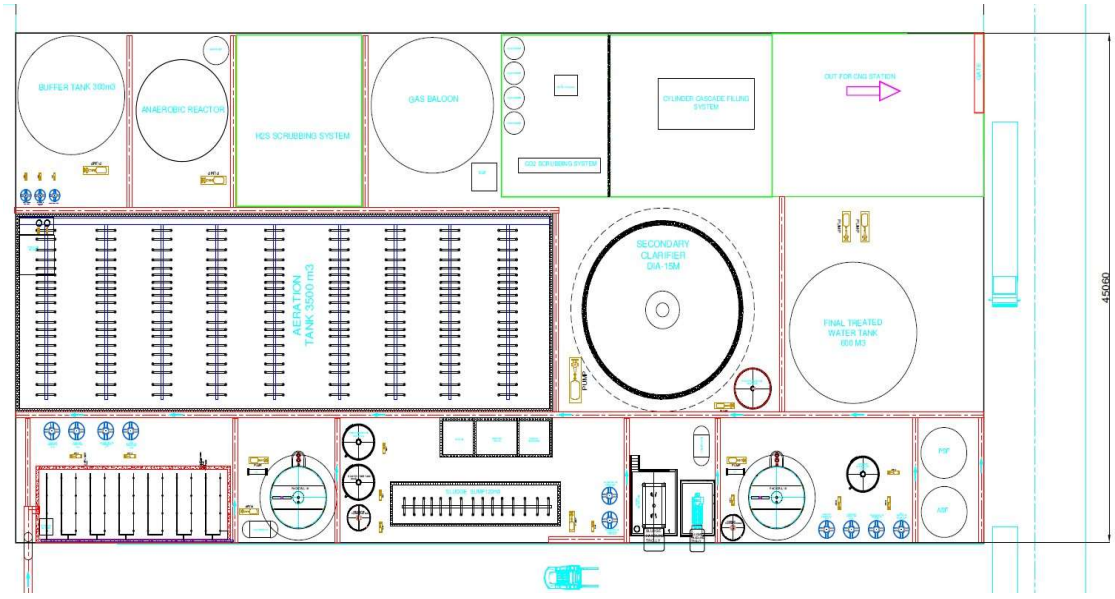

Fig. 5 cylinder cascades

- Reduction in COD: COD in treated effluent was reduced by 70%, demonstrating effective pollutant removal.
- Methane Purity and Energy Production: Bio-CNG produced had a methane purity of >96%, making it viable for transport fuel and generating 2.2–2.4 KWH/m³.
- Financial Impact: Bio-CNG production offset operational costs, achieving a positive ROI within 3 years by reducing treatment costs and adding revenue from fuel production.
- Environmental and Social Impact: Odor issues were significantly mitigated, improving product quality and allowing mills to export without odour-related limitations.

Discussion

- Benefits of Bio-CNG in Paper Industry: Bio-CNG production transforms waste into a valuable resource, addressing both environmental and economic concerns.
- Operational Efficiency: Integration of anaerobic digesters reduces the secondary treatment load, further lowering COD before the effluent reaches the tertiary stage.
- Implications for Sustainability: This approach aligns with global sustainability goals, promoting renewable energy and waste management.
- Challenges: Initial investment in infrastructure and maintaining optimal microbial conditions in the digester were noted as potential operational challenges.

Note:- The Anaerobic Digestion system, at 400 TPD Kraft paper mill, designed to handle a daily COD load of 18,000 kg and an effluent volume of around 4,000 m3/day, was strategically installed at the pulp and paper facility. Over the past 2 years of operation, the system consistently demonstrated impressive results, achieving an average COD reduction of 65-70% and generating over 7,000 m3/day of biogas further purified to remove H2S and CO2 to get pure methane used for Transport fuel to replace Diesel/Petrol.

Table 1: Effluent Characteristics Pre- and Post-Treatment

Parameter	ETP Effluent	Treated Water
COD (mg/L)	5000	250
BOD (mg/L)	2000	<30
TSS (mg/L)	500	<50
Temperature	Ambient	Ambient

Table 2: Energy and Environmental Outcomes

Metric	Value
COD Reduction (%)	Up to 70%
Energy Generation	2.2–2.4 kWh/m³ Bio-CNG
Transport Fuel Efficiency	0.42–0.45 kg Bio-CNG per m³
Project ROI Timeline	< 3 Years

Conclusions:

Eliminating foul smells,
Enhancing paper quality,
Ensuring financial viability with Bio-CBG projects

The integration of anaerobic digesters in ETPs within kraft paper mills is a transformative solution that addresses odour management, regulatory compliance, and financial sustainability. Bio-CNG production from mill effluent transforms an environmental liability into an economically viable, renewable resource.

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