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TRASH TO TREASURE – BIO-CNG FROM RECYCLED-BASED PAPER MILL WASTE

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Abstract:

The Kraft paper industry in India is grappling with a severe crisis marked by production shutdowns and financial instability, attributed to challenges in exporting paper due to quality issues. A significant contributor to this crisis is the unpleasant odour associated with Kraft paper, hindering its acceptance in international markets. Kraft paper mills employing Zero Liquid Discharge (ZLD) methods face unique obstacles, including odour, subpar quality, exorbitant treatment costs, high chemical consumption, and elevated power costs. This paper addresses these challenges by introducing a holistic 360-degree solution developed by Parason.

Parason's comprehensive solution aims to revolutionize both effluent treatment and revenue generation through the production of Bio Compressed Biogas (Bio-CNG). Presented as a turnkey approach, this innovative solution transforms waste from recycled-based paper mills into a valuable resource, offering a sustainable and transformative path forward.

By converting waste into a valuable resource, this solution presents the Kraft paper industry with a pathway to a brighter and more sustainable future. The integration of Bio-CNG not only ensures economic viability but also aligns with environmental stewardship by serving as an Eco friendly alternative to diesel and petrol, contributing to a positive transformation in the industry's prospects and significantly to the reduction of air pollution

1. The Solution - Etp With Anaerobic Digester

- Mitigating Odour Issues in Kraft Paper Industry through ETP with Anaerobic Digesters and Bio-CNG.
- Transforming ETP into a Valuable Asset.
- Trusted Source of Treasure – ROI within 3 Years.

The Kraft paper industry faces a critical challenge associated with the unpleasant odour emanating from paper products, impeding their acceptance in international markets and contributing to production shutdowns. To address this multifaceted issue, we present a transformative solution that integrates an Effluent Treatment Plant (ETP) with Anaerobic Digesters and harnesses Bio-Compressed Natural Gas (Bio-CNG). This innovative approach not only tackles odour concerns but also transforms the ETP into a valuable asset, offering a reliable source of revenue with a Return on Investment (ROI) achievable within a remarkably short span of 3 years.

2. Strategy:

Working on Two Phases - Anaerobic Digester and CBG/Bio-CNG

In the first phase, our strategy involves integrating advanced anaerobic digesters within the existing Effluent Treatment

Plant (ETP) of Kraft paper mills. The primary objective is to mitigate odour issues associated with paper production while optimizing effluent treatment. This phase aims to transform the ETP into a more environmentally sustainable facility by efficiently treating effluents and co-generating biogas through anaerobic digestion.

The second phase focuses on the production of Compressed Bio-Gas (CBG) or Bio-Compressed Natural Gas (Bio-CNG). A dedicated production plant is established to convert the biogas generated in the first phase into a valuable resource. This not only provides an alternative energy source for the facility but also opens up new revenue streams by selling CBG to external markets or utilizing it as a clean energy source for in-house power generation.

3. Characteristics of Influent in Kraft Paper Industry: A Comprehensive Analysis

Understanding the intricate characteristics of influent is paramount in optimizing the performance of effluent treatment processes within the Kraft paper industry. This paper

S.N	PARTICULARS	UNIT	VALUE
1.	pH	-	6.5 – 7.5
2.	BOD	mg/l	2000
3.	COD	mg/l	6000
4.	TSS	mg/l	3000

delves into a comprehensive analysis of the influent's key attributes, shedding light on the factors that influence the efficiency of wastewater treatment and the subsequent impact on the overall operational dynamics of the industry.

4. Characteristics of Final Treated Effluent in the Kraft Paper Industry: A Comprehensive Overview

Understanding the characteristics of the final treated effluent is a critical aspect of assessing the effectiveness of wastewater treatment processes within the Kraft paper industry. This paper provides a comprehensive

S.N	PARTICULARS	UNIT	VALUE
1.	pH	-	6.5 – 8
2.	BOD	mg/l	<30
3.	COD	mg/l	<250
4.	TSS	mg/l	<50

overview of the key attributes of the final treated effluent, examining the success of treatment measures in meeting regulatory standards and promoting environmental sustainability.

5. Effluent Treatment Plant (ETP) Process:

Effluent treatment is a pivotal aspect of ensuring environmental sustainability and regulatory compliance within the Kraft paper industry. This paper provides a detailed exploration of the ETP process, encompassing primary treatment through physio-chemical methods, secondary treatment via biological processes, anaerobic digestion for biogas production, subsequent Bio-CNG production, aerobic treatment, tertiary treatment for water polishing, and effective sludge handling.

5.1. Primary Treatment – Physio-Chemical Treatment:

Initial removal of large solids through processes like screening and sedimentation.

Application of physio-chemical methods such as coagulation and flocculation to facilitate the separation of suspended particles.

5.2. Secondary Treatment – Biological Treatment:

Implementation of biological treatment methods to break down organic pollutants.

Utilization of activated sludge processes or other biological reactors to enhance microbial degradation.

5.3. Anaerobic Process for Biogas Production:

Introduction of anaerobic digestion to treat organic matter and produce biogas.

Anaerobic breakdown of complex organic compounds into simpler substances, with the concurrent generation of methane-rich biogas.

5.4. Bio-CNG Production:

Integration of a dedicated plant to convert the biogas produced during anaerobic digestion into Bio-Compressed Natural Gas (Bio-CNG).

Utilization of Bio-CNG as an alternative and sustainable energy source.

5.5. Aerobic Process:

Application of aerobic treatment post-anaerobic digestion to further reduce remaining organic pollutants.

Facilitation of microbial processes in the presence of oxygen for enhanced pollutant degradation.

5.6. Tertiary Treatment - Water Polishing:

Final polishing of the effluent to meet stringent discharge standards.

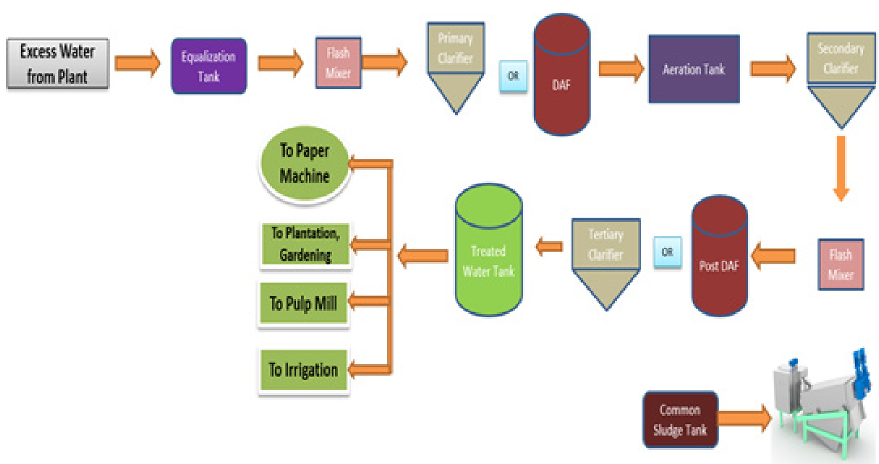
Employment of advanced treatment methods such as filtration, disinfection, and nutrient removal.

5.7. Sludge Handling:

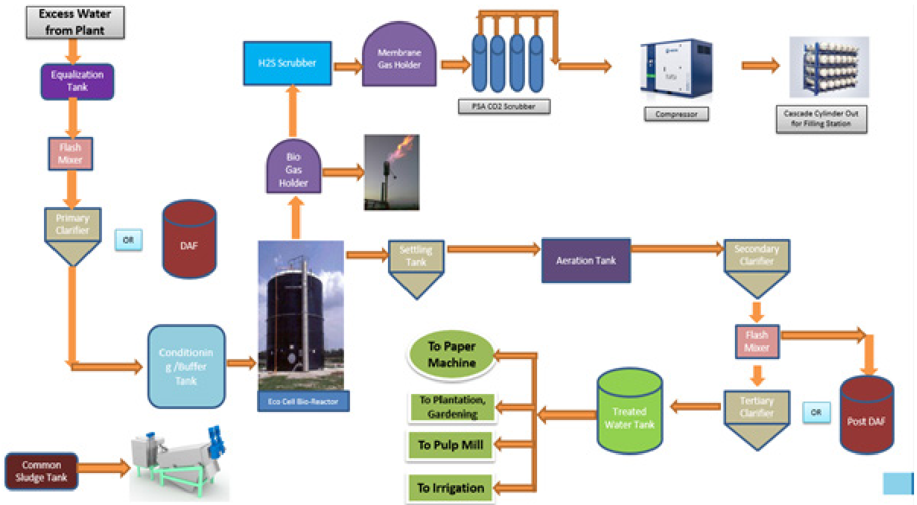
Efficient handling and disposal of sludge generated during the treatment processes.

Exploration of sludge management strategies, including dewatering and potential reuse.

6. Etp Process Flow Diagram Without CBG Plant



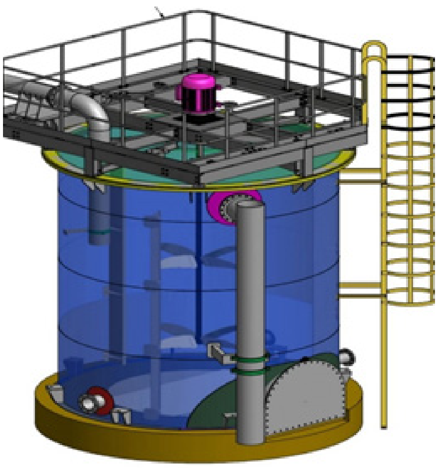
7. Etp Process Flow Diagram With CBG Plant



8. Conditioning Tank:

Optimizing Water Characteristics and Nutrient Homogenization

The conditioning tank plays a crucial role in the effluent treatment process, serving as a key unit for homogenizing water characteristics and facilitating the uniform distribution of essential nutrients.



9. Anaerobic Treatment

Anaerobic treatment stands as a key component in the Kraft paper industry's commitment to sustainable practices, specifically in the conversion of paper mill effluent into Compressed Bio Gas (CBG). This paper explores the utilization of a new generation, high-rated solid separation anaerobic reactor consisting of two separators. The anaerobic treatment process focuses on the conversion of organic matter in both liquid and solid waste to bio-methane and valuable manure through microbial action in the absence of air.

Highlighting the conversion of seemingly waste materials into valuable resources such as bio-methane and nutrient-rich manure.

Results: 70% Reduction in COD:

Implications of COD reduction on environmental impact, compliance, and operational efficiency.

CBG Production:

Exploration of the bio-methane produced through anaerobic digestion as Compressed Bio Gas (CBG).

Utilization of CBG as a sustainable energy source for various applications, contributing to the industry's circular economy.

Operational Benefits and Environmental Sustainability:

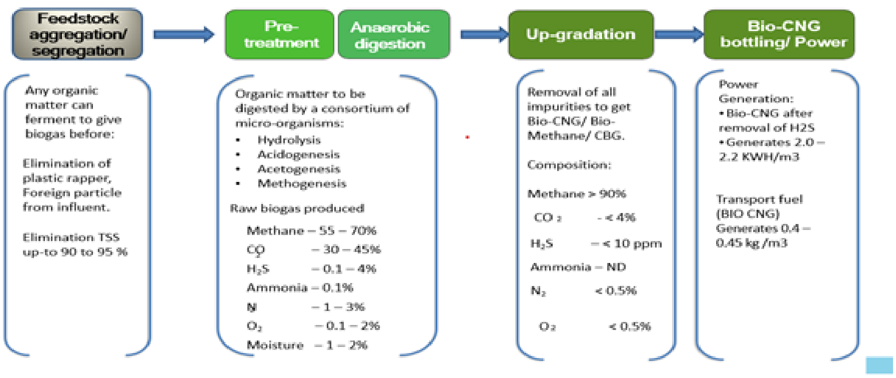
The integration of anaerobic treatment not only results in significant COD reduction but also provides operational benefits such as biogas production and nutrient recovery. The paper emphasizes the role of CBG as a sustainable energy source, aligning with environmental sustainability goals.

10. Biogas Holder & Flare System

There is circular tank for Biogas holding.

The generated biogas from the anaerobic reactor being stored to safeguard the reactor & being purified in CBG plant and in case of any shut down in CBG plant the raw bio gas being flared for safety point of view.

11. Bio-Cng Production Steps and Specification



12. Bio Gas Purification:

Biogas Purification: Enhancing the Quality of Bio-methane for Sustainable Utilization

Biogas, derived from anaerobic treatment of paper mill effluent, presents an opportunity for sustainable energy production. This paper focuses on the crucial step of biogas purification, ensuring the quality enhancement of bio-methane for various applications. The purification process involves the removal of impurities such as carbon dioxide (CO_2), hydrogen sulfide (H_2S), and moisture, resulting in a purified biogas suitable for applications like Compressed Bio Gas (CBG) production.

12.1. Importance of Biogas Purification:

Explanation of the significance of purifying biogas to enhance its quality.

The role of purification in making biogas suitable for various applications, including CBG production.

12.2. Impurity Removal Process:

Detailed description of the purification process, focusing on the removal of impurities like CO_2, H_2S, and moisture.

Technological methods employed for efficient impurity removal.

12.3. Carbon Dioxide (CO2) Removal:

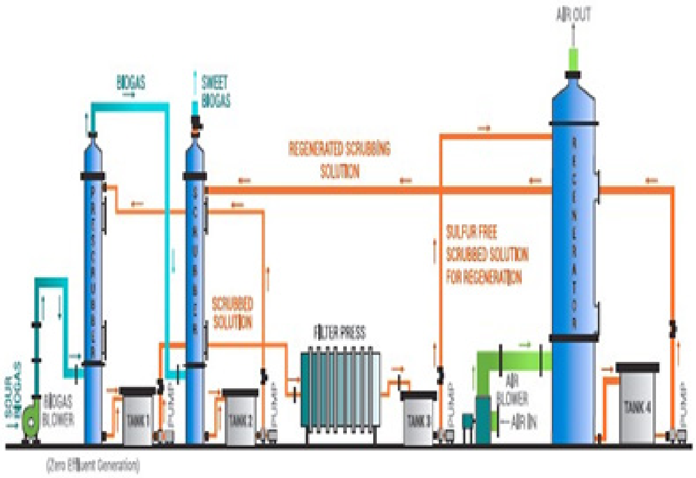
Techniques and technologies for separating CO_2 from biogas, addressing its role in reducing energy content and ensuring compliance with quality standards.

Strategies for achieving high-purity methane content.

12.4. Hydrogen Sulfide (H_2S) Removal:

Exploration of H_2S removal methods, considering its corrosive nature and adverse effects on downstream applications.

Overview of technologies ensuring the safe and effective removal of H_2S.



13.Biogas Balloon: Efficient Storage and Utilization of Purified Bio-methane

The utilization of purified bio-methane, obtained through the biogas purification process, necessitates an effective storage solution. This paper explores the role of a biogas balloon in providing efficient storage for bio-methane, ensuring its availability for various applications such as Compressed Bio Gas (CBG) production and other energy utilization methods.

14. High Pressure Compressor System

High-Pressure Compressor System for Efficient Compressed Bio Gas (CBG) Production

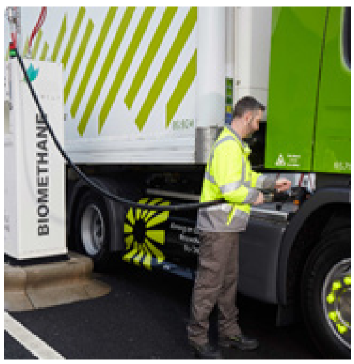
The production of Compressed Bio Gas (CBG) from purified bio-methane requires a robust high-pressure compressor system. This paper explores the key components, operational considerations, and benefits of a high-pressure compressor system.

15. Cylinder Cascades Filling System for Efficient Distribution of Compressed Bio Gas (CBG)

In the realm of Compressed Bio Gas (CBG) utilization, the cylinder cascades filling system plays a pivotal role in ensuring the seamless distribution of bio-methane for various applications. This paper explores the design, components, operational considerations, and benefits of a cylinder cascades filling system, emphasizing its importance in efficiently filling CBG cylinders for storage, transportation, and widespread usage

16. Compressed Bio Gas (CBG) Filling Station: Infrastructure for Sustainable Energy Distribution

As the demand for sustainable energy sources continues to grow, Compressed Bio Gas (CBG) filling stations have emerged as key components in the distribution network. This paper delves into the design, functionality, operational considerations, and benefits of a CBG filling station, highlighting its crucial role in facilitating the widespread adoption of bio-methane as a clean and renewable energy alternative



17. Case Study: Anaerobic Digestion Revolution in Pulp and Paper Sustainability

• Introduction:

In response to the growing demand for sustainable energy practices, a leading pulp and paper facility embarked on a transformative journey by implementing an Anaerobic Digestion system. This case study delves into the project's key elements, from installation and operation to the collaborative efforts driving the facility's sustainable energy initiatives.

• Project Overview:

The Anaerobic Digestion system, at 200 TPD kraft paper mill, designed to handle a daily COD load of 18,000 kg and an effluent volume of around 4,500 m3/day, was strategically installed at the pulp and paper facility. Over the past 1.5 years of operation, the system consistently demonstrated impressive results, achieving an average COD reduction of 65-70% and generating over 5,000 m^3/day of biogas.

• Environmental Impact:

The adoption of anaerobic digestion not only addressed pollution concerns but also significantly reduced the pollution load treated through the conventional activated sludge process. This reduction had a cascading effect on energy and chemical consumption in the conventional activated sludge process, contributing to the overall environmental sustainability of the facility.

• Biogas Utilization and Purification:

The composition of the generated biogas, predominantly methane (CH_4) at 65-70%, carbon dioxide (CO_2) at >25%, and hydrogen sulfide (H_2S) at <1%. Collaborative efforts aimed to purify and compress the biogas up to 98% methane concentration. A 3-ton per day Compressed Biogas (CBG) plant is being installed, featuring an H_2S scrubber system using chelating ion technology and CO_2 removal through a four-tower Pressure Swing Adsorption System (PSA).

• Commercialization and Sustainable Practices:

The facility took a significant step towards commercializing the generated biogas by entering into an agreement with HPCL under the Sustainable Alternative towards Affordable Transportation (SATAT) scheme. This initiative aligns with broader sustainability goals and presents an innovative model for the utilization of bioenergy in vehicular transportation.

• Operational Metrics:

The operational success of the Anaerobic Digestion system is reflected in key metrics, including a design COD load of 18 MT/day, a biogas generation rate of 0.45 m^3 per kg of COD reduced, and a hydraulic retention time of 5.5 hours. These metrics underscore the efficiency and effectiveness of the implemented anaerobic digestion process.

• Conclusion:

The integration of the Anaerobic Digestion system at this pulp and paper facility marks a significant milestone in the shift towards sustainable energy practices within the industry. This case study exemplifies the potential of anaerobic digestion for bioenergy generation, its positive environmental impact, and the collaborative efforts that drive the transformation towards a more sustainable and eco-friendly industrial landscape.

18. Cost-Benefit Analysis/Return on Investment (ROI) Analysis for Anaerobic Digester and Bio-CNG Project in the Kraft Paper Industry

Flow rate	4500	M3/day
COD of effluent	6000	mg/lt
Total load	27	MT/Day
COD reduction in Anaerobic digester	70	%
COD reduction	4200	mg/lt
Reactor outlet COD	1800	mg/lt
COD reduction	18.9	MT/Day
Raw bio gas generation	0.45	M3/kg COD reduction
Total Raw Bio gas generation	8505	m3/Day
Raw Bio Gas flow rate	**8505**	**M3/Day**
Running hrs	24	Hrs
	354	M3/Hr
Methane	65.00	%
Methane content	230	M3/hr
System Methane Losses	8.00	%
Final Product Methane	212	M3/hr
Methane Density	0.69	
Methane	146	Kg/Hr
	3509	Kg/Day
	3.51	MT/day
Working days	330	
Investment (excluding land cost)	**18,00,00,000**	**(Anaerobic digester, H2S scrubber, CO2 removal, compressor, cascades) including Civil**
	18	Cr
Opex for CBG plant		
Power, man power, chemicals, spares etc	2,50,00,000	
	2.50	Cr
Revenue of sale to Govt (present Rate)	67	Rs/Kg
Revenue /year	77591355	Rs/Year
	7.76	Cr
Net Profit	52591355	Rs
	5.26	Cr
Capex	18,00,00,000	
ROI (excluding interest and depreciation)	**3.5 - 4**	**Years**

If go with own CBG pump		
Sale price (Present)	90	Rs/kg
Revenue	104227193.1	Rs/Year
	10.42	Cr
Extra expenditure for pump station	2,00,00,000	(For compressor, dispenser, land etc)
	2	Cr
Total expenditure	200000000	
	20	Cr
Total revenue	104227193.1	Rp
Opex for pump (power, manpower, repair and maint)	5500000	Rp
	0.55	Cr
Total Opex	30500000	Rp
	3.05	Cr
Net Profit	73727193.07	
	7.372719307	Cr
ROI	**3.0**	**Years**
Other benefits		
MNRE subsidy (New and Renewable Energy)	7500000	Rs/MT CBG
Govt Subsidy	26319998.25	
	2.63	Cr
Carbon Credit	8000000	
	0.8	Cr
Net Investment	165680001.8	
	16.6	Cr
Payback	**2.5 - 3**	**Years**

The implementation of an anaerobic digester and Bio-CNG project in the Kraft paper industry represents a significant investment with the potential for both economic and environmental returns. This paper conducts a thorough Return on Investment (ROI) analysis, evaluating the financial viability and sustainability aspects of integrating anaerobic digestion for effluent treatment and Bio-CNG production.

19. Unlocking the Potential of Bio-CNG: A Comparative Analysis of Various Feed-stocks

The production of Bio-CNG from different feed stocks comprehensive analysis of the potential of Bio-CNG derived from various feed stocks, evaluating their feasibility, environmental impact, and economic viability within the context of the industry's energy needs.

SR NO	SOURCE OF FEEDSTOCK	Bio CNG Gas (Kg/Day) Potential per 50 Ton of feed stock
1	POME (Palm Oil mill Effluent)	750-800
2	Cow Dung	750-800
3	Poultry Litter	1400-1500
4	Press Mud	2200-2500
5	Napier Grass	2200-2500
6	Food Waste/Organic MSW	2200-2500
7	EFB (Empty Fruit Bunch)- Palm	3200-3500
8	Paddy Straw	5000-5500

20. Investment Breakup for Municipal Solid Waste (MSW) Based Bio-CNG Plant: A Comprehensive Financial Analysis

The establishment of a Bio-CNG plant utilizing Municipal Solid Waste (MSW) as a feedstock requires a detailed financial breakdown to assess the feasibility and attractiveness of the investment. This paper provides an in-depth analysis of the

SR.NO.		AMOUNT OF BIO CNG GENERATION		
	Particulars/Capacity	3 MT	5 MT	10 MT
1	Land Required (in Acre)	2	6	7.5
2	Pre-treatment	2	3	5
3	Civil (Including Digester)	2.5	8	15
4	Purification system	2.5	4	5
5	Compression System	1	2	4
6	Cascade filling system	1	2	4
7	Miscellaneous	1	1	2
	Total Amount (Cr)	10	20	35

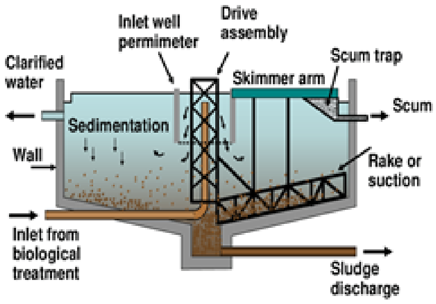
investment breakup, offering insights into the capital expenditure, operational costs, and potential revenue streams associated with MSW-based Bio-CNG production.

21. Aerobic System

An Aerobic System in an Effluent Treatment Plant (ETP) refers to a wastewater treatment process that involves the use of oxygen to biologically degrade and remove contaminants from industrial or municipal effluent. In an aerobic system, microorganisms, typically bacteria, break down organic pollutants in the presence of oxygen, converting them into simpler and less harmful substances.

22. Secondary Clarifier

A Secondary Clarifier is a crucial component in the wastewater treatment process, specifically following the aeration stage in an Effluent Treatment Plant (ETP). After the wastewater undergoes aeration, where biological processes occur to reduce organic pollutants, a secondary clarifier serves the purpose of separating the treated water from the activated sludge or biomass generated during aeration.



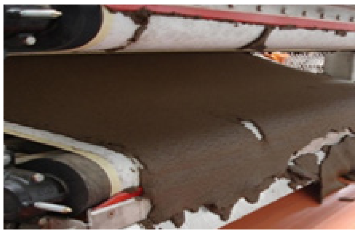
23.Tertiary Treatment with Pressure Sand Filter and Activated Carbon Filter in Wastewater Treatment:

Tertiary Treatment: Tertiary treatment is the final stage of the wastewater treatment process, following primary and secondary treatments. Its primary goal is to further polish the effluent from the secondary treatment, removing any remaining impurities, contaminants, or residual solids to meet stringent water quality standards before discharge or reuse.

- Pressure sand Filter
- Activated Carbon Filter

24. Sludge Handling in Effluent Treatment Plants (ETP) using Belt Filter Press:

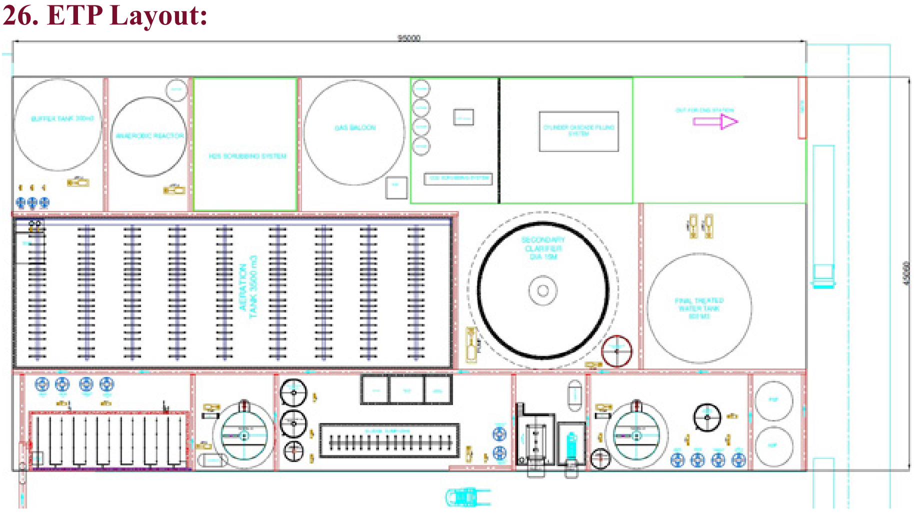
Sludge handling is a critical component of wastewater treatment, especially in Effluent Treatment Plants (ETPs), where the focus is on managing and processing the generated sludge effectively. The Belt Filter Press is a commonly used technology for dewatering sludge, reducing its volume, and facilitating further handling and disposal.



25. Sludge Handling in Effluent Treatment Plants (ETP) using Sludge Screw Press:

The Sludge Screw Press is a modern and efficient technology used for dewatering sludge in Effluent Treatment Plants (ETP). It utilizes a screw mechanism to effectively squeeze out water from the sludge, resulting in a more concentrated and manageable sludge cake.

26. ETP Layout:



27. Etp: From Obligation To Valuable Asset

- Eliminating Foul Smells,
- Enhancing Paper Quality, \
- Ensuring Financial Viability with Bio-CNG Projects

Effluent Treatment Plants (ETPs), once perceived as regulatory obligations, are undergoing a remarkable transformation into valuable assets through the integration of Bio -CNG (Compressed Natural Gas) projects. This paper explores how this synergy not only addresses environmental compliance but also eliminates foul smells, enhances paper quality, ensures financial viability, and ultimately transforms the ETP from a mandatory requirement into a trusted source of treasure. By significantly improving consumer experience through the eradication of foul smells from corrugated boxes, this integrated approach sets a new standard for sustainable and value-driven waste management practices.