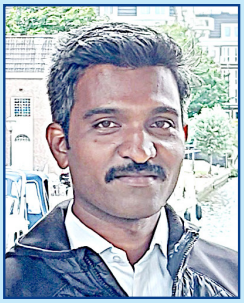
ISSN: 0379-5462
IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association
Vol. 36, E1, 2024, p. 139-144

REVOLUTIONIZING GREEN PRACTICES: ROLE OF BIO-METHANATION TECHNOLOGY'S TRANSFORMATIVE ROLE IN PULP & PAPER MILLS FOR NET ZERO EMISSIONS AND SUSTAINABLE FUTURE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Abstract:

In context of the increased emphasis on Net Zero Emissions, Circular Economy, Water & Energy Conservation, Green Energy biomethnation routes for treatment of wastewater has gained significant interest in pulp and paper industry in recent times. The major driving factors are the benefits of the technology with respect to reduction in pollution load along with co-generation of biogas which can be used as fuel or can be converted to compressed biogas and sold. Moreover, pretreatment of high pollution and organically rich wastewater if segregated and treated through biomethanation can reduce the operational costs significantly in terms of energy and chemical consumption as well facilitate compliance to stipulated norms Pulp and Paper industry effluent is having SCOD of 3000 to 6000 mg/l (agro wet washing, bagasse wet washing, RCF based kraft mills) and BOD of 1200 to 2500 mg/l. These substrates have high biodegradability potential, The energy cost to reduce the organic pollutant with anaerobic followed by aerobic is 3 to 4 times lesser than treating them through stand-alone aerobic (activated sludge process. Further, the sludge generation post aerobic is reduced 5 to 6 times when pretreated anaerobically.

Key words: *Net Zero emissions, Circular Economy, Bio-methanation, Aerobic, SCOD, BOD, Biogas, Non-renewable energy, Biodegradable, Organic pollutant*

Introduction:

Net Zero Emissions, Circular Economy, Water & Energy Conservation are some of the priority agenda before the industries to achieve environmental sustainability and environmental compliance. Of the over 900 pulp and paper mills in India around 75 % of the paper production is reported to be from RCF based paper mills. One of the best and sustainable route achieve the above targets is Bio methanation which facilitates reduction in pollution load along with cogeneration of biogas thus reducing the dependence on conventional fossil fuel, reduces energy and chemical consumption in conventional ETP as well as reuse / recycling of treated effluent Also due to lesser organic pollutant post Bio methanation, sludge generation in the aerobic treatment will come down significantly as indicated in **Figure 1**.

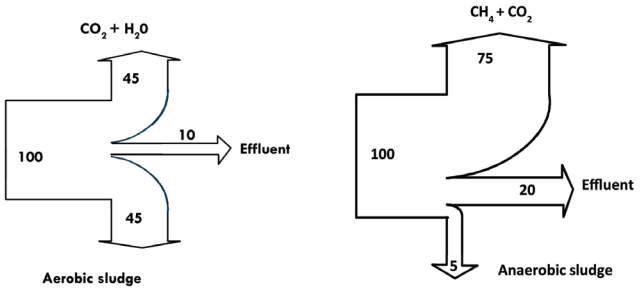


Fig 1. Mass Balance in Aerobic & Anaerobic Treatment

As indicated in Figure 1 in bio methanation the organic pollutant is converted into biogas and less amount of organic pollutant contribute to the sludge generation whereas in aerobic process around 45% organic pollutant contributes to sludge generation and balance 45% is converted into off gases. So, the integration of Bio methanation followed by aerobic is one of the best suited solutions for the pulp and paper industry to ensure:

- Conversion of organic pollutant into valuable biogas.
- Reduce the greenhouse gas emission such as CO2.
- Reduce the sludge production. Hence sludge handling cost will be minimised.
- Finally, this integration help paper mill to contribute towards net zero emission theme.
- Reduce operational expenses in downstream.

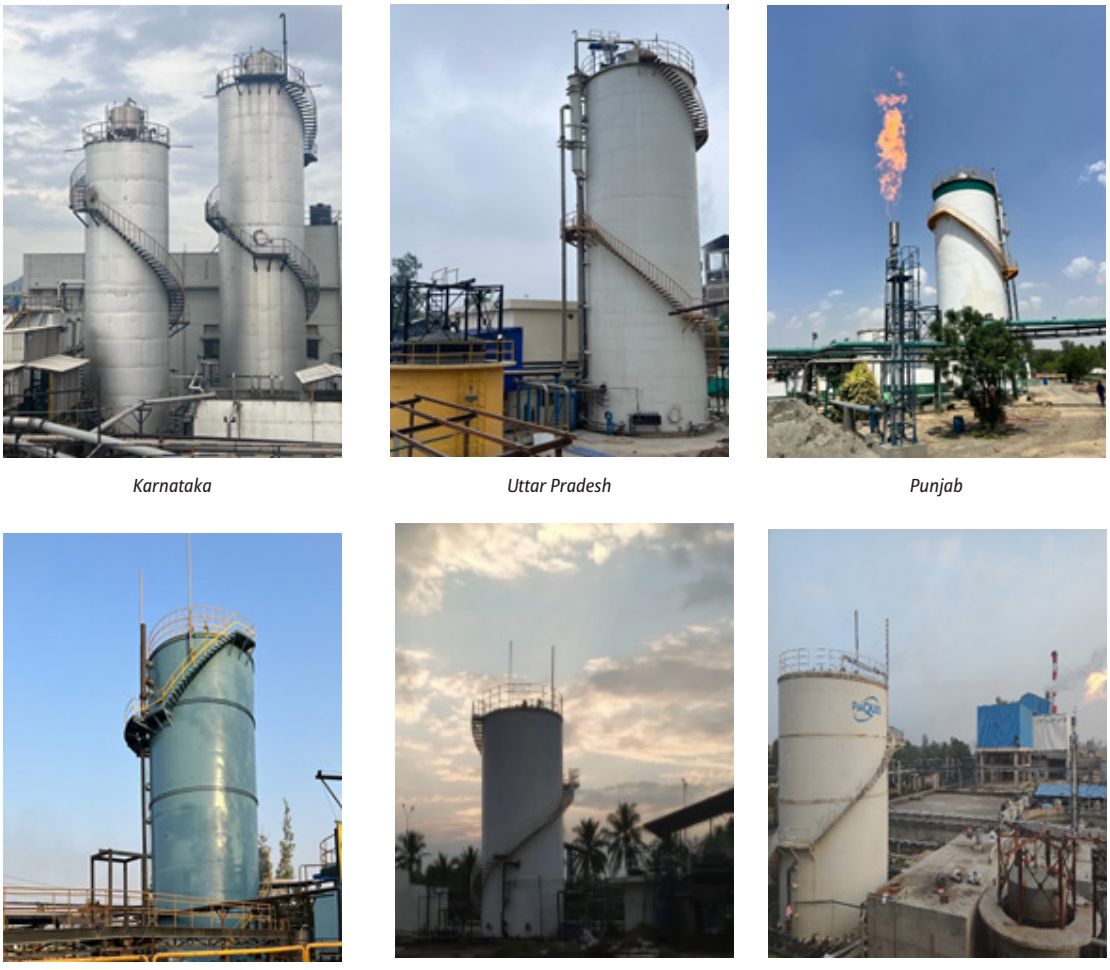
Bio-methanation Technology with High-rate Configuration:

High-rate reactor is one promising new generation bioreactors which are unique due to its compact design (lesser footprint) and high-performance efficiency High-rate reactors operate with granular biomass which is denser and having high settling velocity than the flocculant biomass. The retention time of the high-rate reactor is about 4 to 10 hours. Within short span of time, 70% - 95% of organic pollutant gets converted into biogas and granular biomass. The general process that takes place in the high-rate reactor are as below:

- Acidification: In this stage, complex organic compounds break down into simpler components, producing organic acids. This sets the foundation for subsequent processes by creating a favourable environment for acid-forming microorganisms.
- Acetification: Here, organic acids from the acidification phase transform into acetate and other intermediates. Acetate formation is crucial as a precursor to methanation, contributing to the overall conversion of organic matter into methane.
- Methanation: In the final stage, methane (biogas) is generated through the microbial conversion of acetate and other intermediates. Methane-forming microorganisms thrive in the anaerobic conditions of the reactor, leading to a significant reduction in organic pollutants and the simultaneous production of valuable biogas.

Above process is common process for any bio methanation plant, but new generation high-rate reactor is capable to execute it at much rapid rate i.e. within fraction of hours, whereas in conventional system it takes few days.

In recent times, as indicated in **Figure 2** in recent times agro based pulp and paper mills and RCF based Kraft Paper Mills (operating on zero liquid discharge) have opted for new generation high-rate bioreactors to reduce the pollution load, meet environmental compliance and contribute to India's efforts towards zero carbon emissions.



Karnataka *Uttar Pradesh* *Punjab*

Haryana *Tamil Nadu* *Karnataka*

Fig 2. Snapshots of BIOPAQ® IC and BIOPAQ®ICX installation in Indian Pulp & Paper Industry

Benefits of the High-rate Bio-methanation plant:

High-rate reactor has the below benefits:

1. Ensures ETP stabilisation within a week time.
2. Has lower footprint than conventional system.
3. Retention time of the high-rate reactor is lesser than conventional reactor.
4. As the internals are made up of high-grade plastic materials, it will not react with any corrosive gases. Hence the lifetime of the internals are more than 15 years.

Bio methanation Contribution towards Net Zero Emissions through Bio methanation: Case Study

A brief overview of the biogas generation with high-rate bioreactors installed recently in pulp and paper mills in various states is summarized in Table 1.

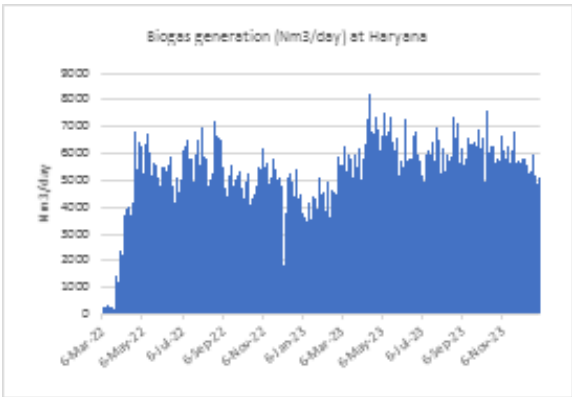
Table 1: Biogas Generation in Pulp & Paper Mills

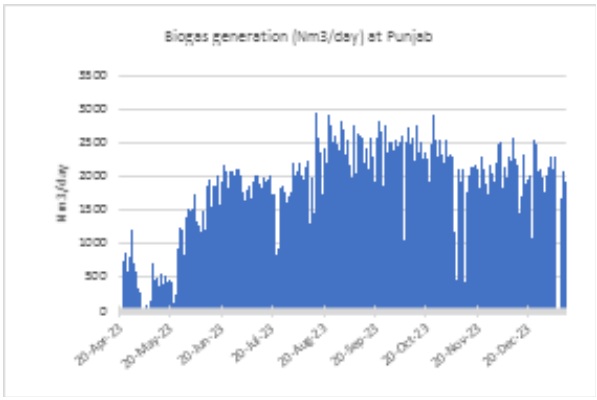
S. No	Location	Production capacity (TPD)	Raw material	Biogas generation (Nm^3/d)	Biogas generation (Nm^3/MT of paper produced)
1	Tamil Nadu	150	Wastepaper	2500	16.7
2	Tamil Nadu	400	Wastepaper	5000	12.5
3	Karnataka	400	Wastepaper	6000	15
4	Karnataka	300	Wastepaper	3500	11.7
5	Karnataka	300	Wastepaper	3500	11.7
6	Haryana	350	Wastepaper and wheat straw	5500	15.7
7	Uttar Pradesh	400	Wastepaper, bagasse, and wheat straw	6000	15
8	Maharashtra	150	Wastepaper	2000	13.3
9	Jharkhand	220	Wastepaper	3500	15.9
10	Punjab	200	Wheat straw	2600	13

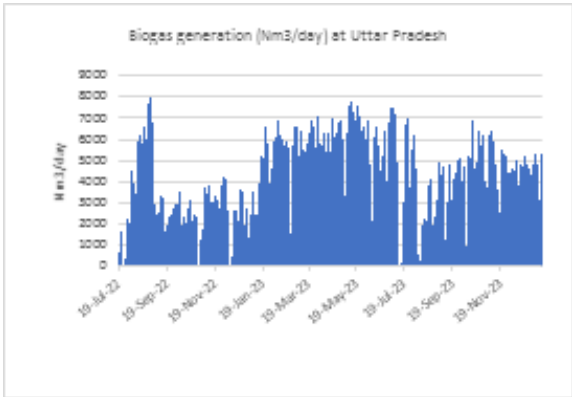
From above table it is evident that agro based pulp and paper mills and RCF based paper mills (specially operating on ZLD) have high potential for biogas generation through high-rate bioreactors the wastepaper-based paper mills which adopting high-rate reactor has ability to generate biogas of 12 to 17 Nm3/MT of paper produced. The agro based pulp and paper mills with wheat straw as major raw material are generating ~13 Nm3 of biogas per MT of paper produced. Most of the mills listed above is using the biogas into their boiler to save the fuel cost. One of the mills listed above is purifying the biogas and is selling it to gas station under SATAT scheme.

Sustainability of Bio methanation in Different Pulp & Paper Mills

The sustainability of bio methanation process adopted by pulp and paper mills indicated in Table 1 has been represented graphically in terms of stability in biogas generation **(Fig 3)** and SCOD removal efficiency with respect to SCOD of influent is indicated in **Fig 4.**







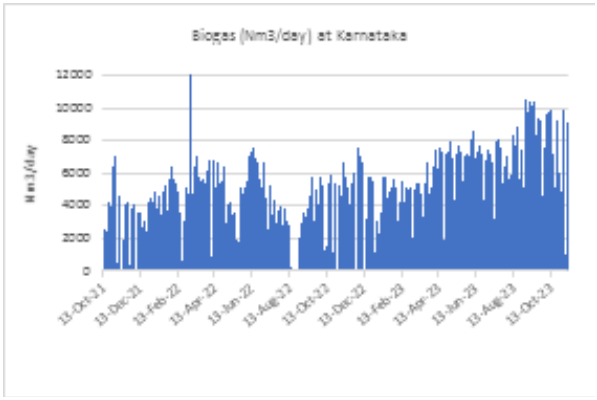


Fig 3. Graphical representation of Biogas Generation Nm3/d in Different Pulp & Paper Mills

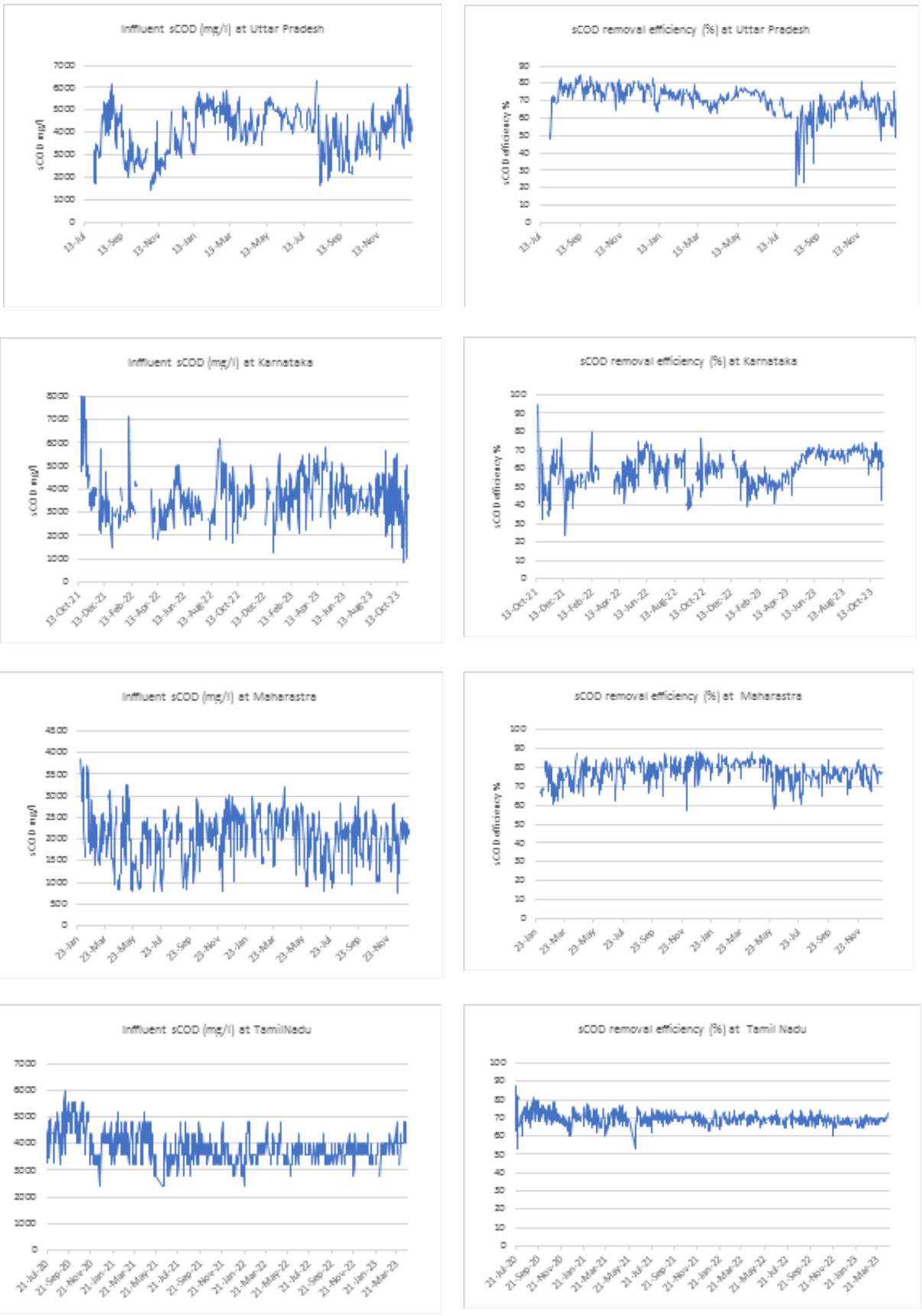


Fig 4. SCOD Concentration in the Influent and SCOD removal efficiency

Conclusion

High-rate Bio methanation followed by aerobic has proved to be an effective and techno- economically viable technology for treatment of pollution load due to its inherent benefit in converting organic pollutants into valuable biogas. This combination of the technology is proving to be of great help to pulp and paper mills in reducing their dependency on the non-renewable fuels and improving environmental compliance. Further improved treated effluent quality after anaerobic and aerobic treatment make its suitable for reuse back into the mill in identified process or non-process area leading to reduction in freshwater consumption and consequently effluent discharge. In all the bio methanation technology is a way forward towards pulp and paper industry's contribution towards net zero emissions.

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