नवीन और
नवीकरणीय ऊर्जा मंत्रालय
MINISTRY OF
NEW AND
RENEWABLE ENERGY

सत्यमेव जयते

# SARDAR SWARAN SINGH NATIONAL INSTITUTE OF BIO-ENERGY

(An autonomous institute of Ministry of New and Renewable Energy, GoI)

SSS NIBE


Quarterly Newsletter

# Bio-ऊर्जा

July 2024

Issue 7

# *Word from the Director General, SSS-NIBE*

*The seventh issue of SSS-NIBE's quarterly newsletter is scheduled for release as we complete the first quarter of the financial year 2024–25.*

*I had an opportunity to present to Prof. Ajay K. Sood, Principal Scientific Adviser, Government of India, the view of the institute on cultivation of biomass for green hydrogen production, emphasizing on the benefits of cultivation of rapidly growing biomass with low to medium ash content.*

*This quarter witnessed signing of MoU with industry for piloting of in-house biogas technology developed at the institute. I attended 32nd European Biomass Conference and Exhibition, at Marseille, France between 24 and 27 June, 2024 as Paper Reviewer and as member of the Scientific Committee and also co-chaired a technical session. I had the opportunity to understand and review the ongoing research and innovation at global level in bioenergy sector, which included all forms of conversion pathways, including thermochemical, biochemical and chemical routes. Several one-to-one interactions were held with individual researchers and also R&D institutes. Also, interacted with the Indian delegation representing Indian Federation of Green Energy (IFGE), who had put up an Exhibition stall. The brochure of SSS NIBE was circulated, in anticipation of bringing more visibility to the institution at global forum. Also, two SRFs – Mr Rakesh Godara and Ms Gaganpreet Kaur participated in the event and presented their research work.*

*Dr. G. Sridhar*
*(Director General)*
*SSS-NIBE*

## UTILIZATION OF PADDY STRAW FOR BIOFUEL PRODUCTION

By Lalitha Shree and Sachin Kumar

In the last century, the globe has been affected by global warming and climate change. Climate change is accelerating the melting of glaciers and ice sheets in Antarctica, contributing to rising sea levels and disrupting global ocean currents and ecosystems. The warming temperatures and shifting weather patterns are also threatening the stability of Antarctic ice shelves, potentially leading to more rapid ice loss. The Himalayan region has seen a 40% decrease in ice, leading to water scarcity, reduced crop yields, and food crises in countries like Pakistan, Nepal, and India. To tackle environmental issues and meet the increasing energy demands while reducing reliance on fossil fuels, many countries are turning to bioethanol as an alternative fuel source. Bioethanol is derived from renewable biomass such as agricultural waste and algae, offering a sustainable energy solution. By utilizing agricultural residues, it is possible to generate electricity, liquid fuels, and fertilizers with minimal waste, aligning with the UN's Sustainable Development Goal 7 of delivering clean and sustainable energy to all by 2030.[1] Currently, India ranks third globally in terms of energy consumption. Ethanol is being produced in multiple states across the country, with a total capacity of 136.4 billion liters. States like Uttar Pradesh, Karnataka, and Maharashtra have a surplus of ethanol production, which the government believes is sufficient to achieve a 20% blending target (E20) in Ethanol Supply Year 2025-26. While most ethanol is currently derived from crops like sugarcane, sweet sorghum, corn, and wheat, this approach presents challenges such as the food-versus-fuel dilemma, high feedstock prices, agricultural investments, and supply chain issues. Consequently, there is a shift toward second-generation ethanol production using agricultural residues, forest waste, grasses, municipal solid waste (MSW), and industrial waste, known as lignocellulosic biomass (LCB). This biomass mainly comprises cellulose, hemicellulose, lignin, and other solids and ash containing inorganic materials. The use of non-edible feedstocks, like LCB and agricultural wastes such as paddy straw, for the production of cleaner and sustainable fuels like second-generation ethanol is crucial for meeting the targets set in India's biofuel policy. These resources can be cost-effective and readily available and have the potential to alleviate food scarcity by using crops and materials that are not designated for human consumption. Paddy straw, in particular, is a conventional and abundant resource that can be utilized for power generation and ethanol distillation.

The remaining unused Paddy Straw has the potential to be used for the production of 2G ethanol. Paddy straw is commonly found in Asian countries and research indicates that it and its by-products can have positive environmental and economic impacts. For instance, in Thailand, 0.2% of paddy straw is used as biofuel, 53.6% is utilized for rural energy in China, 4.6% is used for combustion in Japan, and 28% is employed for biogas production in India.[2] Additionally, paddy straw by-products can also serve as fertilizers for agricultural purposes. Furthermore, while there are crops such as corn and sugarcane that are used to derive ethanol, their production is insufficient to meet global demand.

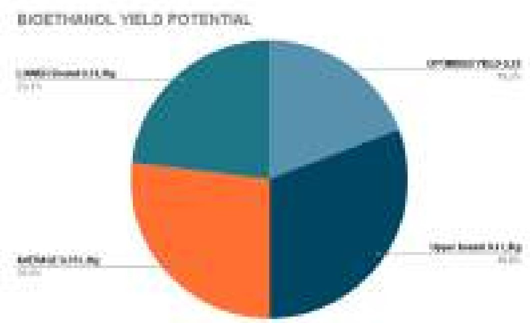

Paddy straw to bioethanol process.

As a result, non-edible LCB is becoming an increasingly attractive option, as it can be utilized to produce 2G ethanol and other valuable products in a biorefinery. The process of utilizing LCB for ethanol production involves several steps, including pretreatment, enzymatic hydrolysis, and product recovery. Pretreatment, in particular, is a crucial step and accounts for roughly 30-40% of the total capital



1. Hans et al., Process biochemistry, 85, (2019) 125-134.
2. Harun et al., Energies, 15(15), (2022) 5542.

expenditure and operating expenses (Capex and Opex costs). Therefore, it is recommended to conduct a techno-economic study prior to establishing the process.




Potential for Bioethanol from Paddy straw

With a potential yield of 250 liters of bioethanol per ton of paddy straw, there is a significant opportunity to harness this agricultural residue for sustainable energy production. While challenges exist, ongoing research, technological advancements, and supportive policies can help realize the full potential of paddy straw as a valuable feedstock for bioethanol production. This approach not only provides environmental and economic benefits but also contributes to a sustainable energy future. The Indian government has been promoting the use of agricultural residues like paddy straw for bioethanol production through policy incentives and funding for research and development. National Policy on Biofuels aims to increase ethanol blending in fuels. Using paddy straw to produce ethanol is an innovative approach to addressing both agricultural waste and energy needs. Here's an overview of how this can be implemented in a country. Paddy straw is collected from rice fields after the harvest. The collected straw is cleaned, chopped, and pre-treated to break down the lignocellulosic structure, making it more accessible for fermentation. Pretreatment includes physical (Milling or grinding to reduce particle size), chemical (Using acids, alkalis, or other chemicals to break down hemicellulose and lignin, leaving cellulose exposed) and biological methods (Employing enzymes or microbes to degrade lignin and hemicellulose). Next process is for hydrolysis, which includes Specific enzymes (cellulases) are added to convert cellulose into fermentable sugars like glucose. The sugars produced from hydrolysis are fermented by microorganisms (typically yeast) to produce ethanol. The ethanol is then separated and



3. GoI, MoPNG. (2018). National Policy on Biofuels.
4. Jameel et al., Results in Chemistry 7 (2024) 101549.

purified through distillation to obtain fuel-grade ethanol. Residual materials can be used as animal feed, fertilizers, or further processed into other bio-products.

One of the major challenges in efficient collection, storage, and transportation of paddy straw are logistical challenges that need to be addressed. Developing a robust supply chain is essential. Improving the efficiency of pretreatment and hydrolysis processes to maximize sugar yield and ethanol production remains a critical area of research. The costs associated with enzymes, pretreatment chemicals, and process optimization need to be managed to make bioethanol production economically viable.[3]

## Unveiling the role of biochar as a catalyst support for converting methane-rich biogas into hydrogen in a sustainable way

By Bijoy Biswas

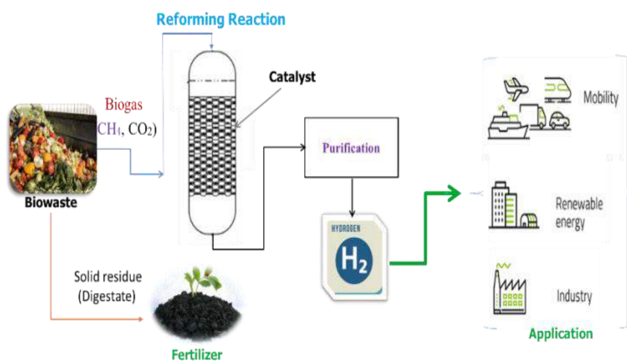
Biogas is produced through anaerobic digestion of organic materials such as agricultural waste, manure, municipal solid waste, and sewage. This process generates a gas mixture typically containing 55-75% methane and 35-40% carbon dioxide, along with trace amounts of other gases nitrogen, hydrogen sulfide, etc., and the amount of these gases depends on the temperature of the digestion reservoir and the type of biomasses.[4] Utilizing methane-rich biogas for hydrogen production not only provides a sustainable hydrogen source but also reduces greenhouse gas emissions by converting methane, a potent greenhouse gas, into useful energy.[5] Hydrogen production from methane-rich biogas is a promising method for generating clean energy. The conversion of methane to hydrogen ($H_2$) involves various catalytic processes, each with its advantages and challenges.

The primary catalytic processes for converting methane-rich biogas to hydrogen include steam methane reforming (SMR) {Reaction: $CH_4 + H_2O \rightarrow CO + 3H_2$}, partial oxidation (POX) {Reaction: $CH_4 + 1/2O_2 \rightarrow CO + 2H_2$}, autothermal reforming (ATR) {Reaction: Combines SMR and POX, $CH_4 + 1/2O_2 + H_2O \rightarrow CO + 3H_2$}, and dry reforming of methane (DRM) {Reaction: $CH_4 + CO_2 \rightarrow 2CO + 2H_2$}.[6] Among these, dry



5. Corrente et al., Fuel 368 (2024) 131561.
6. Mokheimer et al., Fuel 359 (2024) 130427.

reforming is a promising pathway for hydrogen production because biogas naturally contains $CO_2$, while, for the other processes, it will be necessary to separate the $CO_2$ from the biogas mixture. Dry reforming process utilizes $CO_2$, thereby reducing greenhouse gas emissions and producing hydrogen or syngas ($H_2$ + CO). However, the main drawback is the synthesis of suitable catalysts, as they promptly deactivate due to carbon deposition on the catalyst surface and pores. Furthermore, during biogas reforming, small amounts of nitrogen and hydrogen sulfide ($H_2S$) can significantly influence catalyst activity. The presence of nitrogen dilutes reactant gases, thereby reducing reforming efficiency. Meanwhile, $H_2S$ poisons the catalysts by forming metal sulfides, blocking active sites, and decreasing catalytic activity and lifetime.[7] Thus, managing these trace gases is crucial for maintaining catalyst efficiency and longevity. Nickel-based catalysts supported on silica and alumina are commonly used due to their cost-effectiveness and high activity. In addition, researchers have explored other mono and bimetallic catalysts for hydrogen production. Despite their effectiveness, these catalysts are prone to coking and sintering, leading to deactivation. Noble metals like platinum (Pt), ruthenium (Ru), and rhodium (Rh) are highly effective for hydrogen production and offer better resistance to coking and sintering but are expensive.[5,8]




Hydrogen production form biogas

Despite the aforementioned challenges, establishing suitable, cost-effective, and highly active catalysts for biogas dry reforming reactions to produce hydrogen need to be investigated. Biochar is a carbon-rich product obtained from the pyrolysis and hydrothermal carbonization/liquefaction of biomass. Biochar has gained attention as a catalyst support material due to its ability to



7. Yin et al., Chemical Engineering Journal 398 (2020) 125534.
8. Bahari et al., International Journal of Hydrogen Energy. 2024.

disperse a greater number of active metals on its surface. It stabilizes the catalyst by reducing sintering and coking because of its high surface area, porosity, and presence of functional groups. Furthermore, by modifying the pyrolysis or carbonization conditions, biomass feedstock, and ex-situ physico-chemical methods, the properties of biochar can be tailored to enhance its performance as a catalyst support. Combining biochar with other materials, such as metal oxides or zeolites, can create composite catalysts with synergistic effects that improve hydrogen yield and catalyst durability.[9] Additionally, biochar is relatively inexpensive compared to traditional catalyst supports like alumina and silica. Biochar-supported metal catalysts could offer a sustainable and cost-effective alternative for hydrogen production from biogas. The biochar-supported catalytic pathway has not been thoroughly explored yet, but this catalytic process is currently in its initial stages and could exceed those currently in operation.

# News and Events

## Signing of MoU between SSS NIBE and ORSL

An mou was signed between SSS-NIBE and organic recycling system limited (ORSL) on 8th april, 2024 to collaborate on sustainable technology development. SSS-NIBE and ORSL joins hands to propel Napier grass based anaerobic digestion process for biogas generation. Strategic partnership aims to maximize biogas potential of Napier grass advancing India's renewable energy agenda.

## Visit to NIT Hamirpur

On April 7th and 8th, 2024, Dr. Sachin Kumar (Scientist-C) and Dr. Sanjeev Mishra (Scientist-D), along with their project team, visited Hamirpur. During this visit, they conducted a workshop cum awareness program at NIT Hamirpur, Jal Shakti Vibhag Hamirpur, and NSCBM Government College Hamirpur. Additionally, the team inspected various Sewage Treatment Plants (STPs) at NIT Hamirpur and finalized the location for



9. Santos et al., Applied Catalysis B: Environmental 282 (2021) 119.

establishing a 5000 L raceway pond dedicated to algae cultivation.

Workshop at NIT Hamirpur

## One Day Workshop

Our institute conducted a one day workshop on 30th April, 2024 on the theme Idea, Research, Innovation, Intellectual Property Rights and Technology Transfer jointly supported by Punjab State Council for Science & Technology (PSCST), Govt. of Punjab and Department of Science & Technology, Govt. of India. The workshop was inaugurated by Chief Guest Dr. G. Sridhar, Director General, SSS-NIBE and Ms. Divya Kaushik, PSCST, Chandigarh under guidance of Dr. Sachin Kumar, Scientist-C, SSS-NIBE. The workshop was aimed to help faculty, students, researchers, and startup enthusiasts understanding how to come up with ideas, conduct research, innovate, and protect their intellectual property rights (IPR) and technology transfer. Moreover, the workshop delved into the translational research, highlighting its crucial function in bridging the gap between academia/ research and industry.

One Day Workshop on Research, Innovation, and Intellectual Property Rights

## Celebration of National Technology Day

National Technology Day is celebrated annually to honor the successful nuclear tests conducted in Pokhran on May 11, 1998, marking a significant milestone in India's history. It is a day dedicated to recognizing the technological advancements and innovations achieved by India's scientific and industrial community. On May 9, 2024, our institute commemorated National Technology Day by organizing a lecture. The keynote address was delivered by Prof. Adarsh Pal Vig, Chairman of the Punjab Pollution Control Board (PPCB). During his lecture, Prof. Adarsh Pal Vig highlighted the issue of stubble burning of paddy straw in fields and proposed solutions to address this problem by converting waste into wealth. He shared insights into the policies and projects undertaken by the Government of Punjab aimed at creating secondary income for farmers from waste agriculture biomass.

National Technology Day Celebration

## Meeting with Principal Scientific Adviser

On May 14, 2024, a meeting themed 'Biomass to Bioenergy - Path Forward' was convened under the Chairmanship of Prof. Ajay K. Sood, Principal Scientific Adviser (PSA) to the Government of India (GoI). The primary agenda of the meeting was to deliberate on biomass availability and its cultivation on degraded lands for the production of green hydrogen. Representatives from various ministries and research institutes attended, contributing innovative strategies for advancing green hydrogen production from biomass. During the meeting, the Director General, SSS-NIBE presented findings on the suitability of available biomass for green hydrogen production, emphasizing the cultivation of rapidly growing biomass with low to medium ash content. The Chair concluded the session by advocating for biomass cultivation on both private and government-owned lands to meet India's energy demands.

One day Workshop on Biogas

## One day Workshop on Biogas

The Ministry of New and Renewable Energy, GoI hosted a one-day workshop titled "National Biogas Roadmap for Viksit Bharat" on May 22, 2024, in New Delhi. Dr. Sachin

Kumar (Sci-C), Dr. Sanjeev Mishra (Sci-D), Dr. A. Senthil Nagappan (Sci-D), along with five research fellows from SSS-NIBE, participated in the workshop.

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