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)

Quarterly Newsletter

Bio-ऊर्जा

April 2024

Issue 6

Word from the Director General, SSS-NIBE

The sixth issue of SSS-NIBE's quarterly newsletter is scheduled for release as we complete the last quarter of the financial year 2023–24. As part of capacity building activity, two major national level training programs/workshops were successfully conducted at our campus. The first being a five-day National hands-on training program on Biogas Technology and second being a two-day National Workshop on biomass based clean cooking. It is heartening to share that there was overwhelming response for both the programs, with large no. of participants from academics, researchers and industry, offering ample opportunity for knowledge sharing, networking and collaboration.

This quarter also witnessed discussions with several industries about the piloting of in-house biogas and 2G technologies developed at the institute. A few more NDAs were signed. The other major accomplishment was the signing of a strategic MoU with Indian Institute of Technology Roorkee, which will address academic and research partnership in the area of bioenergy and bioproducts.

As it goes without saying, we appreciate your thoughts and recommendations to improve communication in the upcoming newsletter.

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

Research and Innovation

Innovations in biogas technology

By Gagandeep kaur, Research Scholar

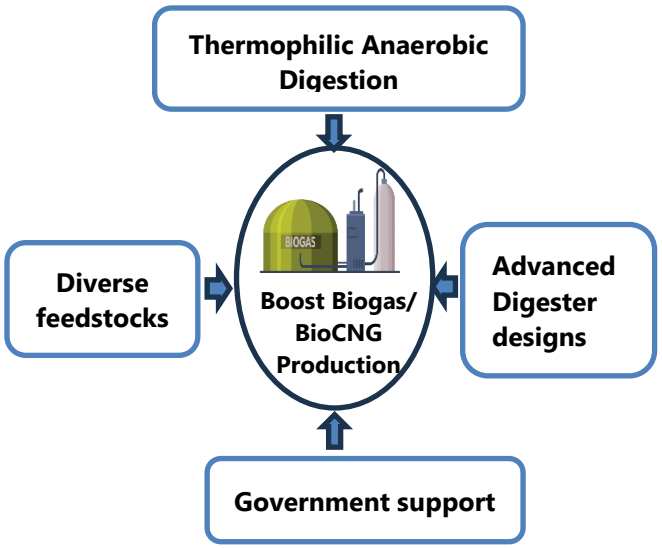
In the transition towards a sustainable and low-carbon future, the biogas industry plays a vital role. Recent advancements in biogas production have been attributed to the increased focus on Net Zero renewable energy sources. At COP26, India announced its ambition to become a net-zero emitter by 2070—an important milestone to combat climate change. As per MNRE study, the current availability of biomass in India is estimated at about 750 MMT per year with estimated surplus biomass availability at about 230 MMT per annum covering agricultural residues. Around 50 MMT of rice straw is burned annually, which is the most common practice for managing rice crop residues mainly due to its simplicity, low cost, short window between rice harvest and wheat sowing, lack of human resources and lack of viable uses for residues. Burning residue is a major contributor to air pollution, emitting around 1.5 MMT particulate matter, 150 MMT CO_2, other greenhouse gases (e.g., NO_2, SO_2, CO, CH_4, NH_3) and volatile compounds, resulting in a wide range of respiratory infections in humans.

A range of cutting-edge technologies and policy incentives are poised to propel biogas to substantial growth and have the potential to improve the global energy picture. A significant advancement in biogas production has been the development of advanced anaerobic digestion technologies. Thermophilic digestion is an emerging advanced technique nowadays in the biogas sector due to its potential benefits, such as fast substrate utilisation, high biogas yield, high methane concentration, etc., over the conventional technique. To contribute to renewable energy generation, Biochemical Conversion Division, SSS-NIBE, Kapurthala has developed an in-house thermophilic consortium for anaerobic digestion of different feedstocks, including agro-residues, grasses, kitchen waste, municipal solid waste, etc., for enhanced biogas and biomethane production. The development of a thermophilic consortium involves the isolation and selection of

different thermophilic microorganisms that can work together in a synergistic matter to enhance the efficiency of the substrate. Consortium use has several advantages, such as a fast rate of substrate utilisation, low hydraulic retention time (HRT), lesser risk of pathogens and high biogas yield.

Feedstock	Biogas yield (m^3/ton-TS)	BioCNG yield (kg/ton-TS)	HRT (Days)
Paddy straw	400-450	170-190	12-15
Kitchen waste (Hydrogen-rich)	200-250	--	05-07
Kitchen waste (Methane-rich)	500-550	210-230	12-15
Napier grass	400-600	170-250	15-20
Water hyacinth	300-400	125-170	20-30
Corn stover	400-450	170-190	20
Banana pseudostem	350-400	150-170	20

Moreover, this consortium works well on a variety of feedstocks, including lignocellulosic biomass and generates biogas with high methane content. The biogas and biomethane potential of a variety of substrates such as Napier grass, paddy straw, kitchen waste, food waste, water hyacinth etc., has been tested by using this consortium and it worked well on all the feedstocks with the production of methane-rich biogas and low HRT. Expected yields from the indigenous technology are as shown in table 1.



Recent innovations for boosting biogas/BioCNG production

Diversifying feedstock sources is another innovative aspect of biogas. Traditionally, agricultural waste and animal manure have been used in biogas production. The development of pre-treatment techniques and inhibition mitigation technology has made it possible to utilize a broader range of feedstocks, including food waste, faecal sludge, and energy crops. Besides expanding biomass availability for biogas production, diversifying feedstock sources supports

waste management challenges and promotes circular economies. Currently, R&D is focused on lignocellulosic biomass (straws, pulps, stalks, husks, etc.) which is a significant energy source, but has more complex cellular structures. Also, the approved biogas technology comes in a variety of sizes including small, medium, and large flexi biogas plants, with a daily biogas output ranging from 1 to 25 cubic meters.

Globally, governments are implementing supportive policies and market incentives to encourage biogas development. These incentives include feed-in tariffs, renewable energy certificates, tax incentives, and grants. It stimulates investment in biogas infrastructure, fosters the development of new technologies, and creates a favourable market environment for the growth of the biogas industry. Sustainable and low-carbon energy futures are made possible by the biogas industry's continuous evolution and innovation. The anaerobic digestion industry is poised for significant growth, owing to advances in technologies, feedstock diversification, biogas upgrading, and supporting policy frameworks. Further expanding its potential is the integration of biogas with renewable energy systems, hydrogen production, and decentralised energy production. The biogas industry holds great promise for reducing greenhouse gas emissions, achieving energy security, and fostering a circular economy as a renewable energy solution with immense potential.

Revolutionizing Waste Biomass with Hydrothermal Carbonization (HTC): Biochar Production and Its Diverse Applications

By Kaustubh khaire, Postdoctoral Fellow

Hydrothermal Carbonization (HTC) is a thermochemical process that involves converting biomass materials, such as agricultural residues, forestry waste, or organic waste streams, into carbon-rich biochar/hydrochar[1]. The process occurs under moderate temperature and autogenous (automatically generated) pressure conditions in the presence of water, typically at temperatures ranging from 180°C to 250°C[2]. During HTC, biomass undergoes complex chemical reactions, resulting in the decomposition of organic

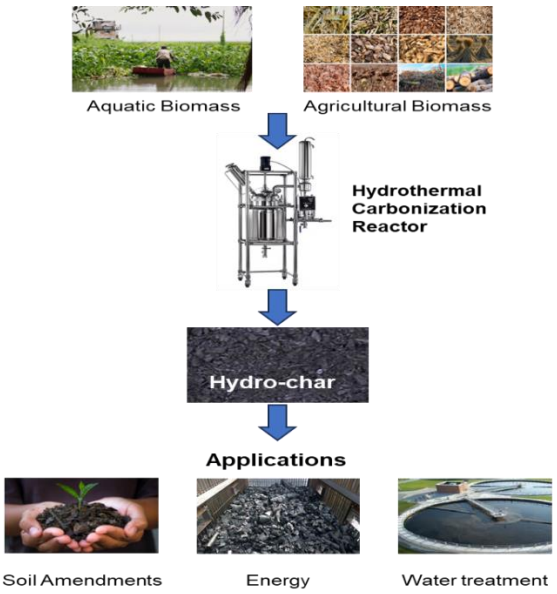
1. Sabry, T. M., et al., (2024). Journal of Molecular Structure, 1302, 137397.
2. Daneshvar, S., et al., (2024). Geoderma Regional, 36, e00740.

matter and the formation of carbonaceous solids. In the HTC process, biomass is mixed with water to form slurry, and then heated under autogenous pressure in a reactor vessel. The combination of heat, pressure, and water triggers hydrolysis, dehydration, and polymerization reactions within the biomass, producing biochar.

Biochar produced via HTC offers several advantages over traditional methods. Firstly, HTC boasts high conversion efficiency, typically exceeding 90%, due to water's role in facilitating biomass breakdown and carbonization[1]. It operates at moderate temperatures and autogenous pressures, reducing energy consumption compared to alternatives like pyrolysis or gasification. Another benefit is its versatility in handling various feedstocks, including lignocellulosic materials and wet biomass streams like sludge or algae, thereby reducing waste and promoting resource efficiency. Additionally, HTC biochar production integrates with waste management systems to valorize organic waste and mitigate greenhouse gas emissions by sequestering carbon in the soil[3].

Recent advancements in HTC technology have led to improvements in biochar production methods and expanded applications across various fields. Novel technologies optimize process parameters and enhance biochar quality and yield. Innovations in reactor design, heat transfer, and process control enable more efficient production. Emerging techniques like microwave-assisted HTC and continuous flow reactors offer new opportunities to improve efficiency and consistency. Moreover, HTC biochar improves soil health and fertility by enhancing water retention, nutrient availability, and microbial activity, promoting plant growth and productivity. It also contributes to soil carbon sequestration, mitigating climate change impacts. HTC biochar's efficiency, versatility, and environmental sustainability make it a promising solution for waste management, soil improvement, and climate change mitigation. Continued research and development are crucial to unlocking its full potential and promoting widespread adoption across various sectors.

3. Aktas, K., Liu, H., & Eskicioglu, C. (2024). *Journal of Environmental Management*, *356*, 120619



Process of hydrochar production from various agricultural biomass through hydrothermal carbonization and its applications

Applications of Hydrothermal Carbonization Biochar

HTC biochar offers versatile applications across various fields, particularly in environmental remediation, water treatment, and agricultural sustainability[1]. With its high surface area, porosity, and adsorption capacity, HTC biochar effectively sequesters contaminants and improves soil quality. Contaminated sites, such as industrial areas or mine tailings, often harbor pollutants like heavy metals or organic compounds, posing risks to ecosystems. Its porous structure binds contaminants, diminishing their mobility and toxicity[2]. Moreover, HTC biochar fosters microbial activity, nutrient cycling, and soil structure, facilitating natural contaminant attenuation over time. When applied to agricultural soils, HTC biochar also improves soil fertility by enhancing nutrient retention and availability, promoting microbial activity, and fostering root development[2]. By processing organic waste streams through HTC, valuable resources are recovered and transformed into stable carbonaceous materials, reducing waste generation and environmental pollution. In agricultural settings, HTC biochar can be incorporated into soil management practices to improve crop yields, reduce nutrient runoff and leaching, and mitigate soil erosion.

HTC biochar has the potential to serve as a renewable energy source through combustion or gasification processes. As a carbon-rich material, HTC biochar has high energy content and can be utilized as a solid fuel for heating, electricity generation, or bioenergy production[2]. By combusting HTC biochar, energy is released in the form

of heat, which can be utilized for various industrial processes or converted into electricity through steam turbines or gas engines. Alternatively, HTC biochar can be subjected to gasification, a thermochemical process that converts carbonaceous materials into synthesis gas (syngas), a mixture of hydrogen and carbon monoxide that can be further processed into biofuels, chemicals, or electricity[2]. By incorporating HTC biochar into filtration systems or treatment reactors, contaminants such as heavy metals, organic pollutants, and pathogens can be effectively removed from water streams, improving water quality and reducing environmental pollution. In wastewater treatment applications, HTC biochar acts as a filtration medium or adsorbent material, capturing pollutants as water passes through the porous structure of the biochar. Contaminants are adsorbed onto the surface of the biochar particles, allowing for their removal from the water stream.

Opportunities and Challenges in Expanding HTC Biochar Applications

The evolving field of HTC biochar presents numerous opportunities and challenges. Opportunities include expanding biochar applications beyond soil amendment to environmental remediation, water treatment, renewable energy, and advanced materials. However, challenges such as technological barriers, economic viability, regulatory constraints, and environmental concerns must be addressed for HTC biochar to realize its full potential. Collaborative efforts among researchers, industry, policymakers, and communities are essential for overcoming these challenges and driving global adoption. HTC biochar aligns with several UN Sustainable Development Goals, including those related to climate action, clean water, sustainable agriculture, and responsible consumption. Despite its potential benefits, HTC biochar faces challenges such as technological barriers, environmental concerns, economic viability, and regulatory constraints. Addressing these challenges requires optimizing process efficiency, mitigating environmental impacts, ensuring economic viability, and fostering market acceptance. In conclusion, HTC biochar

holds promise for addressing environmental and societal challenges, but overcoming obstacles will require interdisciplinary collaboration, innovation, and strategic alignment with sustainability goals.

News and Events

Republic Day celebration

The institute enthusiastically celebrated the 75th Republic Day on January 26, 2024. The Institute's Director General unfurled the flag on this occasion. After the flag unfurling ceremony, the DG, SSS-NIBE planted trees on the campus. Additionally, researchers, SSS-NIBE personnel, and their families organized a cultural event to add to the celebrations.

SSS-NIBE & IITR Sign Strategic MoU

On February 9, 2024, a strategic Memorandum of Understanding (MoU) was formally inked between SSS-NIBE and the esteemed Indian Institute of Technology, Roorkee (IITR). This collaborative agreement delves into various avenues for partnership in the realm of bioenergy and bioproducts. The key initiatives include the enrollment of research scholars for PhD programs at IITR, the initiation of innovative academic programs such as integrated PhD, exchange programs for faculty as visiting scientists, joint submission of research and development proposals, as well as mutual training endeavors.

SSS-NIBE signed an MoU with IBA

An MoU has been signed between Indian Biogas Association (IBA) and SSS-NIBE to extend their existing collaboration. The primary objective of this extension is to further promote SSS-NIBE's in-house technologies, such as CBG and 2G ethanol, through joint initiatives. These initiatives include organizing meetings and workshops with potential industries, as well as exploring opportunities for pilot and demonstration plants. Additionally, the focus will be on

scaling up the aforementioned technologies for industrialization purposes. The MoU also encompasses activities such as testing the biogas potential of various biomass and waste materials, providing allied laboratory services, and offering capacity building and training programs, including online and skill development courses. Furthermore, the collaboration will involve research and other activities related to biohydrogen and green hydrogen.

National Training Program on Biogas technologies

SSS-NIBE and the Indian Biogas Association (IBA) collaborated to host a comprehensive five-day National hands-on training program titled 'Biogas Technology and its Implementation' from February 19 to 23, 2024. The primary objective of this initiative was to enrich participants' understanding and practical expertise in biogas technology while fostering collaboration among industry experts. A diverse group of around 35 participants representing academia, industry, NGOs, and startups engaged in the program. This gathering served as a platform for exchanging knowledge and gaining insights into the contemporary landscape of biogas technology and its practical applications. The inauguration ceremony was graced by esteemed guests, including Dr. A. R. Shukla (President, IBA) and Dr. G. Sridhar (Director General, SSS-NIBE). Following the inauguration, a series of informative talks were delivered by renowned speakers hailing from academia, research and development sectors, and industries. These sessions delved into various critical themes, namely: Biogas Process and Design, Biogas Operation & Maintenance, Biogas Upgradation and Power Generation, Application of Algal Technology in Biogas, and Biogas Policy & Financing.

Throughout the training program, participants actively engaged in hands-on

experiments aimed at deepening their understanding of application-oriented biogas production techniques. Additionally, an insightful industrial visit to a cow dung-based biogas plant in Ludhiana provided participants with practical insights into the operation, maintenance, and commercial aspects of biogas production. Overall, the National Hands-on Training Programme facilitated a dynamic learning environment, empowering participants with the requisite knowledge and skills to contribute effectively to the field of biogas technology implementation.

National Workshop on biomass based clean cooking

SSS-NIBE, Kapurthala, organized a two-day National Workshop on "Biomass-based Clean Cooking Solutions" from February 29 to March 1, 2024. The workshop was also supported by the UNDP. During the inaugural ceremony on February 29, Dr. G. Sridhar, DG, SSS-NIBE, delivered the keynote address, emphasizing the importance of biomass-based cooking, particularly in rural areas. Dr. Jatinder Kaur Arora, Executive Director, Punjab State Council for Science and Technology (PSCST), was the Chief Guest, and Dr. Sangita M. Kasture, Scientist-G from MNRE, was the Guest of Honour. The workshop attracted over 40 participants from academia, industries, government agencies, and non-profits organizations. Dr. Sangita M. Kasture acknowledged the prevailing challenges within the clean cooking sector and encouraged stakeholders to collectively devise technological and business-driven solutions for a seamless transition towards cleanliness. She also shed light on the governmental support extended to the sector through biogas-based cooking initiatives.

Chief Guest Dr. Jatinder Kaur Arora presented insightful statistics, underscoring the enormity of the clean cooking problem and emphasized the role of women entrepreneurship in addressing it, along with

PSCST's efforts in promoting women entrepreneurship.

Speakers in their talks covered a wide range of topics including the need and design of biomass-driven solid (agri-residue, pellets/briquettes, etc.), liquid (ethanol), and gaseous (biogas) fuels-based clean cooking solutions, health effects of traditional vis-à-vis clean cooking technologies, current cooking scenario in India, improved cookstove designs and carbon credits-based business models for biomass cooking. A stove testing demonstration was carried out on the first day of the workshop for all the participants.

International Women's Day celebration

On International Women's Day, our female staff members, including Dr. Banafsha Ahmed, Research Associate, along with Ms. Gaganpreet Kaur and Ms. Nisha Yadav, Senior Research Fellows, participated in the International Women's Day event hosted at the Ministry of New and Renewable Energy (MNRE) in New Delhi on March 8, 2024.

Participation in Flower Show

The horticulture staff of SSS-NIBE enthusiastically participated in the flower show hosted by Pushpa Gujral Science City, Kapurthala, showcasing their expertise and dedication. Their efforts were rewarded with the first prize, marking a significant achievement for the institute.

Prize distribution of Hindi Pakhwada

During the trimester, SSS-NIBE organized a Hindi committee meeting aimed at promoting the language's usage and appreciation within the institute. The event featured distinguished guest speaker Dr. V K Aggarwal, who shared valuable insights. Moreover, the DG, SSS-NIBE

took part in honoring the winners of various competitions held as part of Hindi Pakhwada 2023, recognizing their achievements and contributions to promoting Hindi language and culture.

******For suggestion please contact at sss.nibe@nibe.res.in******

Published by:
Director General,
Sardar Swaran Singh National Institute of Bio-Energy,
Kapurthala, Punjab,
Pincode-144603

Website: http://nibe.res.in
Email: sss.nibe@nibe.res.in
Twitter@SssNibe
Telephone: (+91)1822507406
Facebook: https//www.facebook.com/SSS.NIBE

Publication Team:
Editor: Dr. Sandeep Kumar Assistance**:** Mr. Hitesh Sharma, Ms. Suambada Kumari