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A Report on Webinar on
"An Overview of Anaerobic Digestion Process for Biogas Production"
Organized by Department of Mechanical Engineering
Date: 12.10.2023 | Time: 03:00 PM | Venue: Seminar Hall – B

Submitted by: **Dr. Anantha Raman L., Assistant Professor, Dept. of ME, MITS**

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Coordinated by: **Dr. Anantha Raman L., Assistant Professor, Dept. of ME.**
Dr.Dhrubajit Sarma, Assistant Professor, Dept. of ME.

Resource Person: **Dr Deepanraj Balakrishnan, Research Faculty, Department of Mechanical Engineering, Prince Mohammad Bin Fahd University, Saudi Arabia.**

The event commenced at 03:00 PM, opened with a greeting to all attendees by Dr. Anantha Raman L., Assistant Professor of Mechanical Engineering at MITS, Madanapalle. This was followed by remarks from Dr. S. Baskaran, the Head of the Mechanical Engineering Department at MITS, Madanapalle.

Dr. Anantha Raman then provided a concise introduction of the main speaker for the day. Following this, the session was given to **Dr. Deepanraj Balakrishnan**, a Research Faculty from the Department of Mechanical Engineering at Prince Mohammad Bin Fahd University, Al-Khobar, Saudi Arabia.

Dr. Deepanraj initiated his talk by expressing his deep gratitude to the attendees, the organizing team, department head, principal, and the management of MITS, Madanapalle for the chance to impart his expertise on "**An Overview of Anaerobic Digestion Process for Biogas Production**." Throughout his captivating online presentation, **Dr. Deepanraj** provided invaluable perspectives on several key topics.

His session aimed to educate the students on the subsequent areas:

- Need for renewable energy.
- Types of biofuels.
- Biogas and its types.
- Different production techniques.
- Applications around the world.

Need for renewable energy:

In a world increasingly aware of environmental challenges and the dangers of depleting non-renewable resources, the speaker interacted with the students, emphasizing the urgent need for renewable energy.

Environmental Concerns: The speaker painted a vivid picture of the ecological devastation caused by fossil fuels. From the billowing smokestacks belching pollutants into the air to the devastating oil spills that tarnished our oceans and harmed marine life, the speaker laid bare the environmental costs of non-renewable resources. He spoke of rising sea levels, intensifying natural disasters, and the overall phenomenon of climate change – all of which are exacerbated by human reliance on fossil fuels. In contrast, renewable sources of energy like solar, wind, and hydro power offer a means to generate power without these detrimental effects.

Economic Viability: Moving away from the environmental narrative, the speaker delved into the economic repercussions of our continued dependence on fossil fuels. He spoke of the volatile nature of oil prices, the geopolitical tensions surrounding oil reserves, and the countless subsidies poured into the fossil fuel industry. The speaker argued that as non-renewable resources become scarcer, prices would inevitably rise, placing enormous financial strains on economies worldwide. On the other hand, renewable energy, once the infrastructure is set up, can be harnessed at a much lower cost and has the potential to generate countless jobs in research, development, and maintenance.

Sustainability and Future Generations: Lastly, the speaker appealed to the audience's sense of responsibility towards future generations. He spoke of a vision where our children and their children could inherit a world not plagued by energy shortages or marred by environmental catastrophes. The speaker highlighted how, unlike fossil fuels, renewable resources like the sun and wind are virtually inexhaustible, ensuring that humanity won't be left in the dark once oil wells run dry.

Types of biofuels:

First Generation Biodiesel: The speaker's initial focus was on the first-generation biodiesel, which is derived primarily from edible oils. This category includes vegetable oils like soybean, rapeseed, and palm oil. The audience was reminded of the advantages of these biodiesels: their compatibility with existing diesel engines, reduction in greenhouse gas emissions, and the ease of production. However, the speaker didn't shy away from discussing the controversies surrounding these biofuels. Namely, the food vs. fuel debate, where the large-scale production of first-generation biodiesel can divert food resources and potentially raise food prices.

Second Generation Biodiesel: Moving on, the speaker shed light on the second-generation biodiesel, which is produced from non-edible plant sources. Examples provided included Jatropha, algae, and waste cooking oil. The speaker emphasized the sustainability factor of these biodiesels, as they don't compete with food crops. Furthermore, they mentioned how certain sources, like algae, have a higher yield per acre than their first-generation counterparts.

Third Generation Biodiesel: The audience's attention was then captured by the third-generation biodiesel, which is based on advanced biofuel technologies and processes. The speaker elaborated on how these biodiesels are typically produced using microorganisms like bacteria and fungi. The unique aspect of these biodiesels is that they can be tailored to produce specific types of fuels, allowing for greater optimization and energy yield.

Advanced Biofuels: Lastly, the speaker touched upon advanced biofuels, which don't neatly fit into the previous categorizations but are significant, nonetheless. They explained that these biodiesels are derived from a broader array of biomass sources and have reduced greenhouse gas emissions. Examples include biofuels produced from cellulosic materials or waste gases.

Biogas and its types:

What is Biogas?: The speaker began by defining biogas as a mixture of gases produced by the anaerobic digestion or fermentation of organic materials. With a hint of enthusiasm, he described how it's primarily made up of methane and carbon dioxide and can be used as a renewable energy source for heating, electricity, and transportation.

Types of Biogas:

a. Landfill Gas: The speaker delved into the first type, landfill gas, which arises from organic waste decomposing in landfills. He mentioned its potential as an energy source, noting that if left unchecked, it can escape into the atmosphere and contribute to the greenhouse effect.

b. Sewage Sludge Gas: The focus then shifted to sewage sludge gas. The speaker elucidated how wastewater treatment plants produce this type of biogas during the treatment of sewage. Harnessing this gas, he remarked, can help power the very plants that produce it, creating a sustainable energy loop.

c. Agricultural Biogas: Discussing the agricultural perspective, the speaker brought forth agricultural biogas. He described how it's generated from organic materials like manure, plant waste, and specially grown energy crops. The dual benefit of this type, as he highlighted, is waste reduction and energy production.

d. Industrial Biogas: Industrial processes, too, have their contribution to biogas. The speaker detailed how food and beverage production residues, for instance, can be converted to biogas. This not only helps industries manage waste but also provides an alternative energy source for their operations.

e. Syngas (Synthesis Gas): Lastly, the speaker introduced syngas, which is slightly different from the other types. Produced from the gasification of organic materials rather than fermentation, syngas contains hydrogen, carbon monoxide, and a small amount of methane. Its versatility was emphasized as it can be used for electricity, heating, and as a base for producing liquid fuels.

Different production techniques:

Anaerobic Digestion (AD): The speaker began with perhaps the most common method, Anaerobic Digestion. He explained that AD involves breaking down organic materials in the absence of oxygen using microorganisms.

Four stages were highlighted:

a. Hydrolysis: The breaking down of large organic molecules into simpler sugars, amino acids, and fatty acids.

b. Acidogenesis: The conversion of those simple molecules into volatile fatty acids and alcohols.

c. Acetogenesis: Here, the intermediate products are further converted into hydrogen, carbon dioxide, and acetic acid.

d. Methanogenesis: Methane is finally produced by methanogens in this stage.

Landfill Gas Recovery: Drawing attention to our waste disposal methods, the speaker discussed how landfills aren't just waste dumping grounds. As organic waste in landfills decomposes anaerobically, methane-rich gas is produced. Through landfill gas recovery systems, this gas can be captured and used as a renewable energy source.

Gasification: Venturing into thermochemical processes, the speaker introduced gasification. He elucidated that in this method, organic materials are exposed to a limited amount of oxygen or steam, but not enough for complete combustion. The resulting gas, syngas, is a mixture of hydrogen, carbon monoxide, and a bit of methane.

Pyrolysis: Continuing the thermochemical journey, the speaker touched upon pyrolysis. He described how organic materials are thermally decomposed in the absence of oxygen, producing biochar, liquid bio-oil, and syngas. The diverse products make this method particularly intriguing for varied applications.

Fermentation: Finally, the speaker brought up fermentation, particularly for hydrogen production. He outlined how certain bacteria can produce hydrogen gas when fermenting sugars, offering another pathway for biogas production.

Applications around the world:

Cooking and Heating: The speaker began with the humblest, yet most widespread application. In many developing nations, biogas is used as a household fuel for cooking and heating. By using biogas digesters that convert animal dung and organic waste, rural families can replace firewood or coal, reducing deforestation and indoor air pollution.

Electricity Generation: Next, the topic shifted to larger scales. Biogas, the speaker emphasized, is being used in combined heat and power plants (CHP) to generate electricity. Whether it's from agricultural residue in Europe or landfills in North America, biogas offers a sustainable way to power communities while reducing greenhouse gas emissions.

Vehicle Fuel: Delving into transportation, the speaker highlighted how countries like Sweden and India are making strides in using biogas as a transportation fuel. Compressed or liquefied biogas is finding its way into buses, trucks, and even cars, serving as a cleaner alternative to gasoline and diesel.

Waste Management: One of the prominent points the speaker emphasized was the dual-purpose role of biogas in waste management. From urban food waste in cities like San Francisco to animal manure in Dutch farms, biogas production helps in waste reduction while producing valuable energy.

Grid Injection: A more advanced application the speaker explored was the purification and injection of biogas into natural gas grids. Countries like Germany have made significant advancements in upgrading biogas to biomethane, making it compatible with existing gas infrastructure.

Industrial Heating: The industrial sector wasn't left behind in the discourse. In regions like Southeast Asia, where agro-industrial activities are prevalent, biogas is utilized for drying and heating processes, leading to substantial cost savings and carbon footprint reduction.

Q&A Session:

After the lecture, there was a lively question and answer segment where students eagerly interacted with **Dr. Deepanraj Balakrishnan**, seeking more insights and explanations.

The event was wrapped up with a heartfelt expression of gratitude by **Dr. Dhrubajit Sarma**, Assistant Professor from the Department of Mechanical Engineering. He extended his thanks to the management, **Dr. C. Yuvaraj** (Principal of MITS), **Dr. S. Baskaran** (Head of the Mechanical Engineering Department), the faculty members from the ME department, and all the attending students for their invaluable support in making the guest lecture a success.