BioResources & Technology

Pretreatment of Lignocellulosic Material from Agro-waste to Increase Biomethane Production

Authors:

Digging into the background of the research of Hidayatul Fitri, PhD student at the Biogas Research Team under the guidance of Assoc. Prof. Dr. Hynek Roubík.

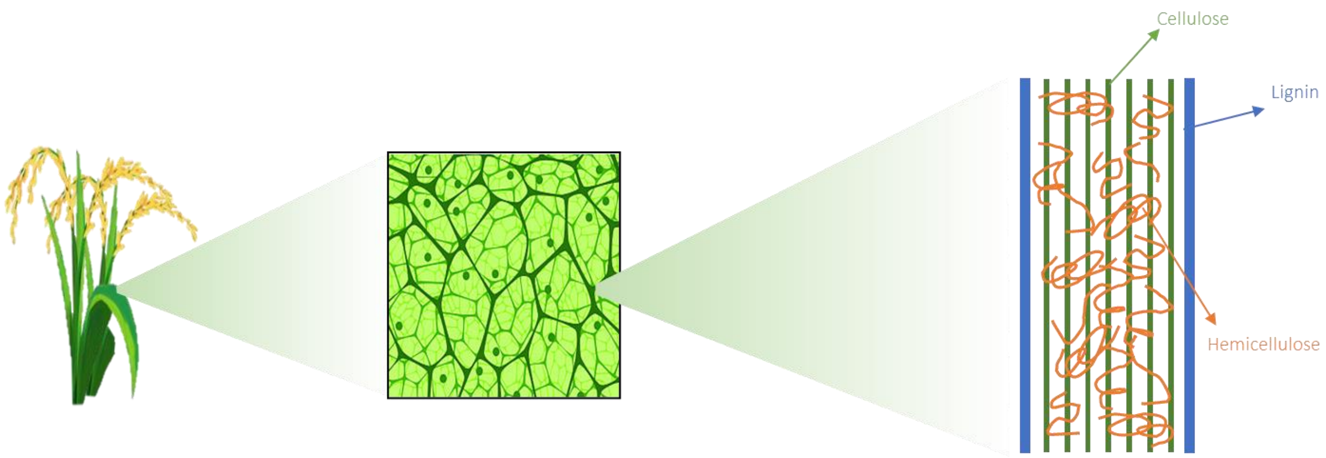
The young researchers of the Biogas Research Team (BRT) are diligently working to increase the visibility of the success and potential of bioenergy sources. From Indonesia to Vietnam to Ethiopia and beyond, their efforts to highlight the impact and importance of incorporating renewable energy technologies are creating change worldwide.

With this popularization series, we aim to showcase the impact of our research on renewable energy in strategic countries around the globe.

Lignocellulosic Biomass (LB)

The lignocellulosic material comprises three main components: lignin, cellulose, and hemicellulose, which are the source of biofuel production, including biogas. Lignocellulosic refers to the dry matter of plants mostly derived from agriculture and forestry. Lignocellulosic is a promising renewable energy resource that could promote waste management solutions and mitigate greenhouse gas (GHG) emissions. Cellulose is made of glucose polymers, and hemicellulose is made of five different sugar polymers, which are used to produce biomethane.

Why agriculture waste?



Structure of lignocellulosic material

Agriculture is a source activity that establishes and provides a primary need for food security. Agriculture activities generate residues after harvesting and food processing. Most agricultural waste has been addressed as a viable resource for energy generation. The by-product of post-harvesting processes results in many abundant and diverse crops, such as straw, stalk, husk, bagasse, and peat.

The utilisation of agricultural residues is a key control to waste management. Most farmers, especially in developing countries, consider burning the residues in the field as the most cost-effective way to clear their land for new plantations.

Recalcitrant of Lignocellulosic Biomass (LB)

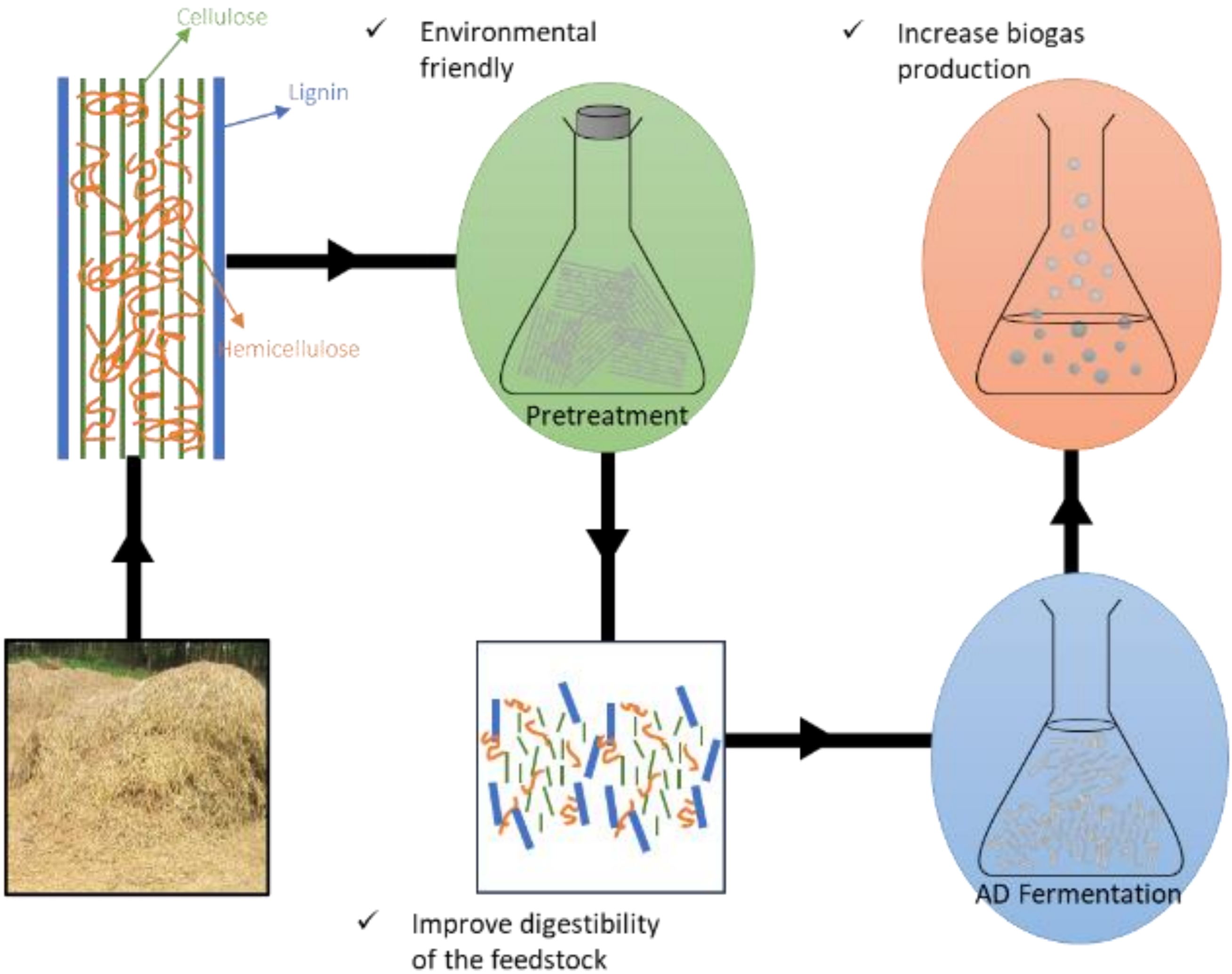
One of the major limitations of the lignocellulosic material is the complex structure of the polymer matrix recalcitrant to microbial and enzymatic degradation. The antidegradation property, as a result of its lignin polymer, protects the plant cell from microorganisms and chemical degradation. The presence of lignin controls the permeability of plant cells and limits the access of enzymes to cellulose and hemicellulose. Thus, removing lignin is the primary factor in the recalcitrant characteristic of LB and the most challenging stage to overcome biomethane conversion.

Overcoming recalcitrant strategies

Before utilising the LB materials for energy conversion, they need special treatment. To alter the recalcitrant structure, pretreatment is a preliminary method to improve the digestibility of LB. The degradation of LB related to the lignin content binds both cellulose and hemicellulose. Opening more access to cellulose and hemicellulose promotes the easy breakdown and conversion into fermentable sugar. The structure of LB is required to make cellulose or hemicellulose more accessible for conversion. Various pretreatment methods have been developed that can be used to remove lignin and provide more access to polysaccharide polymers, such as physical, chemical, biological, and combined methods. However, biomethane production needs further assessment of the impact of recalcitrant lignocellulosic material and the development of advanced technology pretreatment.

Optimisation of Anaerobic Fermentation

Due to the complex structure of the lignocellulosic material, it is difficult for it to be degraded in the anaerobic fermentation process. It is a critical step in biogas production that can affect the yield of methane. The pretreatment of the LB material can be considered a good way to improve the stability of the fermentation process and the production of methane. In addition, not only using animal manure but also combining various organic wastes, for example, agro-waste, can help to increase biogas yields.



Enzymatic hydrolysis pretreatment technologies for lignocellulosic biomass.

Future perspective

Unused and under-utilised waste is a problem for the environment. The disposal of agricultural waste by dumping in landfill or burning contributes to the emission of greenhouse gases. By adding the agro-biomass together with the animal manure can improve the anaerobic process in generating biogas for energy. Valorisation of wastes into value-added products through anaerobic digestion can be an applicable solution for the management of agrowaste.

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