Atriplex crassifolia: a potential halophytic substrate for Biogas production

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Abstract

Among biofuels, biogas is undeniably a promising cost-effective green energy resource for waste material valorization. Instead of conventional crops, halophytes can be utilized for effective biogas production as they are widely available and are also a cheaper source. In this study, an optimized pretreatment of halophyte *Atriplex crassifolia* was carried out by choline chloride and lactic acid (deep eutectic solvent). Biocontent estimation of substrate revealed that *Atriplex crassifolia* exhibited cellulosic content of 37.5% which increased up to 79.3% after fully optimized pretreatment. Moreover, pretreated *Atriplex crassifolia* when subjected to anaerobic digestion, generated biogas production yield of 32.2mL/g. The results revealed *Atriplex crassifolia* as a promising substrate for biogas production due to its high cellulosic content.

Introduction

Presently, a massive chunk of global energy demand i.e., ≥ 84% is sustained through fossil fuels. Recently, researchers have shifted the focus towards the development of renewable energy reserves. Among all renewable energy options, lignocellulosic biomass is considered an inexhaustible energy resource and a vital substrate for the production of biogas.

Crop production is facing severe constrictions because arable lands are shrinking due to freshwater shortage and soil salinization. About 43% of the Earth's land is arid or semi-arid while, 98% water is saline. Approximately 20% of irrigated land is degrading due to salt, leading to economic fatalities of about 27.3 billion US$ per year, mandating the necessity of utilizing salt-tolerant halophytes for renewable energy production. As halophytes grow in degraded saline lands, thus they are an upright source of cheap LCB.

Halophytes can uptake significant amounts of salt and therefore, can be effectively utilized for achieving the remediation of saline lands. Additionally, halophytes can also be used to construct wetlands for reducing biological and chemical compounds, which eventually treat wastewater as well. The widely distributed halophyte i.e., genus Atriplex consists of about 250 species. Atriplex belongs to the subfamily Chenopodioideae and family Amaranthaceae. The genus Atriplex includes several species, such as *Atriplex canescens*, *Atriplex hortensis*, *Atriplex lentiformis*, and *Atriplex crassifolia* etc.

Halophytic biomass is getting a lot of attention due to food-vs-energy crisis. Moreover, production of biogas from halophytes such as *Atriplex crassifolia* diminishes the competition for fertile land and freshwater demands as well, displaying the potential of halophytes to effectively compete with other conventional crops for biogas production.

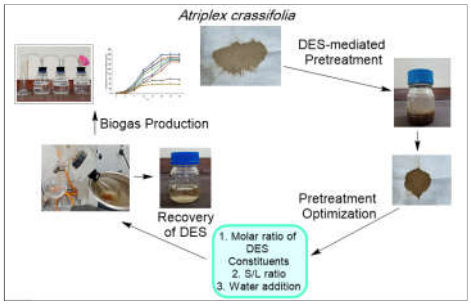
Methods and Materials

Collection of *Atriplex crassifolia* : The halophyte was collected from the arenas of KSK campus, GC University, Lahore, Pakistan and grinded into fine powder (particle size <1.5mm).

Pretreatment: The pretreatment was done by ChCl: LA-DES. Optimization parameters were molar ratio of DES constituents, solid-to-liquid ratio, and water addition in the DES.

Biogas production: The biogas production was attained via AD and biogas quantification (mL) of was done by water displacement method.

Statistical analysis: Statistical analysis was performed by SPSS Modeler 16.00 (IBM Analytic, New York, NY USA).



Results

Biocontent estimation revealed *that Atriplex crassifolia* consisted of 37.5% of cellulose, 32.5% of hemicellulose, and 19.2% of lignin content as displayed in **Table 1**.

After fully optimized ChCl: LA- mediated pretreatment, 89.5% of lignin was eliminated and cellulosic content also enriched up to 79.3%.

The fresh DES pretreated *Atriplex crassifolia* provided maximum biogas production value of 161 mL with biogas production rate of 0.32 mL/h.

The ChCl: LA-pretreated *Atriplex crassifolia* recorded 32.2 mL/g of cumulative biogas production yield due to increased cellulosic content as shown in **Chart 1**.

Table 1. Characterization of pre-hydrolyzed biomass and inoculum

Characterizing factors	*Atriplex crassifolia*	Anaerobic sludge
Cellulose (%)	37.5 ± 1.3	-
Hemicellulose (%)	32.5 ± 1.1	-
Lignin (%)	19.2 ± 0.4	-
pH	5.5 ± 0.6	7.9 ± 0.1
TS (g/L)	52.4 ± 1.5	24.3 ± 0.9
VS (g/L)	41.8 ± 1.2	14.6 ± 0.2
tCOD (g O_2/L)	103 ± 3.5	28.5 ± 1.1

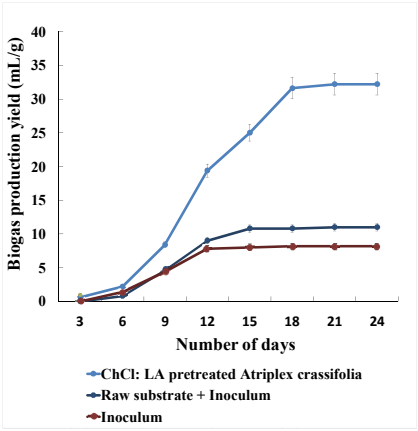


Chart 1. Biogas production yield (mL/g) of *Atriplex crassifolia*

Discussion

The high cellulosic content (37.5%) of raw *Atriplex crassifolia,* which was further increased (79.3%) after ChCl: LA-mediated pretreatment rendered it extremely suitable for biogas production.

When *Atriplex crassifolia* was subjected to biogas generation, a gradual rise in biogas production was observed until 9 days of incubation, and the peak values were obtained after 21 days.

The fresh DES pretreated biomass sample provided maximum biogas production yield of 32.2 mL/g while the raw substrate also generated a meager biogas yield of 12.2 mL/g. These results indicated the efficacy of *Atriplex crassifolia* in begetting high biogas production values.

Conclusions

Atriplex crassifolia was demonstrated as an efficient halophytic biomass for biogas generation due to its high cellulosic content.

Fully optimized DES-based delignification (ChCl: LA (1:2); 15% diluted DES; S/L ratio of 1:15) of halophyte proved highly effective in enhancing the cumulative biogas production values i.e., up to 161 mL in comparison to the raw substrate.

Biogas production by *Atriplex crassifolia* improved by 37.9% after ChCl: LA-mediated pretreatment due to its increased content of cellulosic sugars, eventually suggesting that effective pretreatment can further improve the biogas generating potential of the halophyte.

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