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Waste Biomass as an energy and materials resource

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Nowadays, the need to recover the post-pandemic economy, find solutions for climate change through sustainable practices, decarbonize human activities, and close the industrial circularity loops keeps the biomass research field active and dynamic. The research topics include creative uses of biomass as feedstock to produce materials and energy.

Biomass is, by definition, a renewable energy and materials resource. Biomass production worldwide depends on multiple factors predominantly driven by the pursuit of energy and food independence and security of each country. With the dynamic geopolitical activity, large traditionally arable areas and new cultivation sites are productive, yielding waste biomass. The yearly worldwide production of plant waste biomass surpasses 140 Gt [1], an astronomical number; however, most of it is not utilized. Other biomass sources are the forestry industry, municipal solid waste, and dedicated energy/materials crops.

Private and public sectors in many countries are pursuing Decarbonization targets. These aim for balancing anthropogenic greenhouse emissions sources and sinks by 2050, popularized in the Paris Agreement. By slowing down carbon-containing emissions production and further sequestering some of it, humanity will decrease the concentration of greenhouse gases, aiming to weaken climate change. Fossil-derived fuels, materials, and chemicals are a significant source of carbon-containing emissions, so moving away from them or using them efficiently may help decelerate atmospheric carbon inputs. However, existing carbon needs to be removed to decrease the carbon concentration in the air.

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The photosynthetic capabilities of plants include capturing CO2 using sunlight to grow biomass, pumping carbon into their structures, and storing energy as chemical bonds. Traditionally, the old bioeconomy used these plants for energy and construction materials. However, the rapid increase in the use of coal and petroleum fueled the industrial revolution and relegated the biomass option. Noteworthy, biomass cultivation remains a viable option to obtain chemical building blocks, heat, structural materials, dyes, medicine, and food. Furthermore, if some of the carbon in biomass can satisfy human needs and the rest can be locked into the ground, with the added benefit of soil amendment, i.e., biochar production and sequestration, the atmospheric carbon content will be reduced. This option could be one of the tools for decarbonizing human activity. However, many other efforts should coexist to decrease atmospheric greenhouse gases within a reasonable timeframe.

Biomass production challenges include land-use change effects, soil health decline, and biomass source geographical dispersion. Local development initiatives can tackle many of these issues by allowing biomass cultivation for local needs, maintaining the waste biomass in the region for preserving soil health, and preventing long transportation of

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resources to central processing facilities. Additionally, local families could benefit from creating waste biomass markets as a source of additional income.

A plethora of waste biomass applications can be found in the literature, like biopolymers production, supercapacitors, high strength fibers, nanomaterials, food flavoring, biofuels, bio-solvents, filtering media, photothermal materials, hydrogels, pharmaceuticals, nutraceuticals, bioactive compounds, catalysts, sugars, alcohols, acids, biochar, and chemical building blocks. Despite challenges of their own, most of the applications have excellent potential to become commercially available in the near future. As always, more research is needed.

In an ever-growing energy and materials market, waste biomass brings opportunities to fight climate change, proposes important routes for decarbonization, and is at the center of the bioeconomy. Many challenges are preventing biomass endeavors from becoming commercially available; however, today and tomorrow's research community and brilliant minds will find the solutions to these challenges.

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