



Rethinking Organic Residues: The Potential of Biomass in Brazil



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Submission: 📅 October 02, 2017; **Published:** 📅 March 29, 2018

Introduction

Since the 1970s, the complex relationship between people and nature has been gaining prominence in the world forums related to global environmental changes. The consequences of landscape transformation worldwide have been increasingly recognized not only by the scientific community, but also by the general population. As the world population continues to grow, there is an increasing pressure on water and land to provide an adequate supply of food and industrial products. Projections indicate that by 2030 the population will be 8.5 billion of inhabitants and in 2050 of 9.7 billion [1]. Lack of successful solutions for the conservation of ecosystems and adequate destination for the waste may lead to serious environmental and socio-economic consequences.

One of the biggest challenges today is maintaining industrial production without compromising environmental quality, here referred to as the conservation of natural and human resources. Agriculture and intensive industrial production, which since the middle of the 17th century with the 1st Industrial Revolution has been gaining new forms, needs to be rethought. These processes attend the demand of part of the population with food and products. However, do not solve the problem of the enormous availability of waste derived from these activities. Together with the exploitation of resources, pollution is one of the biggest challenges nowadays. For example, Asian countries outperformed in the 1990s the nitrogen oxide emissions of North American and European countries and this trends continue, representing [2], a race against time for environmental conservation.

Several scientific initiatives have emerged with the aim of creating new uses for waste. For instance, the use of residues such as microalgae for biodiesel production [3], biomass for energy production [4], agricultural residues and municipal solid residues for biogas production [5], use of organic waste for composting and vermicomposting [6], and use of woody, agricultural, urban and industrial pyrolyzed residues to improve soil conditions [7,8,9]. Waste is increasingly being perceived by farmers and industries as an input for their businesses, as well as being included in a system with reduced environmental impacts. Brazil is a country with large

amounts of residual biomass derived from extensive forest and industrial areas.

This biomass represents a future potential for replacing the production of energy derived from fossil fuels, such as oil and coal, by cleaner mechanisms. The use of residual biomass in agriculture as a source of renewable energy represents an opportunity to reduce environmental problems such as degradation of natural resources, pollution and forest fires. This paper reviews literature related to the use of environmental residues in Brazil. An important point in relation to this issue is to emphasize that biomass should not be withdrawn from its natural source for these processes, but used only when it obtains the character of waste.

Agriculture in Brazil

The 1950s Green Revolution that contributed to tripling in volume and productivity of food worldwide through the adoption of technological package (machinery, selected seeds, fertilizers, pesticides and irrigation), in Brazil began between the 60s and 70s. The adoption of the technological package had its first incentive in the government of Castelo Branco (1964-1966) with the Government's Economic Action Plan, which sought to boost the agricultural sector by expanding its production of food and raw material, increased exports and substituting imports, incentives to mechanization, among others [10].

The creation of these projects and the others that were created over the years boosted a new socioeconomic and spatial configuration in the country with the hegemony of agro industrial complexes. It was at that moment that there was a great incentive of the state in research to increase agricultural productivity through universities and EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária) in 1973.

The Cerrado biome was the first in the country to receive the technological package, culminating in the expansion of agricultural activity mainly in the cultivation of grains [11]. During this period, the development of new technologies allowed the transformation of the infertile soils once considered unsuitable for agriculture in extremely productive lands [12].

Over the years, the expansion of the agricultural frontier has surpassed the limits of the Cerrado towards the Amazonian biome and new areas have been incorporated in the productive process. Current data indicate that the Cerrado has an area of deforestation of 98 million hectares [13], in a total of 203 million hectares of biome [14]. And the Amazon an area of deforestation of 74 million hectares [15] in a total of 419 million hectares of biome [14]. According to the FAO, Brazil compared with other developing countries had the highest rate of deforestation in recent years [16].

Residual Biomass in Brazil and its Role in Energy Production

With the expansion of the agricultural frontier more wastes are generated. In Brazil, the most significant residues of agriculture, livestock and forestry are: sugarcane bagasse [17], animal waste [18], rice hulls [19] and plant material such as twigs, leaves and wood [20]. The use of these residues for energy production and application in crops represent not only an alternative for better environmental quality, due to the high energy demand and improvement of soil conditions, but also for economic growth. It was in 1975 that the first initiative in the country to substitute energy derived from petroleum for sources less aggressive to the environment emerged. Ethanol, produced through sugarcane bagasse, was a landmark for the emergence of the PRÓ-ALCOOL program [21]. Sugarcane bagasse, by its history is the residue used in greater expressiveness in the country to produce energy. The sugar and alcohol industry has been developing this activity in the mills themselves, since it is a profitable alternative when compared to the possibility of transporting the biomass to a different location for the generation of energy.

Another residue derived from sugar-alcohol production is vinhoto, which has been used to produce biogas [18]. The sector is responsible for supplying the internal and external ethanol market, which had its demand increased by the introduction of flex-fuel cars from the 90's [22]. Thus, it is important to highlight that the sugar and alcohol industry is reinventing itself when using its waste to produce energy. However, it is important to emphasize that the production of sugarcane should not be destined to produce energy, but rather to use its waste for generation. Brazil has also a significant production of animal waste, since the production of animal proteins in the country is growing fast.

The country emits the equivalent of 792.5 thousand tons of methane in environments with anaerobic conditions [18], gas that could be used to produce energy through biodigesters. There are also problems related to the contamination of water courses by these residues, making water unfit for consumption and causing death of aquatic animals. Public policies are therefore needed, highlighting the use of this residue for energy production as it has been developed in small rural properties in the Brazilian northeast [23].

Rice hull and coconut shell play an important role in the Brazilian residue scenario. The country, for example, is considered

annually one of the largest rice producers in the world [24]. Coconut has recently been on high demand owing to its health benefits [25]. Coconut cultivation has been stimulated and introduced in several regions of the country, and its greatest productions are in the littoral range, favored by the tropical conditions of these regions. There are also new pathways for the use of forestry residues such as the use of urban pruning, construction waste, waste packaging and discards and waste from wood industries.

The use of these materials for energy purposes occurs through the pyrolysis of this material, direct combustion and incineration, gasification and briquetting [26]. The potential for biomass energy generation in Brazil is large, representing an alternative mainly in rural areas with restricted or no access to energy. Its use has advantages because it may contribute to lowering energy production costs, does not require skilled labor, generates employment, and may help combating rural exodus through introduction of novel approach [27]. And just as the sugar and alcohol industry, the paper and cellulose production sector presents good prospects to produce electricity; therefore, incentives for the use of these residual biomasses should be better planned.

From the data presented, it is known that Brazil has a great availability of residues derived from its agropastoral and forestry activities, which are of great relevance for the country's economy. Table presents data on the quantity of residue in the largest amount in the country. Although the energy derived from sugarcane bagasse is the most developed in Brazil, this is not the residue with greater availability (Table 1). The largest residue in Brazil is the animal waste, for example cattle, poultry or swine. The forestry residues it is part of the third residue in greater availability, followed by rice hulls and coconut shells.

Table 1: Information on Brazil's main residues.

Biomass	Residue production (t)
Sugarcane bagasse	748.636.167
Animal residues	1.703.733.970
Rice husk	12.301.201
Coconut shell	1.790.739
Forestry residues	30.000.000

This characteristic is related to the location of the country in the tropical and subtropical strip, considered the best zone of the world to produce biomass. Thus, given the incentives and recognition of the need to change the energy matrix in the world, Brazil has a privileged role for the development of research and technology for the use of residue in energy production. In 2010, the first biogas laboratory was installed in the country, in the Itaipu technological park, aiming to promote technological development to produce energy derived from plants and animal waste [18].

Residual Biomass and its Role in the Soil

Intentional use of biomass residues in soils in the world is not a recent invention. The application of carbonized waste material

in soils in Japan is a millenarian practice and its use in crops is a past knowledge [28]. In Brazil, the Amazonian Dark Earths (ADE), with the presence of carbonized residual material, giving peculiar characteristics to these soils. The ADE are soils of pre-Columbian origin, with contrasting characteristics when compared to the soils of the Amazon region in general weathered. It presents a high degree of resilience and fertility [29], and for these attributes has been motivating researches for further exploration of this phenomena.

Several research point out that these attributes are related to the presence of carbonized residues that, in interaction with microorganisms, enzymes, fauna and chemical reactions, formed a material of high value. The presence of this carbonized material provided bases for the search for New Black Earth [30]. Biochar is a product that seeks to imitate the characteristics of the carbonized material present in the ADE. It is produced by pyrolysis of residual forest biomass such as tree pruning and agro pastoral waste biomass such as sugarcane bagasse, crop residues, manure, among others. In this process, in addition to the production of biochar there is the production of bio-oil and biogas, fuels that can replace oil.

Residual biomass transformed into biochar has a high capacity to store its carbon, as it is more resistant to degradation by microorganisms when compared to the original material. A product with such characteristics can add value to the waste, both by creating an innovative use for a traditional product, and by being the object of raising funds derived from practices in line with the Clean Development Mechanism concept, once considered its capacity to carbon transfer from the atmosphere to a stable compartment, which is the soil organic matter [31]. The application of biochar of eucalyptus in an experiment with rice, resulted in increase of this food in the second cycle [7] and the application of biochar with poultry manure increases the yield of maize in the Amazon region [8]. In the forest restoration studies with seedlings of Brazil nut, the species native to the Amazon basin, have suggested that substrates with 30% and 50% of biochar derived for wood had higher seedling growth relative to the growth of seedlings grown in forest soils [32].

Other case studies with seedlings of *Tachigali vulgaris* (carvoeiro), a species native to the Cerrado, show that biochar from eucalyptus applied in concentrations of 12.5%, 25% and 50% had a significant effect on the development of the seedlings, and the concentration of 50% resulted in the healthiest leaves during the dry season [33]. Composting and vermicomposting are also methods that use residue for the formation of fertilizer. Both processes can occur in the rural and domestic environment which promotes diversification of uses for organic waste. These two processes comprise a low cost technological system for the transformation of organic residues into compounds that may have high nutritional value for plants [34].

Soil is a natural resource of great importance for the growth and maintenance of forests, regulating the hydrological and biogeochemical cycles, as well as the great supplier of food. The use of residues in soils, are efficient to improve their conditions as cited

in the studies above, and may replace the Green Revolution system that are more aggressive to the soil resource. Mechanized and high fertilizer use of agrochemicals in the world has become a major threat to soils resulting in erosion, desertification and destruction of plant cover. Brazil is the largest consumer of pesticides in the world [35], and the toxicity risk class of pesticides indicate only the degree of hazard of a product and do not define exactly what the risks are [36].

Government oversight is weak, outdated legislation and tax dispensation ensures that the country continues to lead the ranking in a position that expos serious health risks to the population. For progress to be made regarding soil conservation in the world and in Brazil, it is necessary for the executive, legislative and judicial powers dialogue with scientists and civil society for decision-making, so as not to approve measures that are going towards contrary sustainable standards. The use of residues for application in agriculture, such as the use of biochar and methods such as composting and vermicomposting, have been presented as viable alternatives to reduce environmental damage, so more investments in research happen over the next years.

Final Considerations

Residues and its transformation into energy is an ally to the development of countries, because it generates an alternative source of energy production. As supply of energy rises, the price decreases. Energy derived from biomass generates not only environmental and economic benefits but also social, as energy production in poor rural environments, which encourages new attractive rural activities. In agriculture, the use of waste is ancient wisdom, emphasizing the importance of knowledge of the so-called traditional populations. The New Black Earth, with the presence of biochar, symbolizes new forms of mitigation of the current environmental problems. The development of this soil conditioner with characteristics like the carbonized product found in the ADE makes this product investigated, one of the few capable of improving soil degradation, in some cases improving food production and reducing greenhouse gases, in a single combination. Symbolizing an important step in the change of conventional agro pastoral production systems, which has destroyed natural resources.

The analysis of the use of waste for energy production and use in agriculture are of fundamental importance. It is necessary to focus on residual biomass management because the problem of waste has been related to the destruction of forests, soil pollution, water, air and public health globally. Much of these wastes are not treated properly and are intended for open-pit dumps [37,38]. Therefore, government, universities, research institutions and society must unite for more sustainable use of organic wastes in Brazil and worldwide.

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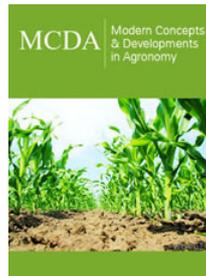
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