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Cleaner production and environmental aspects of the sugarcane-alcohol segment: Brazilian issues

Produção mais limpa e aspectos ambientais do segmento álcool de cana de açúcar: Problemas brasileiros

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ABSTRACT:

Current article, inserted within the Cleaner Production (CP) theme, focuses on the sugarcane-alcohol segment in Brazil. The main aspects and environmental impacts of the sector are underscored and demonstrate how CP may contribute towards the solution of its environmental issues. Methodology is foregrounded on a bibliographical review of scientific essays and consultations of organizations dealing with the themes CP Environmental Management and Sugarcane-Alcohol Chain Management. Results show that the sugarcane-alcohol sector causes both positive and negative environmental impacts and CP may be a strategy for the solution of current issues.
Keywords: Cleaner production; Sugarcane, Environmental Impacts; Perspectives.

RESUMO:

O artigo atual, inserido dentro do tema de produção mais limpa (CP), centra-se no segmento de cana de açúcar-álcool no Brasil. Os principais aspectos e impactos ambientais do setor são ressaltou e demonstram como o CP pode contribuir para a solução de seus problemas ambientais. A metodologia é promovida em uma revisão bibliográfica de ensaios científicos e consultas de organizações que lidam com os temas CP gestão ambiental e gestão da cadeia de álcool de cana de açúcar. Os resultados mostram que o setor de cana de açúcar-álcool provoca impactos ambientais positivos e negativos e CP pode ser uma estratégia para a solução de problemas atuais.
Palavras-chave: Produção mais limpa; Cana de açúcar, impactos ambientais; Perspectivas.

1. Introduction

Brazil is the biggest sugarcane producer in the world, with more than 590 million tons per year (2012/2013 harvest) (UNICA - THE BRAZILIAN SUGARCANE INDUSTRY ASSOCIATION, 2013).

The country is also the biggest sugar producer, with 25% of world production and 60% of exports worldwide (DRABIK et al., 2014; UNICA - THE BRAZILIAN SUGARCANE INDUSTRY ASSOCIATION, 2013). Brazil ranks second in the production of ethanol, with 20% of world production and 20% in exports worldwide (UNICA - THE BRAZILIAN SUGARCANE INDUSTRY ASSOCIATION, 2013). The sugarcane-alcohol segment, featuring a sectorial GNP of US$ 48 billion, has a robust economic productive position and sustainability due to such a renewable source of energy (GOLDEMBERG, 2007; GOLDEMBERG et al., 2004; OLIVEIRA; VAUGHAN; JR, 2005).

However, several current environmental and social issues should be solved (ARBEX et al., 2014; MARTINELLI; FILOSO, 2008; MAZZOLI-ROCHA et al., 2014; RIBEIRO; JABBOUR, 2012) so that the Brazilian sugarcane-alcohol segment could be synonymous to sustainability. Cleaner production (CP) may have its best challenge. The sugarcane-alcohol segment produces wastes and byproducts with positive and negative impacts on the environment. Whereas a good impact would be the co-generation of electricity by sugar and alcohol industrial plants, the pollution produced by fossil fuel and cane wastes would provide unsafe and harmful impacts. In this context, the current paper involves CP themes applied to the sugarcane-alcohol segment in Brazil and aims at providing the main environmental implications for an in-depth knowledge with regard to the manner CP measures may diminish or are diminishing the impacts caused.

2. Methodology

The paper comprises a review of the scientific literature on the subject matter and consultations to organizations that deal with the theme CP Environmental Management and Sugarcane-Alcohol Chain Management.

3. The main environmental aspects of the sugarcane-alcohol segment

Production processes of a sugar and alcohol mill occur within the agricultural area and in the industrial segment. Activities between crop cultivation and sugarcane harvest are developed in the agricultural region, whereas the manufacturing processes of sugar and alcohol distillation belong to the industrial sector (JENA; POGGI, 2013; OMETTO; HAUSCHILD, 2009). Needless to say, environmental impacts occur within the two segments.

The main negative impacts in agriculture are a decrease in biodiversity, excessive production of wastes (bagasse), contamination of surface water and soil; soil impounding by machines; silting and greenhouse gas effects (MAZZOLI-ROCHA et al., 2014; SILVEIRA et al., 2014).

Perhaps one of the most criticized and discussed items with regard to the negative impacts of sugarcane activities is the burning of the plant´s dry leaves and the subsequent emission of carbon dioxide (CO2) into the atmosphere (MARIN et al., 2012; OMETTO; HAUSCHILD, 2009; SOUZA; SEABRA, 2014). Carbon dioxide is absorbed by the sugarcane plant during its development and growth (OMETTO; HAUSCHILD, 2009) and is released to the atmosphere within a few minutes when the straw is burnt as a preparation for cane cutting.

Besides carbon dioxide, ozone also impacts the atmosphere. It is a polluting gas which does not easily dissipate at low altitudes. It may also damage the growth and the development of other plants (AZANIA; AZANIA, 2014). Soot emission is a byproduct from setting fire to the sugarcane fields and burning the dry leaves. It causes respiratory diseases and plenty of dirt (RIBEIRO, 2008). There is evidence of Polycyclic Aromatic Hydrocarbons (PHAs), a cancer-causing compound, in the blood of most sugarcane workers (LANGOWSKI, 2013) and in people living in the neighborhood of the burning fields and plant leaves (ARBEX et al., 2014; ASSUNÇÃO et al., 2014).

So that problems derived from burning may be avoided, Brazil law n. 11241 prohibits setting fire to sugarcane straw. By 2021, no sugarcane leaf burning will be allowed within the area where mechanical harvesting is possible. Sugarcane burning will be illegal by 2031 in areas with more than 12% slopes where harvest by machines is impractical and only hand labor may be employed (ASSEMBLEIA LEGISLATIVA DE SÃO PAULO., 2002). Further, gases produced by fossil fuel and emitted by machinery used for harvesting, such as tractors, trucks and harvesting machines, should also be taken into account (OMETTO; HAUSCHILD, 2009). The most harmful gases for the environment, which are produced from the burning of fossil fuel, are carbon monoxide, carbon dioxide, nitrogen oxide, sulfur oxide and atmospheric particulate matter (CARVALHO et al., 2015; MOITINHO et al., 2013).

The main impacts caused by industrial production are caused by the high consumption of water for sugarcane processing and the production of vinasse and solid sugarcane residue. Vinasse is largely the byproduct derived from the fermentation of sugarcane in the manufacture of alcohol; secondly, it is the byproduct originating from the manufacture of sugar. The solid sugarcane residue comprises a mixture of decantation slime derived from the sugar clarification process and from ground bagasse. Vinasse is a byproduct rich in organic matter (CHRISTOFOLETTI et al., 2013; JENA; POGGI, 2013; LAIME et al., 2011; PIACENTE, 2005; SILVA; GRIEBELER; BORGES, 2007). Its production ranges between 10 and 15 liters for each liter of alcohol produced. It is normally used in fertirrigation (soil irrigation with vinasse). Vinasse provides a negative impact on the environment, such as soil and underground water contamination when employed in excess (CHRISTOFOLETTI et al., 2013; LAIME et al., 2011).

Extremely sandy soils absorb a meter of vinasse every four days, whereas in more compacted soils the same amount is absorbed every eight days. These are high risk conditions since reversion is slight after contamination (CHRISTOFOLETTI et al., 2013; PIACENTE, 2005).

Solid sugarcane residue is a protein-rich compound. It is employed in the irrigation of the soil prepared for the planting of sugarcane and in the furrows where the sugarcane seedlings are planted (GONZÁLEZ et al., 2014). An average of 35 kg of the byproduct is obtained from one ton of sugarcane (PIACENTE, 2005).

The use of solid sugarcane residues and vinasse replacing chemical products decreases costs at the rate of approximately US$60 per hectare (UDOP - UNIÃO DOS PRODUTORES DE BIOENERGIA, 2015). However, the solid sugarcane residue, similarly to vinasse, may damage the soil and underground water if it is badly managed or incorrectly stored (ALMEIDA JÚNIOR et al., 2011; CASTRO, 2011; PRADO; CAIONE; CAMPOS, 2013). In fact, it should not be disposed of directly in the soil but on plastic tarpaulins (PIACENTE, 2005).

4. Cleaner production in the sugarcane-alcohol segment

One of the main aims in the CP management model is to increase environmental efficiency and minimize risks for people and the environment (WU; OLSON; BIRGE, 2013). CP establishes priorities according to the following ranking: prevention, reduction, reuse and recycling, treatment coupled to recovery of materials and energy, treatment and final disposal (BARBIERI, 2011). It may be applied throughout the life cycle of products, processes and services (GAIARDELLI et al., 2014) with several aims comprising the conservation and/or optimizing the use of water, energy and prime matter, coupled to the elimination or decrease of the toxicity of residues.

Foregrounded on the manner vinasse and solid sugarcane residue are applied by entrepreneurs, they are actually a case involving CP applicability. Exceptions exist with regard to the use of the residues since they are frequently employed incorrectly by the sugarcane-alcohol plants (FRAVET et al., 2010; HASSUDA; REBOUÇAS; CUNHA, 1991; SILVA; GRIEBELER; BORGES, 2007).

Sugarcane bagasse is another waste produced by the sugarcane-alcohol segment and which serves as a CP applicability. Bagasse, derived from the ground sugarcane during manufacture, is employed as a prime matter for several materials, such as energy (JENA; POGGI, 2013). The co-production of energy from sugarcane bagasse in Brazil has been focused upon in several research Works (CHEN; KHANNA, 2013; SOVACOOL, 2010) and underscored by investments due to its capacity for the Brazilian Energy Matrix. The capacity for the generation of energy from sugarcane bagasse corresponds to approximately 7% of total electric power produced in Brazil, although the hydroelectric sources is largely the most representative, featuring 70.6% (EMPRESA DE PESQUISA ENERGÉTICA (BRAZIL), 2014).

In Brazil, a ton of sugarcane averages 140 kg of bagasse (SANTOS et al., 2012), 90% of which may be employed for the production of electricity (thermal or otherwise). The exploitation of sugarcane straw, normally left on the field (when harvest is mechanical) or burnt (when manually harvested), should also be taken into account.

One of the main assets of the co-production of electric power in the Brazilian context is the decrease of risks (SANTOS; SOUZA; DIAS, 2013) caused by possible power failure due to prolonged droughts. It must be highlighted that 64.9% (EMPRESA DE PESQUISA ENERGÉTICA (BRAZIL), 2014) of electricity produced by the Brazilian Energy Matrix comes from hydroelectric plants. This is currently (2014-15) highly relevant since the important southeastern region in Brazil is experiencing one of the worst droughts in its history with terrible consequences to all (ASSIS et al., 2011; BLACK et al., 2010; WADE et al., 2010).

Nevertheless, since energy from sugar mills may be potentially employed during harvest time, other alternatives exist to improve current production potential, with such measures as: i) replacement of low pressure boilers by high pressure ones; ii) conservation of the use of thermal and electromechanical energy in the process; iii) the possible use of sugarcane straw as fuel added to bagasse (LEME, 2005).

Besides the above cases for CP application by the Brazilian sugarcane-alcohol segment, others may be underpinned, as Table 1 shows.

Table 1 – CP uses for wastes produced by the Brazilian sugarcane-alcohol segment

Wastes	**Origin / Composition**	**Examples of CP measures**	
		Decrease	**Reuse / Recycling**
Water from the washing of sugarcane	*Origin*: Washing of sugarcane prior to grinding / *Composition* : high sucrose rates, mainly when plants are burnt; vegetal matter, earth and pebbles.	Elimination of burnings for the separation of straw; reduces the concentration of soil and pebbles; washing may be eliminated; washing on different tables where defibrillation occurs (avoids loss of the adherent bagasse and plant fragments); Dry removal of impurities.	Recycling in the absorption process (recovery of part of the diluted sucrose) ; Recycling in the washing process (a treatment required for the removal of large solids and sedimentary residues; eventually to remove soluble organic compounds).
Water from barometric condensers and condensed water in the	*Origin*: Concentration of broth / *Composition* : water with sugar carried by droplets .	Decrease loss of syrup: decrease in flow speed, decrease of temperature in condensation water. Recovery of syrup: use of obstacles that decrease carriers (separators of	Recycling of water in the process (care should be taken on sugar rate). Recycling in the process, albeit in another stage, such as: absorption of the sugarcane, washing of the treacle after the crystallization of sugar, vapor

evaporators		carrier), increase in the hight of evaporators.	production, washing of filters, preparation of solution for liming (in clarification).
Bagasse	_Origin_: Grinding of the sugarcane and extraction of the broth / _Composition_ : cellulose, with 40% - 60% moisture.	No	Co-generation of electric power ; manure (used as fertilizer) ; production of animal feed ; production of agglomerates ; production of cellulose.
Solid sugarcane residue	_Origin_: Filtering of the slime produced in the clarification process / _Composition_: residues from liming, rich in phosphates.	No	Soil conditioner ; production of animal feed.
Vinasse	_Origin_: residues from the distillation of fermented treacle for the production of alcohol / _Composition_: high BOD and COD	No	Fertilizers (adequate appication rate is mandatory. Otherwise, contamination occurs).
Water from the washing of fermentation tanks	_Origin_: washing of the fermentation containers to obtain alcohol (reduced volume) / _Composition_ : similar to vinasse, but more dilluted (approximately 20% of the vinasse).	No	Fertilizers (adequate appication rate is mandatory. Otherwise, contamination occurs).
Treacle	_Origin_: manufacture of sugar / *Composition*: high BOD.	Tottally used iin the production of alcohol.	Production of alcohol ; manufacture of yeast.
Sugarcane tip	_Origin_: cutting of the sugarcane plant for milling/ _Composition:_ vegetal fibers and sugars.	No	Feed for animals.

Source: adapted from (COMPANHIA DE TECNOLOGIA DE SANEAMENTO AMBIENTAL (CETESB), 2002; CONTRERAS et al., 2009; PELIZER; PONTIERI; MORAES, 2007)

5. Final considerations

Massive and ubiquitous environmental pressure has been made on the sugarcane-alcohol segment in Brazil. Organizations linked to the environment movement press so that norms and laws are complied with, whilst the community as a whole requires a more active stance for social and environmental commitment. If well managed, CP may attend to all these interests in the segment.

Up to date, several types of progress have been achieved especially in the reduction of carbon dioxide emitted by the burning of sugarcane straw. The increasing use of harvesting machines and the prohibition of setting fire to the sugarcane plants are the main events that have greatly contributed towards the end of negative environmental impact.

The co-production of electric energy in sugarcane-alcohol plants should be highlighted as a CP asset. However, some of the processes used by the alcohol industry under the environmental pretext are actually disposal means of byproducts, frequently executed inadequately and exploited as measures taken to preserve the environment.

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