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Applications of Sugarcane by-products to mitigate climate change in Ethiopia

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Abstract

Climate change is one of the major issues in both the developed and developing world. Greenhouse gas (GHG) emission is one of the implications for climate change. It is increasing rapidly. Although the emission is much less when compared to the rest of the world, Ethiopia has also faced this global issue. The major source for GHG emission in Ethiopia is agriculture. Therefore, the agriculture sector has to be given more attention in Ethiopia. To overcome the problem, Climate-Resilient Green Economy (CRGE) strategy has been initiated. One way of executing this target is to create a sustainable and environmentally friendly pathway to use agricultural byproducts. Sugarcane is one of the major plants in Ethiopia. Its byproducts are bagasse, molasses, and press mud. Since it is a waste product, it is economical and creates a sustainable and green environment by reducing GHG emissions. Sugarcane byproducts have versatile applications like as fuel, as cement replacing material, as a mitigation for expansive soils, as biosorbent for the treatment of water and wastewater and also as a wood material. However, Ethiopia has not used this byproduct massively as it is readily available. This paper reviews the possible applications of sugarcane byproducts to mitigate climate change.

Key words : Climate change, Greenhouse gas, Climate-Resilient Green Economy, Sugarcane byproduct

1. Climate change in Ethiopia

The effect of climate change has been noticeable in Ethiopia since four to five decades. Long-term fluctuation of temperature, precipitation, wind, and other elements which indicates climate change has been noticed in Ethiopia. Lowering in agricultural production has been observed due to the increase in yearly rainfall variability, droughts, and heavy precipitation. Access to clean drinking water has also decreased is due to climate change in Ethiopia. Change in mean annual temperature has been recorded by an increment of 1.3°C between 1960 and 2006 which tells a 0.28°C average rate increase per decade (1).

The GHG emission of Ethiopia is very low compared to other countries. However, studies have proved that the emission has increased compared to a few years ago. Majority the energy consumptions in Ethiopia are satisfied by biomass sources. Agriculture is the most dominant cause for the emissions of GHG in Ethiopia. It basically contributes 50% of the total GHG emissions. Besides to agriculture, forestry contributes to the total GHG emissions with 37%. Since most of the emission is from agriculture, reduction in this sector is much needed. Anthropogenic activities have majority contribution for the rise of Ethiopia's GHG emissions. Therefore, as the population increases the future GHG emissions will also increase (2).

Climate change in Ethiopia drives the foundation and formation of sustainable development model to

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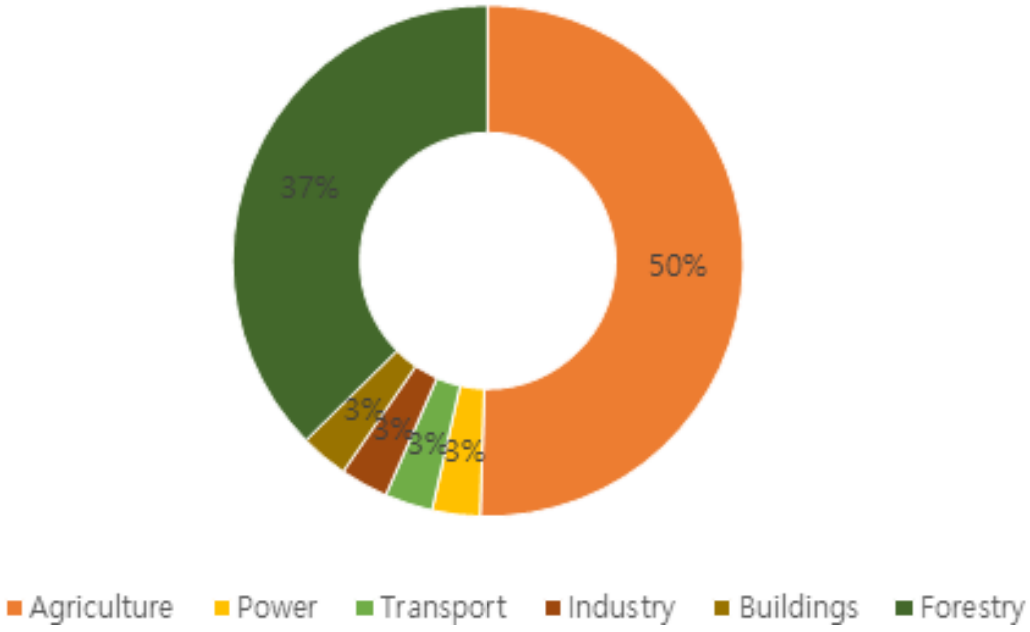

Figure 1. GHG emission sources

mitigate the adverse problems of climate change. As a result, the initiative of Climate-Resilient Green Economy (CRGE) has been formed by the Ethiopian government on 2011. The main aim of the initiative was to create a green economy by mitigating the effects of climate change and keep GHG emissions as low as possible and as a result that will lead to the goal of the country which is to achieve middle-income status before 2025 (1).

2. Sugar factory and their byproducts in Ethiopia

Sugarcane development in Ethiopia had begun in 1951 and the production of sugar started in 1954/55 at Wonji Sugar Factory in which a Dutch company, HVA (Handlers -Vereenging Amsterdam) was the owner (3). Currently, there are around fourteen sugar

Table 1. General information about sugar factories in Ethiopia

Factory	Established year	Cane plantation land area(ha)	Design capacity of crushing(ton/d)	Production of sugar(ton)	Energy production(MW)	Ethanol production(m^3)
Wonji	1954	7000	6250	174,000	20	
Metehara	1970	10,000		136,692	9	12,500
Fincha	1998	67,098	12000	270,000	31	20,000
Tendaho (2 factories)	2014	50,000	13000	330,694	60	31,000
Kessem	2015	8413	6000	153,000	26	12,500
Arjo	2015	5108	8000			
Omo-Kuraz (4 factories)	Under construction	100,000	60,000	1,339,000	415	130,810
Tana belles	Under construction	50,000	12,000	2420		20,827
Wolkayit	Under construction	50,000	24,000	484,000		41,654

factories in the country; seven of them (Wonji, Metehara, Fincha, Tendaho 1, Tendaho 2, Kessem and Arjo) are completed whereas the rest six (Omo-Kuraz 1 - 4, Tana belles, Wolkayit) are under construction. Totally 2.89 million tons of sugar is being produced, which is very less when compared to Brazil that the leading country in the production of sugar. Current sugar factories and undergoing projects are summarized in the table below.

Current sugar production of Ethiopia is below the national demand and this resulted in importing of huge amounts of sugar per annum (4). Although the current sugar factories in Ethiopia have huge potential for the re-utilization of the byproducts produced, it is not being used as much as the readily availability.

3. Applications of Sugarcane byproducts

The main byproducts of sugarcane are bagasse, molasses, and press mud. After the extraction of cane juice, the byproduct produced is called Bagasse which is fibrous residue. In sugarcane industries, bagasse is used as fuel resulting in its combustion and production of ash as the end product. This waste is typically disposed into pits in Ethiopia. 2.7 million tons of residual bagasse production has been recorded per annum from those factories mentioned above and serves as sources of biomass (5).

Agricultural waste is the main source of biomass in Ethiopia. Among those wastes sesame, coffee, and sugarcane are the major ones. Besides the agricultural byproducts, organic wastes also make Ethiopia to be one of the leading country in biomass production. Utilization of those readily available agricultural wastes is liable because it will reduce the emission of carbon and the pollution to the environment. This practice not only promotes the CRGE plan, but also supports the agriculture and construction sector. But Ethiopia has not started the utilization of sugarcane by-products.

3.1. Sugarcane byproducts in the production of concrete

Currently, there is a huge shortage of construction materials in Ethiopia, especially cement. This shortage resulted in an increase in cement price. Bagasse ash has a capacity to replace cement due to the similarity in composition. Many studies agreed that Bagasse ash can improve properties. By replacement in some percentage of bagasse ash, compressive strength of concrete can be improved. The reason for the improvements is suggested to be higher silica content (6).

In Ethiopia, replacement of cement by bagasse ash related researches has been performed to evaluate the potential of the waste material. In one study, bagasse ash samples were collected from Wonji sugar factory and used as a cement replacing material. The results of the study showed that higher compressive strength has been obtained by replacing 10% of the cement by bagasse (7).

3.2. Sugarcane byproducts as a Bio-fuel

Majority of energy consumption in Ethiopia is based on traditional biomass fuels and those biomasses are mainly from wood materials which leads to deforestation as a result GHG emissions being increased (5). The climate-Resilient Green Economy strategy planned to implement 5% biodiesel and 15% ethanol blends by 2030. Following the plan, Bio-ethanol production had started in the different Sugar Factories. Bio-fuels are liquid and gaseous fuels that are produced from biomass feedstock. Sugarcane bagasse is the most promising byproduct for the production of biofuels. Ethiopia is more focused on this application and produces a huge amount of biofuels from each sugar factory. However, there is still a shortage of raw materials for the production of fuel. Therefore, oil products for fuel production are currently being imported, which can be a substitute for fossil fuel.

3.3 Sugarcane byproducts as a mitigation for lime stabilization of an expansive soil

Civil and geotechnical engineers have faced a problem with expansive soils all over the globe. Expansive soil covers a huge part of Ethiopia. It creates financial risk for many years (8). Lime stabilization is the most common technique to mitigate this problem. However, recently, industrial byproducts have become the focus area for the utilization of waste materials and sustainability.

One study dealt with the improvement in the strength of expansive soil with the addition of sugarcane bagasse ash (BA). The result depicted BA can be used as an effective additive for augmenting the strength of lime stabilized soil. It indicates that 0.5% BA or lesser is enough to produce optimal improvements to the strength of the stabilized soil

(9). However, Ethiopia is not using this opportunity to mitigate the problem with expansive soil.

3.4 Sugarcane byproduct for water and waste-water treatment

Sugarcane bagasse fly ash (BFA) is as a good biosorbent material for removal and recovery of molecules found in water or wastewater. It contains about one third percentage weight of unburned carbon which makes it to be easily separated and activated (10). Bagasse fly ash (BFA) does not contain toxic metals that are hazardous to human life. Therefore, they can be used as biosorbents in waste and water treatment. One study investigated the removal of COD and color by using powdered activated carbon that is obtained from BFA. The sample was obtained from Matahari sugar factory, Oromiya region, Ethiopia. As a result, 61.6% and 64% removal of COD and color, respectively have been observed, which makes activated BFA a promising option for the removal of contaminants from water and wastewater. Therefore, Ethiopia has the opportunity to use this byproduct as a biosorbent for many industrial wastewaters.

3.5 Sugarcane byproduct as a substitute for wood materials

Sugarcane byproducts have much application because it is sustainable and environmentally friendly. Since forests are being threatened and endangered by anthropogenic activities, sustainable substitution for these resources is a primary need. Although Ethiopia is not up to these applications yet, bagasse can be used as a substitute for wood materials in the production of pulp, paper, and board. It has been used in the pulp industry to produce printing and writing papers. It can also be used for making Bagasse boards and can be considered as a good material to substitute plywood which will be more economical.

4. Conclusion

Climate change in Ethiopia has been observed over the past few decades. Greenhouse gas emission is increasing rapidly. Agriculture is both the dominant sector and also the cause for the increase in GHG emissions in Ethiopia. This leads to build a strategy to control it in a sustainable and environmentally friendly way. Therefore, agriculture should be the focus to mitigate the effect of climate change in Ethiopia. Sugarcane is one of the agricultural plants which is readily available in Ethiopia. Its byproducts have versatile applications for a sustainable and green environment. It can serve as an alternative material for the degrading resources. Since it is a waste material, it is economical and readily available. Sugarcane byproducts can be used as fuel, cement replacing material, mitigation for expansive soils, biosorbent for the treatment of water and wastewater and also as wood material. Ethiopia is one of the major countries in the production of sugarcane, but the use of waste products is not well known yet. The country uses the byproducts as a fuel majorly. But the other applications are not in action. Although many kinds of researches are being done on the use of sugarcane byproducts in construction, it is not being applied on the industry scale yet. Therefore, Ethiopia has to start re-utilizing byproducts of sugarcane massively.

Abbreviations

BA - Bagasse Ash
BFA - Bagasse Fly Ash
COD - Chemical Oxygen Demand
CRGE - Climate-Resilient Green Economy
GHG - Greenhouse Gas

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References

1. **C-RGE, (CRGE).** *Ethiopia's Climate-Resilient Green Economy, Green economy strategy*. Addis Ababa, Ethiopia : s.n., 2011.
2. **Keller, Marius.** *Climate Risks and Development Projects.* Guduru, Oromiya, Ethiopia : s.n., November 2009.

3. **Ethiopian, Investment Agency.** *Investment Opportunity profile for Sugar Cane Plantation and Processing In Ethiopia.* Ethiopia : s.n., June 2012.
4. *Performance Evaluation of Sugarcane Varieties (Cuban origin) at Wonji-Shoa, Metahara and Finchaa Sugarcane plantations in Ethiopia.* **Feyissa Tadesse*, Zinaw Dilnesaw, Yohanis Mekonnenet, Tadesss Negi, Meberatom Fetwi, Netsanet Ayele and Abey Getanh.** September 2014, Global Advanced Research Journals.
5. *Expanding sustenance in Ethiopia based on renewable energy resources - A comprehesive review.* **Mesfin Berhanu, S. Anuradha Jabasingh, Zenebe Kifile.** August 2017, Renewable and Sustainable Energy Reviews, pp. pages 1035-1045.
6. *STUDIES ON PRODUCTION OF GREENER CONCRETE USING AGRO-INDDUSTRIAL WASTE.* **K. Sundra Kumar1, Goriparthi Vankata Ramana2.** October 2016, International Journal for Technological Research in Engineering.
7. **Hailu, Biruk.** *Bagasse ash as a cement replacing material.* Addis Ababa, Ethiopia : s.n., December 2011.
8. *Expansive Soils in Ethiopia: A review.* **Uge, Bantayehu Uba.** May 2017, International Journal of Scientific Research Engineering and Technology.
9. *Bagasse Ash as an Auxiliary Additive to lime stibilization of an Expansive Soil: Strength and Microstructural Investigation.* **Pandian, Jijo James and Kasinatha.** 2018, Advances in Civil Engineering.
10. *Adsorption of sugarcane vinasse effluent on bagasse fly ash: A parametric and kinetic study.* **Kudakwashe Engels chingono, Edmond Sanganyado, Emily Bere, Bongani yalala.** October 2018, Journal of Environmental Management, pp. Pages 182-190.