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SOCIO-ECONOMIC IMPORTANCE OF SUGARCANE AND THE USE OF BAGASSE

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***Abstract*: Bagasse is a waste obtained from agriculture. It is an agro-industrial waste found relevant for biodiversity. It is grown in humid and sub-humid regions across the globe. Sugarcane is an industrial agricultural product recognized for consumptionall over the world. This is efficient at enhancing GDP and increases the volume of trade among nations. Due to its abundance and availability, it can be used for energy cogeneration, environmental sustainability, and powering the community through electricity generation. The deposition of bagasse can possibly enhance and stimulate the growth of microbes. Bagasse can be used to activate the soil for plant growth. It increases water infiltration and nutrient development.It can be used to remove heavy from the soil. A pharmaceutical product is produced from bagasse in combination with various components. It can be fabricated into a valuable product. Bagasse is eco-friendly. Though, regarded as waste but relevant and could be considered as a good constituent for environmental development.**

I. INTRODUCTION

The development of the economy in sub-Saharan Africa is centred on agriculture. This plays a significant role in the GDP in sub-Saharan regions up to about 50%. The processing of crops into a refined product enhances greater value through agro-industries (Lesego et al., 2016; Davidson, 2006). Agro industries are potentially a catalyst through which energy is made available to the community and industrial development. A plan was initiated by the Africa Development Bank in sub-Saharan Africa to accelerate renewable energy. The purpose of this is to promote sustainable development (Ndèye et al., 2015; Fermino& Kamp, 2003; Badr&Badran, 2001). Environmental sustainability and contribution to rural growth can be achieved through rapid energy access, modernize the agricultural sector. Though, the barrier to energy supply had been challenging in some regions of the world (Carvalho et al., 2017; Alexandratos&Bruinsma, 2012). However, there is a gradual break-even through consistent research and effort to embrace agricultural renewable energy. The most economical fibrous waste from sugarcane processing into sugar to provide heat and electricity is called bagasse. An estimate of 565 million tonnes of bagasse is produced yearly. The abundant availability of bagasse is required to provide energy for sugar mills. It is a trace of renewable vitality towards industries. It provides mitigation to climate change and enhanced sustainable development (Mwita et al., 2019; Sabiiti, 2011). It is an alleviation for land degradation and boosting of plant growth. It was also reported in a study that sugarcane bagasse was augmented utilizing getting higher sugarcane production in large quantities, Hence, more or less 7 million piles of bagasse are generated per annum (Lesego et al., 2016; Davidson, 2006). However, the inadequate knowledge on the use of bagasse is centred on the absence of evidence on the hypothetical remunerations of these harsh environments, shortage of right and proper knowhow connected to the possible payback in most developing countries (Mwita et al., 2019; Sabiiti, 2011). Studies within and outside the continent on agriculture utility on a by-product of sugarcane bagasse are required, and thus calls for investigation into the relevance and use of this plant residue (Lesego et al., 2016; Faustino, 2012). This review however investigates the possible payback of unused biomass spawned from sugarcane remains for energy generation, inorganic fertilizer, and its relevance to economic enhancement. Numerous means of exploiting the unused to generate priceless organic fertilizer benefits to stakeholders in the agricultural sector will be outlined to optimize and expand industrial-scale organic fertilizer production to enhance food production.

II. GLOBAL SUGARCANE AND BAGASSE PRODUCTION

Sugar cane is an important agricultural product widely produced in any region of the world. Sugarcane generates quite a lot of waste. This has been found relevant in socioeconomic development and growth across the globe. Sugarcane was initially from Asia. Sugarcane grows better in humid and sub-humid typical weather. (Makul&Sua-iam, 2016; Cheavegatti et al 2011) As of 2013, the eminent nations localized in Latin America and Asia produced approximately 1900 million 23 metric tons of the world sugarcane. Currently, sugar is produced from either cane or beet from more than 120 countries, while it is produced from both cane and beet from eight different countries (International Sugar Organization, 2018). On average,

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nearly 80% of global sugar production comes from sugarcane. Roughly 70% of overall sugarcane is produced from the principal ten nations. These comprise (China, the US, Mexico, Russia, India, Brazil, Thailand, Pakistan, France, Australia) (fig 1). An average of 64 metric tonnes of sugar per year is traded across the globe. The volume of trade internationally accounted for raw sugar was around 60%. Between 2016-18 over 70% of the world trade were from (Brazil, Thailand, EU, Australia, India) in which 45% export was attributed to Brazil. Even though many countries are engaged in sugar production. The largest importing countries as of 2018 were Indonesia, China, and the United States. After the three centuries overall statistical shortage the circle of the sugar market came back to excess in 2018. As of 2019, sugar cane production in India was 34,300 tonnes that account for 24.47% of the world's sugar cane production. And 67.51% was accounted to Brazil, Thailand, China, and Mexico. The world's aggregate sugar cane production was appropriately 140,169 tonnes in 2019 (International Sugar Organization, 2018).

However, the global increase in population will require the need for food and other agricultural product to increase by 50% before 2050 (United Nations, 2015). This is because natural resources from agriculture have been stressed due to soil degradation and unsustainable practice. Even though there has been technological growth, the low yield has been recorded in the last decade. This has caused the high price of raw and processed food across the nations. As a result, conserving and enriching the means of survival of small-scale families and tenant farmers have become a problem (Carvalho et al., 2017; Alexandratos&Bruinsma, 2012). In this regard, substantial improvements in resources efficiency and conservation of waste generation from sugarcane are required globally to encounter the need of increasing and shifting demand for sustenance and may likely reverse environmental degradation. Investment in agriculture and spending on research must be stepped up particularly in developing countries. This is required to promote the adoption of sustainable production. This will help farmers, ecosystems, and communities to adapt to mitigate and build resilience to counter the unsustainable agriculture productivity, realignment of implicit and explicit agriculture to meet the need of the developing population (Carvalho et al 2017).

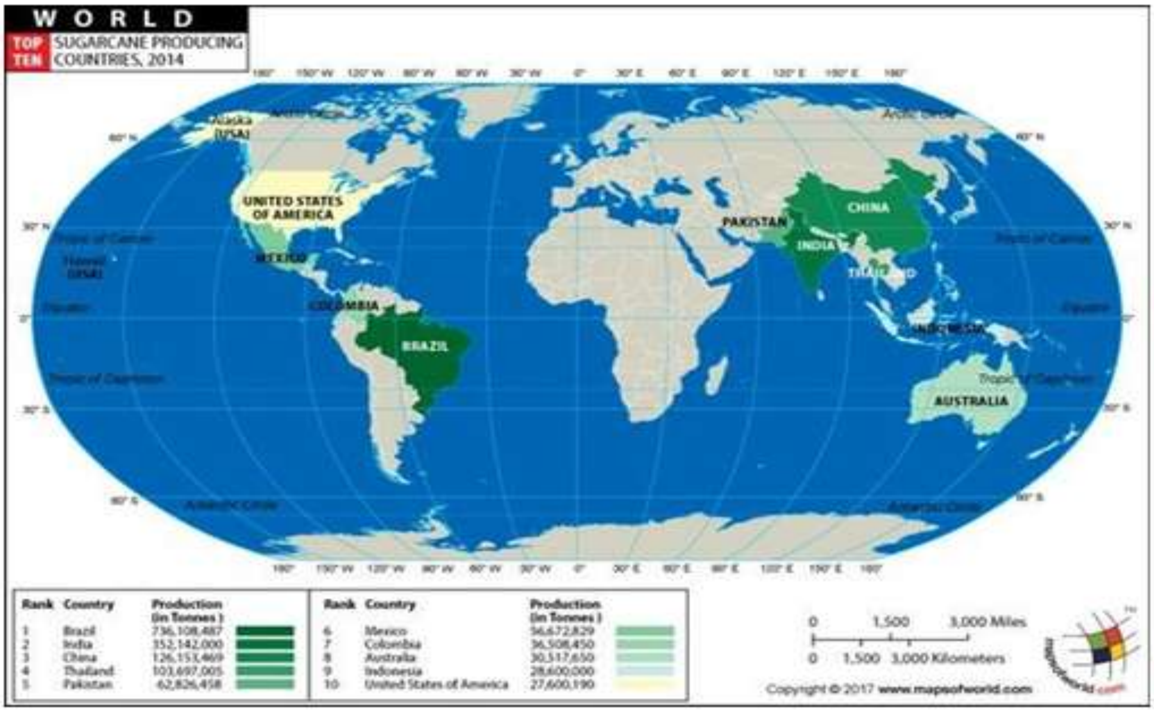

Fig: 1.1. A diagram showing map of sugarcane producers in the world sourced from FAOSTAT 2015

Population growth and relevance of biomass in South Africa

The priority of building resilience agriculture to counter unsustainability depends on the effective utilization of waste derived from sugarcane. Solid waste is a major component of agricultural residues (biomass) in most African countries (Lesego et al., 2016). Biomass can be regarded as decomposable organic matter (Lesego et al., 2016; Okot, 2012). The periodic proliferation incapacity of discarded biomass is a result of an increase in inhabitants, pecuniary evolution, and the value-added level of comfort of the people (AFP, 2018; UNEP, 2009). Yearly, agricultural activities generate 140 million metric loads of discarded biomass worldwide (AFP, 2018; UNEP, 2009). Nevertheless, South Africa is considered one of the largest economically stabilized sugarcane producers among others in Africa. In 2015, the gross domestic product (GDP) of the country remained appraised at 350.63 billion USD; South Africa persists as a few of the prevalent producers of sugarcane in Africa subsequently Nigeria and Egypt (Irena, 2019; FAO, 2015). This resulted in unparalleled population growth and rural-urban movement in Africa increases demand for food and leads to the generation of agricultural residues/wastes. In addition, climate changes and the invasion of diseases can also contribute to the continuous disposal of waste biomass in communities (Ndèye et al., 2015; Paiva et al., 2004). For instance, substantial amounts of valuable agricultural products are converted annually to generate huge quantities of biomass among these is bagasse. Bagasse can be obtained from other agricultural products such as rice husk, maize stovers, grass clippings, soya bean meal, rice straw, and rice hull (Mwita et al., 2019). Generally, South African sugarcane bagasse is combusted to create energy, however, the consequential ash notwithstanding makes up a waste that can be applied in the development of composite ingredients and organic compounds (Mwita et al., 2019; Paiva et al., 2004). This composite material is an important source of soil amendment which reduces water deficit due to percolation hence, enriching absorption and retention of water (Ndèye et al., 2015; Fermino& Kamp, 2003; Badr&Badran, 2001). It produces an effect as an energy fountain for bacteria, fungi, earthworms in addition provide a healthier environment for plant roots (Ndèye et al., 2015; Paiva et al., 2004).

III. SUGARCANE FARMING AND SOCIO-ECONOMIC STATUS IN SOUTH AFRICA

FAO statistics reveal that Southern Africa is the 15th leading sugarcane farmer on the planet (FAOSTAT, 2015). South Africa produced 28.13% of the total harvest that is ascribed to sub-Saharan. Closely at hand are 14 sugarcane crushing firms in South Africa (Lesego et al., 2016; Davidson, 2006). Twelve milling companies have been sited in KwaZulu Natal Province also are in Mpumalanga. Illovo Sugar Limited and TongaatHulett Ltd are the biggest sugar-producing companies in the country. Every single corporation has four sugar crushers; subsequently Tsb sugar (Pty) Limited amid three mills, Gledhow sugar company, Umfolozi Sugar Limited, and UCL company owning a crusher respectively (Davis, 2015; Esterhuizen, 2013). The South African sugar manufacturing is a major exporter of sugar, sell abroad 271, 330 MTRV (metric ton raw value) and (253, 579 MT) of sugar (Conningarth, 2015; Esterhuizen, 2013). Bagasse is produced from sugarcane fibre during the production of sugar. Bagasse is the fibrous sensible which vestiges following the removal of liquor from the sugarcane stubbles (Lesego et al., 2016). African countries produce roughly 5% of sugarcane harvested in the world with 30% of the sugarcane produced comes from sub-Sahara African countries. The principal producer of sugarcane in Africa is South Africa followed by Sudan, Kenya, and Swaziland (Davis, 2015). Annually, an average of 18 million metric tons (MMT) of sugarcane is produced in the country (Irena, 2019; Conningarth, 2015). In 2014, it was reported that an average of 372,000 ha of land was used for sugarcane plantation Steve (Davis, 2015). The three provinces involved in the production were northern Pondoland in the Eastern Cape, Mpumalanga, and thereafter, KwaZulu-Natal became the leading supplier of rain-fed sugarcane (Mpumalanga Province, 2016; South African Sugarcane Association, 2014). It was estimated that irrigation systems in KwaZulu-Natal contributed to growing about 30% of the sugarcane produced (Mpumalanga Province, 2016; Esterhuizen, 2013) in the country. Sugarcane growth is reliant on high rainfall thus, drought or minimal rain drop has an adverse influence on sugar production (Conningarth, 2015; Esterhuizen, 2013). According to the record of the South African Sugar Company, there were almost 24,000 sugarcane farmers in South Africa. Sugarcane is grown by about 22,500 small-scale farmers that produce 8.3% while large-scale farmers produce 1,413,323 of the crops. 83.8% of the total crop was produced by imminent black farmers whilst the remaining 7.94% was produced by milling companies within sugarcane estates (Mpumalanga Province, 2016; Govender, 2012). Currently, land cultivated and potentially used for sugarcane culture is 258 per 1000 hectares. 1300 large-scale farmers are growing about 80% while 20,000 smallholder farmers supply only 20%. 93% of out the grower are 7% in which grown were by own estate (Illovo South Africa, 2017). This supports efficiency and sustainable redistribution of land as part of the land transformation programme. This was design to meet or exceed the aim score in the Broad-Based Black Economic Enablement (BBBEE) classes of property proprietorship, Initiative expansion, and Socio-economic improvement and to providing sustenance amenities to viable and small scale farmers, assisting them to expand the source of revenue of rural people (Illovo South Africa, 2017). In 2015, production in 1.63 per million. Total import in million was 0.46 and export was estimated to be 0.24 (Irena, 2019; ISO, 2018).

IV. CLARIFICATION PROCESS AND USE OF BAGASSE

Bagasse contains approximately 45–50% water, 2–5% dissolved sugar, and 40–45% fibers. It is a co-product of the sugarcane industry after juice extraction. Cellulose (36.0%), pentosans (26.0%), lignin (20.0%) and ash (2.2%) are component of Sugarcane bagasse. Others co products are mill mud and molasses (Kemausuor et al., 2018; Keskin&Hallenbeck, 2012). Sugarcane often undergoes series of processes before the extraction of sugar. At the end of each stage of sugar processing, solid waste is produced. This is as a result of juice clarification syrup passed to the evaporator (Salihi et al., 2016; Keskin&Hallenbeck, 2012). The settled solid is solid waste. The final micronutrients and juice are maximally recovered from mud clarification. This is achieved through filtered on rotary vacuum filters (Salihi et al., 2016; Keskin&Hallenbeck, 2012) fig.2.

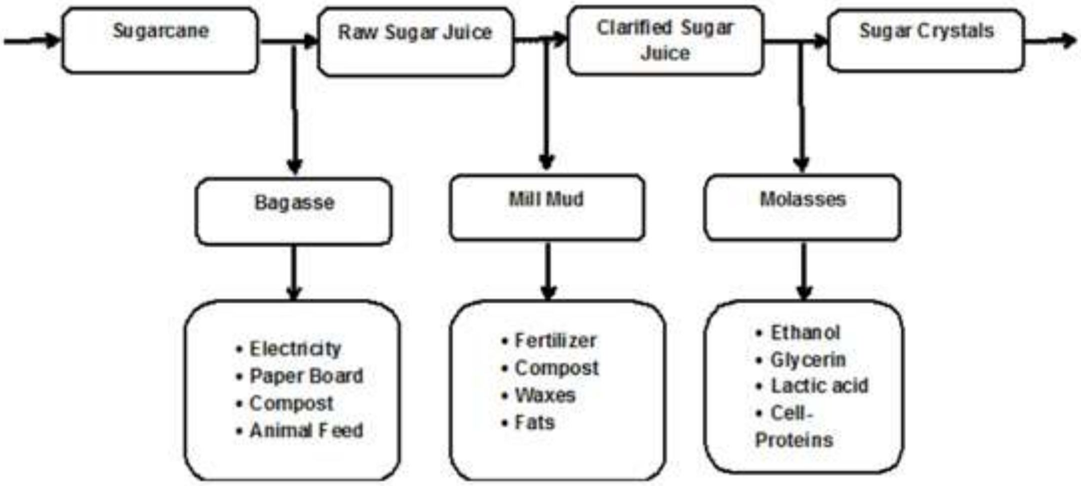

Fig: 2. A diagram showing sugarcane co-products and by-products sourced from (Keskin&Hallenbeck, 2012)

This is obtained during juice extraction from sugarcane. Sugarcane/ beet, generate close to about 30 – 33% of fuel used electricity ethanol (Salihi et al., 2016; Benjamin et al., 2014), adsorbent, and biochar (Salihi et al., 2016), etc. The production of energy from bagasse is eco-friendly and economical (Salihi et al., 2016). In literature, the use of bagasse has been used for composting carbon-based fertilizer, burning for steam invention; assimilation of methane gas creation as well as used as input for pulp and paper creation (Kemausuor et al., 2018; Wongsuchoto et al., 2009).

V. USE OF BAGASSE

Similarly, in South Africa, it could serve many benefits when used in large-scale production. Burning of bagasse produces 1 GWh of electricity and coal. Bagasse is decomposed anaerobically for methane gas (Kemausuor et al., 2018). Bagasse can be used for generating steam used for producing electricity for running the sugarcane industry. Though bagasse has a 50% moisture content, it has a high calorific significance of 9.9 MJ/ Kg. It has properties suitable for a range of value-added renewable products as polymers, building materials, and renewable fuel (Kemausuor et al., 2018). Because of consumer's increasing demand for plastics produced from renewable and sustainable resources, the substantial bagasse-based polymer is considered for use (Wahyudin et al., 2017; Sumarno et al., 2017). The use of bagasse is highly significant in the greenhouse, acid rains, and degree of poison (Rainey &. Covey, 2016). Also, it can be used as a solvent for decontaminating lubricant, wood, resin, production of nylon, rayon and acetate fibre, plastic, explosives (Rainey & Covey, 2016). Bacon and sausages are sometimes smoked with bagasse in Guangxi Zhuang Autonomous Region, China. It was also considered as a treatment for wastewater and pollution control (Wahyudin et al., 2017; Sumarno et al., 2017).

VI. SUGARCANE BAGASSE AS AN ALTERNATIVE FOR INORGANIC FERTILIZER

The research was carried out on the possibility of exhausting agronomic and industrialized phases of sugarcane creation as a globally friendly salvage substitute of generating organic fertilizer that is safer than chemical or artificial fertilizers (Dalia et al., 2017; Kim, 1998). The result shows that coliform bacteria such as salmonella and shigella bacteria in the composted vessel and windrow were destroyed during the composting process due to the high temperature 70 ^{o}C reached at the thermophilic stages with some free nematode (Dalia et al., 2017; Eyheraguibel et al., 2008). This temperature supports the quick composition of weeds, nematodes, and plant pathogenic organisms (El Haggar et al., 2015). The decomposition and putrescible compounds secreted in this process are suitable for eliminating pathogens. Fatty acids are broken down along with compounds that are less susceptible to carbon mineralization. Micronutrients such as calcium, magnesium, iron, manganese, copper, and zinc, are increased in concentration due to composting (Wahyudin et al., 2017; Sumarno et al., 2017). An increased density varies with the fibre content of the mixture. The fibre structure was broken down with time and the particle size decreases causing the porosity of the mixture to decrease. It increases the water-binding capacity and forms a good aggregate (Maulana et al., 2018). It provides nutrients to accelerate photosynthesis (Wahyudin et al., 2017; Sumarno et al., 2017). It accelerates the growth rate of vegetative organs and increases the fresh weight of plants.

VII. ENERGY GENERATION

Energetic cogeneration from sugarcane bagasse was started in Colombia in the '90s. Bagasse electrical cogeneration could be as high as 360MW; sold locally and for generating electricity (Vasocana, 2010). Bagasse cogeneration is an efficient technology utilizing the waste product (bagasse) from the processing of sugarcane to generate heat and power to satisfy the sugar mill, refineries and transferred into national electric use. Several approaches have been used for steam and paper production (Vasocana, 2010). Among is environmental dimension analysis which ensures a balance in mass and energy dissipation for the use of bagasse. According to a report in a particular region, out of 21,000 Kton of sugarcane bagasse, 6000 Kton are produced annually. 5100 Kton was used for the cogeneration process and 900 in paper production (Vasocana, 2010). Several measures had been scheduled to convert sugarcane bagasse for energy generation in South Africa. This biomass contains cellulose, hemicellulose, and lignin, it is however utilized in the production of renewable energy and bio-based chemicals such as bioethanol, and bio-oil (Braude, 2015). Laboratories are currently scaling studies in South Africa where sugarcane has been used as feedstock for bioenergy generation. The biomass potential of bagasse in energy production is therefore promising (Awosusi et al., 2015). The electricity and heat used at the sugar mills from the burning of sugarcane bagasse are at low capacity. This is a practical way of disposing surplus bagasse from occupying landmass. (Braude, 2015; Tomlison, 2004). The efficiency of power produced per sugarcane handled is valued to be 23.5% (Wahyudin et al., 2017; Mashoko, 2013). If augmented, the sugar productionmay possiblyyield 2–5 times more power, have less steam-to developed energy proficiency, and trade energy to the nationwide grid. Southern Africa electricity public utility (ESKOM) currently supplies electricity in South Africa (Awosusi et al., 2015; Govender, 2012; Renewable Energy Independent Power Producers, 2003). Annually, sugarcane from the South African Sugar Industry produces 960 MW of energy per year (Renewable Energy Independent Power Producers, 2003). Report obtained recently that 18 Kha of land was cultivated and 1.42 metric tons of sugarcane were produced in 2018 indicated an increase in production. This amount roughly to half the country's entire sugar output (TongaatHulett, 2018). The sugar industry must produce electricity for its use and contribute to the national grid which is under severe strain (TongaatHulett, 2018). These energy conservation and efficiency measures largely depend on drying and pelletization to greatly reduce the moisture content of bagasse (Awosusi et al., 2015; Vafakhah et al, 2014). Environmental renewable energy wherewithal to the people in the remote areas of KwaZulu-Natal and Mpumalanga remains constant since sugarcane cultivation is a yearly activity. The peak period for sugarcane production in South Africa is usually from April to December and this involves increased power production and supply during peak season (IUCN, 2018; Govender, 2012). The sugar industry (TongaatHulett, 2018; Etambakonga, 2013) can potentially provide for 57,500 direct and 26,200 indirect job opportunities (Awosusi et al., 2015; Fechter, 2011) through feasible cogeneration of electricity, which may improve revenue generation. Through the expansion of sugarcane production to all appropriate rain fed and irrigated areas, ethanol fabrication was potentially possible from direct conversion of sugarcane was about 40.2 billion L (IUCN, 2018). This plays a significant role in the South African economy directly and indirectly because the production of ethanol from sugarcane currently contributes 0.06% to the national GDP (Awosusi et al., 2015; Agarwal, 2013). Notwithstanding the energies utility from sugarcane bagasse for energy generation in South Africa. This is essential for development optimization to strike an equilibrium amid the bulk of discarded waste and energy produced from it.

VIII. THE RELEVANCE BAGASSE TECHNOLOGICAL APPLICATION

Most tropical and subtropical countries use bagasse as a substitute for wood in the creation of pulp, paper, and board in several regions. (Samanta et al., 2015; Rainey &Thomas, 2009). After incineration, the bagasse ash (0.4–0.5%) is used as (silica 70–75%) in glass manufacturing and soil fertility enhancement (potassium and phosphate) (Samanta et al., 2015). Top leaves and roots are primarily used for organic fertilizer and animal feed after decomposition. This has been used frequently to advance soil richness (Thangavelu et al., 2016). Sugarcane biomass can be used as a starting material for huge industries such as energy, excavating, wastewater management, textile, biochemical manufacturing, resources expansion activities, and food processing to deploy technologies to become beneficial and resourceful (Samanta et al., 2015; Naik et al., 2010). Heat, steam, electricity, methanol, and other biofuels, producer gassynthetic fuel oil, biogas, charcoal, methane, ethanol, biodiesel, (Naik et al., 2010; Sims, 2008) are obtained as energy products. The general benefit accrued by these products, and feasible technologies development is as a result of massiveexpanses of harvestscan be acquired from exploitingsurplus biomass of sugarcane. The creation of an efficient environmental and economic is dependent on the advantage of the waste biomass and implementing the appropriate technology. Bioenergy and other industrial products (Thangavelu et al., 2016; Tumuhairwe, 2009) is converted to biomass through various routes. These routes can be classified into three groupings: chemical, thermal, and biological processes. Thermochemical processing of biomass revolves majorly around gasification and pyrolysis and they are currently the most applicable processes in bio-refining platformswhereas the biological processes involve fermentation and anaerobic digestion (Thangavelu et al., 2016; Johnson, 2007). Common and unique products are produced from these industries via refining biomass through numerous technologies and functional activities. These technologies are as much as possible, evaluated for orientation with the wide-ranging attitude of green chemistry to additional short-term the sustainability schedule which biomass processing be disposed to be encouraged. According to research sugarcane bagasse is effective and suitable at removing copper ion ($Cu2+$) insert for all ions from wastewater effluents. The addition of functional groups to non-functional groups of sugarcane bagasse that bond with $Cu2+$ (Lesego et al., 2016, Vafakhah et al., 2014) possesses the ability to remove Uranium (VI) from aqueous solution when applied in a batch and a fixed bed system. Similarly, Shim et al., (2014) found in a study that the use of silica extracted from bagasse can be used as a means of treating water. It was observed the degree of acceptance of uranium ions in a static bed system rest on the feed flow rate, the bed height, and the primaryabsorption of the solution. The result shows that 84–88% Cu ion and 83–87% Cd ion were detached from the adulterated. (Tiwari, 2017; Ashoka&Inamador, 2010) reported that wastewater has been treated by sugarcane bagasse with sulphuric acid and formaldehyde pre-treat. Wastewater treatment has been attributed to the use of sugarcane bagasse (Tiwari, 2017; Raymundo et al., 2010).

IX. INDUSTRIAL APPLICATION OF BAGASSE

Dyes can be removed from effluents using a cheap and effective adsorbent obtained from sugarcane. Sugarcane bagasse pith is prepared from initiated carbon for the elimination of volatile dye from an aqueous solution. The sugarcane bagasse pith contributes to increased adsorbent capacity dye as the activated dose of carbon increases (Thangavelu et al., 2016; Etambakonga, 2013). Bio-adsorbent of textile has been attributed to the use of sugarcane bagasse (Raymundo et al., 2010). In an extensive review carried out by (Bhargava et al., 2016; Pandey et al., 2010), it was found that various products such as drugs and enzymes can be obtained from sugarcane bagasse. High-value plastics are produced from sugarcane bagasse (Bhargava et al., 2016; Shaikh et al., 2009). During sugar production wastewater generated contains several physicochemical properties depending on the capacity of the plant. These effluent characteristics can be optimized for implementing water treatment systems. It can also be used as an adsorbent to treat industrial wastewater (Thangavelu et al., 2016). Treated wastewater can be reused in-floor cleaning, plantation, and agricultural purpose (Tiwari, 2017). More also, Molasses is a co-product of bagasse. It has been used in the pharma industry and distillery for wine production (Bhargava et al., 2016). Human food is fortified with processed bagasse as sugarcane fibre (Kohler, 2019). This fibre promotes intestinal regularity. A high-fat diet may be combined with sugarcane fibre to control type 2 diabetes (Rainey &. Covey, 2016). It was discovered in collaboration research that waste streams from sugarcane industrial by-products can be transformed into a valuable product that cures tooth decay, obesity, and diabetics (Rainey &. Covey, 2016). It was indicated that microcrystalline cellulose used in food and pharmaceuticals will be produced from bagasse residues by 2025.

X. CONCLUSIONS

The development of the economy in sub-Sahara Africa is largely dependent on agriculture. A fibrous waste from sugarcane has been found efficient at energy generation. It provides sustainability for land growth and restoration of degraded land. It is widely grown across the world. An average of 64 metric tonnes of sugarcane is traded across the globe. FAO statistics rated South Africa 15th among the producer of sugarcane in the world. It is a source of development to the community and helps to salvage unemployment in the community. It is used in the industry for treating wastewater. It is capable of removing dye from effluent. It is a source for producing valuable drugs. It is used in the pharma industry and distillery. Microcrystalline cellulose obtained bagasse has been used in food and pharmaceutical industry. Bagasse is economically relevant. However, the by-product can be conditioned into high productivity sub-Sahara Africa to enhance development.

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