A Review on Management and Utilization of Sugarcane Bagasse

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Abstract – Sugarcane bagasse is the material obtained after the extraction of juice from sugarcane. Advances in industrial biotechnology offer potential opportunities for economic utilization of agro-industrial residues. Sugarcane bagasse is the major by-product of the sugar cane industry. It contains about 50% cellulose, 25% hemicellulose and 25% lignin. It is a rich in cellulose content and it is readily available as a waste product with a high sugar content and has potential as an environmentally friendly alternative. This paper reviews about the ways and methods of utilizing bagasse for energy purposes like in construction industry and agricultural industry thereby managing the its huge amount since India is the second largest country producing sugarcane. It can serve as an ideal substrate for microbial processes to produce value-added products such as protein enriched animal feed, enzymes, amino acids, bricks, organic acids and compounds of pharmaceutical importance etc.

Key Words: Renewable energy, sugarcane bagasse, waste management, environment protection, alternative green energy sources, sustainable fuels.

1.INTRODUCTION

The fibrous residue of sugarcane (Fig. 1) after crushing and extraction of its juice, known as 'bagasse', is one of the largest agriculture residues in the world (Pandey et al., 2000). Sugarcane bagasse is the major by-product of the sugar cane industry, It is typically rich in cellulose (44%) and hemicellulose (28%), lignin (21%), ashes (5%) and extractive (2%) Ajala et al 2021. The rest contains lignin, wax, etc. Cellulose has a crystalline structure (about 50–90% crystalline depending on the source of cellulose, while hemicellulose is an amorphous structure containing xylose, glucose, etc . Cellulose is more like a natural linear polymer containing anhydroglucose units linked by β 1, 4 glycosidic bonds. It contains three hydroxyl groups of different reactivity as C-2 and C-3 got secondary –OH groups while a primary –OH can be found at C-6 position. These hydroxyl groups help to produce strong intermolecular and intramolecular hydrogen bonds. These cellulose polymers are distributed in fibrils that are surrounded by hemicellulose and lignin. Lignin actually works as a glue between cellulose and hemicellulose and helps the material to gain rigidity. It is a three-dimensional polymer containing three different phenyl-propane precursor monomer namely, p-coumaryl, coniferyl, and sinapyl alcohol, which are joined together by alkyl-aryl, aryl-aryl, and alkyl-alkyl bonds .The cellulose, hemicellulose, lignin, and small amounts of extractives and mineral salts of SCB are bonded together, physically and chemically with linkages between lignin and cell wall polysaccharides .The sugarcane industry is an important source of revenue in several countries around the world. India is the second-highest producer of sugarcane in the world after Brazil. The largest producer of sugarcane in India is Maharashtra, which produced over 138 lakh tonnes of sugarcane in 2022-23. Sugarcane is a multipurpose crop, used in making sugar, jaggery, khansari, molasses, and even paper.

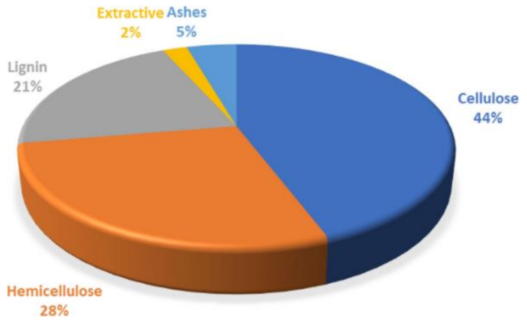

Fig. 1: Contents of bagasse

In India, approximately 60% of the population is involved in agriculture and among the many crops cultivated in the nation, sugarcane is one of the most important Kharif crops. The climate of the country supports the plantation of sugarcane throughout the year. Energy security and environmental conservation issues are likely to remain two of the major long-term challenges facing human existence globally (Sheikhdavoodi et al. 2015). Meanwhile, lignocellulose biomass such as sugarcane bagasse (SCB), corn stover, cereal straw, and forest woody residue (e.g., birch, spruce, eucalyptus) are substances with a high energy content that can assuage the impending energy crisis (Yin 2011; Ajala et al. 2020). They are organic materials obtained from biological sources, mostly plants biomass which is the most abundant global source of renewable materials and their annual global production has been estimated to be 1010 MT (Ajala et al. 2020). The SCB is one of these residues that are in abundance globally, which has the key to solving the global energy problem and environmental concern (Scaramucci et al. 2006). A review of literature indicates that SCB is favored in the manufacturing of high quality green products given its low production cost. This is mainly attributed to the abundant availability of raw materials from the sugar processing plants and its low pre-treatment costs.

2. Utilization of bagasse-

It can serve as an ideal substrate for microbial processes for the production of value-added products such as protein enriched animal feed, enzymes, amino acids, bricks, organic acids and compounds of pharmaceutical importance etc.

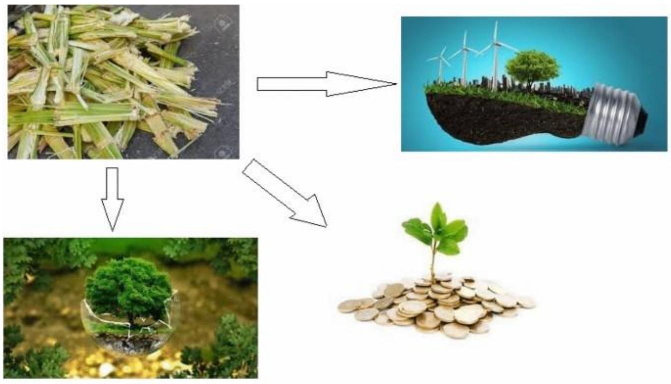

Fig.2: Uses of bagasse

2.1 Use as Bricks:-

Due to limited availability of natural resources and rapid urbanization, there is a shortfall of conventional building construction materials. On the other hand, energy consumed for the production of conventional building construction materials pollutes the air, water and land. Accumulation of unmanaged agro-waste, especially from the developing countries, has an increased environmental concern. Therefore, development of new technologies to recycle and convert waste materials into reusable materials is important for the protection of the environment and sustainable development of the society. Recycling of such wastes by incorporating them into building materials is a practical solution to the pollution problem. The major pollution problems faced by small-scale process industries are due to the huge amount of solid and sludge waste generation and the limited treatment facilities. The use of waste as the brick material is a sustain-able solution to solid waste management; it provides alternative raw material and an additional source of revenue. The raw materials used here are otherwise land-filled and thus add to ever escalating cost of disposal. The burnt sugarcane bagasse residue is commonly known as SBA. The potential production capacity of burnt sugar-cane bagasse residue is around 7–8% of total bagasse consumed (Sales et al, Amin et al) . The resulting CO_2 emissions from bagasse are equal to the amount of CO_2 that the sugarcane absorbs from the atmosphere during its growing phase, which makes the process of co-generation greenhouse gas-neutral (Macros 2010). The bricks thus manufactured using these wastes are energy-efficient due to zero emission of the principal raw materials. The bricks prepared in commercial plants using SBA, quarry dust and lime meet all the requirements as described in the Indian standard. The recycling of solid wastes into sustainable, energy-efficient construction materials is the only viable solution for the problem of environmental concerns and natural resources conservation for future generations.

2.2 Use as a concrete material-

Cement is the most widely consumable material in the infrastructure development works. It is considered as a durable material of construction. However, the environmental issue of cement has become a rising concern, as cement industries are accountable around 2.5% of total worldwide waste emissions from industrial sources [Jayminkumar et. al, and Caldarone et. al.]. It is need of time to rise the use of cement replacement materials in the concrete which can reduce the significant amount of cement consumption, because the production of cement required huge energy, it is also accountable for 5% of global anthropogenic CO_2 release (every ton of cement produces around 01 ton of CO_2), and their usage can also improve the properties of concrete. The burning of organic waste of sugar industry known as bagasse, produces the considerable amount of ash named as sugarcane bagasse ash (SCBA). SCBA is freshly acknowledged as a pozzolanic material; though, there is partial research statistics accessible to -the effects of SCBA on the behavior of concrete. Therefore, it was highly recommended to conducting research on the bagasse and their impact on concrete behavior. Generally, the bagasse waste is disposed to the landfills or disposal sites where ever present in the country and rare studies has been conveyed yet. The bagasse ash can be used as partial cement replacement in concrete. (Mangi et al) showed through the experimental work that the compressive strength increases with incorporating SCBA in concrete. Results indicated that the use of SCBA in concrete (M20) at 5% increased the average amount of compressive strength by 12% as compared to the normal strength concrete. Furthermore, Malyadri [9] has carried out the research on SCBA with 5% cement replacement in M25 (1:1:2) grade of concrete and found that the increase in the strength of concrete with use of SCBA but he never produce the optimum amount of SCBA that proposed to be utilized in sustainable concrete production. In addition to that Kawade [10] has carried out the research work on sugarcane bagasse ash as a partial replacement of cement with 10%, 15%, 20%, 25% & 30% cement replacement in M20, M30 & M40 grades of concrete and found that the OPC could favorably be replaced with SCBA up to maximum replacement of 15%. Although, the optimal replacement value of SCBA content was attained as 15.0%. Similarly, Hussien in their research work showed the results of optimum samples—containing 5% SCBA—showed an increase in compressive strength by 20% and 33% increase in splitting tensile strength compared to control mix and they also showed that The rate of gaining strength increases by time which can be attributed to the fact that using the ash results in the formation of more C-S-H compound as free CH from hydration process of cement would react with silica in SCBA that is characterized by long-term strength gaining. Therefore it can be concluded that the usage of SCBA in concrete is not only a waste-minimizing technique, also it saves the amount of cement. The replacement of cement with SCBA increases the workability of fresh concrete; therefore, use of super-plasticizer is not essential.

2.3 Sugarcane bagasse ash waste as a fertilizer-

Sugarcane bagasse ash waste can be used as a fertilizer . The ash has been found to have potential as a fertilizer for various crops, including soybeans and sunflowers . Studies have shown that the ash can increase the availability of phosphorus (P) to plants, especially when co-processed with alkali-rich residues such as chicken manure . Additionally, the ash has been found to improve the physiology, growth, and development of sunflowers, indicating its effectiveness as a fertilizer . The use of sugarcane bagasse ash as a fertilizer not only provides a sustainable solution for waste management but also reduces the reliance on mineral fertilizers . Dombinov et al showed that the plant P availability was even shown to increase when bagasse was co-combusted with chicken manure due to the formation of plant available Ca-alkali phosphates. Thus, we recommend co-processing bagasse with alkali-rich residues to increase the P availability from bagasse-based ashes to soybeans. Rahmad et al in their research showed that the treatment of compost provides a higher number of sugarcane saplings compared to without the provision of compost. Giving compost from the results of mixing bagasse, filter mud and manure using the mushroom and Trico Plus consortiums gave better results on growth, and production of sugar cane compared to without the provision of compost. Also The results of research by Elsyade et.al (2008) showed that the administration of nitrogen fertilizer and filter mud did not have a negative effect on sugarcane germination. Giving bagasse and filter mud will increase the availability of P element in the soil and the availability of various organic acids and mobilize the P element so that it is easily available to plants (Dotaniya et al., 2013). Another author Nasution developed Liquid made from egg shells and bagasse is the best for the growth of cayenne pepper. Research shows that treating liquid organic fertilizer with egg shells and bagasse affects the weight, length, weight per plot, and number of cayenne peppers planted. However, it does not significantly affect the lifespan of cayenne pepper flowers. An 80% concentration treatment of liquid organic fertilizer from egg shells and bagasse showed the best results. Sugarcane bagasse and filter mud are by-products of sugar mill processing that can be used to increase organic material on the ground and provide benefits for the soil and plants. There are big amount of bagasse and filter mud that can be utilized for agriculture production by using it as compost that can be applied to the field.

3. CONCLUSIONS

Keeping in mind the rate of damage of our environment which includes global warming, ozone layer depletion, climate change, acid rain etc. there is an urgent need to switch towards sustainable energy sources. Renewable energy sources are upcoming as an alternative fuel to power the various industries of our country. Sugarcane bagasse is a widely available biomass which can be utilized in many ways, provides green energy and helps in management of waste. The various applications of SCB have been extensively examined in light of the need for energy and environmental sustainability. The SCB can be regarded as a sustainable feedstock for biofuels production as it was successfully used to produce concrete, bricks and its use as a fertilizer. It can be surmised that SCB is biomass with great potential to supplement global energy demand and foster environmental and economic sustainability.

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