Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6, 325-333
2024
Publisher: Learning Gate
DOI: 10.55214/25768484.v8i6.2066

Effect of utilising of sugarcane bagasse fibers on mechanical properties of composite materials – a review

Marawan M. Hamid[1], Muntadher J. Taher[2*], Hassan Ali Abbas[3]
[1]Dept. of Civil Engineering, College of Engineering, University of Technology, Baghdad, Iraq.
[2]Dept. of Computer Eng. Technology, Al-Safwa University College, Karbala, Iraq; muntadherjtaher@alsafwa.edu.iq (M.J.T.).
[3]Dept. of Building and Construction Techniques Engineering, Madenat Alelem University College, 10006, Baghdad, Iraq.

Abstract: Natural fibers are frequently employed in the engineering of building materials. However, the highly beneficial nature of using sugarcane fiber waste imbedded with concrete as a construction material may enhance the ductility and crack control of brittle concrete. This review summarized the effect of using sugarcane bagasse fibers in a several of concrete types and illustrated the significant leverage on the mechanical properties of concrete. Because of its biodegradable features and chemical components, sugarcane bagasse (SCB) has prompted a lot of attention as a promising and flexible component in composite materials. Material researchers have been motivated to develop "green" materials with low pollutant indices by the desire to discover low-cost strategies to lessen environmental effect. The three categories of sugarcane byproducts discovered and categorized were bagasse fiber, bagasse sand, and bagasse ash.
Keywords: *Bagasse ash, Bagasse, Cellulose, Sugarcane.*

1. Introduction

Cement, aggregates, and water are the three primary components that go into the production of concrete. However, in order to further enhance the durability of the concrete, a number of additional elements, one of which is known as addictive, were included in the mixture [1, 2]. Concrete has a low susceptibility to corrosion and the effects of weathering, and it has a high compressive strength. Concrete, on the other hand, has a low tensile strength and is prone to cracking because of the brittle nature of the material [3, 4]. Nowadays, there is an increasing demand for concrete in industries; researchers and scientists are developing alternate binders that are eco-friendly and contribute towards waste management [5-7], especially for agricultural waste such as sugarcane. Many previous experiments have been conducted by using different volumes of sugarcane bagasse. Bagasse fiber is a by-product of the sugarcane industry, which plays a part in the manufacturing of either sugar, rum, or biofuel. Due to sugarcane's relatively high tensile strength, it is possible for it to assist in improving the inadequate tensile strength of concrete 4.

Bagasse is a fibrous residue of sugarcane that is left behind after the juice has been extracted (see Fig. 1), and it is one of the most significant examples of agricultural waste in the world [8-11]. Sugarcane residues have the potential to be used for a broad variety of purposes, as shown by the extensive conversion of sugarcane residues into a variety of products such as paper, feed stock, and biofuel [8, 11, 12]. The primary components of SCB have been determined to be cellulose, hemicellulose, lignin, ash, and wax. The following components may be found in sugar cane bagasse, which is more often referred to as SCB [13]:

- 40-50% glucose polymer cellulose in a crystalline structure.
- 25-35% hemicelluloses composed of xylose, arabinose, galactose, glucose, and mannose.

* Correspondence: muntadherjtaher@alsafwa.edu.iq

- 15-35% lignin and lesser amounts of mineral, wax and other components.

Because of its composition, SCB is an interesting candidate for application as a reinforcing fiber in composite materials, with the end goal being the production of unique materials with particular chemical and physical properties. In turn, this is desired for the expected performances based on the targets that have been defined. A review of the relevant published research indicates that SCB is the material of choice for the manufacture of high-quality environmentally friendly goods because of its low cost of manufacturing. This is mostly the result of the abundant supply of raw materials provided by sugar processing plants as well as the low costs associated with the pre-treatment process.

As can be seen in Figure 1, bagasse must first be subjected to three days of treatment with a solution of sodium hydroxide (NaOH) that has been diluted by 50%. (1). The treatment aims to get rid of impurities and make the sugarcane survive longer when it is used in concrete by doing both of these things. Following the processing of the sugarcane bagasse, it is necessary to sun-dry the bagasse before incorporating it into the concrete mixture [14].

Figure 1.
Sugarcane that have treat in sodium hydroxide solution.

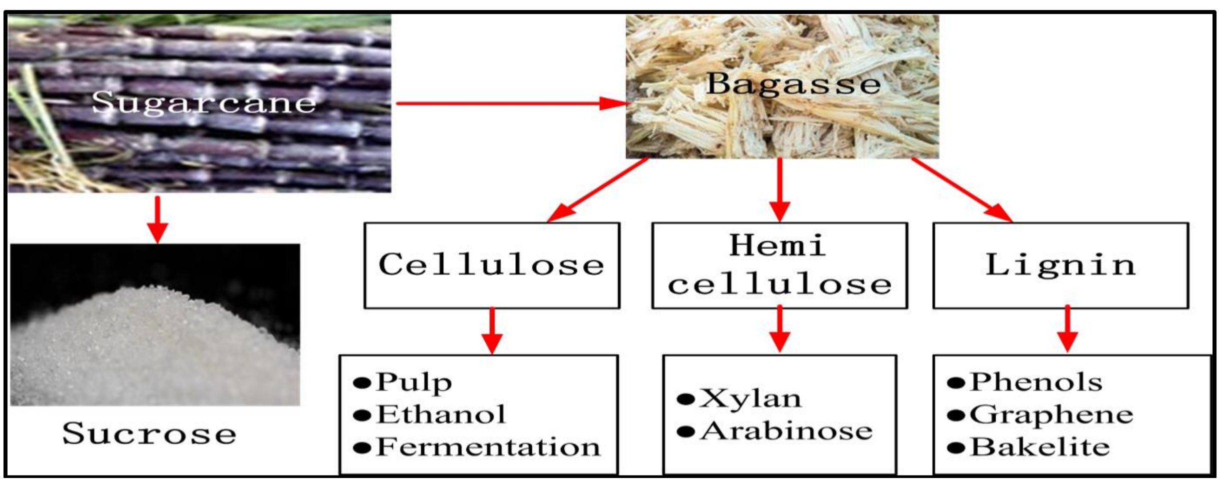

Figure 2.
Sugar cane bagasse (SCB) chemical components.

Sugarcane Bagasse as Fiber Reinforcement

Sugarcane is a global agricultural staple, and the byproduct of pressing the cane to obtain its juice is known as "bagasse." Sugarcane bagasse is produced in excess of 200 million metric tons per year in

ISSN: 2576-8484
Vol. 8, No. 6: 325-333, 2024
DOI: 10.55214/25768484.v8i6.2066

India. Sugarcane is a naturally occurring and infinitely renewable agricultural resource [15]. Approximately 50% cellulose, 25% hemicellulose, and 25% lignin make up sugarcane bagasse [16].

The crystalline structure of the cellulose in sugarcane bagasse accounts for its excellent performance as a composite reinforcement [17]. The crystalline structure of the cellulose in sugarcane bagasse accounts for its excellent performance as a composite reinforcement. When bagasse is chemically broken down, it contains around 50% beta-cellulose, 30% pentosanes, and 2% ash. The composition of the fiber is affected by age, fiber source, soil conditions, and extraction procedure. The bagasse ingredients are given in Table 1.

Rice straw and wheat straw, two other natural fiber sources, have ash contents of 17.5% and 11.0%, respectively, which are often greater than that of sugarcane bagasse; as a result, they are not typically used as raw materials in the production of composites [8]. Bagasse consists of rind and pitch. Low molecular weight fibers (cellulose, hemicellulose, and lignin) make up the exterior hard component (rind) [15]. Bagasse fibers in their raw state are seen in Figure 1.

Moreover, sugarcane bagasse fibers possess inherent biodegradability, making them suitable for applications in areas where environmental sustainability is a critical consideration. Research by Patel et al. (2022) highlighted the potential of sugarcane bagasse-reinforced composites in automotive and construction industries, where lightweight and high-strength materials are essential. The growing body of literature underscores the viability of sugarcane bagasse as a reinforcing agent, positioning it as a key component in the development of sustainable composite materials.

For instance, a study by Pinto et al. (2021) reported that sugarcane bagasse fibers reinforced with polymer matrices exhibited improved mechanical performance and thermal stability. Additionally, the use of sugarcane bagasse in composites contributes to the reduction of environmental impact by decreasing reliance on non-renewable resources and lowering carbon footprints.

Table 1.
Bagasse composition details.

No	Composition of Bagasse	References
1	Cellulose 50.4%, Hemicellulose 28.5 %, lignin 14.9%, ash 2%	(Xiong, 2018) [18]
2	Cellulose 43%, Hemicellulose 10.1%, Lignin 33.23%, ash 1%, Moisture 6.45%	(Ibrahim et al., 2020) [19]
3	Cellulose 40%, Hemicellulose 24.5%, lignin 20%, wax 3.5%, ash 2.4%, silica 2%	(Mulinari et al., 2009) [10]
4	Cellulose 49.44%, hemicellulose 23.19%, Lignin 12.56%, Ash and extractives 14.8%	(Ramleea et al., 2019) [20]
5	Cellulose 36.32%, Hemicellulose 24.7%, lignin 18.14%	(Vilay et al., 2008) [21]
6	Cellulose 35.46%, Hemicellulose 31.25%, lignin 23.7%, ash 9.5%	(Kordkheili et al., 2012) [22]

Cellulose is hydrophilic, which means it attracts water, which then forms a thicker water layer, potentially blocking enzyme diffusion and halting the degradation of nearby items [23]. The tensile strength is stated to be in the range of 20–50 MPa, while the tensile modulus is given as 2.7 GPa [24].

The hydrophilicity of sugarcane bagasse, like that of all other naturally occurring cellulosic fibers, is a disadvantage because it promotes swelling and a loss of mechanical properties. This is true for all naturally occurring cellulosic fibers. The scarcity of natural fibers might be alleviated to some degree if these fibers were modified in some way by being subjected to a variety of chemical treatments [25].

Alkali, potassium permanganate, acetylation, silane treatment, benzoylation, acetone treatment, and acrylation are some of the extensively utilized treatments that have been described in the relevant body of research. Other processes include acrylation. These treatments aim to get rid of or alter the accessible polar groups so that they become more hydrophobic and are compatible with the composite matrix materials. This is done in order to develop composites that can be relied upon [26-29].

Table 2.
Tensile properties raw and-treated bagasse fibers [20, 21].

References	Bagasse fibers	Tensile strength (MPa)	Tensile modulus (GPa)
Remleea et. al. [15]	Untreated fibers	20–50, 96	2.7, 6.42
Vilay et al. [16]	Alkali-treated fibers	156	7.13
Vilay et al. [16]	Acrylic acid-treated fibers	229	8

2. Mechanical Characterization of Bagasse-Based Matrix Composites

Several studies have been reported using bagasse as reinforcement in different polymer systems to form the composite materials. The following few examples of composite concrete made from bagasse fibers are shown in Table 3. It has been reported that bagasse fiber loadings of up to 20 % may be found in a range of synthetic and natural matrix systems.

Most studies found that increasing the fiber loading to 20% enhanced mechanical characteristics such tensile strength, elastic modulus, flexural modulus, flexural strength, and impact strength.

The bonding between matrix systems and bagasse fibers has been enhanced by the use of fiber treatment procedures such alkali treatment, acrylic acid treatment, and silane treatment. Chemically treating fibers to alter their properties has also led to composites with reduced propensities to absorb water.

Researcher showed that the SCBA concrete had significantly higher compressive strength compare to that of the concrete without SCBA; but some other researcher illustrated that the sugar cane bagasse fibers have little impact on the compressive strength of concrete.

Table 3.
Research on the mechanical properties of composites using bagasse as a reinforcing material.

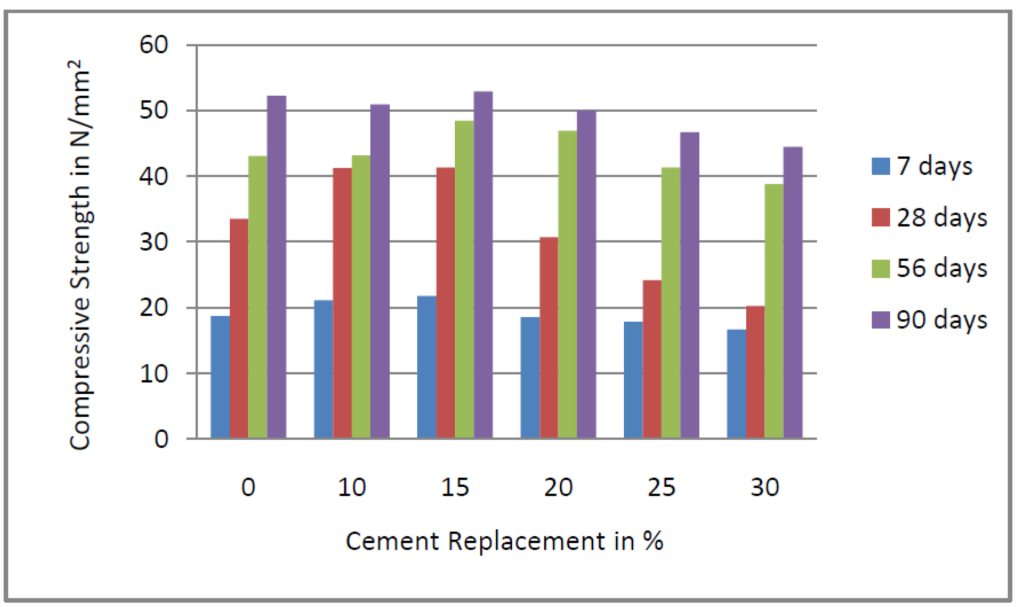

Figure 3.

Table 3.
Research on the mechanical properties of composites using bagasse as a reinforcing material.

No	Authors & Journal	References title	Materials	Results
1	U.R.Kawade et. al. International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 7, July 2013	Effect of use of bagasse ash on strength of concrete	Cement, sand, gravel, SCBA for 0, 10, 15, 20, 25 and 30% replacement	• The compressive strength of concrete made with SCBA was much greater than that of concrete made without SCBA. • It was shown that SCBA could successfully replace up to 15% of the cement in a mixture without negatively affecting the results. • The use of a superplasticizer is not necessary since the improvement in new concrete's workability brought about by partial cement replacement with SCBA obviates the need for such superplasticizer.
2	Seyed Alireza Zareei et. al. Construction and Building Materials 184 (2018) 258–268	Microstructure, strength, and durability of eco-friendly concretes containing sugarcane bagasse ash	Cement, aggregate, micro silica, SCBA	• In general, partial replacement of cement with SCBA improved the performance of lightweight concrete more than the other concrete types. The results indicated that improvements in strength and impact resistance compared with the control sample when cement was replaced with bagasse ash at 5%. It was also found incorporation of BA improved durability and quality of SCC.
3	Juliana Petermann Moretti et. al. Construction and Building Materials 172 (2018) 635–649	Self-compacting concrete incorporating sugarcane bagasse ash	Sugarcane bagasse ash (SBA) as a filler material	• According to the findings of tests conducted with mortar and concrete, SBA is capable of being used fruitfully in powder-type SCC as a filler material, and it has an excellent capacity for self-compaction. The strength levels are sufficient for the majority of today's applications in civil engineering.
4	Mohd Azrizal Fauzi et. al. © Springer Nature Singapore Pte Ltd. 2018 Technology and Social Sciences https://doi.org/10.1007/978-981-13-0074-5_44	Utilisation of sugarcane bagasse ash and sawdust ash as cement replacement material in the production of structural concrete	Cement, SCBA, sawdust ash as a replacement	• SCBA's ability to act as a filler between the pores and the voids in concrete can be seen when the amount of water absorbed is reduced due to the presence of the SCBA in water absorption tests. • Cement replacement is optimum at 5% indicating the maximum value of compressive strength has a negative impact on concrete after 5% addition of SCBA replacement.
5	Guilherme Chagas Cordeiro et. al. ACI MATERIALS	Use of Ultra-Fine Sugar Cane Bagasse ash as	Cement, aggregate, and (0, 10, 15, and 20%	• The results indicate that the mechanical properties of concretes were not significantly changed by the use of SCBA for all levels of replacement.

	JOURNAL, Title no. 105-M56	mineral admixture for concrete	)of a residual ultra-fine SCBA as cement replacement	• The ultra-fine SCBA concretes presented superior performance in the rheological, water sorption capillary, and rapid chloride-ion permeability tests as compared with the reference mixture. The maximum adiabatic temperature rise of CC substantially decreased (11%) by replacement of 15% of cement by ultra-fine SCBA.
6	Festus Olutoge et. al. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 2015*	Strength Characteristics of Concrete Reinforced With Sugar Cane Bagasse Fiber	Cement, aggregate, (*0, 0.5, 0.75, 1.0 and 1.25%) SCBF, superplasticizer, w/c 0.5*	• There is very little of an effect that sugar cane bagasse fibers have on the compressive strength of concrete. After SCBF was included, there was a noticeable decrease in its severity. • The incorporation of sugar cane bagasse fiber into concrete resulted in a substantial decrease in both the flexural and splitting tensile strengths of the material. Bagasse fiber from sugar cane is not suited for use in concrete since it does not increase the compressive, flexural, or splitting tensile strengths of the concrete.
7	Francisco Hernández-Olivares et. al. Construction and Building Materials 247 (2020) 118451	Short sugarcane bagasse fibers cementitious composites for building Construction	OPC, Sugarcane bagasse short fiber in presence of CO_2	• The sugarcane fibers pre-treatment here proposed was verified effective, not-expensive and simple, easily acceptable for rural manufacturing of eco-friendly and sustainable building materials, minimizing chemical waste generation Increasing of specific gravity, modulus of rupture, compressive strength, Young's Modulus. decreasing of porosity and water absorption
8	Cristel Onésippe et. al. Composites: Part A 41 (2010) 549–556	Sugar cane bagasse fibers reinforced cement composites: Thermal considerations	cement, sand, water, $CaCO_3$, bentonite, silica fume, acrylic styrene polymer and SCBF heat treated or chemical treated	• The greatest findings for specific heat are achieved with CBAGB, however both kinds of composites exhibit lower specific heat than the matrix alone. • The more fibers there are, the lighter the specimen; the lower its thermal conductivity and specific heat. The thermal conductivity of alkaline fibers is lower than that of ratified fibers.

Compressive strength was found to be substantially greater in the SCBA concrete compared to the concrete without SCBA. It was discovered that, within a 15% range, SCBA may be used instead of cement with similar results. The best results, however, were shown at a 15% replacement rate for SCBA. Fresh concrete's workability is improved when SCBA is used to replace some of the cement.

3. Application of Bagasse Ash as Filler Material

Research conducted on the use of bagasse ash as a filler in composites has revealed an improvement in the hybrid composites' mechanical properties. These hybrid composites use various combinations of natural fibers as reinforcements. Bagasse ash, when used as a filler material in composite materials, has been shown to exhibit thermal stability up to about 3% of the total filler content [3]. The Table 4 below illustrates some of the outcomes that were obtained by using ash from bagasse as filler.

Table 4.
Applications of bagasse ash as filler in composites.

No	Major observations	Process used	Reference
1	Using hybrid banana-flax composites that included 3% ash led to a significant improvement in the material's flexural, tensile, and impact strengths. The banana-kenaf hybrid composites loaded with 5% bagasse ash were found to have the highest flexural and tensile strengths possible. The bagasse ash content of the hybrid sisal-flax composites led to an increase in the impact strength of the composites. The most thermally stable of the banana-kenaf composites were the ones that included 3% ash.	Using bagasse ash with a particle size of 350 nm as a filler material (1, 3, or 5% of the total weight fraction) and vacuum-assisted resin transfer moulding, hybrid bio composites were made of banana-flax, sisal-flax, banana-kenaf, and sisal-kenaf.	Vivek & Kanthavel [30]
2	In a matrix composed of Al-7075, a mixture containing 6% bagasse ash and 5% graphite achieved a maximum tensile strength of 299.4 MPa and a BHN of 99.6. This combination had the lowest percentage of elongation, which came in at 4.9%, compared to others that had lower quantities of ash and graphite.	In an Al 7075 matrix with stir casting, sugarcane bagasse ash was used as a filler with various amounts of graphite.	Imran et al. [31]

4. Recommendations

SCBA is a specific type of pozzolana that has the potential to be used in concrete production at a rate of up to 20% as a partial replacement for cement. For the purpose of environmental sustainability, SCB may be used into the production of concrete that is not only lightweight but also durable and economical. Due to the fact that it is extensively disseminated throughout the country.

5. Conclusion

In this review, we take a look at how bagasse from sugarcane may be used in combination with other composites, either as a filler or a reinforcement in various applications. The following is an inference that may be drawn from this.

- It is possible that SCBA might be used in place of cement up to a specific amount (perhaps 15%), with the same or comparable effects.
- Because the partial replacement of cement by SCBA increases the workability of the new concrete, it is unnecessary for a super plasticizer to be added.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 325-333, 2024
DOI: 10.55214/25768484.v8i6.2066

- Increases in SCBA replacement decrease the workability of fresh concrete showing more water is needed to make it workable.
- In general, partial replacement of cement with SCBA improved the performance of lightweight concrete more than the other concrete types.
- The compressive strength of concrete made with SCBA was much higher than that of concrete made without SCBA.
- Bagasse fibers derived from sugar cane have a negligible impact on the compressive strength of concrete. The use of SCBA tends to produce a lower density concrete.
- The specific heat of SCBF show weaker than the specific heat matrix alone.
- Thermal conductivity of composite with higher volume fraction of SCB is lower.
- The sugarcane fibers pre-treatment here proposed was verified effective, not-expensive and simple, easily acceptable for rural manufacturing of eco-friendly and sustainable building materials, minimizing chemical waste generation.

References
[1] Abdulridha, A., 2022. Effects of the Cement Kiln Dust on the Ultrasonic Wave Velocity in the cement mortar. *Sensors and Machine Learning Applications*, *1*(2), pp. 1-5.
[2] Abdulredh, M., Hashim, R. and Tuama, W.K., 2022. Ultrasonic sensing of properties of eco-friendly cement mortar. *Sensors and Machine Learning Applications*, *1*(2), pp. 1-5.
[3] Irwan, J.M., Faisal, S.K., Othman, N., Wan, I.M.H., Asyraf, R.M. and Annas, M.M.K., 2013. Performance of concrete using light waste PET fibre. *Advanced Materials Research*, *795*, pp.352-355.
[4] Govindarajan, D. and Jayalakshmi, G., 2011. XRD, FTIR and microstructure studies of calcined Sugarcane Bagasse Ash. *Advances in Applied Science Research*, *2*(3), pp. 544-549.
[5] Deb, P., Debnath, B., Hasan, M., Alqarni, A.S., Alaskar, A., Alsabhan, A.H., Khan, M.A., Alam, S. and Hashim, K.S., 2022. Development of eco-friendly concrete mix using recycled aggregates: Structural performance and pore feature study using image analysis. *Materials*, *15*(8), p.2953.
[6] Chandrasekar, R., Gkantou, M., Nikitas, G., Hashim, K., Pradeep, H.R. and Ahuja, A., 2022, May. Integration of 3D concrete printing in the construction industry: a short review. In *International Conference on Geotechnical Engineering-IRAQ* (pp. 445-452). Singapore: Springer Nature Singapore.
[7] Hamad, M.A., Nasr, M., Shubbar, A., Al-Khafaji, Z., Al Masoodi, Z., Al-Hashimi, O., Kot, P., Alkhaddar, R. and Hashim, K., 2021. Production of ultra-high-performance concrete with low energy consumption and carbon footprint using supplementary cementitious materials instead of silica fume: A review. *Energies*, *14*(24), p.8291.
[8] Pandey, A., Soccol, C.R., Nigam, P. and Soccol, V.T., 2000. Biotechnological potential of agro-industrial residues. I: sugarcane bagasse. *Bioresource technology*, *74*(1), pp.69-80.
[9] Trejo-Hernandez, M.R., Ortiz, A., Okoh, A.I., Morales, D. and Quintero, R., 2007. Biodegradation of heavy crude oil Maya using spent compost and sugar cane bagasse wastes. *Chemosphere*, *68*(5), pp.848-855.
[10] Mulinari, D.R., Voorwald, H.J., Cioffi, M.O.H., Da Silva, M.L.C., da Cruz, T.G. and Saron, C., 2009. Sugarcane bagasse cellulose/HDPE composites obtained by extrusion. *Composites Science and Technology*, *69*(2), pp.214-219.
[11] Trejo Estrada, S., 2009. Comparative hydrolysis and fermentation of sugarcane and agave bagasse. *Bioresource Technology*, *100*, pp.1238-1245.
[12] Reddy, M.R., Chandrasekharaiah, M., Govindaiah, T. and Reddy, G.V.N., 1993. Effect of physical processing on the nutritive value of sugarcane bagasse in goats and sheep. *Small Ruminant Research*, *10*(1), pp.25-31.
[13] Sun, J.X., Sun, X.F., Zhao, H. and Sun, R.C., 2004. Isolation and characterization of cellulose from sugarcane bagasse. *Polymer degradation and stability*, *84*(2), pp.331-339.
[14] Khalid, F.S., Herman, H.S. and Azmi, N.B., 2017. Properties of sugarcane fiber on the strength of the normal and lightweight concrete. *MATEC web of conferences*, *103*, pp. 01021.
[15] Almazán, O., Gonzalez, L. and Galvez, L., 1999. The sugar cane, its by-products and co-products. *Proceedings of the Third Annual Meeting of Agricultural Scientists, Réduit, Mauritius*, 17-18 November 1998, 1999.
[16] Huang, Z., Wang, N., Zhang, Y., Hu, H. and Luo, Y., 2012. Effect of mechanical activation pretreatment on the properties of sugarcane bagasse/poly (vinyl chloride) composites. *Composites Part A: Applied Science and Manufacturing*, *43*(1), pp.114-120.

[17] Trindade, W.G., Hoareau, W., Megiatto, J.D., Razera, I.A.T., Castellan, A. and Frollini, E., 2005. Thermoset phenolic matrices reinforced with unmodified and surface-grafted furfuryl alcohol sugar cane bagasse and curaua fibers: properties of fibers and composites. *Biomacromolecules*, *6*(5), pp.2485-2496.

[18] Xiong, W., 2018. Bagasse composites: A review of material preparation, attributes, and affecting factors. *Journal of Thermoplastic Composite Materials*, *31*(8), pp.1112-1146.

[19] Ibrahim, M.I.J., Sapuan, S.M., Zainudin, E.S. and Zuhri, M.Y.M., 2020. Preparation and characterization of cornhusk/sugar palm fiber reinforced Cornstarch-based hybrid composites. *Journal of Materials Research and Technology*, *9*(1), pp.200-211.

[20] Ramlee, N.A., Jawaid, M., Zainudin, E.S. and Yamani, S.A.K., 2019. Tensile, physical and morphological properties of oil palm empty fruit bunch/sugarcane bagasse fibre reinforced phenolic hybrid composites. *Journal of Materials Research and Technology*, *8*(4), pp.3466-3474.

[21] Vilay, V., Mariatti, M., Taib, R.M. and Todo, M., 2008. Effect of fiber surface treatment and fiber loading on the properties of bagasse fiber–reinforced unsaturated polyester composites. *Composites Science and Technology*, *68*(3-4), pp.631-638.

[22] Kordkheili, H.Y., Hiziroglu, S. and Farsi, M., 2012. Some of the physical and mechanical properties of cement composites manufactured from carbon nanotubes and bagasse fiber. *Materials & Design*, *33*, pp.395-398.

[23] Matthews, J.F., Skopec, C.E., Mason, P.E., Zuccato, P., Torget, R.W., Sugiyama, J., Himmel, M.E. and Brady, J.W., 2006. Computer simulation studies of microcrystalline cellulose Iβ. *Carbohydrate research*, *341*(1), pp.138-152.

[24] Kordkheili, H.Y., Hiziroglu, S. and Farsi, M., 2012. Some of the physical and mechanical properties of cement composites manufactured from carbon nanotubes and bagasse fiber. *Materials & Design*, *33*, pp.395-398.

[25] Karp, S.G., Woiciechowski, A.L., Soccol, V.T. and Soccol, C.R., 2013. Pretreatment strategies for delignification of sugarcane bagasse: a review. *Brazilian archives of biology and technology*, *56*, pp.679-689.

[26] Aguiar, M.M., Ferreira, L.F.R. and Monteiro, R.T.R., 2010. Use of vinasse and sugarcane bagasse for the production of enzymes by lignocellulolytic fungi. *Brazilian Archives of Biology and Technology*, *53*, pp.1245-1254.

[27] RG, C., 2012. Study of sugarcane bagasse pretreatment with sulfuric acid as a step of cellulose obtaining. *International Journal of Nutrition and Food Engineering*, *6*(1), pp.6-10.

[28] Mahesha, G.T., Shenoy, S.B., Kini, V.M. and Padmaraja, N.H., 2018. Effect of fiber treatments on mechanical properties of Grewia serrulata bast fiber reinforced polyester composites. *Materials Today: Proceedings*, *5*(1), pp.138-144.

[29] Zhao, X.B., Wang, L. and Liu, D.H., 2008. Peracetic acid pretreatment of sugarcane bagasse for enzymatic hydrolysis: a continued work. *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology*, *83*(6), pp.950-956.

[30] Vivek, S. and Kanthavel, K., 2019. Effect of bagasse ash filled epoxy composites reinforced with hybrid plant fibres for mechanical and thermal properties. *Composites Part B: Engineering*, *160*, pp.170-176.

[31] Pandey, A., Soccol, C.R., Nigam, P. and Soccol, V.T., 2000. Biotechnological potential of agro-industrial residues. I: sugarcane bagasse. *Bioresource technology*, *74*(1), pp.69-80.

ISSN: 2576-8484
Vol. 8, No. 6: 325-333, 2024
DOI: 10.55214/25768484.v8i6.2066