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Characterization of Calcined Sugarcane Bagasse Ash and Sugarcane Waste Ash for Industrial Use

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Abstract

The utilization of waste material provides a satisfactory solution to some of the environmental concerns and problems associated with waste management. In this study sugarcane bagasse ash and sugarcane waste were calcined at 400^{0}C, 600^{0}C, 800^{0}C and 1000^{0}C temperature for 2hours.These samples has been chemically and physically characterized in order to evaluate the possibility of their use in metallurgical and materials industry. XRF analysis for chemical composition of the samples, XRD analysis for determination of composition and presence of crystalline material as well as physical properties has been studied. Carbon content has been determined by elemental analyzer. Bagasse ash is an industrial waste that mainly consists of high amount of silica (SiO_2) and carbon materials. Calcium, magnesium and potassium oxide presents as main minor compound. As temperature increases, the sugarcane bagasse ash (SCBA) and sugarcane waste ash (SCWA) color changes from black to grey and white which indicates that the carbon content present in the SCBA and SCWA were reasonably reduced. The ignition loss of SCBA and SCWA was significantly reduced with increasing temperature. Particle size analysis indicates sample fineness was improved with increasing temperature.

Keywords: *Bagasse ash, sugarcane waste ash, calcination, particle size*

1. Introduction

A large amount of industrial waste is producing day by day in Bangladesh. In present special attention has been devoted to the waste minimization practices, pollution prevention, and sustainable development as applied to the material field.

Sugar industry lays an immense importance in agro-based economy of Bangladesh. Sugar cane, the only raw material of this industry is the main cash-crop of north Bengal of our country. Sugarcane is produced in 2.05% land of the country and it contributes 5.52% to agricultural GDP [1]. There are 15 sugar mills in Bangladesh and the bagasse is the major by-product of these mills. Some amount of the by-product is used as fuel for boiler in the millhouse. Mostly this is either under-utilized or unutilized as a source of heat energy. It is creating waste management problem, specially in the sugar milling sites.

Sugarcane bagasse (SCB) which is a voluminous by-product in the sugar mills when juice is extracted from the cane. It is, however, generally used as a fuel to fire furnaces in the same sugar mill that yields about 8-10% ashes containing high amounts of un-burnt matter, silicon, aluminum, iron and calcium oxides. But the ashes obtained directly from the mill are not reactive because of these are burnt under uncontrolled conditions and at very high temperatures. Ganesan et al [2] stated that 1 ton of sugarcane generates 280 kg of bagasse, and that based on economics as well as environmental related issues, enormous efforts have been directed worldwide towards bagasse management issues i.e. of utilization, storage and disposal.

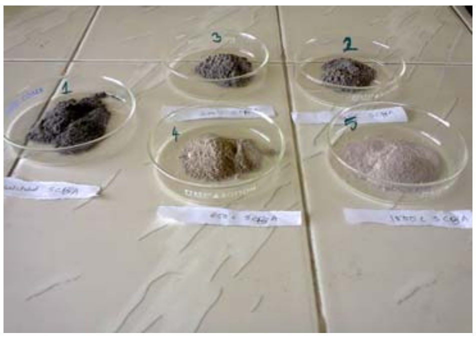
The ash, therefore, becomes an industrial waste and poses disposal problems. It's utilization as an adsorbent as well as mineral admixture in cement and concrete has been examined [3]. Recently, the use of agriculture solid waste materials as pozzolans in the manufacture of blended mortars and concrete has been the focus of research [4,5, 6]. ASTMC618 [7] classified SCBA as N pozzolan and adapted for use in making cement [8, 9]. According to Sing et al [10], the ash produced by controlled burning of agro waste materials below 700°C transforms silica content of the ash in to amorphous silica and can be used as a pozzolanic material. SCBA has proved to be a viable by-product for admixture in cement, with its intrinsic characteristic such as high content of silica in the form of quartz [3]. However, the high carbon content is an obstacle for its use in cement/mortars.

Therefore it would be valuable if the unburned carbon in SCBA could be removed and used for other applications.

In the present study, the collected SCBA and SCW are fired at different temperatures and the calcined SCBA and SCWA are characterized in order to use in the metallurgical and materials industry.

2. Materials and methods

SCBA and SCW were collected from Joypurhat Sugar Mill, Joypurhat, Bangladesh. Sugarcane waste was dried, crushed and then sieved on passing 250 microns. Both SCBA and SCW samples has been calcined at 400°C, 600°C ,800°C and 1000°C temperature for 2hours under controlled condition. At the end of each process, the ash was taken out of the furnace and cooled to room temperature. After cooling, the ash was stored for characterization. In this condition the grey and grey white colour (Fig.1) of the SCBA and SCWA indicated as complete burning.



(A)

(B)

Figure1. (1)Uncalcined bagasse ash (A) and Sugarcane waste (B) and calcined at different temperature (2) 400^0C (3) 600^0C (4)800^0C and (5) 1000^0C

The samples were determined by X-ray fluorescence Spectrometer (XRF) method following the procedures of Goto & Tatsumi [11] using Rigaku ZSX Primus XRF machine equipped with an end window 4.kW R^H-anode X-ray tube. The phase composition of the uncalcined and calcined samples were determined by the XRD analysis of the sample with Bruker X-ray Diffractometer model operating with a CuKα radiation source (Kα=1.5406 A_O). Particle size was determined by sieve analyzer using various sizes of sieve. The percentages of CHNS were carried out by an Elemental Analyzer of model EA 1108 according to the ASTM D3176-84 standard test procedures. The loss of ignition was determined by the mass loss of these samples after heating at 1000^0 C.

3. Results and Discussion

3.1. Chemical Analysis

The chemical compositions of the bagasse ash and sugarcane waste are given in Table 1 and Table 2. It can be seen that the bagasse ash waste powder contains a large amount of silicon oxide and this amount increase with increasing temperature. Chemical composition of SCBA confirmed to be a good pozzolana since the sum of SiO_2, Al_2O_3 and Fe2O3 is 70.10% for raw material and 73.13% when sample calcined at 1000^0C, thus meeting the requirement of 70% minimum recommended by ASTM C618[7]. From Table1 and Table 2 it shows that loss of ignition was significantly decreased with increasing temperature. So, organic matter percentages were low for calcined SCBA and SCWA.

Table 3 and Table 4 shows the percentages of carbon, nitrogen, hydrogen and sulphur of SCBA and SCWA. The percentage of carbon indicates that raw bagasse ash decrease 63% when sample calcined at 400^0C and 97% decrease when calcined at 1000^0C. Carbon percentage of sugarcane waste also significantly reduced when sample calcined at different temperature. According to Corderio et al [12] states that carbon and volatile compounds present in the SCBA are considerably removed at higher calcinations temperature.

“Table1. Chemical compositions of uncalcined and calcined bagasse ash (SCBA)”

Oxides/wt%	Raw SCBA	400^0C	600^0C	800^0C	1000^0C
SiO_2	60.75	62.55	61.93	62.57	62.40
Al_2O_3	4.14	4.31	4.44	4.70	5.02

Na_2O	0.77	0.66	0.74	0.86	0.83
MgO	2.39	2.20	2.43	2.34	2.27
P_2O_5	3.39	3.37	3.42	3.40	3.46
SO_3	1.81	1.70	1.73	1.71	1.79
K_2O	14.63	14.37	14.25	13.86	13.40
CaO	4.48	3.56	3.71	3.49	3.69
Fe_2O_3	5.27	4.88	5.01	4.87	5.71
LOI(1000^0C)	5.24	4.17	3.34	1.27	0.37

"Table 2. Chemical compositions of uncalcined and calcined sugarcane waste (SCW)"

Oxides/wt%	Raw SCW	400^0 C	600^0 C	800^0 C	1000^0 C
SiO_2	15.61	18.62	20.39	20.59	23.20
Al_2O_3	3.22	4.06	4.75	4.99	5.28
Na_2O	0.10	0.27	0.25	0.37	0.52
MgO	1.38	1.97	2.02	2.07	2.10
P_2O_5	10.82	12.87	14.16	14.07	14.63
SO_3	11.95	8.72	8.38	8.93	6.71
K_2O	6.48	5.45	5.42	5.06	4.52
CaO	40.24	40.22	38.64	37.48	36.78
Fe_2O_3	7.32	5.52	3.98	4.34	4.39
LOI(at1000^0C)	77.6	39.7	20.33	2.06	0.77

Table 3. Ultimate analysis of uncalcined and calcined bagasse ash

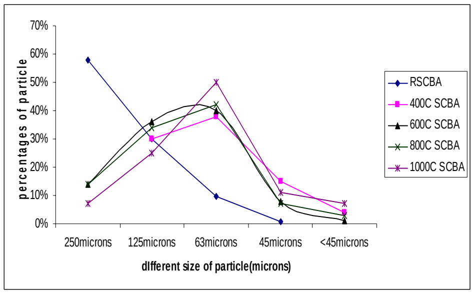
	N%	C%	H%	S%
Raw SCBA	5.85	1.60	0.63	0.319
Calcined at 400^oC	1.86	0.58	0.3	0.222
Calcined at 600^oC	1.57	0.53	0.24	0.177
Calcined at 800^oC	3.22	0.13	0.238	0.203
Calcined at 1000^oC	3.94	0.037	0.214	0.275

Table 4. Ultimate analysis of uncalcined and calcined SCWA

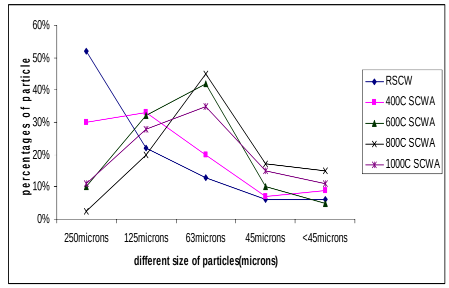
	N%	C%	H%	S%
Raw Sugarcane waste	3.85	38.05	5.43	0.802
Calcined at 400^oC	6.63	28.84	1.93	0.803
Calcined at 600^oC	3.93	5.41	0.71	2.085
Calcined at 800^oC	6.37	0.621	0.28	1.366
Calcined at1000^oC	2.07	0.116	0.18	1.533

3.2 Particle size analysis

Figure 2 shows particle size distribution of raw and calcined sample. Particle size was determined by sieve analyzer using various sizes of sieve, the bulk of the retained sample on five consecutive sieves corresponding to 250µm, 125µm,63µm,45µm and <45 µm size fractions (Figure2) respectively. Most fine particle found at 63 µm size and at 800^0C temperature we found most fine size for SCWA and at 1000^0C temperature, found fine particle for SCBA. So, it could be helpful for several metallurgical industries.



(a)



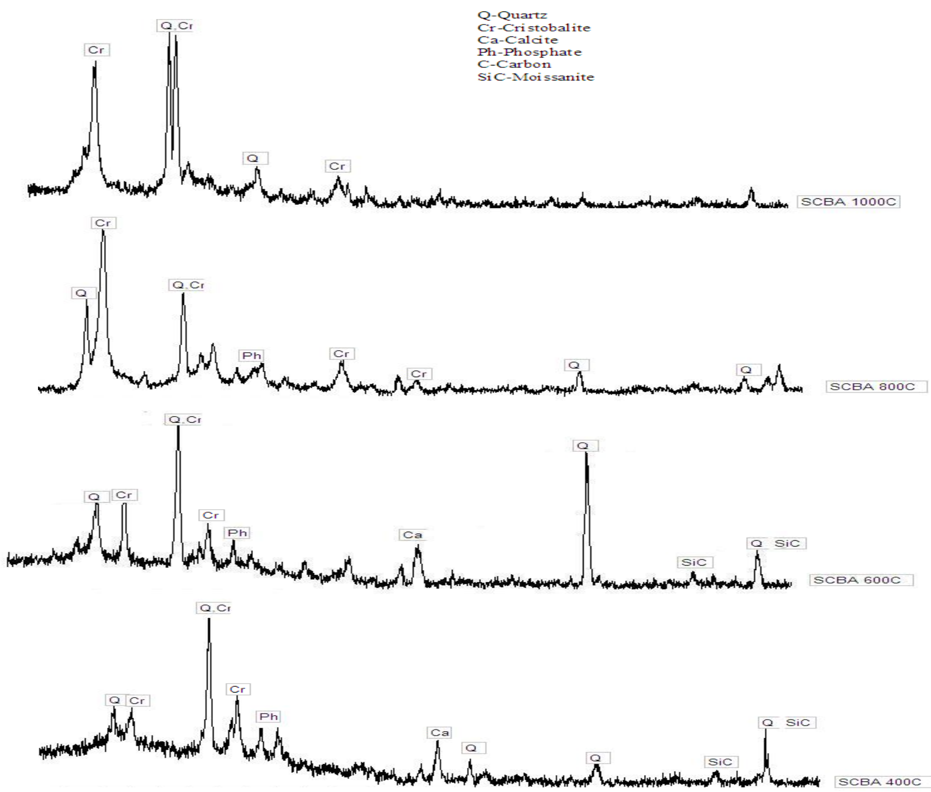
(b)

Figure2. Particle size distribution of the sample of uncalcined and calcined SCBA (a) and SCWA (b)"

3.3 Phase analysis

The XRD patterns (Fig.3) show a remarkable difference between calcined and uncalcined bagasse ash, which suggests that phase transformation has take place. For bagasse ash (Fig. 3), silica is the primary component with small amounts of calcium and other compounds. The peak observed from the uncalcined SCBA and 400°C and 600°C calcined SCBA samples indicates the amorphous nature of silica. For the SCBA 800°C (Fig.3), some sharp and intense peak starts to show up, this may be due to the recrystallisation of amorphous silica to crystalline with temperature and this implies that the crystallanity increases as temperature increases. At 1000°C, the bagasse ash becomes highly crystalline (Cristobalite is the main phase) as evident from sharp reflection peaks.

In uncalcined SCW (Fig. 3), silica and carbon are the primary component with small amounts of calcium, anorthite and other compounds. For the SCWA 800°C and 1000°C, (Fig.4), some sharp peak of crystobalite and anorthite starts to show up and more quartz phase has been observed, this indicates that the crystallanity increases as temperature increases.



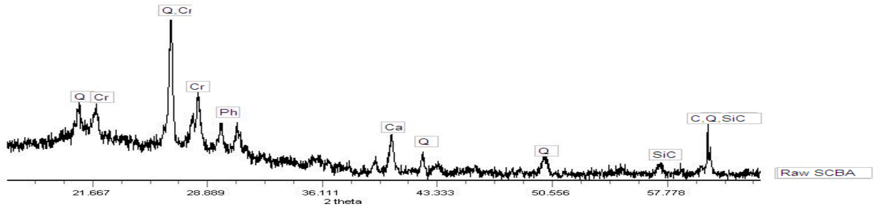


Figure3. XRD analysis for uncalcined and calcined SCBA (Q-quartz, Cr-cristobalite, Ca-calcite Ph-phosphate, C-carbon, SiC- moissanite)

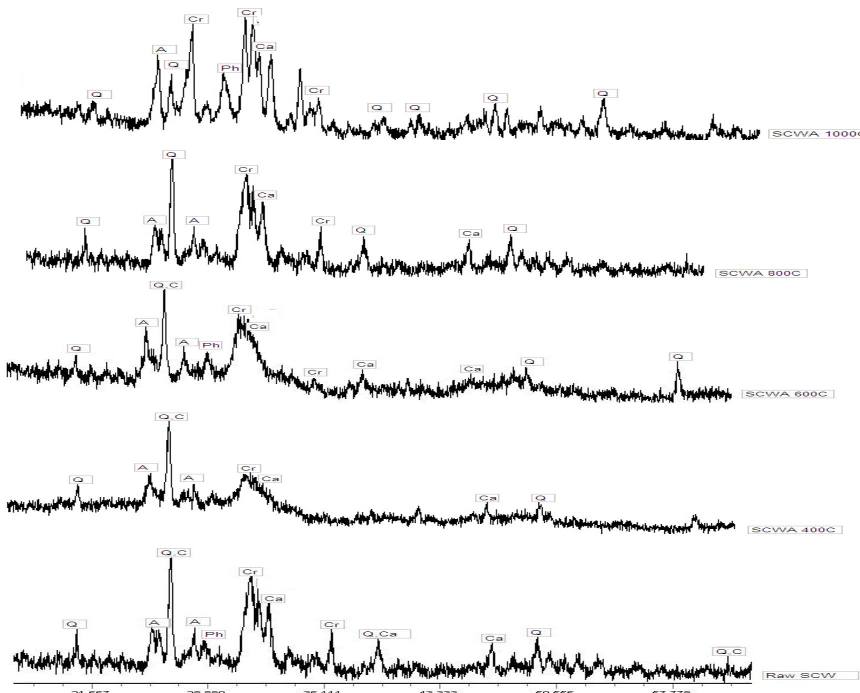


Figure4. XRD analysis for uncalcined and calcined SCWA (Q-quartz, Cr-cristobalite, Ca-calcite, Ph-phosphate, C-carbon, A-anorthite)

4. Conclusion

From the analysis of the results given above, the followings conclusions can be made:

1) The XRD results showed that bagasse ash and sugarcane waste ash structure have been changed from amorphous nature (400°C to 800°C) to crystalline materials (1000°C).

2) As temperature increases, the bagasse ash and waste ash colour changes from black to grey and white which indicates that the carbon content present in the samples were reasonably reduced. Carbon percentage obtained from elemental analyzer also confirmed minimization of carbon content.

3) Also with fine particle size characteristics, implies that these calcined samples can be used as facing sand molding during casting operations.

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6. References

[1] www.bsfic.gov.bd

[2] Ganesan, K., Rajagopal, K., & Thangavel, K. "Evaluation of bagasse ash as supplementary cementitious material". *Cement and Concrete Research,* 29, 515-524.2007

[3]D. Govindarajan and G. Jayalakshmi, "XRD, FTIR and Microstructure studies of calcined sugarcane bagasse ash." ***Adv. Appl Sci Res.*** 2(3):544-549, 2011

[4] J. Payá,. J. Monzó, M. V. Borrachero ,L. Díaz-Pinzón and L. M. Ordóñez, "Sugar-cane Bagasse ash(SCBA): studies on its properties for reusing in concrete production", *Journal of Chemical Technology & Biotechnology* ,Volume 77 Issue 3, pp. 21 – 32.2007

[5] A. Goyal, H. Kunio, Ogata and Mandula, "Properties and Reactivity of sugarcane Bagasse Ash,"*12th International colloquim on structural and geotechnical engineering,* vol 1, 1-5, 2007

[6] K.C.P. Faria., R.F. Gurgel, and J.N.F.Holanda, " Recycling of sugarcane bagasse ash waste in the production of clay bricks" *Journal of Environmental Mangement*, 101, pp. 7 -12. 2012

[7]American Society for Testing and Materials Standards ASTM C618 Standard Specification for Fly Ash and Raw or Calcium Natural Pozzolanas for Use as a Mineral Admixture in Portland Cement Concrete, Pennsylvania, USA, Volume 04.02,1992.

[8] A.R. Mead, "Temperature-Instrumentation Observations at Pine Flat and Folsom Dams," *Symposium on Mass Concrete,* SP-6, American Concrete Institute, Detroit, pp. 151-178, 1963

[9] R.G. Smith, "Alternatives to Ordinary Portland Cement"*, British Building Society Journal.* Page 1-17, 1992

[10]. N.B. Singh, S.S. Das, N.P. Singh and V.N. Dwivedi, "Hydration of bagasse ash-blended Portland cement" ***Indian J. Eng. Mater. Sci.,*** 16, 415-422. 2000

[11] A. Goto,, and Y. Tatsum. "Quantitative analysis of rock samples by an x-ray fluorescence spectrometer (II)." *The Rigaku Jour* 13(2):20-39, 1996.

[12] G.C. Cordeiro, R.D. Toledo Filho, E.M.R. Fairbairn, "Pozzolanic activity and filler effect of sugar cane bagasse ash in Portland cement and lime mortars." ***Constr. Build. Mater.,*** 23, 113,2008