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Physical Properties and Content of Silica in Different Varieties of Rice Husk Found in Sri Lanka

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ABSTRACT

Rice Husk (RH) is one of the main agricultural wastes available abundantly in Sri Lanka. Physical properties such as moisture content, average bulk density and porosity of seven varieties of RH found commonly in the western province of Sri Lanka were studied in this research. Moisture content varies between 10.38% -12.80%, the average bulk density varies between 372.90 kg m^{-3} - 523.94 kg m^{-3} and the porosity varies between 46% - 68% of these samples. The highest amount of silica was estimated as 98.2% for BG300 variety of RH and the lowest amount of silica was estimated as 78.3% for Suwandal variety of RH. A typical SEM image and XRD analysis was done to characterize the extracted silica from Rice Husk Ash (RHA). Considerable reduction in particle size of silicain RHA from 10.1 Å to 8.10 Å was observed after the synthesis process.

1.0 INTRDUCTION

Rice is the staple food of the inhabitants of Sri Lanka. The total land devoted for paddy is estimated to be about 708,000 Hectares at present. On average 2 – 3 million metric tons of paddy is produced annually in Sri Lanka[1]. Percentages of husk in paddy vary widely between 14 % - 27 % according to the geographical location and variety, but 20% can be taken as a fair average. An analysis in Sri Lanka showed about 22 % of paddy mass is Rice Husk (RH)[2]. RH is commonly used as a fuel for household, operating rice mills and as an animal feed. Considerably large amount of RH is burnt to ash creating a great environmental threat that causes damage to the land and the environment in which it is dumped. Disposal of this Rice Husk Ash (RHA) is a great challenge. Lots of ways are being studied by the researchers to transform this RHA into a viable commercial product.

Over the years, several studies have showed that when RH is burnt, it generates between 17 – 20 % ashes, made up of about 87 – 93 % of silica[2-5]. Very few investigations have been conducted in Sri Lanka to extract silica from post-harvest residues[6,7]. Recent studies in Sri Lanka[8] on extraction of silica from post-harvest residues such as RH, Coconut husk and Rice straw have revealed that RH is more suitable than the other post-harvest residues to obtain industrial standard silica having particle size possibly in the range of nano scale. The objective of this study is to investigate the physical properties of extracted silica obtained from different varieties of RH found commonly in the western province of Sri Lanka.

2.0 METHODOLOGY

2.1 Moisture content

Moisture content of the RH sample was determined using the standard oven dried method[8] and using the equation, $MC = \left(\frac{W_{wet} - W_{dry}}{W_{wet}} \right) \times 100$, where, MC is the moisture content (%), W_{wet} is the wet weight of the RH sample and W_{dry} is the dry weight of the RH sample.

2.2 Bulk density

Bulk density of the RH sample was determined using the standard method[8] and using the equation, $\rho_{bulk} = \frac{W_2 - W_1}{V}$, where, ρ_{bulk} is the bulk density of the RH sample, W_2 is the weight of the container and RH sample, W_1 is the weight of the container and V is the volume of the container .

2.3 Porosity

The porosity of the RH samplewas determined using the standard water pycnometer method[8] and using the equation, $P(\%) = \left(\frac{V_i - V_f}{V_s} \right) \times 100$, where, P is the porosity of the RH sample (%), V_i is the initial total volume of the RH sample and the added water, V_f is the final total volume of the RH sample and the added water, V_s is the volume of the RH sample.

2.4 Synthesis of pure silica from rice husk ash

RH collected from the local rice fields was washed with water in order to remove dirt and burnt in air to get black ash. This burnt black ash was then put into a muffle furnace at temperature of 700 ^{0}C for 2 hours until it became white ash. This white ash sample called the Rice Husk Ash (RHA) was used to extract silica. This process was done separately for each RH sample collected. Extractions of silica from these RHA samples were done in the following manner. Ten grams of each sample was boiled in 80 ml of 2.5 M sodium hydroxide solutions while stirring in a covered 250 ml Erlenmeyer flask separately for 3 hours. The solutions were filtered using the Whatman No. 41 ashless filter paper and the respective residues were washed with 20 ml boiling water separately. Each filtrate was allowed to cool down to room temperature and 5 M H_2SO_4 was added until it reached pH of 2. Then NH_4OH was added to each filtrate until it reached a pH of 8.5 and allowed to be at room temperature for 3.5 hours. The silica was separated by suction filtration using a Buchner funnel and the filtrate was thoroughly washed. Each sample was then oven dried at 120 ^{0}C for 12 hours and allowed to cool down to room temperature naturally.

2.5 XRD and SEM analysis

X-ray diffraction (XRD) patterns and SEM images were obtained for the raw RHA and for the extracted silica samples.The XRD system used in this analysis has an acceleration voltage of 40 kV and current of 30 mA. X-rays having the wavelength of 1.54 Å was used in this XRD system. The diffraction angle 2θ was scanned 10^0 to 80^0

at a rate of 4^0/min. The Scherer's formula $B_{sher} = \frac{0.9\lambda}{B\cos\theta}$ was used to calculate the particle size of the extracted silica. Here, B_{sher} is the particle size of a small crystal, B is the broadening of the diffraction line at half its maximum intensity in radians, λ is the wavelength of the X-ray, θ is angle of corresponding peak.

3.0 RESULTS AND DISCUSSION

The Table 1 show the moisture content, bulk density and porosity of different varieties of RH found commonly in the western province of Sri Lanka.

Table 1: Moisture content, Bulk density and Porosity of different varieties of RH found commonly in the western province of Sri Lanka

Rice variety	Moisture content / %	Bulk density / kg m^{-3}	Porosity / %
BW272-6-B	10.87	438.61	68
BW 367	11.64	372.90	60
BG359	12.80	423.98	58
LD365	10.38	351.43	54
BG300	10.73	408.95	46
Maavee	10.91	523.94	58
Suwandal	10.53	385.85	58

The moisture content varies between 10.38% -12.80 % for the varieties of RH selected for this study. These values are comparable to the values for RH varieties from China, Nigeria[9,10] and some other varieties found in Sri Lanka[6].The average bulk density varies between 372.90 kgm^{-3} - 523.94 kgm^{-3} for the varieties selected. These values are comparable to the values for the RH of Long grain, Short grain, Cascara de arroz and Japonica from china[11]. However, these values are somewhat higher than the values obtained by Ismail *et al*., for other varieties from Sri Lanka[6]. This variation may be due to different varieties of RH and their different geographical locations. The porosity varies between 46 % - 68 % for the varieties of RH selected for this study. These values are comparable to the values for the RH of Long grain, Short grain, Cascara de arroz and Japonica from china[11]. The Table 2 show the extracted silica content (%) from RHA of different varieties of RH found in Sri Lanka in a specific geographical location.

Table 2: Extracted silica content (%) from RHA of different varieties of RH found commonly in the western province of Sri Lanka.

Rice variety	% of silica content
BW272-6-B	89.7
BW 367	79.4
BG359	94.6
LD365	88.7
BG300	98.2
Maavee	96.7
Suwandal	78.3

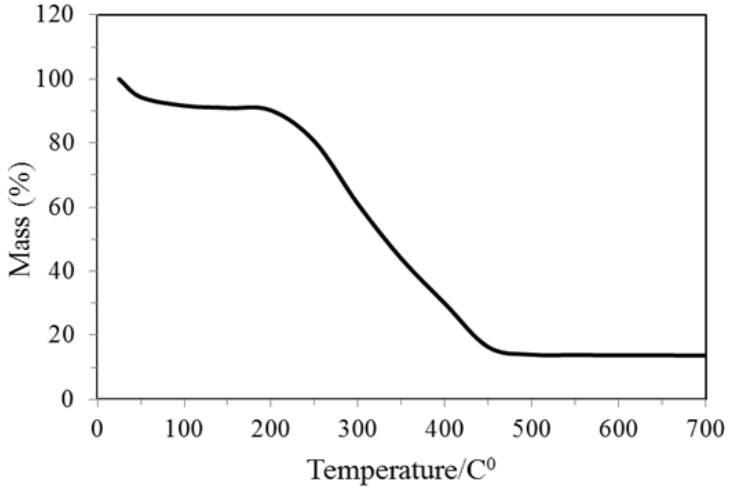
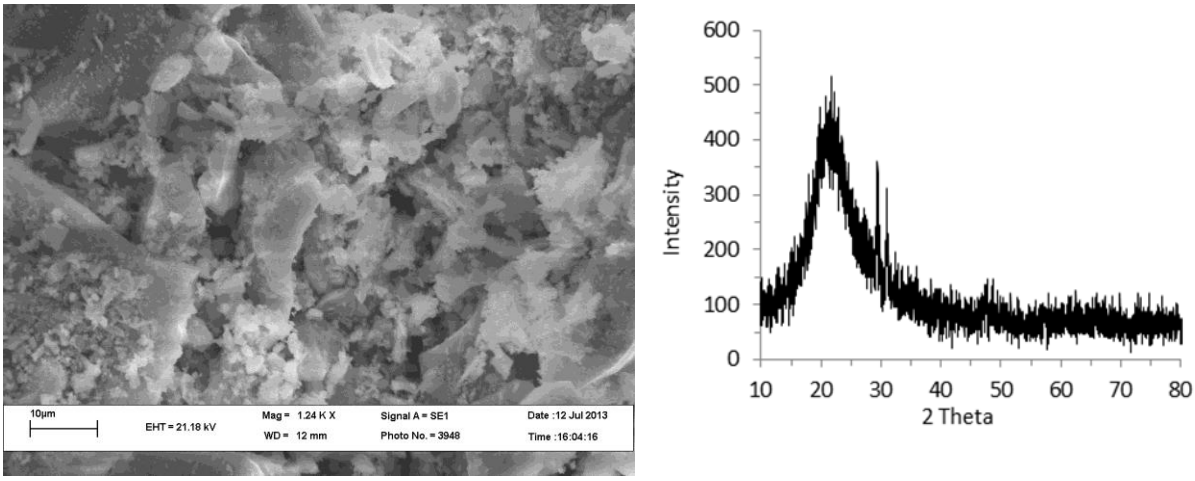


Fig. 1: TG curves for BG300 variety of RH

Fig. 1 shows the Thermal Gravimetry Analysis (TGA) of the BG300 variety of RH. TG graph reveals (Fig.1) that the water content in the rice husk released in the temperature interval 25 ^{0}C – 120 ^{0}C is around 10%. It also shows clearly that the final residues obtained in the form of ash for BG300 variety of RH is around 15%. Table 2 reveals that the silica content varies between 79.4% - 98.2% for the varieties of RH selected for this study. The variety BG300 has the highest content of silica (98.2%) and the variety Suwandal has the lowest content of silica (78.3%) among the varieties studied. These values are comparable to the values obtained by the other researchers in similar studies[3 - 9].

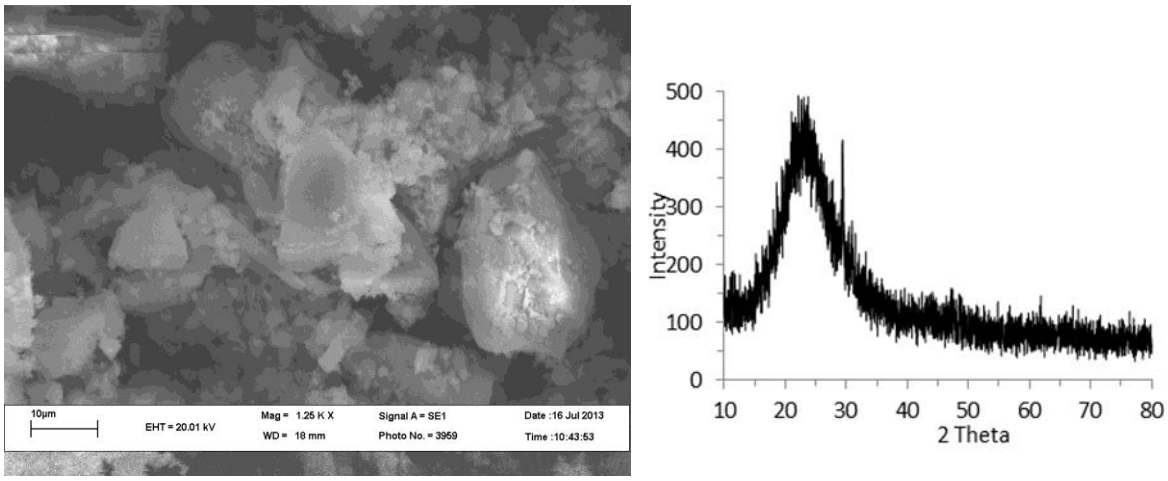
A typical SEM image and XRD spectra of raw RHA of BG300 is presented in Fig. 2(a) and Fig. 2(b) respectively. SEM image shows large particles of silica with a carbon background. The XRD spectra of raw RHA shows broader peak centred at 2θ angle of 22^0. It confirms the amorphous nature of the silica[4]. This seems that according to Scherer's formula it has an average particle size of 10.1 Å (~1.01 nm).



(a) (b)

Fig. 2: (a) SEM image and (b) XRD spectra of raw RHA of BG300

A typical SEM image and XRD spectra of synthesized and extracted silica sample of BG300 is presented in Fig. 3(a) and Fig. 3(b) respectively. SEM image shows the particles of silica. The XRD spectra of extracted silica sample shows broader peak centred at 2θ angle of 23^0. It confirms the amorphous nature of the silica[4]. This seems that according to Scherer's formula it has an average particle size of 8.10 Å (~0.810 nm).



(a) (b)

Fig. 3: (a) SEM image and (b) XRD spectra of extracted silica sample of BG300

The close analysis of SEM of both raw RHA and extracted silica reveals that after the process of synthesis and heat treatment of raw RHA, the sample might have converted to fine particles in the order of nano. The considerable reduction in particle size observed after the synthesis process through heat treatment may be due to the dissociations of silica from the other impurity elements presents in raw RHA and the formation of fine particles.

4.0 CONCLUSIONS

The physical properties such as moisture content, average bulk density and porosity of seven varieties RH found in Sri Lanka in a specific geographical location were determined. Moisture contentvaries between 10.38% -12.80 %, the average bulk density varies between 372.90 kgm^{-3} - 523.94 $kgm^{-3}$and the porosity varies between 46 % - 68%. The silica content of these varies between 79.4 % - 98.2 % the variety BG300 has the highest silica content of 98.2 % and the variety Suwandal has the lowest silica content of 78.3%. The standard SEM image and XRD spectra analysis along with the analysis using standard Scherer's formula reveals that the particle size of the extracted silica could be in the range of nano scale and could be purified to the level of Industrial usage.

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