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Evaluating the Effect of Different Burning Techniques on the Chemical Composition of RHA from Different Region of Pakistan

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***Abstract*—** After maize and sugar cane, rice was ranked as third position as a horticultural commodity. At global level, majority of Asian countries produce and consume the rice. Disposing of rice husk is a big problem and needs attention. In the present study, three different techniques were compared for converting rice husk (RH) into rice husk ash (RHA). The RHA obtained by combustion in drum for 24 hours yielded maximum quantity 97.703 % of SiO2. Therefore, this method was adopted for further studies on samples collected from different regions (Charsada, Swat and Buner) of Province of Khyber Pakhtunkhwa (KPK), Pakistan. By comparing the contents of SiO2 obtained from combustion technique, the Charsada sample containing 97.073% of SiO2 was found best.

***Keywords*—** Rice husk ash, Silica, Waste, SCM, XRF.

I. Introduction

Rice is cultivated in all countries covering about 1% of the world and provides primary food item for world population. It achieves 2nd position regarding its production as well as covering the area [1]. The rice husk (RH), an agro-waste material and having low nutrients, when burnt under controlled temperature, produces amorphous silica content and particles of large surface areas. The use of rice husk ash (RHA) as a supplementary cementitious material has gained significance in construction industry especially in the countries of high rice production like Pakistan [2].

Pakistan is one of the largest agricultural production countries. Rice is considered as one of the major Kharif crops of Pakistan. Further, it is one of the significant export items of the country, sharing 1.40% in Gross Domestic Product (GDP) in the Pakistan National Economy. In Pakistan rice is cultivated on 2.883 million hectors area and annual production of rice is 6.883 million tones [3]. Rice is mainly considered as one of the cash crops of Pakistan. Each year, Pakistan yields about 1.2 million tons of rice husk [4]. Pakistan is ranked 4th largest at international level and contributes about 30% of world rice production.

The annual production of rice in the province of Khyber Pakhtunkhwa (KPK) province is about 125,000 tons and rice husk of approximately 25 thousand tons attained normally [5]. Rice husk production in KPK and selected locations is given in Table 1.

Table 1: Rice Husk Production in KPK for (2015-2016)

Year	2015-2016				
Location	Area (Hectare)	Production (Tonnes)	Area (Hectare)	Production (Tonnes)	Production of Rice Husk in Tonnes
KPK	44442	95948	53932	125312	2324
Buner	214	503	346	686	1983
Charsada	114	273	121	276	2281

Large quantity of RHA is obtained after burning process on RH, which is just used as a fertilizer in limited range so disposing of it is additionally a big problem and needs attention. As from the literature survey it is cleared that after burning of Rice Husk in controlled temperature yields Rice husk Ash having pozzolanic property. After further chemical procedure Silica fume can be extracted from RHA and used as a partial replacement of cement and enhances its properties as well as bring reduction in emission of CO2 caused due to manufacturing of cement. Combustion of Rich husk followed by chemical procedure obtaining Silica Fume and its replacement with cement will enhance the quality of cement.

Rice Husk (RH) is an agro-waste obtained in a rice milling process. Rice husk ash (RHA) is long been famous to have pozzolanic property. Most of the agricultural and rice importing countries produce rice husk as waste in large quantity that makes rice husk ash the most deserving candidate to be used as supplementary cementing materials (SCM) [6]. The annual production of rice was recorded about 6 million tons [4]. Based on research, it was concluded that approximately 20 percent of rice paddy was husk, it indicates that Pakistan has produced 1.2 million RHA. Rice yields large amount of agro wastes. Rice husk (RH) are agro wastes produced from rice mills [7]. RHA was produced from RH if burnt under controlled temperature. Researchers claimed that RHA contains majorly high silica content in its composition approximately 80-90% and construction industry used it as a replacement of cementitious materials to enhance mechanical properties. RHA composed of silica and carbon in addition some other constituents also present in small quantity [7-8]. RHA was used as a pozzolanas which when react with $Ca(OH)_2$ in the existence of water form materials having cementitious properties and use of RHA as a pozzolanas which reduce the cost and make environment friendly [9].

RHA has three types amorphous, partially crystalline and crystalline, however from the research it was concluded that the pozzolanic activity, mechanical properties and durability of amorphous RHA were superior to partially crystalline and crystalline RHA [10]. The RH was used as a fuel for drying of rice. The burning of RH in air formed rice husk ash containing silica and carbon with inorganic impurities [11]. The uncontrolled combustion lead to the formation of crystalline RHA which processes low pozzolanic characteristics. The commercially available RHA contain 3 % of carbon and restrict their use in architectural purposes due to dark pigmentation. [12]. RHA if burnt under control temperature will yield maximum silicon dioxide SiO_2 that can be used as replacement of cement giving more compressive strength [6]. The occurrence of un-burnt carbon in RHA has negative effect on pozzolanic reactivity. The burnt temperature, incineration, ample oxygen was important parameter regarding influencing the reactivity of RHA [9]. 95% silica content powder can be obtained through incineration with heat at 700 oC for 6 hours [11]. After treatment with different temperatures ranging from 300 oC to 1000 oC, the best result in terms of silica is 750 0C which enhances compressive strength compared to others [6].

The requirement of minimizing the content of carbon evolved during the cement manufacture attracts the researchers to work on the usage of industrial by-products to be utilized as a SCM. During the manufacturing of cement one ton net production of cement yields normally about one ton of CO_2. Research on the use of RHA as agro waste RHA was conducted earlier. At a temperature of 500–600 oC incineration of RH yields amorphous SiO_2. While, at a temperature of 800 oC, Cristobalite was observed in the ash at increase temperature of 1150 0C, tridymite as well as huge amount of cristobalite was also seen in the ash [2].

Approximately 90 percent of the rice is formed and consumed by Western and Eastern Asia. Amongst them, Pakistan is also a part of them and is sharing maximum proportion of the rice. In 2009, Pakistan annually produced 9.5 million tons of RHA out of which 0.53 million tons of paddy was produced [13]. So, if that is effectively utilized cement industry will get rid of CO_2 by decreasing its outflow. On other hand it would play important and vital role in reducing the environmental in addition to land pollution. Accordingly, using RHA as a replacement of cement in making of concrete will mark an agro-waste one of the valuable materials. Evaluating RHA cementitious property and its utilization in the low budget housing structures by Ordinary Portland Cement (OPC) replacement by some proportions in concrete one would take good advantage of RHA, disposed off, as an agro waste. By this means enhancing rural economy in addition to it also increases chances of employment [14].

Keeping in view the burning of issue of agro-waste ad importance of RHA in the cement industry, the present research was conducted.

II. METHODOLOGY

The different stages involved in the research methodology are outlined below:

2.1. Rice husk (RH) samples collection

This research was focused on the classification and assessment of RHA collected from different sources i.e. Charsada, Buner and Swat areas of Province of Khyber Pakhtunkhwa. Collection of RH samples is shown in Figure 1.

Figure 1. Rice husk (RH) collection from different location of KPK

2.2. Facilities for Tests

Experimental work was conducted at Pakistan Council of Scientific and Industrial Research (PCSIR), Laboratories Complex, Jamrud Road, Peshawar, Pakistan while analyses and various tests were performed at Central Resource Labs (CRL), Department of Physics, University of Peshawar, Pakistan.

2.3. Conversion of RH into RHA

Rice husk ash (RHA) was generated using three different methods to evaluate maximum SiO_2 at Pakistan Council of Scientific and Industrial Research, Peshawar. RHA specimens were then analyzed for chemical composition by applying X-Ray Fluorescence (XRF) at Central Resource Laboratories, Department of Physics, University of Peshawar.

It was found that the chemical profile of the rice husk ash was varying which was highly depended on the geographical as well as climatic conditions of the rice crop, therefore, specimens of RH (rice husk) from Province of Khyber Pakhtunkhwa (KPK) in the areas of Charsada, Buner and swat were collected as shown in Figure 1.

The rice husk obtained from Khyber Pakhtunkhwa (KPK) Province was firstly burnt under controlled condition. The process of burning was conducted in the PCSIR Complex Labs, Peshawar using the blast furnace. Upon burning, as the changes in the chemical composition of the RHA depends at the degree of applied temperature and different time duration, therefore, following three different methods for burning were used to check the impact of mentioned factors in addition to the geographical as well as climatic conditions:

(a) Method A: Burning of rice husk at 700 oC for 5 hours (sample kept in furnace from the start 0 oC).

(b) Method B: Burning of rice husk at 700 oC for 5 hours (sample kept in furnace when temperature reaches 700 oC).

(c) Method C: Burning of rice husk by combustion process for 24 hours in control environment.

RH samples were kept in the blast furnace made of refractory bricks. Incineration technique adopted for method (A) Sample was kept in the blast furnace made of refractory bricks from the start and temperature was raised to 700oC was fixed and kept this temperature for 5 hours, Though in the 2nd method (B), Sample was kept after temperature reached to 700 oC and was maintained for 5 hours, in the method (C) Sample was kept in Ferro-cement furnace for 24 hours Figure 3 2. After the incineration was completed, the ash was turned cool gradually and the ash was left in furnace. After burning of rice husk, approximately 22% of the ash was collected as ash. When RHA was cooled, then the sample was packed in the polythene bags for further investigations. Methods are shown in Figure 2.

(a)

(b)

(c)

Figure 2. Burning of RH to RHA by (a) Method A (b) Method B (c) Method C

2.4. X-ray Florescence (XRF) Analysis

The ash obtained were analyzed for SiO2 contents using XRF, installed in Central Resource Labs (CRL), University of Peshawar. After the incineration process the RHA Samples were present in fine powder form. Each sample with a mass of 10-15 g was placed in polythene packets for analysis.

III. Results and discussion

Tremendous quantity of rice husk ash (RHA) has been obtained after incineration process that is just used as a fertilizer in limited range so disposing of it is additionally a big problem and needs attention.

This section explains the results of all performed laboratory test including XRF analyses of the collected rice husk (RH) samples of different sites locations of the Pakistan's Province of Khyber Pakhtunkhwa (KP) and obtained from three selected methods of incineration.

A. XRF results

The XRF (X-ray Fluorescence spectroscopy) test was performed on Rice Husk Ash samples obtained from various sites of Charsada, Bunair and Swat Khyber Pakhtunkhwa (KP) province of Pakistan for determining the oxide profile in the CRL (Centralized Resource Laboratories) situated in the University of Peshawar. The analyses were conducted using TEM Model (JEM2100), Oxford Instruments, United Kingdom, for obtaining the composition of all the major desired oxides in the RHA sample. The finding was applied for the samples obtained from three methods of burning i.e. (A) Burning of RH at temperature, 700oC for 5 hrs (sample kept in furnace from the start 0oC (B) Burning of RH at 700oC for 5 hrs (sample kept in furnace when temperature reaches 700oC) (C) Burning of Rice Husk (RH) by Combustion process for 24 hrs in control environment. It is observed that contents of SiO2 was recorded in the range of 95.40 to 97.073. It was found that RHA obtained from method C yields maximum amount of SiO2.Tables 2 shows RHA major oxides content produced by Methods A, B and C respectively for the same sample by using different processes.

TABLE 2: OXIDE COMPOSITION OF RHA USING DIFFERENT COMBUSTION METHODS

Oxide Composition	Method A	Method B	Method C
SiO2	95.400	96.530	97.073
CaO	2.202	1.305	1.033
K2O	1.350	1.245	1.159
Fe2O3	0.589	0.439	0.399
SO3	0.237	0.327	0.206
MnO	0.071	0.067	0.061
TiO2	0.069	0.040	0.032
CuO	0.034	0.020	0.0013
ZnO	0.019	0.015	0.011
SrO	0.011	0.007	0.006
Rb2O	0.003	0.003	0.003
ZrO2	0.002	0.001	0.001

Method C was then further used for combustion of RHA obtained from different regions (Charsada, Swat and Buner) of Khyber Pakhtunkhwa, Pakistan. Table 3 shows the XRF results of the samples and it was clearly indicating that Sample obtained from Charsada yields maximum amount of SiO2.

TABLE 3: THE RHA PERCENTAGE COMPOSITION FROM CHARSADDA, BUNER AND SWAT USING METHOD C.

Oxide Composition	Charsadda	Buner	Swat
SiO2	97.073	95.400	95.018
CaO	1.033	2.202	1.666
K2O	1.159	1.350	1.554
Fe2O3	0.399	0.589	1.262
SO3	0.206	0.237	0.323
MnO	0.061	0.071	0.072
TiO2	0.032	0.069	0.061
CuO	0.0013	0.034	0.014
ZnO	0.011	0.019	0.016
SrO	0.006	0.011	0.007
Rb2O	0.003	0.003	0.003
ZrO2	0.001	0.002	0.002

CONCLUSIONS

The main conclusions drawn from the present experimental work include

(a) Based on categorization and evaluation of RHA and comparing the contents of SiO2 from different areas i.e. Charsada, Buner and swat of KPK, the Charsada sample was found best

(b) By applying three different methods for incineration of Rice Husk to RHA to evaluate maximum SiO2, combustion process for 24 hours in control environment (Method C) gave maximum yield of silica.

RECOMMENDATIONS

Based on experimental work following recommendations were drawn for industry:

- In order to get ash of best quality, advanced furnaces and incinerators are required for burning as well as grinding of rice husk.
- Pilot and commercial scale facilities may be established to burn RH into RHA in bulk amount.
- Awareness campaign are required so that Federal and Provincial Ministries for Commerce and Industries should adopt the findings of present studies on large scale in structural materials for socio-economic benefits.

According to the experimental work following recommendations has been suggested for Future Research work:

- A detailed survey of the country is required to investigate the best RH to be utilized in future.
- Further work is suggested to fix exact temperature and time of combustion to obtain a good content of ash.

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