

Quantification and Qualification of Silica Sand Extracted from Padma River Sand

A.S.M.M. Rafi, U.F. Tasnim and M.S. Rahman

Department of Glass and Ceramic Engineering, Rajshahi University of Engineering and Technology, Rajshahi 6204, Bangladesh

Abstract. The sands of Bangladesh's rivers are potentially and economically important hosts for silica sand resources. The work is based on extraction of silica sand from sands of the Padma River and quantification and qualification of extracted silica sand as glass sand. Characterization tests carried out on sand samples collected from sand bars of the Padma River in north-western Bangladesh revealed that the silica content of the sand is 76.4%. The extraction of silica sand from head sand is done by physical separation process. A chemical analysis of extracted sand is done by XRF analysis and the result shows that extracted sand contains 85.9% silica. The qualification analysis is done by glass making and characterizing the glass sample.

1. Introduction

Silica sand is one of the most abundant minerals that can be found in diverse ways such as in quartz crystals, huge forming hills, quartz sand or silica sand, sand stone and so forth. It is quartz that over time, through the work of water and wind, has been broken down into tiny granules. Quartz is the most common mineral in the crust of the Earth comprising an estimated 35% of all rocks [1].

Global demand for industrial silica sand is forecast to advance 5.5 percent per year to 291 million metric tons in 2018, with a value of \$12.5 billion. Several industries applied silica as a major component of production. In general, silica sand demand can be segmented into five major markets: glass, hydraulic fracturing, foundries, building products, and chemicals, as well as other smaller markets [2].

Padma is one of the major river in Bangladesh. The Padma River in central Bangladesh is approximately 100 km long and flows in a south-east direction from the confluence of the Jamuna (or Brahmaputra) and the Ganges to join the upper Meghna River, below which point it is known as the Meghna. River sands contain high amount of silica which can be used in many sectors such as glass making sectors, the photovoltaic applications required a high purity, construction etc. The Ganges-Padma is the major hydrodynamic system that formed one of the world's largest delta complex covering a major portion of the country and also a greater part of West Bengal in India [3].

The main objective of this work is extraction of silica sand from Padma river sand. Then the quantification and qualification analysis is done from the extracted silica sand. That is why, the objectives of this work are - extracting of silica sand from Padma river sand, quantifying of extracted silica sand and comparing with raw sand and checking the qualification of extracted silica sand.



2. Methodology

The silica sand was collected from the bank of the Padma River at the Talaimari balughat where the sands were gathered for construction uses. The collection point co-ordination is latitude-24.359169 and longitude-88.625522.

For physical separation 5 kg raw sand samples were dried in the sun to remove moisture. Separation of heavy, medium and light minerals was carried out depending on specific gravity or density of the minerals using laboratory shaking table. After the gravity separation and drying, the light fractions of Padma River sand was run into the high intensity roll magnetic separator to separate the magnetic and nonmagnetic fractions. The samples were separated at 60 rpm (magnetic fraction) and 140 rpm (paramagnetic fraction) speed by High Intensity Rolling Magnetic separator (HIRMS). The nonmagnetic part was separated again by Induced Roller Magnetic Separation (IRMS) for high precision. The remaining light fraction was separated into ferromagnetic, paramagnetic and nonmagnetic fractions with an Induced Roll Magnetic Separator (IRMS) run at 0.3 A (2000 Gauss) and 3.0 A (20 000 Gauss).

The fractions separated by the Induced Roll Magnetic Separator (IRMS) were then processed by using an electrostatic plate separator (ESPS) operating at 25 kV and a feed rate of 20 rpm to separate the conductive and nonconductive minerals. The nonconductive sand particles contain high amount of silica.

Raw sand sample and extracted silica sand sample (nonconductive fraction of ESPS) were sieved for 15 minutes on Fritsch Vibratory Sieve Shaker using mesh 500 μ m, 250 μ m, 125 μ m and pan for determining the grain size distribution. Nonconductive particles of 250 μ m, 125 μ m size were mainly used as silica sand. 125 μ m size nonconductive sand was used for glass making.

Chemical analysis of Padma River sand and extracted silica sand was determined by X-ray fluorescence (XRF) Spectrometric method using Rigaku ZSX Primus XRF machine equipped with an end window 4 KW Rh-anode X-ray tube operated at 40 KV-60 mA for heavy elements and 30 KV-100 mA for light elements. By comparing the X-ray fluorescence (XRF) Spectrometric result of raw sand and extracted silica sand, the increased amount of silica content can be measured.

The qualification analysis of extracted sand as glass sand was analyzed by making the glass from the sand. Glass samples were made from extracted silica sand and laboratory grade silica sand (99.99%). For making low melting point glass Na₂CO₃, K₂CO₃ and Li₂B₄O₇ were used as fluxing agent. To make a firm glass object three batches were taken from each of the two different amount of batches. These batches are shown in table 1.

Table 1. Batch composition

Sample name	Silica SiO ₂ (gm.)	Sodium Carbonate Na ₂ CO ₃ (gm.)	Potassium Carbonate K ₂ CO ₃ (gm.)	Lithium Tetra Borate Li ₂ B ₄ O ₇ (gm.)	Batch amount(gm.)
(a)	3.1	2.73	1.18	-	7
(b)	3.1	2.73	1.18	-	7
(c)	3.1	2.73	1.18	-	7
(d)	4	-	-	4	8
(e)	4	-	-	4	8
(f)	2	-	-	6	8

Sample (a), (c), (d) and (f) were produced from extracted silica sand and sample (b) and (e) were produced from laboratory quartz. Moreover sample (f) contains more lithium tetra borate than the silica. In this work, sample (a) and (b) was melted in the muffle furnace and other samples were produced by the fusion bead.

The properties of prepared glasses were tested by Micro hardness tester to perform the Vickers test and measuring glass softening point of glass samples. Then the properties of the

sample of extracted silica sand was compared with the properties of the sample of laboratory grade silica sand.

3. Experimental Results and Discussion

3.1 Physical Separation

Physical separation was started with 5 kg raw sand. From gravity separation table the raw sand was separated into three portion light fraction, medium fraction and heavy fraction. Among them light fraction occupy 92% of total weight. After that this light fraction was fed into the high intensity roll magnetic separator, where it was separated into magnetic and nonmagnetic fraction. Here, magnetic fraction was 65% and nonmagnetic fraction was 35% of the total charge. It is observed that the silicon oxide (SiO_2) content is significantly degraded in the magnetic fraction and upgraded in nonmagnetic fraction [4]. It is also observed that the silicon dioxide (SiO_2) content in nonmagnetic fraction of Padma River sand is high which can be potential for glass production. This separation was done to remove iron bearing magnetic minerals from silica sand.

Further processing was continued with the nonmagnetic fraction. Induced Roller Magnetic separator separated the nonmagnetic part into paramagnetic fraction and nonmagnetic fraction. The paramagnetic fraction contains 12% of the total nonmagnetic fraction which was separated by HIRMS and the rest 88% is nonmagnetic. After this separation, the nonmagnetic part of the sample is more likely to have higher silica content. The paramagnetic portion (garnet, ilmenite) was separated from the sample. The ESPS separate the nonmagnetic fraction of IRMS into conductive part and nonconductive part. The result shows that the conductive fraction contains 22.04% of the total nonmagnetic fraction and the rest 77.96% is nonconductive. This separation was done to remove feldspar and other aluminosilicates mineral form silica sand. As silica sand is non-conductor it is easily separated by this process. ESPS separated the fine conductors from coarse nonconductor rich streams. The nonconductive portion obtained from the ESPS is mostly the silica.

So by the physical separation process the amount of extracted silica sand is 1108.4 gm. from 5 kg of raw sand of Padma River.

3.2 Characterization Analysis

The raw sand analysis was started with 1.5 kg sand. From this analysis it was found that 72% of the raw sand is in between 500 to 125 μm range.

After that, the grain size analysis of extracted sand was started with 1108.4 gm. of silica sand. After analyzing the extracted sand it was found that about 98% sand is in between 500 to 125 μm range. According to ASTM standard [1] it is clear that the appropriate size range for silica sand is above 125 μm to below 500 μm .

The grain size distribution of the silica sand is improved by the physical separation process. This purification process increases the amount of silica at the standard range about 26.53% [6]. Results of the characterization analysis are listed in table 2.

Table 2. Results of sieve analysis of raw sand and extracted sand.

Size of the sieve (μm)	Raw sand Amount of minerals (%)	Extracted sand Amount of minerals (%)
500	17.00	0.49
250	33.67	46.91
125	38.25	51.25
Pan	11.33	1.35

3.3 Elemental Analysis

Raw sand XRF analysis shows that it has relatively high silica content about 76%. So sand can be processed to improve the silica quality and degraded the impurities content. Sand of 125 μm

size was taken for the analysis. By the analysis it is determined that the raw sand contains other than silica 10.62% Al_2O_3 , 3.19% K_2O , 2.55% CaO , 3.39% Fe_2O_3 in an amount that is noticeable and have other minerals such as MnO , Y_2O_3 , Cr_2O_3 , NiO , ZrO_2 , BaO , Rb_2O etc.

After the physical separation was done. The sand of 125 μm size was taken to do the XRF analysis. The result shows that the silica content of the extracted sand is 85.85%. Some minerals like ZnO_2 , Y_2O_3 and BaO were vanished by the physical separation process.

By the physical separation process silica content increases about 10%. Other impurities such as iron oxide, alumina, phosphorus penta oxide, manganese oxide, chromium oxide etc. are decreased in a large amount. The main impurity which has the most adverse effect on glass strength and color i.e., iron oxide decreased about 50% of its previous weight. Chemical leaching process can be involved for further purification. In table 3, the summarization of the elemental analysis is shown.

Table 3. Compositional analysis result of raw sand and extracted silica sand by XRF analysis.

Name of the materials	Raw sand Elemental amount (%)	Extracted sand Elemental amount (%)
Na_2O	1.7107	1.8261
MgO	1.2113	0.0775
Al_2O_3	10.6174	6.8625
SiO_2	76.3709	85.8465
P_2O_5	0.0887	0.02
SO_3	0.0081	0.0105
Cl	0.0162	0.0216
K_2O	3.1859	2.101
CaO	2.5473	0.9145
TiO_2	0.3089	0.0792
Cr_2O_3	0.3603	0.5566
MnO	0.0566	0.0201
Fe_2O_3	3.398	1.6167
NiO	0.0082	0.0177
ZnO	0.0039	Nil
Rb_2O	0.014	0.0075
SrO	0.0134	0.0122
Y_2O_3	0.0095	Nil
ZrO_2	0.0106	0.0098
BaO	0.0599	Nil

3.4 Qualification Analysis as Glass Sand

3.4.1 Glass Making Analysis. The qualification analysis of extracted sand as glass sand was analyzed by making the glass from the sand. Low melting glass was tried to be produced. For glass preparation six attempts were taken. Among these six samples only two samples were succeed to produce glassy phase sample (a) and sample (b) (from table 1). In fusion bead ingredients were melted quickly. So, those samples didn't have enough time to go through refining process. Samples from fusion bead were not produced in proper glassy phase.

Due to high carbonate content in batch composition of sample (a) there was huge boiling. So the pouring was not successful and sample (a) was broken. Produced samples are shown in figure 1.



Figure 1. Glass samples produced from batch composition (a) and (b).

Sample (a) is whitish and sample (b) is greenish in color. Both of them have some unmelted particles trapped inside the glass because of refining process.

3.4.2 Micro Hardness. Micro hardness test was done to the produced sample (a) and sample (b). Results of these tests are shown in table 4.

Table 4. Results of micro hardness test.

Name of the sample	Micro hardness (HV)
Sample (a)	712
Sample (b)	373

3.4.3 Glass Softening Point. After the micro hardness testing both this two sample go through softening point testing. The softening point of the samples are shown in table 5.

Table 5. Results of softening point test.

Name of the sample	Softening point (°C)
Sample (a)	603
Sample (b)	603

4. Conclusion

As a commodity, silica sand is a low priced product but a primary ingredient for a diversity of products. On the whole, the consumption of silica sand can be measured as indicator to the global economy's trends and circumstances. In our developing country, it is the basic requirements for economic solvency to find out indigenous silica sources. This study is about extraction of silica sand from Padma river sand and analyze its' qualification. Following conclusions are made from this study.

- 98% silica sand is in the 125 to 500 μm size range.
- The XRF analysis result revealed that the silica sand content in the extracted sand is about 86%.
- Further purification should be done by chemical leaching to produce glass sand.

5. References

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Acknowledgments

The authors are grateful for a research grant in the course of this investigation to the authority of RUET as well as Department of Glass and Ceramic Engineering, Rajshahi University of Engineering and Technology (RUET), Rajshahi-6204, Bangladesh.

The help of Institute of Mining, Mineralogy & Metallurgy (IMMM), Bangladesh Council of Scientific & Industrial Research (BCSIR), Joypurhat related to the thesis work were greatly acknowledged.