IOSR Journal Of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 15, Issue 3 Ser. II (May. – June. 2023), PP 42-48
www.Iosrjournals.Org

Study On The Beneficiation Of White Sands In North Sudan

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ABSTRACT
In this research, samples of the white sand materials were collected from north Sudan (ElMetamma area),to determine the volumetric distribution, as well as chemical analysis and to supplement the chemical specifications. To analyze x-ray diffraction was used. The results indicated these samples are mixtures of different mineral sands. Moreover, mainly contains 58% SiO_2 and 42% anorthite feldspar particles having a hardness between 2 to 2.5 on Moh's scale hardness, clayey materials, Kaolinite, and other minerals oxides.
Keywords:*sands, silica, x-ray diffraction,*

Date of Submission: 05-06-2023 Date of Acceptance: 15-06-2023

I. Introduction:

Nowadays, silica is used in a wide range of industries, for example, filtration, water treatment, ceramics, paint, and in buildings. Silica is the name given to a group of minerals composed only of silicon and oxygen, the two most abundant elements in the earth's crust. Silica is found commonly in the crystalline state and rarely in an amorphous state. It is composed of one atom of silicon and two atoms of oxygen resulting in the chemical formula SiO_2.

Sand consists of small grains or particles of mineral and rock fragments of size less than 2mm and greater than 60µm. Although these grains may be of any mineral composition, the dominant component of sand is the mineral quartz, which is composed of silica (silicon dioxide). Other components may include aluminum, feldspar, and iron-bearing minerals. Sand that is of particularly high silica levels and is used for purposes other than construction is referred to as silica sand or industrial sand.

Industrial uses of silica sand depend on its purity and physical characteristics. Some of the more important physical properties are grain size distribution, grain shape, spherical, grain strength, and refractoriness.

II. Industrial Sand (silica sand):

Industrial sand is a term normally applied to high-purity silica sand products with closely controlled sizing. It is a more precise product than common concrete and asphalt gravels.

Silica is the name given to a group of minerals composed solely of silicon and oxygen, the two most abundant elements in the earth's crust. Despite its simple chemical formula,SiO_2, silica exists in many different shapes and crystalline structures. Found most commonly in the crystalline state, it also occurs in an amorphous form resulting from weathering actions on the rocks or plankton fossilization; [1].

For industrial and manufacturing applications, deposits of silica-yielding products of at least95% SiO_2 are preferred. Silica is hard, chemically inert, and has a high melting point, attributable to the strength of the bonds between composition atoms. These are prized qualities in applications like foundries and filtration systems. Quartz may be transparent to translucent and has a vitreous luster; hence, its use in glassmaking and ceramics is desired. Industrial sand's strength, silicon dioxide contribution, and non-reactive properties make it an indispensable ingredient in the production of thousands of everyday products. Some silica sand deposits may cater for the use primarily as metallurgical sand.

The copper and zinc at some smelter uses the sand as a fluxing agent which, in the molten state, reacts with various impurities in the ore and produces a slag. The slag is drawn off with the impurities, leaving a more refined metal behind these metallic elements. [2]

Extracted ore undergoes considerable processing to increase the silica content by reducing the amount of impurities. It was dried to produce the optimum particle size distribution for the intended application; [3].

It is present in the host rock, in the ore being mined, as well as in the soil and surface materials above the bedrock, which is called the overburden.

Fig. (1) Clearly shows the white sands

Physical and chemical properties:

The three major forms of crystalline silica-quartz, tridymite, and cristobalite are stable at different temperatures and have subdivisions. For instance, geologists distinguish between alpha and beta quartz. When at low-temperature alpha quartz is heated a tatmospheric pressure it changes to beta quartz at 573^{o}C.

However; at 870^{o}C tridymite is formed and cristobalite is formed at1470^{o}C. The melting point of silica is 1610^{o}C, which the higher than iron, copper, and aluminum, and its one reason why it is used to produce molds and cores for the production of metal castings; [3].

The crystalline structure of quartz is based on four oxygen atoms linked together to form a three-dimensional shape called a tetrahedron with one silicon atom at its center. Myriad of these tetrahedrons are joined together by sharing one another's corner oxygen atoms to form a quartz crystal.

Quartz is usually colorless or white but is frequently colored by impurities, such as iron, and may then be any color. Quartz may be transparent to translucent, hence its use in glassmaking, and have a vitreous luster. Quartz is a hard mineral owing to the strength of the bonds between it is atoms it does scratch glass. It is also relatively inert and does not react with dilute acid. These are prized qualities in various industrial uses.

Depending on how the silica deposit was formed, quartz grains may be sharp and angular, sub-angular, sub-rounded, or rounded. Foundry and filtration applications require sub-rounded or rounded grains for the best performance;[3].

Processing technologies:

Silica deposits are normally exploited by quarrying and the material extracted may undergo considerable processing before sale or use. The objectives of processing are to clean the quartz grains and to increase the percentage of silica present, to produce the optimum size distribution of product depending upon end use, and to reduce the number of impurities, especially iron, and chromium, which color glass; [3].

To meet these tight specifications, the sand often may have to be subjected to extensive physical and chemical treatment processing.

This involves crushing if the sands are in the form of sandstone, screening and further adjusting the grain-size distribution, together with removing contaminated impurities in the sand and from the surface of the individual quartz grains. The presence of metallic oxides in glassmaking sands usually results in colored glass. If iron is present, the resulting glass is colored green or brown. The iron level is consequently the most critical parameter in determining whether particular sand can be used to make clear glass. Sands used to manufacture colorless glass are therefore likely to be processed further by methods such as acid leaching, froth flotation, or gravity separation. Table (1) illustrates the range of iron levels permitted in each of the grades of silica sand.

Table (1), The maximum iron content percent in the white sand is permitted in the production of various types of glass.

Glass type	Crystal glass	Borosilicate glass	Optical glass	Colorless containers	Clear flat/float glass	Colored containers	Insulating fibers
Iron content (%)	0.00	0.05	0.10	0.10	0.20	0.20	0.30

In ascending order of permitted iron content, the three most commonly produced categories of glass are:

(a) Colorless container glass (or `flint' glass);

(b) Clear flat glass (or `float' glass); and (c) Coloured container glass.

These are also the most significant specification of the various applications for sand from the quarries relating to this merger.

Silicate Structures:

This structure accounts for the high surface area and acicular particle shape of the commercial chromite (at attapulgite) and sepiolite. Sepiolite is the high-magnesia end member containing a minor substitution of Al^{3+} and/or Fe^{3+} for octahedral Mg^{2+} and tetrahedral Si^{4+}. Palygorskite exhibits higher substitution, principally aluminum for magnesium.

The charge imbalance arising from these substitutions is compensated by exchangeable alkaline and alkaline earth cations. Palygorskite and sepiolite differ in the number of octahedral sites per unit cell. In addition to their use as absorbents, chromite clays are used as rheological agents. Fig. (2) Clearly shows the structure of Hormite. When dispersed in water, their needle-like particles de-agglomerate in proportion to the amount of energy applied and form a random colloidal lattice; [4]

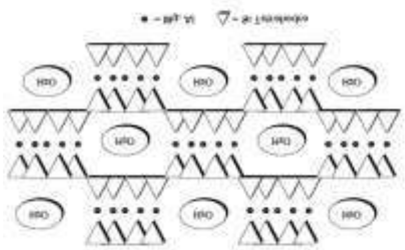
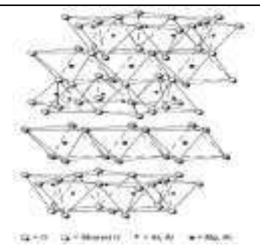
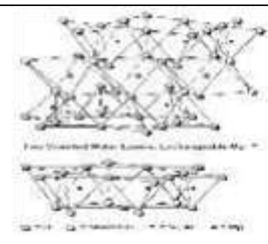
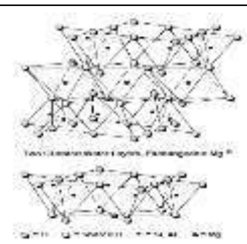
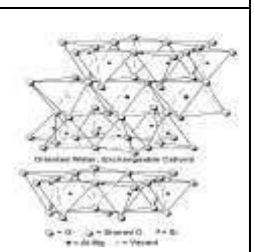


Fig. (2) shows a structure of Hormite

Hydroxyl-bearing brucite sheets between the talc sheets allow for hydrogen bonding and a corresponding increase in delimitation difficulty; [4]. Table (2) illustrates the four types of silica as a basic component of her

Table (2) illustrates the four types of silica

Type name	**Chlorite**	**Vermiculite**	**Mica**	**Smectite clay**
Type Specification	It is laminar and composed of alternating talc and brucite sheets	The result is low-density, high-porosity, concertina-shaped particles	This is due to the relatively weak bonding effect of the univalent counter ion	When Ca2+ is the exchangeable cation, there are two water layers, as in vermiculite; when Na+ is the counter ion; there is usually just one water layer
structure				

III. Materials and Methodology:

Represented white sand samples were collected from Metamma area sand deposits to upgrade these materials. These materials were analyzed by X-ray diffraction before dressing.

The results given in the chart of X.ray diffraction in Fig.4.2 show that these materials contain 58.8 % SiO_2 (silica), 14.9%, Al Si_3 O_8 (microcline) a type of feldspar, 19.4% ($MgFe_3$) Al (Si_3 al) O_{10} $(OH)_8$. (Chlorite is a type of clay and Anorthite, ($Ca\ AL_2\ Si_2\ O_{8}$).And 7.9% $K\ AL_2\ (Si_3\ Al)\ O_{10}\ (OH)_2$ (Muscovite) a type of mica mineral. Examination of the physical properties of the mineralogy and petrography microscope has shown that almost clay materials and kaolin are present in the form of large agglomerates, However, the silica is distributed in a large range of size, while the mica particles are present in the sample in very fine particles(-60µm)

From the results of the x-ray diffraction and the microscope tests, it was believed that washing these sand materials could result in a sort of dressing since washing the clay materials and kaolin which are present in the sample in the form of agglomerates would be disintegrated into ultra fire particles these ultra-fine particles with those very fine of mica particles could be easily separated from the silica sand particles which are coarser than these particles. Therefore, it was decided to wash these materials and separate the silica from the other materials on a 60µm sieve to remove the fine silt and clay particle which have sizes below 60µm.

Apparatus:

1. High-Speed mixer rotates at 1000 rpm
2. A Nest of Sieves and Sieves Shaker.
3. A Digital Balance.
4. A Drying Oven
5. Fresh Water from the Tap was used to perform the tests.

Procedure:

Washing is the simplest and lowest method of cleaning silica sands by remove of clayey materials, iron oxides, and coal by removing shales.

600 grams of the sand materials were agitated with 2 liters of tap water for 10 minutes. Then the sad water slurry was poured into the 60µm sieve, until almost all water with the very fine and ultra–fine particles were passed through the sieve, while the coarse particles that mainly consist of quartz and some or her minerals such as score, which is an iron-rich tourmaline.

After drying the materials remained on the tap of the 60-µm sieve, it was noticed that this material would soil the hand; therefore, these materials are washed again. The tests were performed as before.

The x-ray diffraction analysis and chemical analysis were made. Within the central laboratories of oil and GRASS.

In some of the very pure deposits that are void of heavy minerals, high amounts of clay and silt, and no surface staining, washing is sufficient to produce an acceptable-grade product.

In the process, water is added to the sand and is generally pumped into a blender. Once the minor amounts of fines or clay have been released from the silica sand they can be removed via a variety of methods.

Drying:

In this process, the sample dried in a furnace at about (50-70)^{o}C, which did not change the chemical and physical properties of the white sand.

IV. Results and Discussion:

The results of size analysis for the feed to prior washing process and after cleaning the sand materials from almost all impurities. Tables (4.1) and (4.2) show the size analysis of the feed and that of the concentrate inspection these results indicate that the amounts of materials sizes greater than 1400 µm and those whose sizes are less than 212 µm are reduced after washing. The amount of coarser particles in the feed reduced from 6.68% of the weight of the feed to 0.18 % of the weight of the concentrate.

Results of the particle size distribution of the sample:

Table 4.1 shows the results of the sieve analysis of white sand before washing.

Sieve Size Range (µm)	Sieve Factions Wt (g)	Sieve Factions Wt (%)	Cumulative Over Size %	Cumulative Under Size %
>1700	30	6	6.00	94.00
1700 -1400	3.422	0.68	6.68	93.32
1400 -600	2.48	0.496	7.18	92.82
600 -355	46.435	9.287	16.46	83.54
355 -300	48.906	9.7812	26.24	73.76
300-250	135.201	27.0402	53.28	46.72

250 -212	61.944	12.3888	65.67	34.33
212 -180	96.915	19.383	85.05	14.94
180 -125	44.22	8.844	93.90	6.10
125-0	3.477	6.0954	100.0	0.00

Sieve Size Range (µm)	**(>1700)**	**1700 - 1400**	**1400 - 600**	**600 - 355**	**355 - 300**	**300-250**	**250 - 212**	**212 - 180**	**180 - 125**	**125-0**
Cumulative Under Size %	**94**	**93.32**	**92.82**	**83.54**	**73.76**	**46.72**	**34.33**	**14.94**	**6.1**	**0**

Table 4.2 shows the results of the sieve analysis of white sand after dressing the sand by washing.

Sieve Size Range (µm)	Sieve Factions Wt (g)	Sieve Factions Wt (%)	Cumulative Over Size %	Cumulative Under Size %
>1700	0.694	0.1388	0.14	99.86
1700 -1400	0.219	0.0438	0.18	99.82
1400 -600	6.528	1.3056	1.49	98.51
600 -355	73.623	14.7246	16.21	83.79
355 -300	87.748	17.5496	33.76	66.24
300-250	159.492	31.8984	65.66	34.34
250 -212	54.327	10.8654	76.35	23.47
212 -180	56.473	11.2946	87.82	12.18
180 -125	39.024	7.8048	95.62	4.38
125-0	21.872	4.3744	100.0	0.00

The same trend with the fine particles of sizes less than 250 µm was shown, since a reduction in the percentage of these materials has occurred to them in the concentrate, from 46.72% in the feed to 34.34% in the concentrate.

The reduction in the coarser sizes is due to the disintegration of the lumps and agglomerates of clayey and iron materials and the reduction occurred for materials in the concentrate due to the removal of mica and clay particles, which their sizes as clay particles are usually below 2µm.

The chemical analysis of the concentrate suggests that these concentrates of white sand of Metamma which have been yielded from only washing by water could be employed to produce all types of glasses listed in Table 2.1 Chapter 2 since the percent of iron reduced to approximately 0.00% and SiO_2 increased from around 58% to 93%.

The results of this work are very excellent, but the amount of the orthoclase microcline sand could be removed from these concentrates by treatment and then by the heavy media process since there is a great difference between the specific gravities of the SiO_2 silica (2.66) and Ca AL_2 SiO_2O_8 Anorthite (2.76)

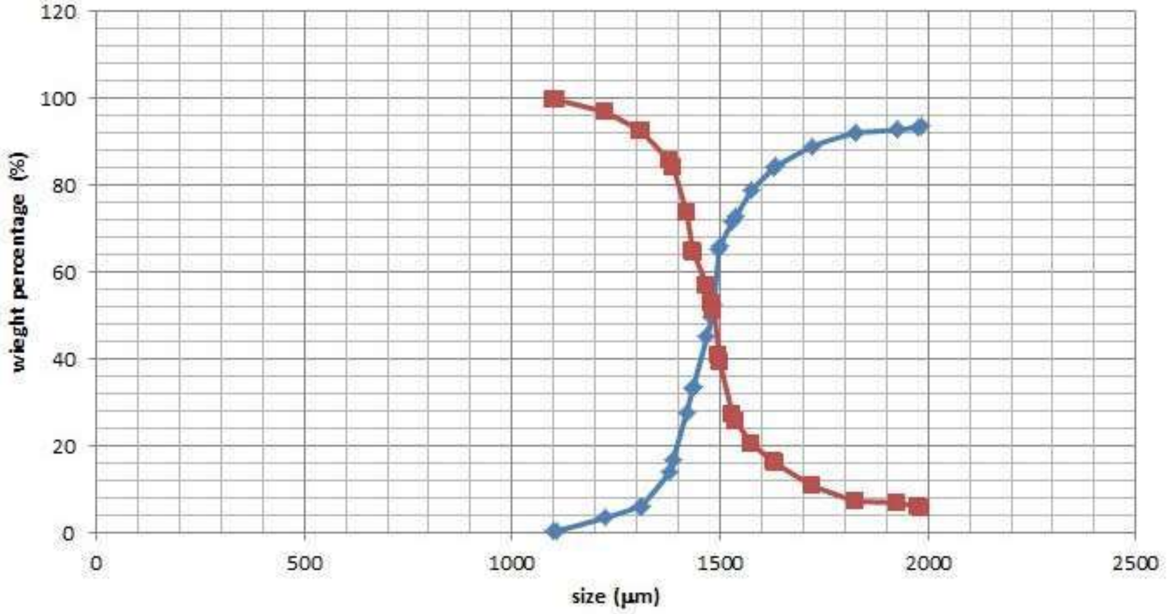


Figure 4.1 shows the cumulative size distributions of Metamma white sands beforewashing.

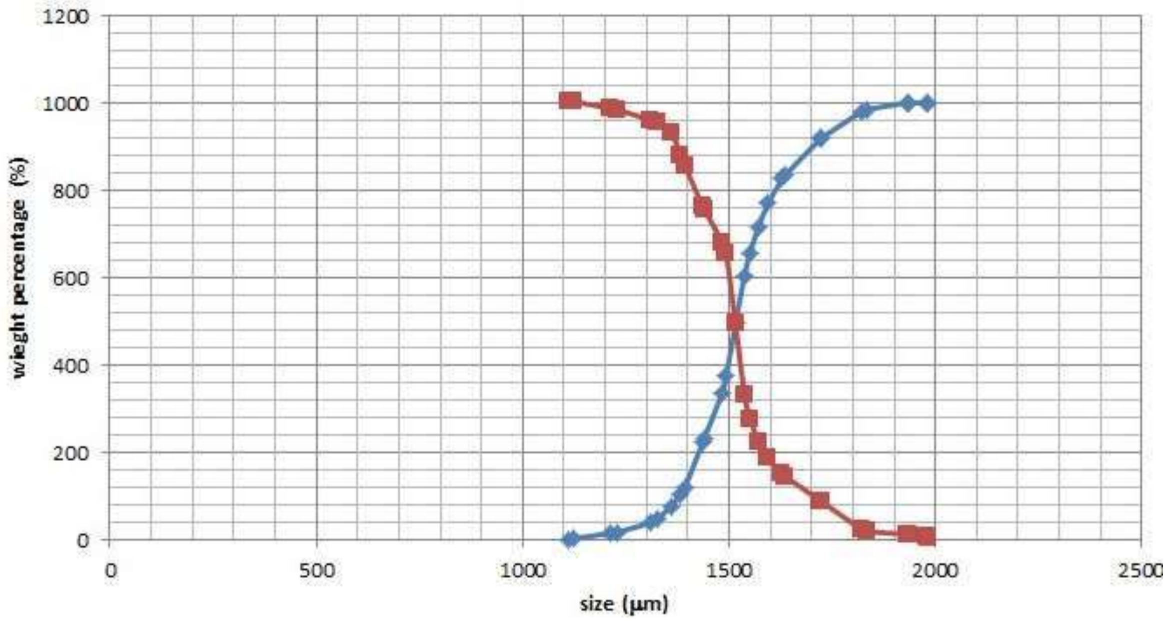


Figure 4.2 shows the cumulative size distributions of Metamma white sands after washing.

Results of Chemical Analysis:

Table 4.3 shows the results of the chemical analysis of the concentrate.

Component	Weight %
Fe_2O_3	0.02
Fe	0.001
SiO_2	93.00
AL_2O_3	1.62
CaO	0.69

L.O.I	0.30

Component	**Fe_2O_3**	**Fe**	**SiO_2**	**AL_2O_3**	**CaO**	**L.O.I**
Weight %	**0.02**	**0.001**	**93.00**	**1.62**	**0.69**	**0.30**

Results of XRD Analysis:

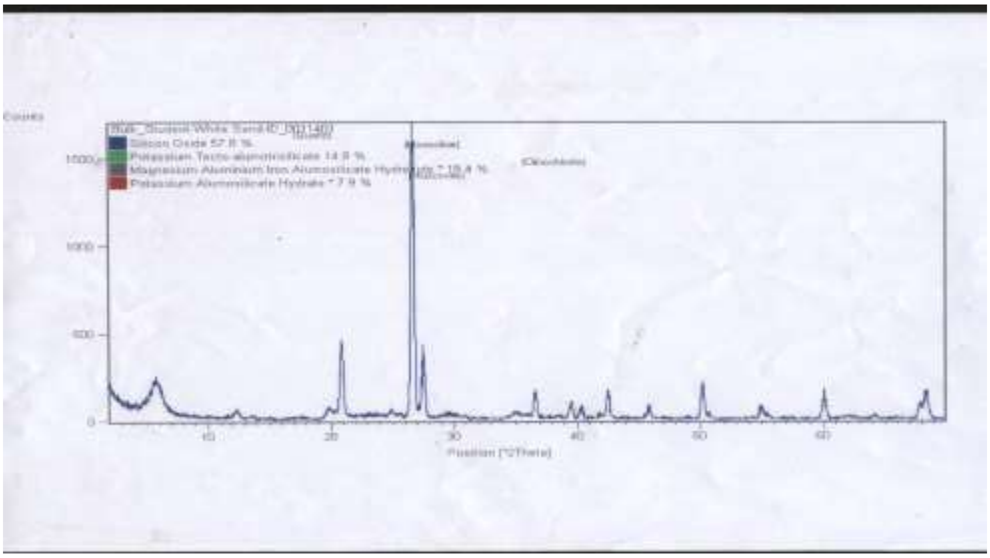


Figure 4.3 shows XRD

V. Conclusion:

A huge deposit of white sand is present in the Metamma area. The materials of this deposit contain quartz of about 58% and the other portion is different complex silicate materials, such as various types of feldspar minerals, chlorite, and clayey minerals.

Dressing these materials by washing them in high-speed mixers could be conducted at very low costs. This process of concentration would increase the SiO_2 in the concentrate to 93% and reduce the iron content to 0.001% however, to remove the other impurity minerals; it is suggested to clean the yielded concentrates from washing by heavy media separation.

Recommendations:

i. Instead of removing the fine and ultra-fine gangue from the feed by screening after being mixed with fresh water, hydrocyclone could be used which is cheaper than the screening process.
ii. Froth flotation could also be used to clean the concentrates resulting from the washing process.
iii. The oil agglomeration process could also be a candidate for further cleaning of the produced concentrates of the washing process.
iv. The washing process should be given the priority of cleaning Metamma white sands

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