Determination and Estimation of Silica and Some Elements in White Sand Collected from Kutum Area, North Darfur State, (Sudan)

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***Abstract*– The aim of the research to determine and estimate silica and some elements in the white sand collected from Kutum area. And the study was compared with previous studies in Sudan and other countries; it has also been compared with USA, UK and Indian standards specification for white sand in glass industries. Samples were collected from Kutum area close to valley near a mountain from different depths and from surface of the earth by using hand tools and the samples were mixed and put in plastic bag for analysis, and characterization, by using analytical techniques such as X ray Florescence (XRF), inductive couple plasma mass spectra (ICP MS) and infrared (IR). Other methods were used such as loss ignition at 1000^{0}C to determinate loss on sand, the gravimetric technique, subtraction methods and acid leaching to obtain metals oxide by percentage in the sand sample. The results revealed that sample contain metal oxides by percentage different in sand sample. The silica (SiO_2) is having the highest percentage 94.84% (approximately 95%), followed by Al_2O_3 2.94, Fe_2O_3 0.39% and CaO 1.45%. According to American, British and Indian standard specification for white sand used in industries, the white sand of Kutum area can be used as source of silica for glass industries, ceramic and solar cells.**

***Keywords*– White Sand, Silica, ICP-MS, XRF and Gravimetric Technique**

I. INTRODUCTION

Silica is the name given to a group of minerals composed 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 one atom of silicon and tow atom of oxygen resulting in the chemical formula SiO_2 .Sand consists of small grains or particles of mineral and Rock fragments. 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 aluminium, feldspar and iron-bearing minerals. Sand with particularly high silica levels that is used for purposes other than construction is referred to as silica sand or industrial sand for a particular source of sand to be suitable for glassmaking, it must not only contain a very high proportion of silica but also should not contain more than strictly limited amounts of metallic elements [1]. Silica sand is also normally required to be well-sorted; most sources of sand used by the Construction industry do not satisfy these requirements and are not therefore, suitable for glassmaking. industrial uses of silica sand depend on its purity and physical characteristics [2], some of Important physical properties are grain size and distribution grain shape sphericity grain strength and Silica sand is an industrial term used for sand or easily disaggregated sandstone with very high percentage of quartz (silica) grains [3].

Quartz is the most common silica crystal and the second most common mineral on the earth s surface. It is found in almost every type of rock, igneous, metamorphic and sedimentary. While quartz deposits are abundant, and Silica sand deposits are also most employed. Extracted are undergoes considerable processing to increase silica content by reducing impurities. It is then dried and sized to produce the optimum particle size distribution for the intended application Silica sand may be produced from both unconsolidated sand and Crush Sandstone [4].

Silica sand perhaps, has got the most diversified use among all the nonmetallic minerals this is because of its common occurrence around the world, distinctive physical characteristics such as hardness chemical and heat resistance as well as low price. Silica bearing rocks and mineral such as quartz, quartzite, silica sand together with other varieties of silica like agate amethyst jasper, flint etc. One of the first to use silica sand is in the glass-making industry at least 4000years ago long be for iron was smelted glass- making was already known craft.

The oldest known specimens of glass were obtaining from Babylon 2600 B.C and from Egypt 2500B.C it could be conclusively proved that the glass making was well established in these countries by around 1500 B.C. Silicon the main constituent of silica does not occur in free state. But silicon compounds are. abundantly available and constitute about 28% of the earth crust [5]. The occurrence of silica sand in the world is widespread and extensive. Good quality silica sand reserves are situated in Uk. Silica sands are essential raw materials for glassmaking and wide range of other industrial horticultural application in 2007 glass sand accounted for 39% of total sales of silica sand foundry sand 11%, sand for

other industrial uses 24% and sand for horticultural and leisure uses 26%. the value of UK silica sand sales was estimated at67 million in 2007 to 2008 the glass industry is the most important consumer of silica sand [6]. Paris- Basin and Aquitaine Basin contain about 90%of silica sand reserves of France. France produces about 6 million tons of silica sand annually [7]. Silica sand in Australia The Cape York mine is the largest silica in Australia and an extensive reserve of about 200 million [8]. Silica sand in Nigeria Study on silica sand quality in Yazaram and Mugulbu in mubi south local government area of adamawa state Nigeria for commercial glass production the percentage of silica are 77.60% for Yazaram [9]. Silica deposits are in Andhra Pradesh, Bihar, Goa, Haryana, Karnataka the reserve is estimated is to be 150 million tones silica sand is available almost in all state of India [10]. In Egypt there are two main location of high-quality silica sand 1st Zaafrana –red sea and the 2nd north and south Sinai [11].

Occurrence of the white sand in Sudan forms an important part of recent industry. The important of white sand as raw material has increase in the last years due to the importance of the silicon compounds in our daily activities, white sands represent in many different areas in the Sudan. It has been gifted with land having great economic natural products and minerals. Previous studies of white sand in Sudan were determined silicon Dioxide from Bara sand the percentage of silica sand were found to be 95,8%and the iron oxide percentage for Bara sand found0,03% while that of Elmtama 90,9% silicon dioxide Silica sand occurrence in country is widespread and extensive important [12].

There are various kinds of white sand in kutum area north Darfur state it has not been study before therefore the objective of current work is to determinate SiO_2 and some element by using Appropriate Analytical techniques such as Gravimetric method, volumetric titration and ICP. Compared with the previous study of white sand in Bara, Elmtama, Karema and in various countries, it also compared with standard Specification for glass making, ceramic industry solar cells chemical production and cement industry.

Location of study

The study area is located in north Darfur state kutum area it lies 120 Kilometers (75 mil) north west of the state capital, Al-Fashir. The town is located along valley, at latitude $14^{0}14$ N longitude 24 ^{0}39 39,30 E is the administrative town of north Darfur district [13].

Fig. 1: The Picture of location of study area sand valley of kutum side mount

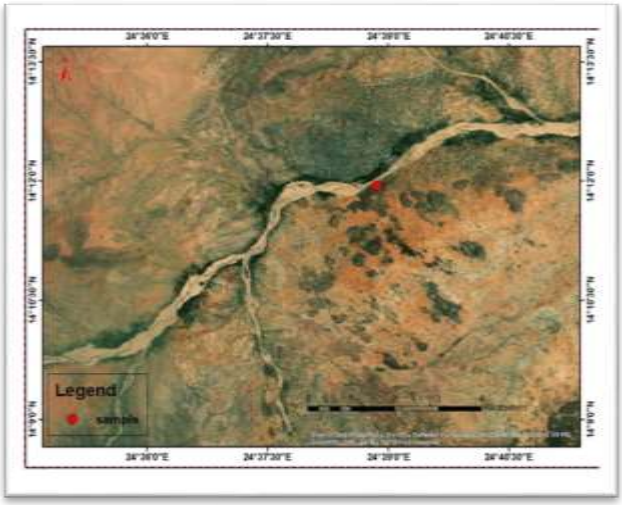

Fig. 2: Illustrate Geological map of the study area kutum valley by Google Earth

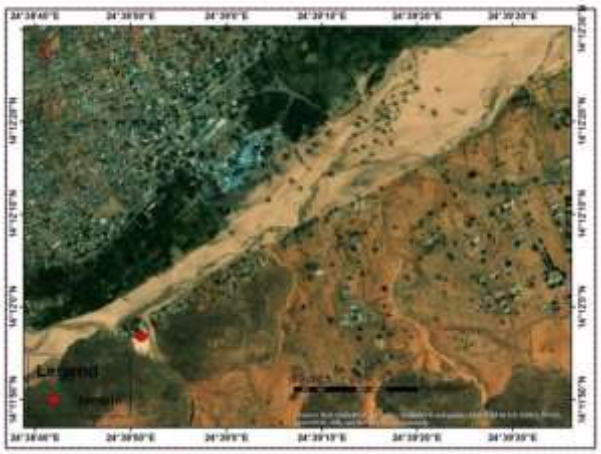

Fig. 3: Geological map illusrated Geologcal map of study area Aerail photos for GPS sampling by satellite

II. MATERIALS AND METHODS

A) Materials

Chemicals solution were used as analytical reagent and includes Concentrated Hydrochloric acid, Dilute Hydrochloric acid, Sodium carbonate, Distilled water, Oxalic acid, Methyl orange indictor Potassium hydroxide solution, Concentrated and diluted ammonia solution, Standard Zinc solution, EDTA (ethylene Diamine tetra acetic acid) solution.

Instrumentation

Handheld XRF [Model Oxford X met 500 XRF] type X. ray fluorescent for determination of elements as (miming).
ICP –MS (inductively coupled plasma mass-spectrometry9000) to determine elements in low concentration range ppb ug/L and low concentration range 1000mg /L <= 1mg/L<= 1ug/L , < 1ug/L ,not detected

Apparatuses

Flask, muffle furnace, platinum crucible (porcelain), dish, flame, desiccators and steam bath.

B) Methods

Samples collection

Three different of sand Samples were collected from kutum valley side of hill close to valley as indicated on the map of study area. From different part of position first sample was taken from surface randomly and second sample was taken from three depths 0-to 15 cm, 15 to 30 and from 30 to 50cm then mixed together. By using hand tools shovel, drilling on plastic bag.

Determination of moisture content

20g was Weighted accurately of the prepared sample in air – oven maintained at 105^{0}C to110 ^{0}C for half an hour. Cooled in desiccators and weighted again, repeated heat and cooled till constant mass is obtained.

Calculation

Moisture content was Calculated in the sample as follows:

$$\textit{Moisture content, percent by mass} = \frac{M - M_1}{M} \times 100 \qquad (1)$$

Where, M=mass in g of the sample taken for the test, and M1=mass in g of the sample after heating

C) Chemical analysis

Determination of loss in ignition

The 1g of sand was weighted in platinum crucible. The contents were then introduced into a muffle furnace for ignition and slowly the temperature was raised in the furnace to 100C^0 for 30 minutes after which it was removed. And was placed in a desiccator to allow it to cool, after cooling the crucible and its content were weighted and percentage loss on ignition was calculated using the formula below:

Calculation

Loss on ignition percent by mass: $\frac{M_1}{M} \times 100 \qquad (2)$

Where, M1 =loss in mass in g on ignition

M= mass in g of the sample take for test

Sample digestion

1g of the fine ground test sample was put into platinum dish. 3g of sodium carbonate was added, after mixing intimately, the dish was covered with lid and was heated over burner slowly, the temperature was increased with caution until the mixture was fused. And was kept at this temperature for 10 minutes and finally was heated till a clear melt was obtained. Then it was removed from the burner and cooled, about 30 ml of dilute hydrochloric acid was added. Allowed the covered dish to stand on a steam bath until disintegration was completed.

Gravimetric determination of insoluble silica

The solution in the dish was Evaporated to dryness on a steam bath and allow the dish to remain on it for some time. May is facilitated by occasional use of glass rod to break up the crust of salt that covered the liquid and tends to prevent further evaporation.
IS 488-1980 was Transferred the dish to an – oven maintained between 105 to 110^{0}Cand bake it for 1 hour. cool the dish and its contents slightly, then added 20 ml of dilute hydrochloric acid 1:1. After about 10 minutes, added 30 ml of hot water and stir the mixture until solution of soluble salts appears to be completed. the dish was Covered and allowed the mixture to digested on steam bath for 10 minutes without stirring. Then filtered with filter piper (what man No 40) is suitable and rinsed the dish with dilute hydrochloric acid (1:19) scrubbing the dish with rubber tipped glass rod. Washed precipitate with hot water until free from chlorides. reserved the filtrate and washing for determination of residual silica. Transfer both the filter paper and precipitate to an ignited and weight platinum crucible. Ignite at allow temperature until the precipitate is free from carbonaceous matter and then heated in the furnace at 1050^{0}C to constant mass (1hour being normally sufficient). cooled and weighted (M1).

Calculation Silica percent by mass

$$\frac{(m1 - m2) + m3 \times 100}{m} + m3 \qquad (3)$$

Where
M1 = mass in g of platinum dish and content before hydrochloric acid treatment
M2= mass in g of platinum dish and residue after hydrochloric acid treatment
M3= mass in g silica present in 500 ml of solution and
Sample taken for test

Determination of Aluminum oxide

50ml aliquot of solution from the filtrate was Transferred to 250 –ml conical flask. Was added two drops of methyl orange indicator followed by 1:1 dilute hydrochloric acid drops wise until the color changed from yellow to red. Was added sufficient EDTA solution to provide an excess of at least 5 ml over the expected number of aluminums (1ml of 0.025m EDTA =1.25 mg Al_2o_3 approximately). Was added dilute ammonia drop wise until the color changed from red to

yellow. 5ml of oxalic acid was added and 25ml of water and heated to boiled for 5 minutes and cooled. 5 ml oxalic acid solution was added, then solution was titrated with titrated with standard zinc solution using orange inductor until color changed to yellow, and then filtered precipitation solution put into furnace, the percentage of Aluminum oxide was calculated.

Determination of Ferric oxide Fe_2O_3

5 ml aliquot of the solution prepared was transferred to 100 ml volumetric flask. Then added 2ml of tartaric acid solution neutralize with ammonia solution, acidify with few drops hydrochloride acid (1:1), 2ml hydroxylamine hydrochloride solution was added. stirred well and added drops of methyl orange inductor. Made up to the mark with water and mixed, allow the solution to stand for the 30 minutes for full development of color.

Calculation

Ferro oxide as Fe_2o_3 percent by $= \frac{M}{M1} \times 0.1429$

Where
M=mass in mg of iron as Fe found in aliquot.
M1=mass in g of the sample represented by the aliquot take

Determination of Calcium oxide

50ml of the sample solution by pipette was Transferred into conical flask20 ml distilled water was added to dilute and placed on the magnetic stirred and added few drops of orange inductor and KOH changed color to purple, then solution was titrated standard EDTA solution until the color change to blue then filtered precipitation solution put into furnace. The percentage of calcium was calculated.

Calculation

Calcium oxide, percent by mass
V×F×100\M
Where
V= volume in ml of standard EDTA solution required for titration.
F=calcium oxide equivalent in g l ml of the standard EDTA
M = mass in g of the sample represented by the aliquot taken

III. RESULTS AND DISCUSSION

A) Results

Characterization of White Sand using XRF

X RF Stands for X–ray fluorescence, its powerful, nondestructive technique for measuring elemental composition from magnesium Mg to U , from parts per million 1o 100%handheld XRF analyzers are portable devices that can be used on location for immediate ,lab quality results to help you determine the next course of action and its needed ,Results of Characterization of white sand sample detected by using Hand Held XRF [Model Oxford X met 500 XRF] type X .ray fluorescent florescent determination of elements as (miming) as following:

Table I: is show the results of XRF Spectrum of white sand sample as soil fp

ELem	PPM	STD	ELem	PPM	SPD
K	3994	2946	Fe	2204	84
Ca	884	2118	Ti	505	303
Sr	41	7	Zr	38	8
CO	30	23	Mo	17	9
W	10	18	Rb	7	6
Se	6	6	Os	6	10
Tl	5	11	Ni	5	10
Hg	1	13	As	0	6

Determination of metals oxide in white sand sample by using Gravimetric, precipitation and subtraction methods

The results of analysis here are metals oxide such as, SiO_2, Al_2O_3 , Fe_2O_3, and CaO, In the white sand sample.

Table II: Illustrated results metals oxide in white sand sample

test	method	Sample
Loss in ignition at1000C% by mass	Ignition method by furnace	0.47%
Silica as SiO_2%by mass	Gravimetric method	94.84%
Aluminum as Al_2O_3% by mass	By subtraction from R_2O_3	2.95%
Ferric as Fe_2O_3% by mass	Volumetric method	0.39%
Calcium as CaO% by mass	Gravimetric precipitation method	1.45%

Table III: Illustrated the results of white sand sample by using ICPMS inductive coupling plasma mass spectra

Elemt	1mg /l	Elemt	1mg/l	Elemt	1mg/L	Elemt	1mg/l	Elemt	1mg/L
AL	3.8	As	72	Ni	11	Zr	33	Sb	68
Ag	2.9	Fe	570	Zn	5.1	Sc	0.38	Cu	79
Er	64	Na	420	Lu	0.75	Ca	190	Mn	5.7
Mo	16	Ti	33	Si	52	K	18	Sr	1.2
Th	23	Li	0.29	Ba	1.5	Rb	850		
Be	0.37	S	52	Ir	150	Cr	5.2		
B	13	Au	4.6	P	140	Mg	140		

Characterization of White Sand using ICPMS Spectrum

Discussion

Characterization by using XRF and ICP indicated the present of Silicon dioxide as higher, and major constitute and beside these were some elements in white sand sample collected from Kutum area. From the results of analysis, it was illustrated SiO_2 was approximately 95% highest percentage of Elements oxide in white sand. According to Indian American and British standard specification of white sand in glass industries, kutum white good for some glass industries. and comparing with white sand sample obtained from north kordofan state Bara area, River Nile state Elmatama area karema the percentage of Silica sand as SiO_2 are 95,8% for Bara, Kutum sand SiO_2 94.84% approximately 95% , Elmatama sand SiO_2 90.9% and karema sand SiO_2 84.2%. And whoever. the percentage of Iron oxide as Fe_2O_3

obtained 0.3% for Bara sand, 0.4 %for Elmetama sand, 2.17% and 0.39% for kutum sand. The percentage of the Al_2O_3 was found as highest one in karema sand 8.438% then Elmatama sand contain 6.382%, Al2O3 at low state in Bara sand 2.871% and kutum sand 2.95% . Percentage of CaO_2obtained in the silica sand sample were very low 0.028 % for Bara sand ,0.158% for Elmatama, 1.422% for Karema sand and 1.45% for Kutum sand. According of Indian, American and British specification standard of white sand kutum sand using for many industries such as glass making and ceramic industries.

IV. CONCLUSION

From the results obtained it can be concluded that silica sand from north Darfur state kutum area it is good in quality because of its high percentage of silica oxide which 94.84% approximately 95% which can be used in glass making and it is can also be concluded that it can be used for extraction of silicon because of it is high percentage of SiO_2 .And even in Comparison with previous studies of white Bara sand and kutum san represented the best one because of its high purity of SiO_2 95.8% in Bara sand and kutum sand SiO_2 record 94.85% approximately 95%according of IS standard specification for glass making, Elmatamasand SiO_2 90.9% and Karema sand the percentage SiO_2 84.2%, Elmatma, kutum and karema sand can be used for colored container glass ,and glass for insulating fiber.

Recommendation

Kutum sand need more purification to reduce the percentage of metals oxide by using another process. For the white sand important, there for the government of Sudan should encourage, assist and invest in the companies that will extract SiO_2 from white sand in Sudan because of the large abundant of it in different parts of the Sudan and leveraging from local materials of country to increase the country's economic**.**

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