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Quantification of Silicon (SI) and Silicon Dioxide (SiO_2) from the Nafud Desert-Al-Qassim Region, Kingdom of Saudi Arabia Using XRD Analysis

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Abstract

This research was conducted in the Qassim region, Kingdom of Saudi Arabia. The goal of this research is to determine the percentage of silicon in the Rub al-Khali desert. Samples were collected from four cities located in the Al-Qassim Region of Saudi Arabia (Uyun Al-Jawa, Al-Fuwailiq, Al-Sulaibiya, and Al-Qawara), from three distinct depths (the earth's surface, 50 cm, and 100 cm). The percentages of silicon in these places vary between the highest value for silicon dioxide, which is 74.47 m/m%, and 34.8 m/m% for silicon in Al-Qawara city at a depth of 100 cm. We used an x-ray fluorescence (XRF) instrument to evaluate the samples. There are high percentage of both silica and silicon in the Nafud desert. Studies have shown that these ratios can help investors benefit from an element of Silicon and silicon dioxide, so the sands of the Nafud desert is sufficient for extracting Silicon and silica in huge quantities. This may transform the Kingdom into a leading country in the global computer technology industry that depends on silicon extracted from the desert sands, the most important of which are microcomputer data processing devices.

Keywords

Silica, Sand, Dispersive X-Ray Fluorescence (EDXRF) Analyzer, Solar Cells, Nafud Desert, Al-Qawwarh

1. Introduction

Sand accounts for 50% of the Kingdom's total area if the other sandy areas are added to the Empty Quarter, and it will become a significant source of income as industrial and technological progress and the need for alternative natural materials replace traditional use in burying coastlines to increase landmass. The opportunities for economic exploitation of sand differ depending on its nature, as indicated. First, white sand is exploited in the industry that uses silicon and silica to make solar cells, computer chips, lenses, and optical fibers. Second, with the development of chemicals and adhesives, red sand can be used in the external cladding of structures and concrete obstacles. It's possible to make sand bricks by applying adhesives. Sand can be compressed to form panels for external cladding with appealing geometric designs and branding. These sands have the potential to propel the Kingdom to the forefront of the global computer technology industry, which relies on silicon mined from desert sand to produce precision computer data processing systems. If the silicon found in the Rub Al-Khali desert was exploited, would it overpower oil? The world uses more than 50 billion tons of sand annually, and the number continues to rise steadily. Thirdly, in addition to sand, there are multi-element structures that contain gravel (small stones) that have been intentionally crushed into nearly equal and numerous sizes and are used in backfilling or reinforced concrete constructions. Unfortunately, agricultural enterprises were importing them from other countries to fill the air cavities of agricultural wells, even though they are accessible and an industry for this commodity might be formed to meet the demand for commercial export [1]. Silicon dioxide accounts for approximately 25% - 50% of the Earth's surface [2]. SiO_2 is a major macromolecular solid in the Earth's crust. While silicon and carbon are both Group IVA elements, silicon is resistant to forming multiple bonds; hence, discrete O-Si-O double bonds, similar to O-C-O double bonds, do not exist. To satisfy silicon's valence of 4 and oxygen's valence of 2, each silicon must be surrounded by four oxygen atoms, and each oxygen atom by two silicon atoms [3]. Silicone had an important influence on the New World economy. Although free silicon is used to purify steel, cast aluminum, and fine chemical industries (typically in the production of fumed silica), small quantities of pure silicon (>10%) are also employed in semiconductor technology. Because silicon is widely used in integrated circuits, which are the foundation of computers, mobile phones, and all electronic devices, it is critical to a wide range of technology. The majority of silicon is utilized commercially without being separated, and in some cases, natural molecules are processed. These include the direct industrial construction usage of clay, sand, and stones. Silica is used in adobe porcelain. Silica is also used in Portland cement, mortar, and stucco ornamentation, and when silica sand is combined with gravel, to make concrete. Silicate is a white ceramic commodity, such as porcelain, and is used in traditional quenched echo-lime glazes. There are more modern silicon compounds, such as silicon carbide abrasives and high-quality ceramics. Silicon is the basis of the ubiquitous silicone polymers called silicon. With climate change and the high concentration of greenhouse gases, there has been an increasing focus on the use of alternative and renewable energy sources. Solar energy is considered one of the most environmentally friendly sources of energy. We can easily convert solar energy into electricity without harming the environment using solar panels. Most solar cells and solar panels are made using silicon, thanks to its physical and chemical properties. It acts as a semiconductor, making the element more compatible with solar panels. However, pure silicon is not used; rather, it is mixed with impurities so that panels and cells can absorb energy from the sun and convert it into electricity. Silicon is also used in the manufacture of electronic devices such as semi-automobiles, transistors, and integrated circuits. It also contains distinctive properties, such as complete electrical insulation. It is also used in the manufacture of sensors. Furthermore, it is responsible for devices for changes in pressure and air, which are known as resistors. Also, what is known as a semiconductor, which is an insulating material, is easily converted into a conductor. There are also several electrons in the material capable of fully conducting electricity, and silicon has a low difference between the valence band and the conduction band. Silicon is also used in the manufacture of many electronic parts, including semiconductors, transistors, and circuits, thanks to its semiconductor property that allows It to perfectly transmit electricity, in addition to having a high melting point, unlike its counterparts. Before being used in electronic devices, silicon is polished in two stages. First, oxygen is removed from the compound, and then it is polished to produce pure silicon. The invention of quantum computers that outperform regular computers marked one of the last milestones in computer technology using silicon-based chips, which could replace regular computers shortly [4] [5]. Silicon Si can be extracted from silicon dioxide or different crystalline forms such as α-quartz, β-quartz, α-tridymite, β-tridymite, α-cristobalite, β-cristobalite, or any oxide that the earth contains [6]. Silicon Si can be extracted from silicon di Silicon is one of the promising semiconductors; silicon has no health hazard to the area in which it is housed, is practically indestructible, affording indefinite operation, and allows efficient device construction or different crystalline forms such as α-quartz, β-quartz, α-tridymite, β-tridymite, α-cristobalite, β-cristobalite, or any oxide that the earth contains [7] [8] [9]. The principal materials for photovoltaic technology are crystalline silicon. Silicon technology is the backbone for electronics such as solar cells and microelectronic components [10]. The first solar cell was manufactured and developed in 1954 by Bell Labs [11]. This cell has low power conversion efficiency (PCE), and a high cost of materials. The latest industry of silicon solar cells has exceeded expectations, but it needs further improvement to reduce the cost and price of the materials from which solar cells are made. Also, it needs to improve its efficiency. The majority of silicon dioxide is produced by mining, which also includes quartz purification and sand mining. Quartz can be used for a variety of tasks, but to create a product that is purer or otherwise more appropriate (such as more reactive or finely grained), chemical processing is needed [12]. Solutions containing sodium silicate are acidified to generate precipitated silica, also known as amorphous silica. To create colorless microporous silica, the gelatinous precipitate, also known as silica gel, is first cleaned and then dried [13]. The idealized formula using sulfuric acid and a trisilicate is:

$$Na_2Si_3O_7 + H_2SO_4 \rightarrow 3SiO_2 + Na_2SO_4 + H_2O \quad (1)$$

Thin films of silica grow spontaneously on silicon wafers via thermal oxidation, producing a very shallow layer of about 1 nm or 10 Å of so-called native Silicon Si can be extracted from silicon di Silicon is one of the promising semiconductors; silicon has no health hazard to the area in which it is housed, is practically indestructible, affording indefinite operation, and allows efficient device construction or different crystalline forms such as α-quartz, β-quartz, α-tridymite, β-tridymite, α-cristobalite, β-cristobalite, or any oxide that the earth contains controlled layers of silicon dioxide on silicon, for example at temperatures between 600˚C and 1200˚C, using so-called dry oxidation with O_2 [14], or moist oxidation with water HO_2 [15] [16], the productions according to Equations (2) and (3).

$$SiO_2 + 2C = Si + 2CO \quad (2)$$

$$Si + HO_2 \rightarrow SiO_2 + 2H_2 \quad (3)$$

In this work, quantitative analysis of sand from King Saudi Arabia-Nafud desert in Qassim area cities of (As Sulubiayh, Al Quwarah, Al Fuwayliq, and Uyun Al Jawa), using energy dispersive x-ray fluorescence (XRF) analyzer is carried out to find out the percentage of silicon and silica. There are no studies about using Qassim sand's silica in industries. This encourages me to do this study.

2. Materials and Methods

2.1. Target Area

The area of study is four cities (As Sulubiayh, Al-Qawwarh, Al Fuwayliq, and Uyun Al Jawa) in the Qassim area, which is a part of the Nafud desert in Saudi Arabia. The Nafud desert is located in northern Saudi Arabia and covers an area of 57,000 km^2 [17] [18].

2.2. Materials

The samples were ground and turned into powder. Then the samples were packed in plastic containers and classified according to area and depth. Then the samples were examined by an XRF analyzer to find out the percentages of silicon and silicon dioxide in each sample.

2.2.1. Fluorescence (XRF)

XRF is a non-destructive analytical method for figuring out a material's elemental composition. It is can be used with solids, liquids, and powders. An efficient technique for both qualitative and quantitative material composition investigation is XRF spectroscopy. At the atomic level, X-ray fluorescence (XRF) can be understood as a straightforward three-step process:

Primary X-rays remove an electron from one of the orbitals in an atom of the substance that surrounds the nucleus.

An orbital hole is created, which puts the atom in an unstable, high-energy form.

An electron from a higher energy outer orbital descends into the hole to restore balance. Fluorescent X-rays are the result of the extra energy being released because this is a lower energy position.

The energy of the released fluorescent X-ray is directly associated with a particular element since the energy difference between the ejected and replacement electrons is typical of the element atom in which the fluorescence process is taking place examined [19].

3. Results and Discussions

Quantitative analysis of the samples was done the results and discussions will be in sections 3.1 and 3.2.

3.1. Results

As shown in the Appendix, the data were taken as-is for every element found in the soil. **Table 1** represents the percentages of silicon and silicon dioxide as taken by the XRF analyzer.

3.2. Discussions

Concerning **Figures 1-6**, we can observe that the Qassim sands are extremely rich in silicon and silicon dioxide, with the percentage of each increasing with ground depth, i.e., digging. Al-Qawara region has high silicon and silica oxide percentages ranging from 30 m/m at the Earth's surface to 34 at a depth of 100 cm for the silicon and for the silicon oxide, ranging from 65 at the Earth's surface to 74 at a depth of 100 cm.

Table 1. The percentages of silicon and silicon dioxide in four cities of the Qassim's desert sand.

Element (Si) m/m%	Compound (SiO_2) m/m%	city	Sample no.
27.53	58.88	Uyun Al Jawa	1
28.01	59.92	Uyun Al Jawa	2
28.46	60.88	Uyun Al Jawa	3
27.23	58.24	Al Fuwayliq	4
25.89	55.38	Al Fuwayliq	5
26.95	57.64	Al Fuwayliq	6
30.58	65.40	Al-Qawwarh	7
33.83	72.36	Al-Qawwarh	8
34.81	74.47	Al-Qawwarh	9
24.43	52.26	As Sulubiayh	10
25.88	55.37	As Sulubiayh	11
22.36	47.82	As Sulubiayh	12

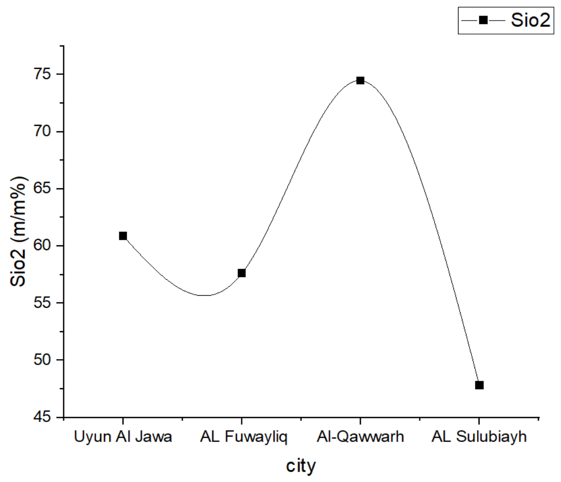

Figure 1. The percentage of SiO_2 (m/m%) at depth of 100 cm for the four cities.

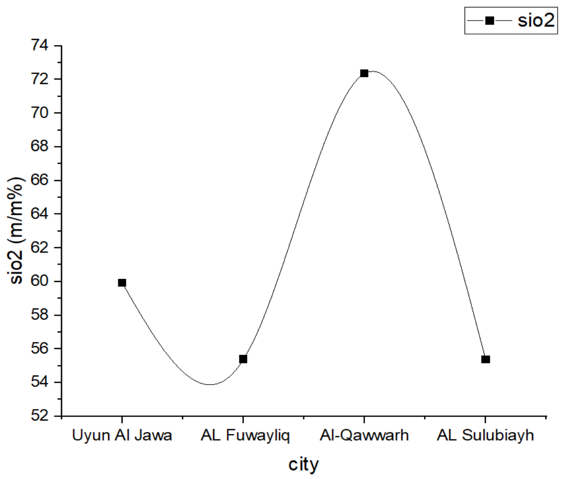

Figure 2. The percentage of SiO_2 (m/m%) at depth of 50 cm for the four cities.

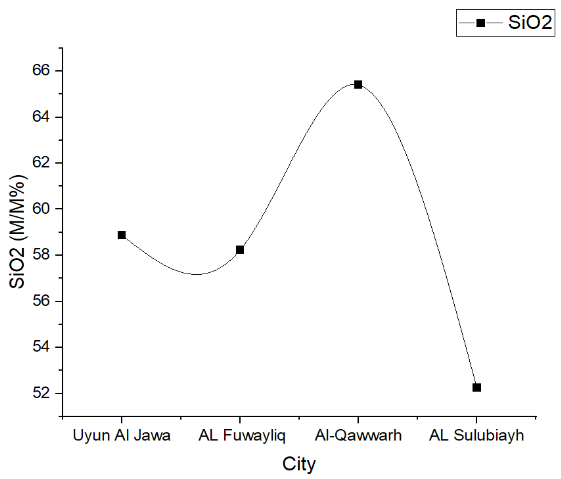

Figure 3. The percentage of SiO_2 (m/m%) at the surface of the ground for the four cities.

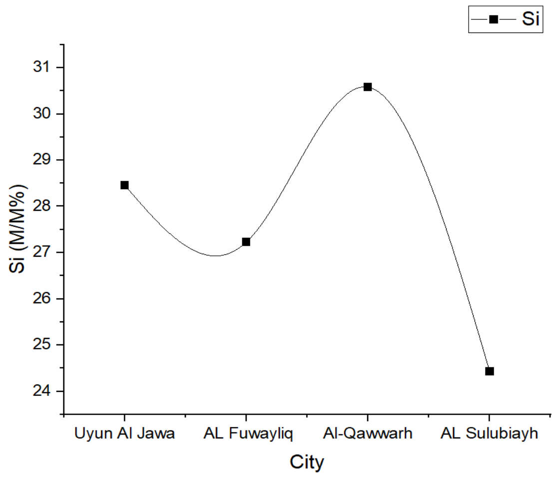

Figure 4. The percentage of Si (m/m%) at the surface of the ground for the four cities.

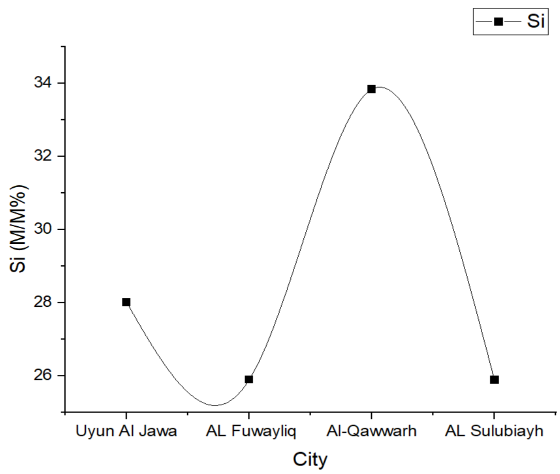

Figure 5. The percentage of Si (m/m%) at depth of 50 cm for the four cities.

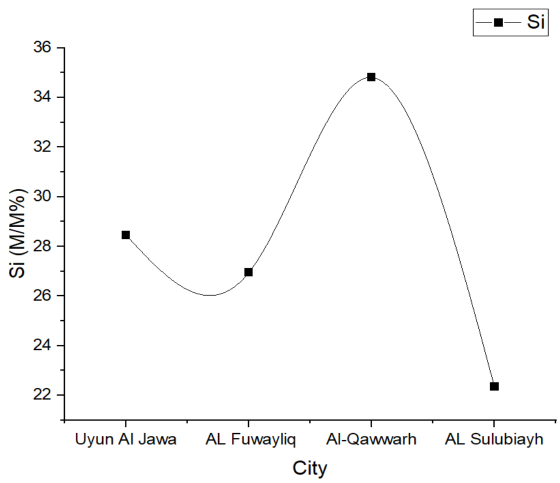

Figure 6. The percentage of Si (m/m%) at depth of 100 cm for the four cities.

Solar energy in Saudi Arabia is a powerful energy resource that can supply proper electricity for residential and commercial use. It's an environmentally friendly and most plentiful renewable resource that can efficiently and cost-effectively power your place cost-effectively. Hence, utilizing solar power in Saudi Arabia has many advantages, such as any other renewable energy that maintains the Earth for generations to come [19].

One goal of Saudi Arabia's Vision 2030 is to diversify domestic energy and reduce the cost of solar panel manufacturing. This could be done by manufacturing solar panels in the Kingdom of Saudi Arabia and benefiting from the presence of silica available in sand [20] [21] [22] [23].

4. Conclusion

Due to progresses in manufacturing and development of renewable energy sources and the establishment of significant solar projects like the Sakaka and Sudair solar PV projects, and computer data processing devices in the Kingdom of Saudi Arabia (KSA), the quantity of silicon and silicon oxide encourages the investor to extract from the Empty Quarter desert, especially the city of Al-Qawara.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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