Quantitative and Qualitative Analysis of Sand in Nafud Desert at Zilfi Province using (ICP-MS) Spectroscopic Technique

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Abstract

In this present study soil samples were collected from an agriculture area of Zilfi Province of Saudi Arabia approximately 260 km northwest, of the capital city Riyadh. The area of study (Nafud Desert in Zilfi Province) was surveyed during December 2012 collecting 21 samples from 7 places (Al sabla, Almata, Jaway, Alaaga, Magra, Shlwan, and Althuare, by taking 3 samples from each place at the surface, 20 cm and 40 cm depth .The concentrations of some elements such as Si, Na, Mg, Ca, K, Al, P, S, Ti, V, Mn, Fe, Ni, Cu, As, Au, Pb, Cr, Co, Cd and Zn were measured , using Inductively Coupled Plasma-Mass Spectrometer (ICP-MS), after sieving and digestion using HNO_3, HCL and HF. In most of the samples the elements (Au or Cd), found to have low concentrations while the element S found to be has the high concentrations. The concentrations of toxic trace elements (Ni, Cd and As), were found have values more than back ground concentrations found in the literature of sandstone. The maximum concentrations of the elements: Pb, Zn, Na, Ca and Cd were found at Al sabla region. On the other hand, the maximum concentrations of the elements: As, and V were found in Shlwan region, while the maximum concentration of Cr was found in Alaaga region. Magra region shows maximum concentrations of elements Au, Si, Ti, P, Al, Fe, Mg,and S. High concentration of elements Cu, Mn and K were found in Althuare region, while Ni in Jaway region, and Co in Magra and Althuare regions.

1. Introduction

Zilfi Province is located to the North of Riyadh, capital of Saudi Arabia approximately 260 km northwest, being in the middle of the Arabian Desert.Quartzose sands with very poor heavy-mineral suites including zircon occupy most of the region comprising the Great Nafud and Rub al-Khali Sand Seas and are largely recycled from thick lower Paleozoic quartzarenites with very minor first-cycle contributions from Precambrian basement, Mesozoic carbonate rocks, or Neogene basalts [1].

Silicon comprises about 28% of the lithosphere and is next to oxygen, the most abundant element. It is found as the oxide in crystalline forms, as in quartz; combined with other oxides and metals in a variety of silicates; and in amorphous forms. Silicon is the most abundant element in igneous rocks and is the characteristic element of all important rocks except the carbonates.

Silica is used primarily in the production of glass for windows, drinking glasses, beverage bottles, and many other uses. The majority of optical fibers for telecommunications are also made from silica. It is a primary raw material for many white ware ceramics Silica is a common additive in the production of foods, where it is used primarily as a flow agent in powdered foods, or to absorb water in hygroscopic applications. It is the primary component of diatomaceous earth which has many uses ranging from filtration to insect control. It is also the primary component of rice husk ash which is used, for example, in filtration and cement manufacturing. Therefore, the study of chemical components and physical properties of the sand found at Nafud dessert in Zilfi province using, (ICP-MS), is carried out.

Silica is most commonly found in nature as sand or quartz. Silica sand is a white or colorless crystalline compound, occurring abundantly as quartz, sand, flint, agate and in many minerals .It is

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used as an essential raw material in the production of glass, foundry, abrasives, filters, and ceramics, in chemical and hydraulic fracturing and on oil fields [2]. Silica sand contains Al, Fe, Ti, Ca, Mg, Mn, Na and K as impurities in varying quantities. Iron, aluminum and titanium impurities can alter the color, chemical, optical and mechanical properties of the product [3,4].In common glass and allied materials; Al is associated with moderate to low quantities of Ti and Fe. For such materials, the quantities of these metals are determined separately by complexometric and colorimetric methods [5]. In the direct titrations however, Al, Ti and Fe interact with one another. Several instrumental techniques such as inductively coupled plasma (ICP) emission and atomic absorption spectrometry (AAS) in such matrixes have been adopted for the determination of the trace metallic impurities [6-9].Voinovitch, have determined Al in the presence of Ti and Fe by employing an excess of EDTA with $ZnCl_2$ as the back titrant at pH 5–6 (in presence of tartaric acid, diammonium phosphate and fluoride) and dithiozoneindicator [10]. In using this method it has been observed that the end point can be affected by the reaction of tartaric acid with Zn as well as dithiozone indicator's slight ability to absorb titanium phosphate.Miles summarized the quantitative analysis of quartz by IR methods[11]. All analytical methods for crystalline silica analysis (XRD, IR and UV-VIS) are particle size dependent, as summarized [12].The concentration of lead, zinc, cadmium, nickel, copper and vanadium in the sediments of nineteen coastal stations in Bahrain were determined by atomic absorption spectrophotometer (AAS) [13]. Several samples of environmental concern were analyzed for trace element content by instrumental neutron activation analysis (INAA) in Tunisian soil, desert and beach sand [14]. Multivariate cluster analysis of some major and trace elements distribution in an unsaturated zone profile, Densu River Basin, Ghana was done using Energy Dispersive X-ray Fluorescence (EDXRF)[15].Grain-size distribution and chemical analyses were carried out on four sand samples randomly taken from the bank of Otamiri River around Chokocho and Umuanyaga, Etche Local Government Area, Rivers State. This was done to assess the purity and suitability of the sands for the making of plain glass [16]. Soil samples containing `Amang` were taken to recover its heavy minerals by separating them into individual minerals, sample containing monazite, ilmenite, and zircon were separated by 8000 G hand magnet. The morphology of each mineral was investigated by computer controlled scanning electron microscopy coupled with an energy-dispersive X-ray detector (CC-SEM/EDX) [17].

Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) technique was used to determine the concentrations of titanium (Ti), vanadium (V), Chromium (Cr), Manganese (Mn), iron (Fe), zinc (Zn), arsenic (As), zirconium (Zr), cadmium (Cd) and hafnium (Hf) in black sands samples [18].

2. Materials and Methods

2.1. Instrumentation

The analytical determination of Si, Na, Mg, Ca, K, Al, P, S, Ti, V, Mn, Fe, Ni, Cu, As, Au, Pb, Cr, Co, Cd and Zn was carried out by ICP-MS(Inductively Coupled Plasma-Mass Spectrometer): ELAN 9000 (Perkin Elmer Sciex Instrumento, Concord, Ontario, Canada). Table1 highlights the operating conditions of the instruments used in this study.

Table 1. Conditions of ELAN 9000 ICP-MS

RF power	1250 W
Nebulizer gas flow	0.92 L/min
Lens Voltage	9.25 V
Analog Stage Voltage	-1762.5 V
Pulse Stage Voltage	1050 V
Number of Replicates	3
Reading / Replicates	20
Scan Mode	Peak Hopping
Dwell Time	40 ms
Integration	1200ms

2.2. Reagents

Nitric acid (69 % v/v), super purity grade from Romil, England. Hydrochloric acid (37% v/v) and hydrofluoric acid (40% v/v) were procured from Merck Germany. High purity water obtained from Millipore Milli-Q water purification system was used throughout the work.

2.3. Calibration

The ICP-MS calibration was carried out by external calibration with the blank solution and three working standard solutions (20,40 and 60 ppm),starting from a 1000mg/l single standard solutions for ICP-MS (A raster grade, BDH laboratory supplies, England for the elements: Si, Na, Mg, Ca, K, Al, P, S, Ti, V, Mn, Fe, Ni, Cu, As, Au, Pb, Cr, Co, Cd and Zn.)

2.4. Sample collection and preparation

The area of study (Nafud Desert in Zilfi Province) was surveyed during December 2012 collecting 21

samples from 7 places (Alsabla, Almatal, Jaway, Alaaga, Magra, Shlwan and Althuare) by taking 3 samples from each place at the surface, 20 cm and 40 cm depth. The samples were transferred to plastics bags, and sieved through 200 mm thieve. Samples were prepared by accurately weighing around 200 mg of sand samples into a dry and clean Teflon digestion beaker, 6 ml of HNO_3,2 ml HCl and 2 ml HF were added to the Teflon beaker. Samples were digested on the hot plate at 120-150°C for approximately 40 minutes. The resulting digest was not clear, so it was filtered through Whitman filtered paper no.42.The filtered digest was transferred to a 50 ml plastic volumetric flask and made up to mark using deionized water. A blank digest was carried out in the same way.

2.5. pH Determination method

An amount of 20 g of dry sieved sample were stirred with ultra-pure distilled water (50 ml) and left to equilibrate over a period of 30 minutes, and then the pH of each sample was measured using a microprocessor pH meter (HANN PH 210). Table 2 lists selected districts for sand sampling points. The soils were classified as moderately alkaline. The soil depth of 20-40 cm registered the highest pH, especially in Al sabla, Shlwan, Jaway and Magra regions. Almatal, Alaaga, and Althuare regions have a higher pH at surface.

Table2. The selected areas for sand sampling points

Dust sample	Sampling site	pH
1	Alsabla at surface	8.72
2	Alsabla (20 cm underground)	8.89
3	Alsabla (40 cm underground)	9.08
4	Almatal at surface	9.21
5	Almatal (20 cm underground)	8.91
6	Almatal (40 cm underground)	9.04
7	Shlwan at surface	9.10
8	Shlwan (20 cm underground)	9.25
9	Shlwan (40 cm underground)	9.31
10	Alaaga at surface	9.05
11	Alaaga (20 cm underground)	9.02
12	Alaaga (40 cm underground)	8.97
13	Jaway at surface	9.12
14	Jaway (20 cm underground)	9.23
15	Jaway (40 cm underground)	9.09
16	Magra at surface	9.11
17	Magra (20 cm underground)	9.18
18	Magra (40 cm underground)	9.18
19	Althuare at surface	8.94
20	Althuare (20 cm underground)	8.92
21	Althuare(40 cm underground)	8.87

3. Results and Discussion

Elemental analyses for 21 sand samples were performed by using inductively coupled Plasma-mass spectrometer (ICP-MS). All calibration graphs are linear in the selected range of each element. The square of the correlation (R^2) ranges from 0.9985-0.099999 for most of the elements in this investigation. Good precision values were obtained. The results have been reviewed in Tables (3-10) and Figures (1-4).
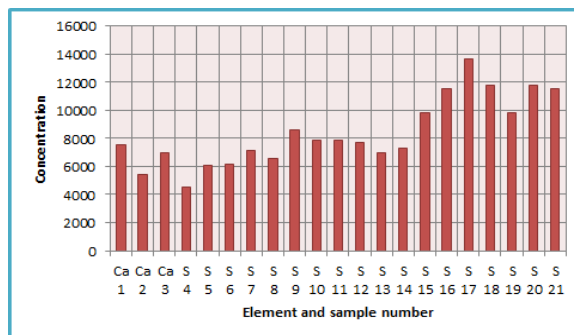

Fig.1.Comparison between maximum concentrations found in sand samples
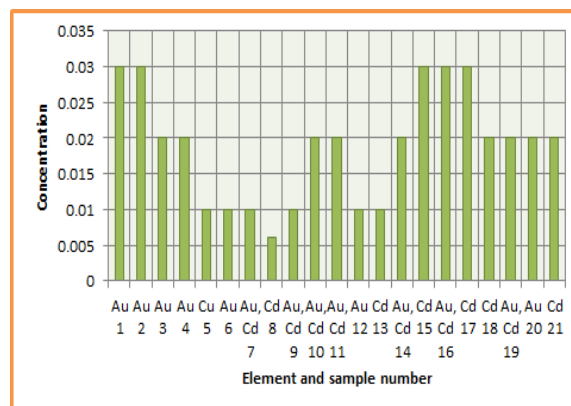

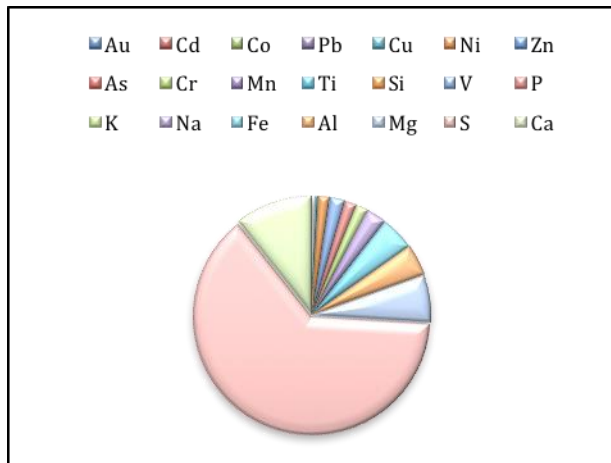Fig. 2. Comparison between minimum concentrations found in sand samples

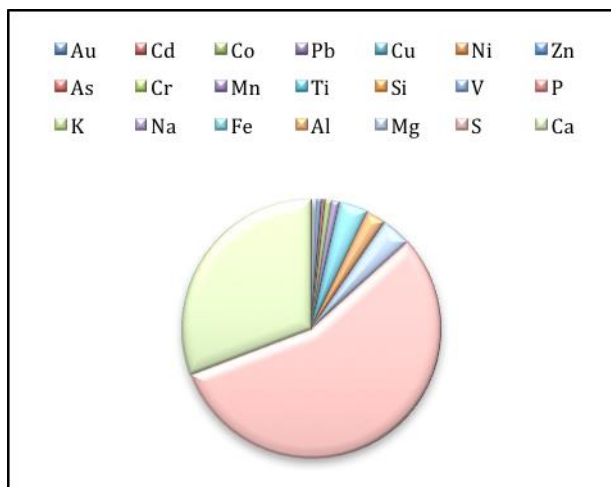Fig. 3. Element minimum concentrations in sand samples

Fig. 4. Element maximum concentrations in sand samples

Magra region at surface contains the higher number of maximum concentrations elements: Co, Ti, P, Fe, Al and Mg. While Shlwan area sample (9), 40 cm depth, contains the maximum number of low elements concentrations which are: Au, Co, Pb, Ni and Fe, also this sample have the higher pH (9.30) over all samples which may be as a result of these elements. In all samples the elements (Au or Cd) represents the low concentrations except sample (5) which have the element (Cu) with low concentration. In samples (1-3) the maximum concentration element is Ca, while the element S shows high concentrations in the rest of the samples.

The concentrations of the elements: Au, Cd, Cu, Ni and V are found to be closed to the concentrations of these elements in the study which include a method of quantitative analysis for the determination of some metals in soils from Northern California by ICP-MS [19]. Also the concentrations of the elements: Zn, Mn, and P in this study are in agreement with the study that used ICP-MS as a method of quantitative analysis for the determination of some metals (As, Ni, Cd, Ag, Pb, Zn, Mn, Sr, Co, Ga, V, Rb, U, Li, Cu) in soils [20]. This study agrees with the study of the Egyptian Black Sands from Abu Khashaba [18] Beach Area that considered ICP-MS as a good technique for its high efficiency of the detection of the trace elements.

The concentrations of toxic trace elements specially (Ni, Cd and As), have concentrations more than back ground values found in the literature of sandstone [21]. According to the study by Suleman et. al. [22, 23] which measured out some trace elements in street dust at Zilfi, the concentration of As was found to be more than the allowed value in literature; this may due to geological nature in this area. The rest of the trace elements (Co, Pb, Cu, Zn, and Cr) have been found less than allowed concentrations in literature, this may due to the fact that these areas under study are far away from pollution. The maximum concentrations of the elements: Pb, Zn, Na, Ca, and Cd are found at Al-Sabla region; this can be attributed to, location of this region next to the city and thus more exposed to contamination from cars and industrial area. On the other hand, the maximum concentrations of the elements: As, and V, are found in Shlwan region, while the maximum concentration of Cr was found in Alaaga region. Magra region contains Au, Si, Ti, P, Al, Fe, Mg, and S maximum concentrations. Cu, Mn, and K maximum concentrations are lie in Althuare, Ni at Jaway, and Co at Magra and Althuare. The minimum concentrations of the elements are as follows: Au (Almatal, Shlwan and Alaaga regions) Cd and Fe (Shlwan region), Co and Pb (Almatal and Shlwan region), Cu, Zn, P, Mn and Ca (Almatal region), Ni (Shlwan, Alaaga ,and Jaway regions), As, V and S (Alsabla region), Cr (Althuare region), Ti and Na (Alaaga region), Si and Al (Magra region), K and Mg (Jaway region).

Table3.Elements concentration in sand samples
(µg/g) = (mg/Kg) = (ppm)

Sample No.	1	2	3
Element	Mean Concentration±SD		
Au	0.03±0.001	0.03±0.001	0.02±0.001
Cd	0.05±0.002	0.06±0.003	0.04±0.002
Co	0.1±0.003	0.09±0.003	0.1±0.004
Pb	0.14±0.006	0.09±0.004	0.1±0.004
Cu	0.6±0.02	0.2±0.007	0.4±0.02
Ni	1.4±0.05	1.2±0.04	1.4±0.04
Zn	4.2±0.1	1.5±0.05	3.4±0.12
As	4.6±0.2	4.8±0.2	5.0±0.11
Cr	4.8±0.2	5.7±0.2	6.5±0.2
Mn	11.5±0.4	8.0±0.3	10.4±0.3
Ti	19.5±0.8	18.6±0.4	18.9±0.5
Si	43.3±0.4	43.8±0.5	43.5±0.9
V	55.1±1.5	55.2±2	63.6±1.1
P	61.4±2	76.9±1.4	88.6±1.6
K	94.0±2	83.4±2.6	90.0±1.0
Na	157.7±4	159.4±2.6	258.2±2.1
Fe	424.7±8	383.5±7.3	408.9±4.1
Al	455.0±6	428.4±14	449.0±9.9
Mg	536.3±16	530.0±10.6	671.7±8.1
S	1721±25	2445.0±41	3239.1±29
Ca	7534.0±113	5431.9±135	6949.7±35

Table 5. Elements concentration in sand samples
(µg/g) = (mg/Kg) = (ppm)

Sample No.	7	8	9
Element	Mean Concentration±SD		
Au	0.01±0.0004	0.006±0.0002	0.01±0.0005
Cd	0.01±0.0004	0.02±0.001	0.01±0.004
Co	0.06±0.003	0.05±0.002	0.04±.002
Pb	0.09±.004	0.05±.004	0.04±0.002
Cu	0.1±0.004	0.1±0.004	0.2±0.0006
Ni	0.7±0.02	0.4±0.02	0.4±0.01
Zn	1.6±0.05	1.1±0.04	0.8±0.03
As	5.0±0.2	4.2±0.1	4.3±0.1
Cr	5.6±0.2	4.8±0.12	5.7±0.2
Mn	10.9±0.5	8.8±0.2	9.9±0.3
Ti	14.9±0.3	11.7±0.3	12.3±0.2
Si	44.3±0.9	44.2±1.0	43.8±0.5
V	55.7±1.6	45.3±1.2	49.6±1.0
P	85.0±2.1	69.7±2	57.1±1.1
K	144.1±2.2	118.0±1.4	126.6±2.3
Na	215.0±2.8	158.7±2.9	152.1±3.5
Fe	216.7±5.9	170.6±2.7	159.3±2.2
Al	320.5±4.5	282.0±10.7	243.2±6.5
Mg	386.3±8.1	348.0±7.7	297.8±3.3
S	1301.1±11.7	644.8±9.0	645.2±9.7
Ca	7116.0±7.1	6532.6±52.3	8572.0±77.1

Table4. Elements concentration in sand samples
(µg/g) =(mg/Kg) = (ppm)

Sample No.	4	5	6
Element	Mean Concentration±SD		
Au	0.02±0.001	0.01±0.001	0.01±0.0005
Cd	0.03±0.001	0.02±0.001	0.02±0.001
Co	0.05±0.002	0.03±0.001	0.04±0.001
Pb	0.05±0.002	0.05±.002	0.04±.002
Cu	0.2±0.01	0.05±0.002	0.04±0.002
Ni	0.7±0.03	0.5±0.02	0.6±0.02
Zn	0.7±0.03	0.7±0.03	0.7±0.03
As	4.5±0.2	4.1±0.1	3.6±0.1
Cr	4.8±0.16	5.0±0.16	5.6±0.1
Mn	7.2±0.3	8.1±0.3	9.2±0.3
Ti	13.3±0.2	11.4±1.2	12.1±0.4
Si	44.0±0.6	44.1±0.8	43.9±0.9
V	45.9±1.3	43.7±1.2	45.3±1.2
P	100.1±3.1	47.5±1.5	48.4±1.0
K	105.2±3.3	111.9±4.1	116.0±1.4
Na	123.5±2.3	134.1±3.2	125.0±2.6
Fe	169.4±2.0	134.3±3.2	135.2±2.0
Al	268.7±6.7	225.7±6.8	232.6±5.3
Mg	311.6±6.2	280.3±9.5	261.6±2.9
S	380.3±5.7	289.4±7.5	452.0±15
Ca	4547.5±45.5	6104.0±61	6153.1±5.2

Table6. Elements concentration in sand samples
(µg/g) = (mg/Kg) = (ppm)

Sample No.	10	11	12
Element	Mean Concentration±SD		
Au	0.02±0.001	0.02±0.001	0.01±0.001
Cd	0.02±0.001	0.02±0.001	0.02±0.001
Co	0.05±0.002	0.05±0.002	0.05±0.002
Pb	0.09±.004	0.09±.004	0.06±.003
Cu	0.1±0.004	0.1±0.004	0.4±0.001
Ni	0.4±0.02	0.4±0.02	0.5±0.002
Zn	2.3±0.07	2.3±0.07	0.8±0.0003
As	5.0±0.2	5.0±0.2	3.9±0.1
Cr	6.9±0.1	6.9±0.1	4.9±0.2
Mn	9.2±0.3	9.2±0.3	10.7±0.3
Ti	11.9±0.3	11.9±0.3	11.5±0.3
Si	43.9±0.9	44.3±0.9	44.2±0.4
V	60.0±1.1	60.0±1.1	50.6±0.6
P	65.5±1.3	65.5±1.3	92.0±1.3
K	156.2±5.0	75.5±3.0	101.1±1.5
Na	160.0±2.2	156.2±5.0	139.8±1.5
Fe	231.9±3.0	160.0±2.2	160.9±3.5
Al	245.7±3.4	245.7±3.4	245.1±5.0
Mg	264.0±2.1	264.0±2.1	275.2±6.3
S	611.4±9.2	611.4±9.2	436.8±11.8
Ca	7848.3±117.7	7848.3±117.7	7721.8±77.2

Table 7. Elements concentration in sand samples
(µg/g) = (mg/Kg) = (ppm)

Sample No.	13	14	15
Element	Mean Concentration±SD		
Au	0.01±0.0005	0.02±0.0005	0.03±0.001
Cd	0.02±0.001	0.02±0.001	0.04±0.02
Co	0.05±0.002	0.05±0.002	0.07±0.003
Pb	0.06±.002	0.06±.003	0.1±.005
Cu	0.4±0.01	0.2±0.008	0.2±0.007
Ni	0.4±0.01	0.4±0.01	2.2±0.08
Zn	0.7±0.0003	0.8±0.0004	3.6±0.08
As	4.0±0.1	3.7±0.04	6.0±0.1
Cr	4.4±0.2	5.5±0.1	6.1±0.2
Mn	9.3±0.3	10.9±0.2	9.9±0.3
Ti	12.1±0.3	11.9±0.4	15.6±0.3
Si	43.8±1.0	44.6±1.0	43.7±1.0
V	56.4±1.2	46.6±1.0	50.9±0.9
P	96.4±3.0	63.6±1.9	83.7±1.6
K	98.1±1.8	93.2±1.1	99.0±1.0
Na	118.8±2.3	100.4±2.0	101.7±0.8
Fe	157.7±4.3	142.1±3.0	175.6±1.9
Al	233.4±2.6	152.5±2.0	221.3±2.0
Mg	257.4±5.9	204.9±3.1	231.6±2.8
S	514.0±13.9	220.8±1.8	432.1±6.0
Ca	7007.7±70.0	7289.2±72.9	9798.1±98.0

Table 9. Elements concentration in sand samples
(µg/g) = (mg/Kg) = (ppm)

Sample No.	19	20	21
Element	Mean Concentration±SD		
Au	0.02±0.001	0.02±0.001	0.04±0.002
Cd	0.02±0.001	0.03±0.001	0.02±0.001
Co	0.1±0.004	0.1±0.004	0.04±0.002
Pb	0.1±0.04	0.2±0.009	0.08±0.004
Cu	1.2±0.04	0.8±0.03	0.1±0.004
Ni	1.4±0.05	1.2±0.05	0.6±0.02
Zn	3.4±0.1	1.3±0.05	1.1±0.04
As	5.1±0.1	4.0±0.1	1.5±0.05
Cr	13.0±0.4	5.3±0.2	3.6±0.1
Mn	14.8±0.3	13.3±0.4	5.3±0.2
Ti	26.7±0.7	30.0±0.8	8.1±0.2
Si	44.5±1.6	43.8±0.6	18.2±0.5
V	68.1±1.6	79.8±2.0	44.0±0.7
P	85.4±1.7	94.9±2.7	69.3±2.1
K	154.9±5.1	144.8±3.5	88.1±1.5
Na	194.6±3.1	188.9±4.0	109.8±1.1
Fe	486.4±6.3	585.6±9.4	184.0±5.7
Al	490.7±10.3	613.8±6.3	310.2±5.9
Mg	535.0±6.4	693.3±12.5	320.9±6.7
S	3127.0±31.3	1081.2±11.9	320.5±8.3
Ca	9824.9±108.1	11754.8±141.0	1717.0±20.6

Table 8. Elements concentration in sand samples
(µg/g) = (mg/Kg) = (ppm)

Sample No.	16	17	18
Element	Mean Concentration±SD		
Au	0.03±0.001	0.03±0.001	0.02±0.001
Cd	0.03±0.001	0.05±0.002	0.04±0.002
Co	0.2±0.006	0.1±0.004	0.07±0.003
Pb	0.2±0.008	0.2±0.008	0.1±0.004
Cu	1.5±0.05	1.4±0.06	0.5±0.02
Ni	1.7±0.05	1.4±0.06	1.0±0.05
Zn	2.2±0.05	2.5±0.07	1.6±0.05
As	4.9±0.1	4.4±0.1	3.6±0.09
Cr	6.7±0.2	7.1±0.2	5.4±0.2
Mn	17.6±0.6	9.9±0.4	6.5±0.2
Ti	40.6±1.3	22.1±0.6	17.9±0.5
Si	42.8±0.4	44.9±0.8	43.9±1.0
V	97.9±1.8	59.8±1.9	61.6±1.8
P	106.5±3.1	115.4±2.9	90.4±2.0
K	122.4±3.4	126.8±3.4	104.5±2.9
Na	171.4±3.4	142.2±3.0	108.7±2.9
Fe	605.8±7.3	422.2±12.2	117.6±2.5
Al	880.8±9.7	434.3±5.6	323.9±5.2
Mg	919.2±10.1	443.7±5.3	353.3±6.7
S	3154.3±31.5	1014.2±10.1	1449.1±17.4
Ca	11508.3±103.6	13691.7±150.6	11775.4±212.

Table 10. Elements minimum and maximum concentrations in
sand samples compared with allowable values

E.	Min. value	Sample No.	Max. value	Sample No.	Allow. Values(mg/kg)
Au	0.01	6-7-9.-12	0.05	17	No data
Cd	0.006	8	0.06	2	0
Co	0.02	6-9	0.04	16-20	50
Pb	0.04	6-9	0. 14	1	14
Cu	0.01	5	14.8	19	15
Ni	0.4	8-9-10-11-13-14	9.9	15	3
Zn	0.5	5	4. 2	1	16
As	4.6	1	12.3	9	1
Cr	3.4	19	6.9	10-11	120
Mn	3.6	6	13.3	20	No data
Ti	9.2	10-11	40.6	16	No data
Si	42.8	16	44.9	17	35.9%
V	55.1	1	159.3	9	50
P	43.7	5	97.9	16	No data
K	46.6	14	194.6	19	No data
Na	75.5	11	258.2	3	No data
Fe	126.6	9	880.8	16	No data
Al	117.6	18	605.8	16	3.2%
Mg	175.6	15	919.2	16	No data
S	1721	1	13691.7	17	No data
Ca	289.4	5	7534.0	1	No data

4. Conclusion and Recommendations

Sample (16) which was collected from Magra at surface contained the higher number of maximum concentrations elements: Co, Ti, P, Fe, Al and Mg. While Shlwan area sample (9), 40 cm depth, contains the maximum number of low elements concentrations which are: Au, Co, Pb, Ni and Fe, also this sample have the higher pH (9.30) over all samples.

In all samples the elements (Au or Cd) represented the low concentrations except sample (5) which have the element (Cu) with low concentration

In samples (1-3) the maximum concentration element is Ca, while the element S showed high concentrations in the rest of the samples.

The toxic trace elements specially (Ni, Cd and As), have concentrations more than back ground values found in the literature of sandstone, while the rest of the trace elements (Co, Pb, Cu, Zn, and Cr) have been found less than allowed concentrations in literature.

The maximum concentrations of the elements: Pb, Zn, Na, Ca and Cd are found at Al sabla region. On the other hand, the maximum concentrations of the elements: As, and V, are found in Shlwan region, while the maximum concentration of Cr was found in Alaaga region. Magra region contains Au, Si, Ti, P, Al, Fe, Mg, and S maximum concentrations. Cu, Mn, and K maximum concentrations are lie in Althuare, Ni at Jaway, and Co at Magra and Althuare.

A further study can be made out to find percentage of silica in sand of Nafud desert so as to be used in some industrial applications such as glass production.

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