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Investigation of Physical and Chemical Soil Properties for Two Selected Sites in Khartoum State (Umm Dom Island) and River Nile State (Al Oteib Area) Sudan

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Soil is an important component of the human environment and is a significant component of terrestrial ecosystems. The aim of this study is to determine physical and chemical soil properties in addition to comparing two sites (Al oteib area) River Nile state and (Umm Dom Island) Khartoum State in soil composition. Two different soil samples were collected randomly from the surface (0-30m) of the two locations (Al oteib area) and (Umm Dom Island) manual, a considerable amount of soil was taken to analyze physical and chemical soil properties. Standard analytical methods were used. Results revealed that the soil texture was sand to sandy loam in the two sites. Chemical analysis of the soil showed that Al oteib area and Umm Dom Island were of neutral reaction pH (7.24, 7.27), Electrical Conductivity ,and the amount of salt was non Saline (0.766 ds/m) in Al oteib and saline (3.42ds/m) in Umm Dom Island. Exchangeable calcium concentration ranged from low

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(3.5megl/L) in Al oteib to high (17.5meg/L) in Umm Dom Island, Exchangeable magnesium concentrations ranged from medium (1.5 meg/L) to high (13.5meg/L) soluble sodium concentration was very low (2.24meg/L and (20meg/L) respectively. Soluble Potassium concentration ranged from high to excessive (1.86meg/L and 7.83meg/L). Both soils were bicarbonate (4 meg/L and 6.5 meg/L), the available organic matter was low to the desirable amount (0.21% and 0.75%), the Percentage of Calcium Carbonate was high (22.05 and 22.3meg/L). Total nitrogen percentages were very low (0.0.014% and 0.028%). The available phosphorus was very low (0.4 ppm and 1.6ppm). The Comparison showed that the amount of Exchangeable Ca and Mg, Soluble Na and K, total N, available P, O.M and O.C, and amount of HCO_3, CO_3, CL were greater in Umm Dom area while the percentage of sand (98.2%) and $CaCO_3$ (22.05meg/L) were higher in Aloteib area. From the field observations and laboratory analysis we concluded that Umm Dom Island soil was more fertile than Al Oteib soil and more suitable for agricultural practice without the need for the addition of external fertilizers.

Keywords: Soil properties; Sudan; physical; chemical.

1. INTRODUCTION

The importance of soil comes from that, the soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface. Soil occupies some space. Soil is characterized by both horizons and layers. These are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment. Soil is not uniformly distributed. The properties of soil vary due to several soil-forming factors. Properties vary very widely. To identify, understand, and manage soils, soil scientists have developed a set of soil classification or taxonomy systems [1]. Among the studies which cover the whole of Sudan, one [2] identifies 16 soil regions. Each is described by particular topographical features or by soil associations. The main areas of soil distribution are also marked on the climatic map as this allows an analysis of soil formation in relation to climate. Some soil regions have, in fact, been delimited in relation to climatic factors and it can be seen that the desert soils approximate the 75 mm Isohyets at about 17°N, from the frontier with Chad in the west to Atbara on the Nile in the east. Semi-desert soils and those of the Red Sea correspond, in a similar manner, to the area between the 75 mm and 200 mm isohyets. The semi-desert and Red Sea soils differ in respect of the particular topography found at the extreme east of the zone: the shallow Red Sea soils on steep slopes are calcareous and sandy fluvisols and are found in the numerous steep valleys descending from the hills towards the eastern run-off areas [3]. Balasubramanian, [4] reported that the classification of soil is the separation of soil into classes or groups each having similar characteristics and potentially similar behavior. A classification for engineering purposes should be based mainly on mechanical properties: permeability, stiffness, and strength. The class to which a soil belongs can be used in its description. A number of systems of classification have evolved for categorizing various types of soil. The World Reference Base (WRB) is the international standard for soil classification systems endorsed by the International Union of Soil Sciences. Classification is basically important to any science. Classification provides the avenue through which research can be addressed in a rigorously systematic manner. Classifications also have more practical applications Rory and Steven [5]. Classification of soils is necessary for all soil survey programs and mapping the soils of any region. Soil surveys employ the principles, and functions of soil science in agriculture, forestry, and engineering to predict soil behavior for different use, management, or manipulation [6]. The particle size distribution or soil texture is one of the essential controls of soil structure and functioning. Soil processes, properties, and specific features are usually related to these distributions, commonly named soil texture Martin, et al. [7]. Fertile soil may contain a number of elements of organic materials that are important to the structure, texture, and cohesion of the soil, as these materials maintain the soil moisture and the nutrients inside it, and it is possible to obtain such nutrients through the use of agricultural fertilizers that are available in the soil [8]. Soil is an important component of the human environment and is a significant component of terrestrial ecosystems. Moreover, Soil is a natural resource comprised of solid

minerals and organic matter, liquids, and gasses that occur on the surface. In addition, soil provides habitats for organisms and moisture and nutrients for the basic requirements of plant growth. Also, the soil is the basis of the production in agriculture and forestry and it is important to study arid and wetland soil. The objectives of this study are to analyze physical and chemical soil properties and to compare two different sites in soil composition.

2. MATERIALS AND METHODS

Soil Samples used in this study were collected from two different sites in Khartoum state (Umm Dom Island) and River Nile state (Al oetib area) Northern Sudan from the surface area (0 - 30cm) considerable amount was taken to analyzed physically and in chemically according to the method of Marc [9]. The collected soil samples were air-dried, crushed and sieved through a 2-mm sieve and kept for physic-chemical analysis to obtain soil texture, pH, electrical conductivity, Calcium and Magnesium, Sodium and Potassium, Calcium carbonate, Bicarbonate, Carbonate and Chloride, Organic matter, Total Nitrogen, and Phosphorus.

2.1 Physical Properties

2.1.1 Particle size distribution

Forty-two grams of soil were weighed and 50 ml of Calgon was added and left for 10 to 15 minutes, after which the contents were transferred to the mixer cone. And mixed for 10 minutes after adding distilled water. Then the contents were transferred to the measuring cylinder and the volume was completed to a capacity of 1000ml. Then the mixture was struck by the paddle and there will be a hydrometer device in which the specific gravity of the granules was measured with a graduated cylinder and lead pellets.

2.2 Chemical Properties

2.2.1 Preparation of saturated soil paste

Two hundred and fifty grams of air-dried soil were weighed and placed in a plastic container then distilled water was added gradually by means of a measuring cylinder taking into account the amount of added water. The soil was moved with a spoonful of soil until it reached a state of saturation, and that was by shining and reflecting light. The paste was placed for two hours (in order to activate hydrogen ions to measure the pH) The saturated solution was extracted by vacuum extraction method using a Buchner funnel fitted with filter paper, then the extraction was collected in a clean container and kept for the following measurement.

2.2.2 pH

To measure the concentration of the hydrogen ion, and to express the acidity or alkalinity of the soil digital pH meter was used.

$$pH = - \text{Log } H$$

2.2.3 Electrical conductivity

Ten grams of air-dried soil were weighed in a plastic container then 50 ml of distilled water was added and it was shaken for 5 minutes. The suspension was filtered using a Buchner funnel. Then the filtrate was transferred to a clean Container. The electrical conductivity was measured using a Digital electrical conductivity meter.

2.2.4 Calcium and magnesium

To measure Ca^{++} and Mg^{++} titration method was used. Five ml of the extract was taken in a conical flask and added to it 20 ml of distilled water until the volume was completed to 25 ml. Then 10 ml of buffer solution was added then 3 to 5 drops of EBT indicator were added Then titrated against Versenate until the color changed from Purple to blue. In the cause of the determination of Ca^{++}, 5 ml of soil extract was pipette into a 50ml conical flask, then 20 ml of distilled water was added to complete the volume to 25 ml, then 5 to 10 drops of NaOH were added and titrated against the Versenate until the color turns from pink to purple.

2.2.5 Soluble sodium and potassium

To determine the amount of Sodium and Potassium in the sample 100 ml of distilled water was added to 5 gm air-dried soil (less than 2mm) and shaken for 1 hour. The suspension was filtered and measured for Potassium and Sodium on a flame photometer at 589 nm. Wavelength. Sodium and Potassium concentration was calculated from a calibration curve.

2.2.6 Bicarbonate carbonate and chloride

Five ml of soil extract was taken into a 50 ml conical Flask 20 ml of distilled water was added

until the volume was completed to 25 ml. Five drops of phenolphthalein were added, the Appearance of pink color was taken as evidence of the presence of carbonates (The pink color did not appear, which indicates the absence of carbonate), then two drops of methyl orange were added, and the solution turned yellow, and it was also titrated against sulfuric acid 0.1N until the color of the indicator turned to an orange color.

In the case of chloride, the titration was done against silver nitrate using a potassium chromate indicator, changing the color from orange to reddish brown.

2.2.7 Organic matter

One gram of air-dried soil was weighed and sifted in a 100 ml volumetric flask, then 10 ml of potassium dichromate was added to the flask, Then 20 ml of concentrated sulfuric acid was added with a graduated cylinder, very carefully on the edge of the flask and was put in a water bath for half an hour and left to cool down, and the volume of the beaker was completed with distilled water and left until a clear solution is formed. 10 ml from the above solution was taken in a 50 ml flask, then 10 ml of orthophosphorous acid and 3 drops of the indicator were added and titrated against ferrous sulfate solution until the color changed from dark green to bright green.

2.2.8 Calcium carbonate

Five grams of soil were weighed in a 250 ml flask 50 ml of hydrochloric acid 0.5 N were added and the beaker was put in a water bath at a temperature of 50 to 60 degree Celsius. Two drops of Phenolphthalein indicator were added and titrated against sodium hydroxide 0.25 N until the color turned pink.

2.2.9 Total nitrogen

One gram of soil was weighed and placed in a 100 ml Kjeldhal flask, 2 g of the stimulating mixture was added to the Beaker 6 ml of concentrated sulfuric acid was added with a graduated cylinder, the digestion flask was put in the digestive system, and left for 2 to 3 hours and gradually increased with time, and when the color of the sample turns from black to blue, it reached the end of the stage. The contents of the beaker were transferred to the avail flask. The contents of the flask were poured into the distillation unit and 20 ml of sodium hydroxide was added. The ammonia was received in an Erlenmeyer flask containing 15 ml of boric acid, which had a red color and turns blue due to the formation of an ammonium borate. Calibrated against hydrochloric acid 0.1 N, then the color of boric acid returns to red, meaning it turns from blue to red.

2.2.10 Phosphorus

Five grams of soil were weighed in a plastic (vail) then 100 ml of a 0.5 N sodium bicarbonate solution was added, the vial was placed in a mechanical vibrator for half an hour, the solution was filtered using filter paper, 5 ml of the filtrate were taken in a 25 ml volumetric flask and then 5 ml of ammonium molybdate solution were added and 1 ml of Tin chloride (stannous chloride) and diluted with distilled water. The spectrophotometer was set at a wavelength of 660 nm. The absorbance of the device to the sample was measured with a quartz or silica cell and the reading was recorded.

3. RESULTS

Physical and chemical soil properties for two selected sites in Khartoum State (Umm Dom Island) and River Nile State (Al oteib area) were analyzed and the results were shown in Table 1.

3.1 Physical Properties

3.1.1 Particle size distribution: (Soil Texture)

The soil texture was determined using the soil texture triangle. The soil Texture of the Al Otieb area and Umm Dom Island were sand and sandy loam and were shown in Figs. 1 and 2.

The percentage of silt sand and clay in Al otieb area and Umm Dom Island were: 1.8%, 92.26%, 5.94% in Aloteib and 19.8%, 54.5%, 25.7% in Umm Dom Island.

3.2 Chemical Properties

3.2.1 Saturation percentage

Calculation of the saturation percentage by the volume of water added to the Paste the saturation ratio of Umm Dom Island sample was 62 % while in Al Oteib sample was 11.25 %.

3.2.2 pH

To measure the negative log of the hydrogen ion activity in the soil solution, a pH meter was used.

Table 1. Soil properties in the study areas Aloetib and Umm Domm Island

Soil parameter	Ca meg/L	Mg meg/L	Na meg/L	K meg/L	HCO_3 meg/L	CL meg/L	O.C%	O.M%	$CaCO_3$ meg/l	N %	P ppm	Clay%	Silt%	Sand%
Aloteib Soil	3.5	1.5	2.24	1.86	4	5.75	0.12	0.21	22.05	0.014	0.4	5.94	1.8	92.26
Umm Dum Soil	30.5	13.5	20.96	7.83	6.5	13	0.44	0.76	22.3	0.028	1.6	25.7	19.8	54.5

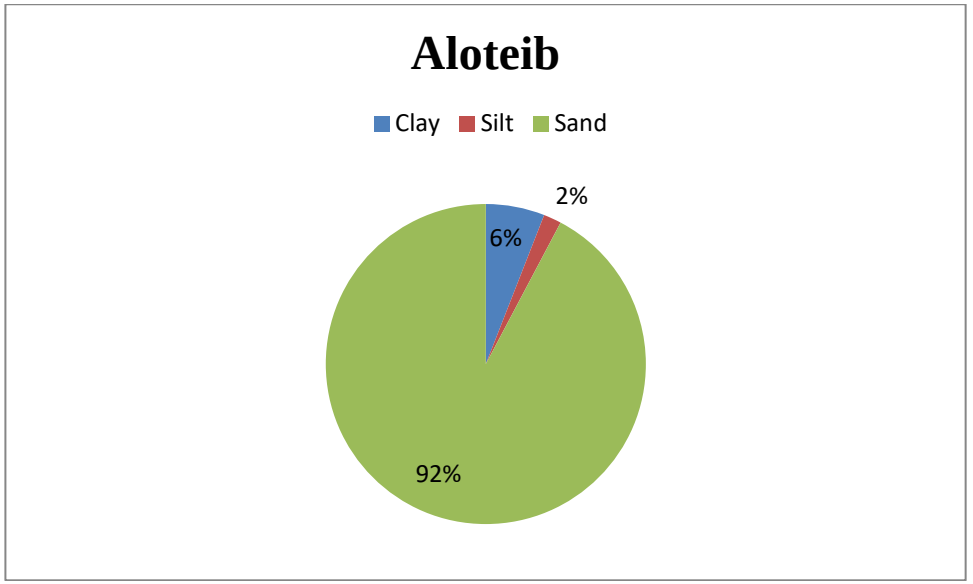

Fig. 1. The percentage of silt, sand, and clay in Al oteib area

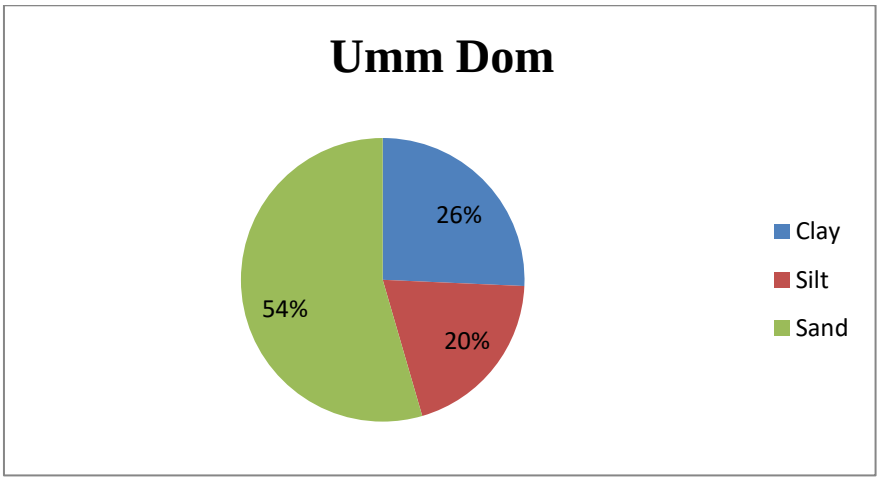

Fig. 2. The percentage of silt, sand, and clay in Umm Dom Island

pH = - Log H

Soils can be acidic, neutral, or alkaline: PH = 4,7,10

Al oteib soil was neutral pH was 7.24 Umm Dom Island soil was neutral pH was 7.27. Soil pH affects the number of nutrients and chemicals that are soluble in soil water.

3.2.3 Electrical conductivity

For measuring the concentration of soluble salts in the soil, the Electrical Conductivity meter was used.

Soil EC estimation for Al Otaib was non saline (0.7 ds/m) while Um Dom soil was moderately saline Ec (3.42 ds/m). EC affects crop yields, crop suitability, plant nutrient availability, and the activity of soil microorganisms.

3.2.4 Calcium and magnesium

The concentrations of soluble calcium and magnesium were calculated and the results showed that the concentrations of soluble Calcium in Al-Aoteib soil was low (3.5 meg/L) and the concentration of Magnesium was medium (1.5 meg/L)while in Umm Dom Island soil the concentrations of soluble Calcium were high (17meg/L) and high concentration of Magnesium (13.5 meg/L).

3.2.5 Sodium and potassium

The determination of the elements Sodium and Potassium by means of a flame photometer.

In Al-Aoteib soil the amount of Sodium were very low (2.24 meg/L) and high concentration of Potassium (1.86 meg/L), while in Umm Dom Island soil the amount of Sodium were very low (20.9meg/L) and there was excessive concentration of Potassium (7.83 meg/L). Sodium is not a plant nutrient and therefore is not necessary for plant growth. High levels of sodium are detrimental to soil tilth and plant growth. Sodium levels are evaluated based on Exchangeable. ESP values above 10 percent are of concern (Marx, 1999).

3.2.6 Bicarbonate, carbonates, and chloride

Carbonates in the soil solution often transformed into bicarbonate in the presence of water. The concentration of carbonate, bicarbonate in Al Aoteib was very low (4meg/L) and medium concentration of chloride (5.75meg/L). The concentration of carbonate and bicarbonate in Umm Dom Island were (6.5 meg/L), and high concentration of chloride (13 meg/L). Soil testing of chloride is not common practice.

3.2.7 Organic matter

Organic matter had low concentration in Al oteib area (0.2%) and desirable concentration in Umm Dom Island (0.76%) soil.

3.2.8 Calcium carbonate

The percentage of calcium carbonate was calculated result revealed that the Percentage of Calcium Carbonate was high and greater in Al-Aoteb (22.05%) than (22.3%) in Umm Dom Island.

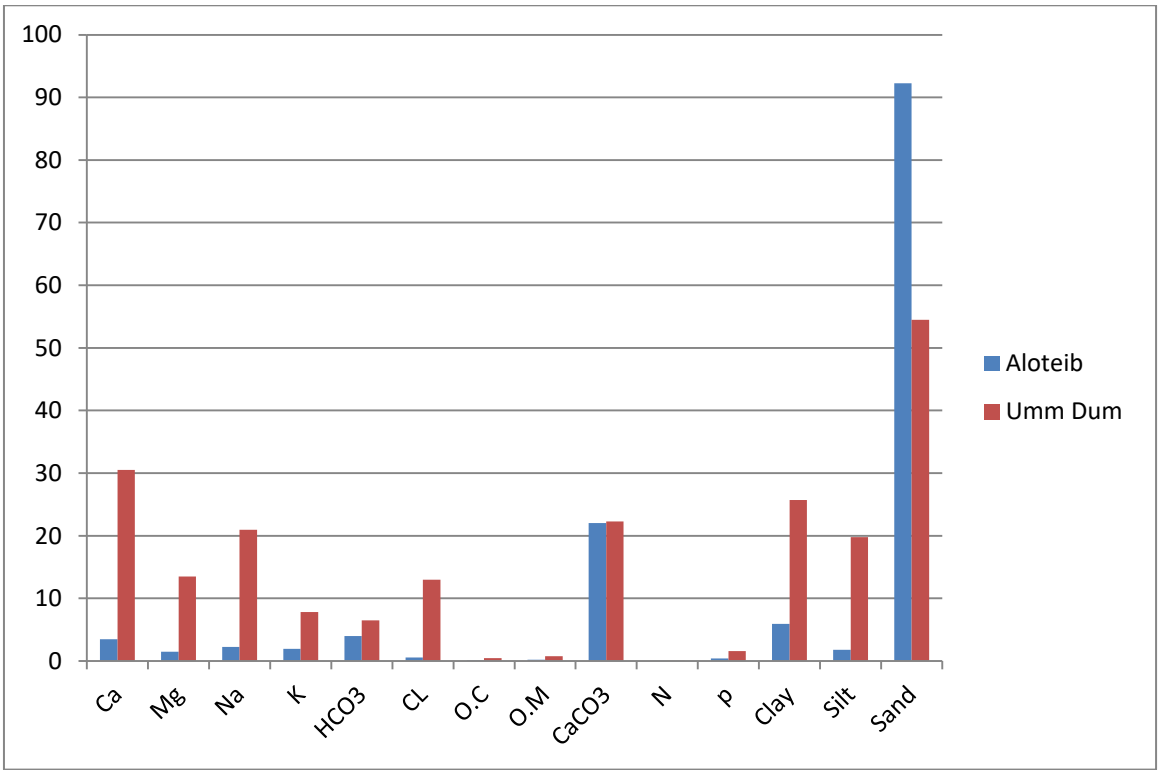

Fig. 3. Soil properties in the two sites of the study areas (The unit appears in the Table)

3.2.9 Total nitrogen

The percentage of Nitrogen was very low (0.014 %) and (0.028%). And greater in Umm Dom Island than Al-Aoteb area.

3.2.10 Phosphorus

The phosphors were read by a spectrophotometer at the wavelength of 660 nm result showed that the amount of Phosphorus was very low (0.4 ppm) in Al oteib and (1.6 ppm) in Umm Dom Island. All Chemical and Physical properties were demonstrated in Table 1 and Fig. 3.

4. DISCUSSION

In both the study areas Aloteib and Umm Dom Island the percentages of clay, silt and sand were (5.94%.1.8% and 92.26%) and (25.74%, 19.8% and 54.5%) respectively. Adam [10] studied the contemporary flood plain in Zalinge-Darfur, he found the soil texture is clay 8.43% and silt 7.3% and the texture class is Loamy sand. Many researchers studied the physical and chemical properties of different soil worldwide, Umeri, et al. [11] studied some sites in Nigeria, and they found that the texture of the soils varied from sand to loamy sand. The concentrations of (Ca) ranged from low to high (3.5 meg/L) and (17 meg/L) and the concentration of (Mg) ranged from medium to high (1.5 meg/L) and (13.5 meg/L). Magnesium deficiencies on acid soils can be corrected by liming with dolomitic lime. Magnesium toxicity can occur in serpentine soils. Calcium deficiency can be corrected by liming with calcium carbonate [12]. The amount of (Na) was very low (2.24 meg/L) and (20.9meg/L) and the concentration of (K) was high to excessive (1.86 meg/L) and (7.83 meg/L.) Sodium is not a plant nutrient and therefore is not necessary for plant growth. High levels of sodium are detrimental to soil tilth and plant growth. Sodium levels are evaluated based on Exchangeable. ESP values above 10 percent are of concern [12]. Both sites were carbonated (4 meg/L and 6.5 meg/L), the percentage of (O.M) was low (0.21%) to the desirable amount (0.76%) the concentration of $CaCO_3$ (22.05meg/L and 22.3meg/L) were very high. Total N% were (0.014% and 0.28%), and the available (P) were (0.4 ppm and 1.6 ppm) respectively. Mahdy and Mostafa [13] studied some soil properties of El-Qasr soils in Egypt, their results revealed that most of the soil texture varied from clay loam to sandy clay loam. The mean value of soil pH, electric conductivity (EC), saturation percentage

(SP), calcium carbonate (CaCO3), cation exchangeable capacity (CEC), organic matter (OM), and sodium adsorption ratio (SAR) were 7.89, 3.34 dSm-1, 52.10%, 7.46 %, 28.08 cmol (+) kg-1, and 3.65, respectively.

5. CONCLUSION

It can be concluded that both areas Umm Dom and Al oteib area were neutral and were bicarbonate and the amount of organic matter was low in both sites, the salinity of Um Dom was more than Al oteib area and the concentration of Calcium and Magnesium, Sodium and Potassium, Carbonate and Chloride, Total Nitrogen, and Phosphorus in Umm Dom Island were higher than Al oteib area while the amount of Calcium Carbonate and the sand percentage was greater in Al oteib area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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