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Physicochemical parameters of groundwater (Foggara) and sand dune (Timimoun) Algeria

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ABSTRACT

This work aims at the characterization of sand dune (Timimoun), which is found in considerable quantity in Algeria Western South, and studies the physicochemical quality of ground water (foggara), using for the drinking and irrigation. In order to perform a chemical analysis of the porous environment studied in summer to provide us with a qualitative and a quantitative information about the chemical composition of the sample, the results obtained show that the quartz (97%) is the most represented mineral, the oxides of aluminum, potassium, iron, chromium, and manganese, identified by the chemical analysis, probably enter in the clayey phase, the granulometric analysis permitted us to determine some parameters as the uniformity coefficient, equivalent diameter, and a comparison of the IR spectrum of the sand (washed and non washed) was achieved, and observations to the scanning electron microscopy and the X-ray analysis are also achieved. A part of this work is devoted to the follow-up of the absorbance of the filtrate at different lengths of waves; Erg sand of Timimoun presents favorable features for its use as being bed filtering in pretreatment. On the other hand, an analysis of ground water (foggara) of Timimoun in the south of Algeria noted Fi indicates that 50% of the samples had magnesium concentrations ($[Mg^{2+}] > 50\,mg/L$), 100% were sulfated, with sulfate ion concentrations exceeding the standard recommended by WHO ($[SO_4^{2-}] > 250\,mg/L$). Moreover, 75% excessive calcium concentrations, with $[Ca^{2+}] > 150\,mg/L$, translated by a strong conductivity of $4030\,\mu S/cm$.

Keywords: Sand (western Erg); Ground water (Foggara); Physicochemical parameters; (Timimoun) Algeria

1. Introduction

Sand filtration has been extensively studied [1–6]. In the basin of Timimoun (in the south of Algeria), the irrational exploitation of water and the use of irrigation system based on the immersion method involves many losses of water by infiltration joining the subjacent layers. Moreover, the discharges of wastewater in an anarchic way contribute considerably to the contamination of the groundwater and lead to the disruption of oasis ecosystems. The development of an alternative source of irrigation in replacement of groundwater would therefore contribute to the fossil

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water protection. The survey and the valorization of the Algerian Sahara sand dune constitute the objective of this work.

2. Materials and methods

The sand dune (Timimoun) sample was physically (Table 1) and chemically (Table 2) characterized. Mean diameter, CU, porosity, and permeability were considered for the physical characterization. In addition to pH and conductivity, oxides: Cr_2O_3, Fe_2O_3, Al_2O_3, K_2O, MnO, Na_2O, MgO, and SiO_2 contents were determined to characterize chemically sand of dune used.

The measured physical parameters for F1 (El ouajda), F2 (Allamellal), F3 (Tlalet) and F4 (Taoursite) Fig. 1, are the following: the pH, total dissolved salt (TDS), and the conductivity. The determined chemical parameters are as follows: calcium, magnesium, sulfates, chloride, nitrate, nitrite, bromine, iodine, zinc, manganese, and phosphates according to the techniques standard of analysis. The dosage methods [7] used are in presented the following:

- The pH, TDS, and the conductivity, potentiometer method (Consort 861).
- The volumetric analysis: it is applied to the quantitative analysis of the calcium and magnesium. The calcium and magnesium concentration of the samples are determined by titration complexometric, with the ethylenediaminotetraacetic acid disodium salt.
- The nitrates are measured by the potentiometer method (specific electrode).
- The spectrophotometers has been used for the dosage of the sulfates.
- Colorimetric for the determination of the content some: bromide, iodine, zinc, and manganese (Hanna HI 83200 multiparameter ion-specific meter).

Table 1
Physical characterization of the sand of dune

Equivalent diameter (mm)	Uniformity coefficient (CU)	Permeability 10^{-2} m/min	Mass volumetric (kg/m^3)	Porosity (%)
0.17	1.91	1.64	2.56	38.14

3. Results and discussion

3.1. Physicochemical characterization of Timimoun sand dune

The physical and chemical characteristics of the sand tested are presented in Tables 1 and 2, respectively. Their characterization confirmed their potential to be used as filtration media, since the equivalent diameter, the CU, the porosity, and the permeability were in the ranges 0.17 mm, 1.91, 38%, and 1.64×10^{-2} m/min, respectively, the saltiness is very weak represented by the conductivity that is of 157.7 μS/cm, the insoluble matter rate is of about 97% (composed essentially of quartz). The weak organic matters and the granular analysis show that that the soil is very.

The sand belongs to the fine category, and it is confirmed well by the weak porosity of 38.14%; this character is more or less thin of the sands and can be quantified also by the equivalent diameter observed by the scanning electron microscopy (SEM) (Fig. 2) and valued by the granular analysis. As in remark in the Table 1, the CU is well lower to 2, by convention, so of CU is consisted between 1 and 2, the granulometry is uniform [8–9].

Physical (Table 1) and chemical (Table 2) characterization of the sand dunes showed that the characteristics of sand used are close to those reported in the available literature [1,10].

The results (Table 2) show that quartz is the most represented mineral. When compared with the other elements, the oxide of calcium presents an important concentration (the presence of the calcite $CaCO_3$ recognized like soluble and that can conditioned the presence of Ca^{2+} in water).

The presence of the calcium oxide, iron, and aluminum oxides (Table 2) can be an indicator of the presence of FeO(OH), Fe_2O_3, and $Al(OH)_3$, which are recognized like being of the minerals of strong reactivity and having a strong adsorbent power on the phosphor [11]. The oxide of calcium very probably

Table 2
Chemical characterization (%) of the sand: STIL: Timimoun sand dune washed

	Cr_2O_3	Fe_2O_3	Al_2O_3	K_2O	Na_2O	MnO	CaO	MgO	SiO_2	pH	Conductivity (μS/cm)
STIL	0.004	0.17	0.16	0.01	0.009	00	1.004	0.016	97.11	6.8	157.7

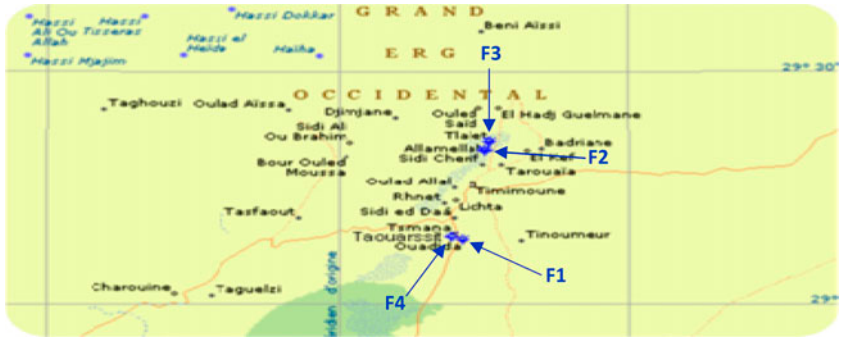

Fig. 1. Sites sampling of Timimoun.

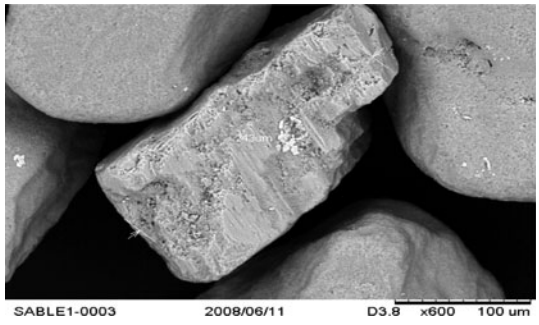

Fig 2. Observation to the SEM: Timimoun Sand dune.

presents the concentrations due to the presence of the calcite ($CaCO_3$).

3.1.1. IR spectrums of Timimoun sand dune

The infrared spectrums have been recorded by means of a spectrophotometer thermo Nicolet AVATAR 320 FTIR. In the analysis of the IR spectrum of the raw sand samples and after washing, Fig. 3 shows that some strips in the spectres of raw sample disappear or move after washing and that are bound

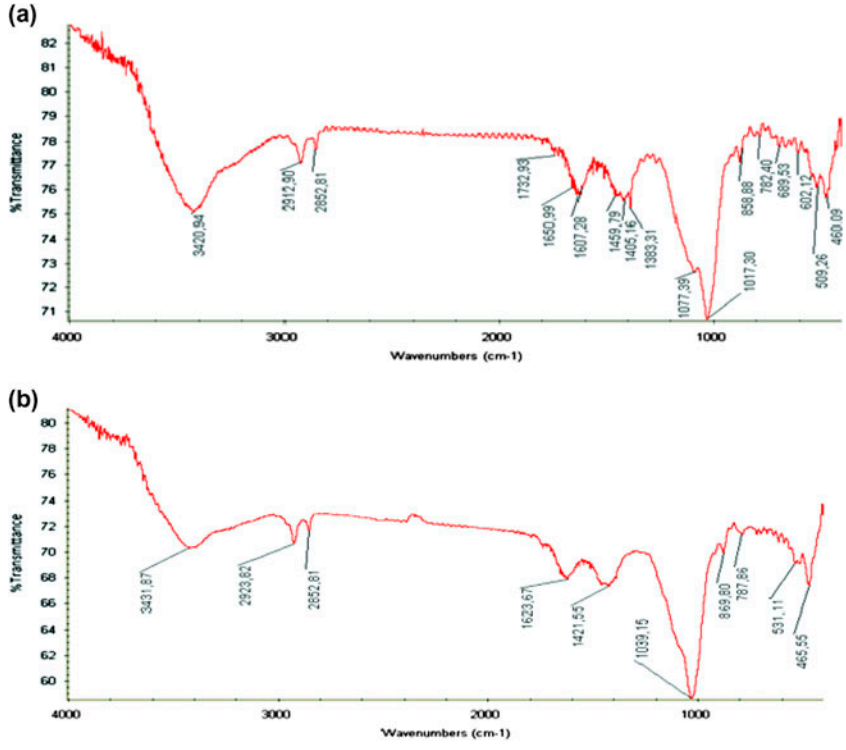

Fig 3. IR spectrum of Timimoun sand dune: (a) Sand no washed and (b) Sand washed.

probably to the presence of the foulness associated with the clay.

The strips 467, 698, 1,031 cm^{-1} and 755, 789 and 538 cm^{-1} is, respectively, characteristic to the vibration of the link Si–O and Si–O–Al of the kaolinite, and the strip 875 is characteristic to the vibration of CO_3 of the calcite [12]. One essentially discovers the following:

- The displacement of the strips 460–465 and 1,017–1,039 cm^{-1}as well as 782–787 $cm^{-1}$and 509–531 cm^{-1} between the sand nonwashed and washed.
- One clearly observes the reduction in the intensity of the picks of the strip 1,650 cm^{-1} (sand nonwashed) toward 1,623 cm^{-1} (sand washed).

The results obtained by this analytic technique confirm those obtained by X fluorescence, and indeed, the present majority phases in the sand of Timimoun are the calcite ($CaCO_3$) and the kaolinite (Al_2O_3 $2SiO_2$ $2H_2O$).

3.1.2. X-ray analysis of Timimoun sand dune

Chemical analysis of the sample shows that the SiO_2 (97%) is the mineral most represented confirmed by X-ray analysis (Fig. 4).

3.1.3. Absorbance of the filtrates after passage on the Timimoun sand dune

The time of washing of the sand dune (Fig. 5), lasted 95 min, the reduction in the absorbance according to the time of washing for all wavelength (λ) used, the maximum value of the absorbance places in the ultraviolet domains that been of 0.108 for $\lambda = 200$ nm. A less important absorbance is observed in the domain of the visible 0.010 for $\lambda = 860$ and 900 nm for the first filtrate (AbsF1).

The observations to the misses: 80×, Fig. 6 of the top of the sand after the passage of the washing water clearly shows that washing took place.

3.2. Ground water (Foggara) analysis

3.2.1. Physicochemical Analysis of Timimoun ground waters

The analyses show that the Foggara waters (F_1, F_2, F_3 and F_4) contain variable concentrations in mineral substances translated by a strong conductivity of 4,030 µS/cm and with maximal contents for them (04) samples analyzed Fig. 1: 39.43 mg/l nitrates, 6 mg/l nitrite, 1,614 mg/l chlorides, 889.89 mg/l sulfates 252 mg/l Ca^{2+}, and 75.6 mg/lMg^{2+}, 2.7 mg/l phosphates, 0.3 mg/l phosphor, 1.1 mg/l iodine, 0.44 bromine mg/l, the analyzed ground waters prove to be globally enough loaded and constitute a true threat for the environment since they are used for the irrigation from where the phenomenon of gone back up it of salts is very likely. The term foggara designates an ground gallery that consists drained the waters of the aquiferous tablecloth of the tray toward the irrigated lands situated in the depression. The foggara is composed of several wells with variable depths united to their bases by a gallery, that is, characterized by variable geometric measurements of a region to the other next one the nature of the lands. The foggara drains the tablecloth of water thanks to the difference of pressure that exists between the draining gallery and the surface of the aquiferous tablecloth and that

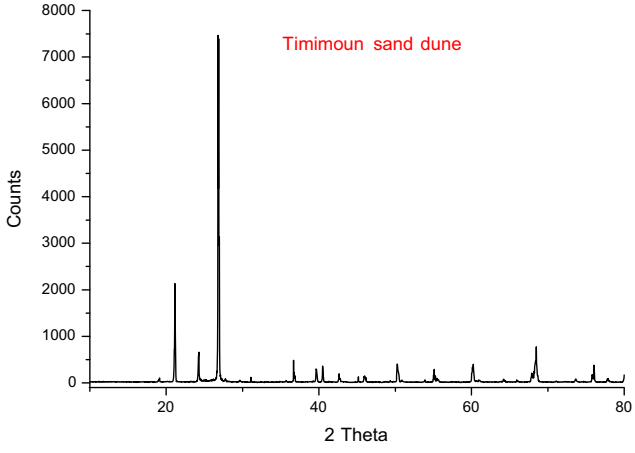

Fig 4. X-ray spectrum of Timimoun sand dune.

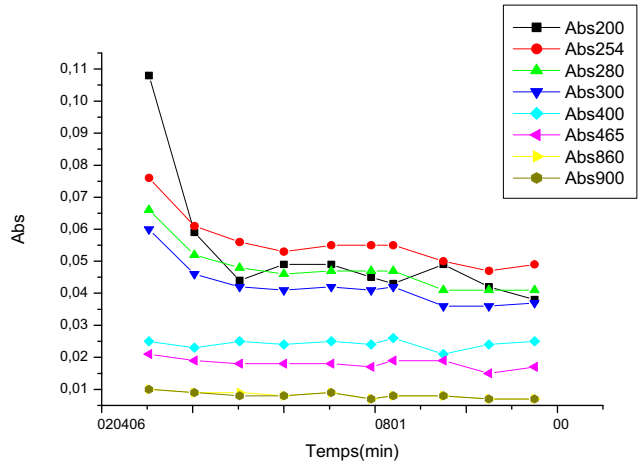

Fig 5. Evolution of the absorbance to different lengths of waves according to the time of washing.

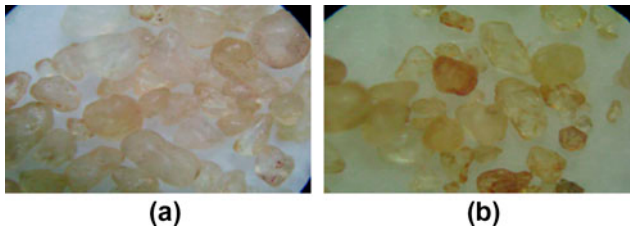

Fig 6. Observations to the misses: x 80, photo of the top Timimoun sand dune (a) washed and (b) no washed.

Fig 7. Description of the foggara.

the drained debit is proportional to the height folded back of the water tablecloth (Fig. 7).

3.2.2. Graphic representations

Diagram of schoeller-berkaloff and Stiff: All chemical analyses of F_i water samples have been represented by means of Schoeller-Berkaloff and Stiff diagrams.

3.2.3. Characteristic ratios

The physical–chemical analyses allow to realize, the exploitation of the ratio that can be an indicator of the quality of water, the study of the characteristic ratio most current in hydro geochemistry allows to specify the groundwater provenance environment and to compare their chemical concentration [13].

Calculations and comparisons of the analyses are facilitated by transforming the weights into milliequivalents and which will be indicated by the letter "r" preceding the chemical symbol.

- "$\mathbf{rMg^{2+}/rCa^{2+}}$" Ratios

This fraction is lower to 1 for 100% of water analyzed; it shows a concentration raised of the calcium, if we refer to the precedent results 75% of the total number of water analyses ($N = 4$) is chlorinated calcic and 25% sulfated calcic, the calcium can be due to the dissolution of rocks that can freed the calcium as the calcite ($CaCO_3$), gypsum ($CaSO_4$) what makes that the waters of foggara of Timimoun are more calcic than mangnesiennes. The content of Ca^{2+} is superior to 250 mg/l.

- "$\mathbf{rSO_4^{2-}/rCl^{-}}$" Ratios

The chemical analyses show the analyzed samples are chlorinated the concentration passes 1,600 mg/l and the one of the sulfate passes 800 mg/l, this fraction is lower to 1 for 75% of water analyzed, what determines the predominance of the chlorides on the

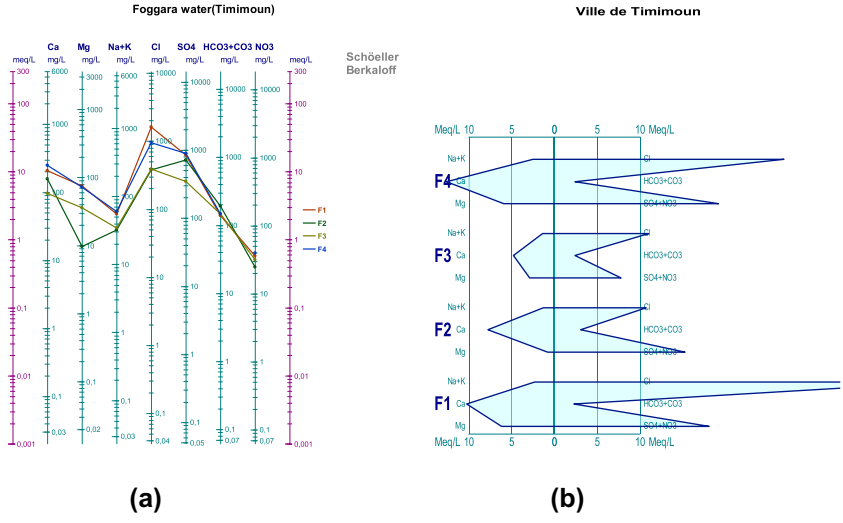

Fig 8. Diagram of (a) Schoeller and (b) Stiff for (Fi).

sulfates thing confirmed in the ordering of Stiff and Schoeller that can be explained by the washing of the lands marnogypsiféres.

- "$\mathbf{rNa^+/rCl^-}$"Ratios

This fraction is lower to 1 for all the samples of water analyzed and confirmed by the fraction $\mathbf{rSO_4^{2-}/rCl^-}$. It can be explain by the deposit of salts under conditions climatic (weak pluviometer and important concentration in salts) and again by the clayey land washing by the rainwaters (Fig. 8).

4. Conclusion

The chemical analysis of the sand contains 97% of SiO_2, considered as being the insoluble part and a nonnegligible part of CaO, Al_2O_3 and Fe_2O_3, confirmed by IR analysis, and the results obtained by this analytic technique confirms those obtained by X fluorescence and X-ray analysis; indeed, the present majority phases in the sand are the calcite ($CaCO_3$) and the kaolinite (Al_2O_3 $2SiO_2$ $2H_2O$).

The different content comparison made for the analyzed waters (Foggara) to the admissible maximal values fixed by WHO permits to conclude that according to the contents, oscillating for the phosphate for (1.2–2.7 mg/l), the nitrites for (0–6 mg/l), the chlorides for (380–1614 mg/l), the sulfate for (347.99–889.98 mg/l), the calcium for (96–252 mg/l), the magnesium for (9.6–75.6 mg/l), and the contents made of manganese of all recorded studied waters pass the maximal limits fixed by (WHO), let us note an important conductivity reaching a maximum is 4,030 μS/cm, these waters are charged compared too much to the norms.

The concentrations of zinc recorded are lower to the norms fixed for the drinking [14] and the irrigation [14].

The contents in observed nitrate are lower to the fixed norms by (WHO); the maximum is of 39.43 mg/l. The bromine and the iodine present a maximum of 0.44 and 1.1 mg/l, respectively.

Erg sand studied presents favorable features for its use as being bed filtering in pretreatment, we dress that a treatment (washing) sand can improve its performances seen the results gotten in this work.

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