



Water physico-chemical properties of the Khafjee and Jubail Sabkhas, Eastern Saudi Arabia

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Article published on October 19, 2018

Key words: Sabkhas , Water, Electrical conductivity, Total Dissolved Salts.

Abstract

The present study deals with the physico-chemical characteristics of the water samples from Khafjee and Jubail sabkhas, Eastern Saudi Arabia. 20 samples were collected and analyzed. The values obtained were compared with values recommended in water quality standards by WHO. Water quality parameters such as pH, EC, TDS, D.O, turbidity and temperature in correlation with Sodium, Potassium, Calcium, Chlorides, Sulfates , Phosphates and Nitrates were analyzed. The results of Khafjee water show that the PH of water around the allowable WHO range of 7.85. Electrical conductivity (EC) of the water samples were in range from 5.54 to 143.9 $\mu\text{s}/\text{cm}$. The highest desirable level of EC at 25 C is 750 $\mu\text{s}/\text{cm}$ (SLS,1983). Total dissolved solids (TDS) were in range of 3552 to 92096 mg/L. These values exceeded the maximum allowable limit of 250 mg/L for drinking water (WHO,1997). The presence of high amount of inorganic materials might have attributed for highest values of TDS in the water sampled. The turbidity values were ranged from 0.75 to 3.09 NTU at the water sampled. The Chloride value exceeded the maximum allowable limit at < 250 mg/L. All Phosphates and Nitrates concentrations in the water samples were within the permissible limits (< 250 mg/L) whereas Sulfates concentrations exceeded the allowable limit. The results of the Jubail water show that the PH of water samples range from 7.70 to 7.85. The PH remains within the allowable WHO range of 7.85. Electrical conductivity (EC) of the water samples were in range from 5.21 to 5.67 $\mu\text{s}/\text{cm}$. The highest desirable level of EC at 25 C is 750 $\mu\text{s}/\text{cm}$. The EC remains within the allowable SLS limit (SLS,1983). Total Dissolved Solids (TDS) were in range of 3334.4 to 3628.8mg/L, these values exceeded the maximum allowable limit of 250 mg/L for drinking water (WHO,1996). The Turbidity values were ranged from 0.74 to 19.7 NTU at the water sampled. The chloride value exceeded the maximum allowable limit at < 250 mg/L. All Phosphates and Nitrates concentrations in the water samples were within the permissible limits (< 250 mg/L) whereas Sulfates concentrations exceeded the allowable limit.

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Introduction

Sabkha is an Arabic term which is widely used nowadays to describe the coastal and inland saline flats or play as built up by deposition of silt, clay, muddy sand and etolian sand, in shallow albeit and sometimes extensive depressions. The depositions are commonly saturated with brine and often are salt encrusted (Powers *et al.*, 1966). Originally the term was applied to both coastal and inland saline depressions in North Africa and the Middle East, such as the salt-encrusted, supra tidal flats of Abu Dhabi, along the Arabian Gulf (Christian *et al.*, 1957; Shearman, 1966).

The Sabkhas in Jubail essentially are near sea level, flat area of fine grained soils, partially cemented by salt (Sodium Chloride) and Calcium Sulfates. Very little Carbonate was found. The rest of the site was covered by sand dunes, which further inland, reached a height of 30 m (James and Little, 1994). Saudi Arabia has a hot-dry climate and is classified as an arid region occupying about 5% of the world's arid zone (Bashour *et al.*, 1983). Relative humidity is low except along the coastal zone where it sometimes reaches 100%.

The average annual temperature is 33°C in summer and 14°C in winter with a wide seasonal and diurnal variation (48°C) (El-Khatib, 1980). The mean solar radiation was recorded as 550 cal cm^{-2} day $^{-1}$ for the months of July and August; and 325 cal cm^{-2} day $^{-1}$ for the months of December and January in the Riyadh region (Water Resources Department, Ministry of Agriculture and Water, 1988). The rate of pan-evaporation was lower along the coastal and high terrain and higher in the interior mainly due to a high presence of desert conditions.

The monthly evaporation rates were 540 mm in July at Hail at 988 m elevation, 270 mm in Biljurshi at 2,400 m elevation, and 310 mm in Qatif at 5 m elevation. The rainfall Variations between the years are very high. The physic-chemical parameters are considered as the most important principles in the identification of the nature, quality and type of the water for any aquatic ecosystem.

Materials and methods

Study area and sampling method

Water samples (n=20) were collected in well cleaned autoclaved bottles from Khafjee and Jubail sabkhas in Eastern Saudi Arabia , which are : Khafee latitude 28 24 and 59 99 N and longitude 48 29 and 59 99 E; Jubail latitude 27 00 and 40 39 N and 49 39 and 29 70E The collected water samples were subjected to physic-chemical analysis using standard methods. Electrical conductivity, temperature, Total Dissolved Solids (TDS) and PH were measured immediately after collection and then, the samples were immediately transferred to the laboratory and stored at temperature below 4 C for the analysis of the other parameters.

Analytical methods

Water characteristics parameters such as PH, EC and TDS were measured at the site using digital PH/EC/TDS Meter (Model HI 98130). Spectrophotometer (HACH 2010) was used to measure Nitrate and Phosphate.

Results and discussion

The results of the analysis were summarized in the Table 1 and compared with WHO levels. In order to test the degree of association between minerals and salts content and some physic-chemical parameters (such as PH, EC, TDS, D.O., turbidity and temperature) in Khafjee and Jubail water samples, a Pearson's correlation was carried out. Correlation coefficient (r) was used for the investigation of statistical significant correlation at level for < 0.05 (Tables 2 and 3).

Water characteristics of Khafjee water samples

The results show that the PH of water samples range from 7.77 to 7.99. The PH remains around the allowable WHO range of 7.85. Electrical conductivity (EC) of the water samples were in range from 5.54 to 143.9 $\mu\text{s}/\text{cm}$. The highest desirable level of EC at 25 C is 750 $\mu\text{s}/\text{cm}$ (SLS, 1983). Total dissolved solids (TDS) were in range of 3552 to 92096 mg/L.

Table 1. Water Chemical constituents of Khafjee and Jubail sabkhas (mean+SE).

Parameter	Khafjee water sample	Jubail water sample
Temperature	21.25±0.06	21.02±0.16
pH	7.9±0.02	7.779±0.06
EC	30.19±14.47	5.551±0.04
Salinity(Ec×.64)	(19.32±9.26)	(3.552±.0256)
TDS	19320.96±9259.14	3552.64±25.38
D.O	4.67±0.31	4.78±0.12
Turbidity	1.514±0.26	3.281±1.84
Sodium ions(mg/l)	5912.8±3144.99	782.2±9.13
Potassium ions(mg/l)	357.6±195.19	49.3±0.94
Calcium ions(mg/l)	462.8±215.38	122.8±0.53
Chlorides(mg/l)	10374.8±5149.25	1545.7±16.54
Sulfates(mg/l)	1567.3±551.05	552.8±4.60
Phosphates(mg/l)	0.209±0.005	0.194±0.005
Nitrates(mg/l)	1.383±0.32	0.96±0.12

These values exceeded the maximum allowable limit of 250 mg/L for drinking water (WHO,1997). The presence of high amount of inorganic materials might have attributed for highest values of TDS in the water sampled. Temperature varied from 20.9 to 21.5 C. The turbidity values were ranged from 0.75 to 3.09 NTU at the water sampled. The minimum value 1496 mg/L of chloride was observed. The Chloride value exceeded the maximum allowable limit at < 250 mg/L.

All Phosphates and Nitrates concentrations in the water samples were within the permissible limits (< 250 mg/L) whereas Sulfates concentrations exceeded the allowable limit. PH was positively correlated with Na, K, Ca, Chloride , Sulfate, Phosphate and Nitrate. EC, TDS and temperature were positively correlated with all tested minerals and salts parameters except Phosphates. D.O and turbidity were negatively correlated with Na, K, Ca , Chlorides , Nitrate and Sulfates.

Table 2. Pearson's correlation coefficients for selected physic-chemical parameters of Khafjee water sample.

	Na	K	Ca	Chloride	Sulphate	Phosphate	Nitrate
pH	0.4621	0.4252	0.4286	0.5235	0.6439	0.3043	0.6352
EC	0.9978	0.9933	0.9938	0.9999	0.9811	-0.1342	0.9636
TDS	0.9978	0.9933	0.9938	0.9999	0.9811	-0.1342	0.9636
D.O	-0.8547	-0.8384	-0.8402	-0.877	-0.9042	0.1702	-0.8629
Turbidity	-0.0187	-0.0291	-0.0282	-0.0037	0.0279	0.0616	-0.0015
Temp.	0.4045	0.3985	0.3986	0.4197	0.4381	-0.2359	0.4693

Water characteristics of Jubail water samples

The results show that the PH of water samples range from 7.70 to 7.85. The PH remains within the allowable WHO range of 7.85. Electrical conductivity (EC) of the water samples were in range from 5.21 to 5.67 µs/cm. The highest desirable level of EC at 25 C is 750 µs/cm. The EC remains within the allowable SLS limit (SLS,1983).

Total Dissolved Solids (TDS) were in range of 3334.4 to 3628.8. These values exceeded the maximum allowable limit of 250 mg/L for drinking water (WHO, 1996). Temperature varied from 20.4 to 21.2 C. The turbidity values were ranged from 0.74 to 19.7 NTU at the water sampled. The minimum value 1490 mg/L of Chloride was observed. The Chloride value exceeded the maximum allowable limit at < 250 mg/L.

Table 3. Pearson s correlation coefficients for selected physic-chemical parameters of Jubail water sample.

	Na	K	Ca	Chloride	Sulfate	Phosphate	Nitrate
PH	-0.8078	-0.6623	-0.03901	-0.7759	-0.4684	0.1796	-0.1002
EC	0.081	0.1328	0.3899	-0.6009	-0.2889	-0.0645	0.3734
TDS	0.081	0.1328	0.3899	-0.6009	-0.2889	-0.0645	0.3734
D.O	-0.3038	-0.1165	-0.1337	-0.0266	-0.5083	-0.4306	-0.9158
Turbidity	0.3331	0.1939	0.2478	0.126	0.6111	0.4599	0.9041
Temp.	-0.602	-0.5926	-0.3948	-0.1455	-0.0891	-0.1699	-0.6173

All Phosphates and Nitrates concentrations in the water samples were within the permissible limits (< 250 mg/L) whereas Sulfates concentrations exceeded the allowable limit.

TDS were positively correlated with Na, K, Ca, and Nitrate. Turbidity was positively correlated with all tested minerals and salts parameters, while temperature and D.O were negatively correlated with all tested parameters.

PH was positively correlated with phosphate. EC and

Table 4. The results of the study done on the Sea water in Gulf Coast, Eastern Province, Saudi Arabia (Sadiq, 1992;).

Parameters	
PH	8.1
Salinity (g/l)	35
Calcium (g/l)	0.41
Magnesium (g/l)	1.28
Sodium (g/l)	10.76
Potassium (g/l)	0.4
Bicarbonate	0.14
Chloride (g/l)	19.35
Sulfate (g/l)	2.71

According to Table (1) it is clearly observed major cations were Na+ <Ca++ <K+ and all samples exceeded the desirable limit of WHO for drinking water (except K+ in Jubail water sample).

from 0.1 -0.5. Water salinity is also defined by EC. The WHO recommends that the chloride concentration of the water supply for human consumption should not exceed 250 mg/L.

The abundance of the major anions is Cl- < SO4-2 < NO3- < PO4-3 and all of the samples exceeded the desirable limit of WHO for drinking water (WHO, 2011).

Salinization is a global environmental phenomenon that affects many different aspects of our life (Williams, 2001); changing the chemical composition of natural water resources , degrading the quality of water supplying to the domestic and agriculture sectors, contribution to lose of biodiversity, loss of fertile soil, changing of local climatic conditions, and creating severe health problems (Tek, 2003).

Salinity in water is usually defined by the Chloride content or total dissolved solids content, although the Chloride comprises only a fraction of the total dissolved salts in water. The Cl-/TDS ration varies

The relation between salinity and electrical conductivity was shown in the equation (the salinity in gm λ = EC \times .64). The comparison between the results of (Sadiq, 1992) and the present study showed

that salinity values were more in Sadiq study (35gm/l) while in our study it was (19.32 \pm 9.26gm/l) in Khafjee and (3. 552 \pm .0256gm/l) in Jubail.

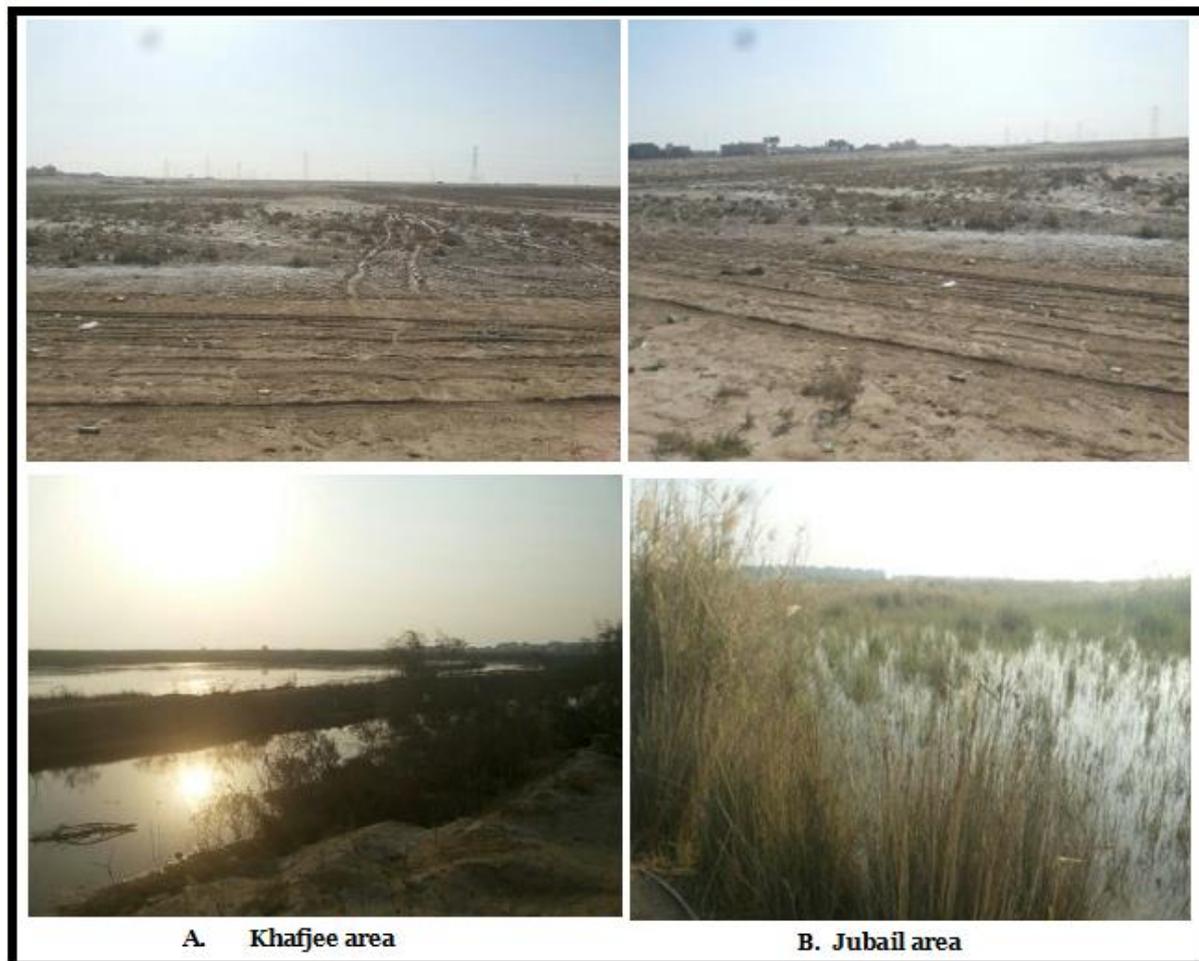


Fig. 1. Marking

Conclusion

The physic-chemical analysis of water from Khafjee and Jubail sabkhas, Eastern Saudi Arabia shows a very high concentration of salts. These high concentrations of salts give rise to a very corrosive environment.

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