

An Investigation of Ground Water Resources Quality in Sistan and Baluchistan Province, 2015

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Abstract

Sistan and Baluchistan province with an area of 187,500 km², accounts for 11.4% of the total area of the country as the biggest province. Considering the population density, it is one of the lowest populated provinces in Iran. Quality of the ground water is determined by its chemical, physical, and biological properties. Since chemical elements play a significant role in the type and amount of the usage of these resources, in this work, it's been aimed to determine and interpret the dominant type of water and critical points by measuring the important and influential physical and chemical properties including the concentrations of sulfate, fluoride, calcium, chloride, magnesium, and sodium ions, as well as other physical and chemical parameter in 800 samples from different areas of the province in 2015. The final goal is to contribute to solving the current water crisis of the country by gaining the knowledge for better management of these water resources, now and in the future. The results demonstrated that, in all cities of the province, all parameters were within the limited range, except for sodium, which was revealed to be higher than the limited range in majority of the cities. Among these cities, the quality of the water in Zahedan and Chabahar was obtained to be comparatively worse. Furthermore, the dominant type in Sistan and Baluchistan province was detected to be sodium sulfate and then sodium bicarbonate.

Keywords: *Chemical elements, water quality, ground water, GIS, Sistan and Baluchistan*

Introduction

Preservation of water resources from contaminants is one of the significant

priorities for organizations dealing with water, due to the increasing need for water (1).

One of these contaminants includes the leakage and penetration of the contaminants resulted from human activities such as industrial activities into these ground water resources as well as penetration of salty waters (2).

In Iran, in particular in southern parts, water resources are severely exposed to the contaminants because of the presence of prevalent contamination sources including salty water of the vicinity lakes, agricultural return flow, and evaporation of shallow ground water (2). One of such areas is Sistan and Baluchistan province which is the biggest province of the country with an area of 187,500 km², forming 11.4% of the total area of the country (3). Considering the population density, it is one of the lowest populated provinces in the country. Statistical data show that, Sistan and Baluchistan is considered an arid and semi-arid province.

This, in fact, is confirmed by low rainfall, high temperatures, and high evaporation rate. There are no permanent rivers and streams in this area. Practically, from mid-spring on, majority of the surface streams dry out (4). Therefore, it is considered a region with poor surface water resources. Hence the major source of water supply in the region is ground water which are used through subterranean streams and wells (e.g., wells supplying the water of Zahedan and Zabol cities) (5).

Thus, due to the absence of permanent surface water, life and survival in this arid and desert region is tied to the presence or absence of groundwater resources. Quality of groundwater in the south and southwest regions is very convenient, however, as approaching to the north and northeastern regions, the amount of minerals in the water increase and the quality of the water descends (6).

Water quality has always been a concern as one of the most important characteristics of drinking water. Natural water reflects the properties of the soils and rocks it gets in contact with (7). Water quality is usually defined as water sampling and analysis of existing conditions. Chemical testing of

water may specify the existence of contamination in the past and present. Hence, to evaluate the drinkability of water for human and limit the consumption of harmful material as well as investigating the material affecting public acceptability of the water, certain predetermined criteria must be regulated and followed (4, 8).

For each of these parameters, standard values have been specified in Iran and in the world. The desired turbidity value in Iranian standard and the maximum allowable amount in Iranian and world standard are determined as $NTU \leq 1$ and $NTU \leq 5$, respectively. The desirable limit of pH in the Iranian national standard and the highest limit are 7-8.5 and 6.5-9, respectively. WHO standard regulates pH as ≤ 8 . Taste and odor thresholds for chlorine are 5 and 2 mg/L for distilled water, respectively. Majority of people will recognize the taste of chlorine or its products with concentrations below 5 mg/L. In fact, the taste of chlorine is recognizable in concentrations between 0.6 to 1 mg/L to most people, but has no detrimental effect. In Iran, the standard for highest limit of manganese (Mn), calcium (9), magnesium (Mg), and sodium (10) are determined as 0.5, 250, 50 and 200 mg/L, respectively (4).

Other chemical parameters include: fluorine: daily intake of fluoride depends on geographical region. If one's diet includes fish and tea, the exposure is in particular high through food. Exposure to fluoride in drinking water depends on the temperature, and as the temperature increases, the amount of fluoride in the water must be below 1.5 mg/L (3, 4). Nitrate and nitrite: In many water resources, especially groundwater resources, nitrate level increases as a result of agricultural activities. In Iran, the standard values for nitrate as NO₃ and nitrite as NO₂ are reported as 50 and 3 mg/L, respectively. Furthermore, due to simultaneous presence of nitrate and nitrite in drinking water, the sum of their concentrations is recommended not to exceed 1 mg/L, and each one of them should not be judged on itself (4, 10). Chloride: the high concentration of chloride results in a taste in drinking water.

The highest limit of taste for chloride anion depends on the type of the accompanying cation. This limit for sodium, calcium, and potassium salts of chloride is within 200 to 300 mg/L. There is not any health-based value regulated for it. In Iran, the maximum permitted level of chloride is reported as 400 mg/L on the basis of CL (4, 11). Sulfate: the presence of sulfate in drinking water may result in remarkable taste. Undesirable taste of the water varies with the nature of accompanying cation. The taste limit varies from 250 mg/L for sodium sulfate to 1000 mg/L for calcium sulfate. The unpleasant taste reaches down to the minimum amounts at values below 250 mg/L.

Considering the fact that, there are differences between magnesium and sulfate ions in terms of changing the taste and dyspeptic disorders, if the magnesium level exceeds 30 mg/L, the sulfate level must not exceed 250 mg/L. Sodium: the taste limit for sodium is 200 mg/L, and since it is not possible to draw certain conclusions for health effects of sodium, no guideline has been obtained (9-12). Total hardness: the public acceptance for water hardness varies in different societies.

The World Health Organization has not set any guideline values for water hardness causing adverse health effects (4, 12). Water with a hardness higher than 200 mg/L, could lead to mass precipitation in the distribution system and the excessive use of soap. On the other hand, water with a hardness of below 100 mg/L, will be highly corrosive to pipes. Total dissolved solids (TDS) and electrical conductivity (EC): TDS is a parameter strongly affecting the taste of drinking water. The water with a TDS of below 500 mg/L is considered an excellent drinking water.

A TDS of 500 to 1000 is considered alright and a value in between 1000 to 1500 is allowed for drinking, but water with a TDS value greater than 1,500 is not acceptable as drinking water. Electrical conductivity (EC) shows the ability to pass electrical current through water. This has the same characteristics as TDS. In Iranian standard, the maximum value of TDS is determined as 1500 mg/L. This value is 1000 mg/L

according to the standards of WHO. Iranian standards limit the total hardness of water to 500 mg/L, but WHO does not recommend any values (4, 13).

Considering the importance of the subject, not only in Iran, but also in all countries, national standards are regulated to preserve the health and welfare of the people in the society (13). To date, many studies have been conducted regarding the subject in different areas of the country (14, 15). In this regard, this study aimed to evaluate chemical parameters of drinking water resources of Sistan and Baluchistan province, and furthermore compare them with national standards.

Materials and Methods

This study was conducted for one year, during 2015. The study population, were ground water resources of cities of Sistan and Baluchistan province (Figure 1) and considering the diversity of these resources, random cluster sampling method was utilized for sampling.

The sampling took place from distribution network in the closest place to the resources, where water was extracted. Two samples were taken from each resource (within a week). A total number of 1600 samples (two times) were collected from different regions of Sistan and Baluchistan province which were selected by GIS software and using IDW (Inverse Distance Weighted). Two general types of experiments were performed including instrumental and titrimetric experiments.

The titrimetric experiments included temporary and permanent hardness, calcium and magnesium, alkalinity, sulfate and chloride, which were performed on the basis of the methods illustrated in water and wastewater experiments reference book (9). The total hardness, calcium and magnesium, titration with EDTA, alkalinity titration with hydrochloric acid or sulfuric acid 0.02 normal were measured according to the reference book. The chloride was measured by iodometric and silver nitrate methods.

As for the instrumental experiments, evaluation of EC and TDS took place using Aqualytic EC-meter model CD20 with

accuracy of 0.01, made in Germany. Turbidity was measured by a Hatch turbidity-meter model P2100 made in USA, with accuracy of 0.01. pH was measured using a Meterohm pH-meter model 654 made in Switzerland. All these instruments were found in Laboratory of Water and Wastewater Chemistry of School of Public Health, Zahedan Medical Sciences University. Evaluation of chlorine takes place through two o-Toluidine and DPD methods.

In this work, DPD was used to measure the chloride present in the samples, since o-toluidine is a carcinogenic method. Anions and cations were measured using a T80UV-Vis spectrophotometer and finally, the distribution of dominant elements in the province was drawn by the GIS system.



Figure 1: Locations of the cities of Sistan and Baluchistan province

Results and Discussion

As a strong solvent, water is found with various qualities in the nature. Since there may be a wide variety of materials in the water, some of which are harmful for humans and other livings, examination and testing drinking water is necessary for public health (16). Physicochemical experiments demonstrated that, majority of

the anions and cations found in the ground water resources of this province were below maximum desirable standards of drinking water during 1387-1388, and range within the permitted limit.

The average calcium ion in all cities was found to be below the limited level, however, the amount of this ion was determined to be greater than 250 mg/L in water resources of Soldan of Chabahar, Temin Bala, Domak, Rahmatabad of Zahedan, Katookan of Saravan, Zarabad of Konarak, which is higher than the standard range.

The average amount of chloride ions were found to within the permitted range in all the cities, except for water resources of Lar Bala, Gergrook, Lar Payin, Rigmalek, Kheyraabad, Rahmatabad, Sarjangal, garaghe, and Domak of Zadedan, Sabzgaz, Eftekharabad, Goharkooh, Chahshahi, and Akbarabad of Khash, Zarabadhian, of Konarak, Lad of Sarbaz, Chahan, of Nikshahr, Goharmili, katookan, Chad, Garsaman, Tozgi, Eskandasht, and Kalehook of Saravan, Sefidabe of Zahak, Saeidabad, Denev, Gonbad, Hoodian, Varan, param, Nokabad, and Machugasem of Iranshahr, Soldan, Zirdan dam, Kalkasan, and Zardbon of Chabahar which were calculated to be higher than 400 mg/L that is greater than the standard amount. The highest value of chloride was found in the water resource of Lar Bala of Zahedan. Average values for sulfate ion were found to be within the permitted range for all cities except for Konarak and Zahedan.

The water resource of Lar Bala of Zahedan found to contain the highest amount of sulfate with about 1500 mg/L, which was distinguished from rest of the cities. The average and even maximum acidity values were obtained to be within the permitted range for all cities.

The values of average turbidity, which is an important parameter in water treatment, were determined to be below the desirable amount in all cities during the year, except for Zahak. Other than Zahedan, average TDS values were also found to be within the desirable range and below 1500 mg/L.

Furthermore, considering the ground water resources, Zahedan with maximum of 40/6310, Ladiz excelled all in maximum values which were determined in other cities. Average values of sodium ion were greater than 200 mg/L, which lies outside the standard range for all cities other than Zahak, Sarbaz, Nikshahr. The maximum amount of sodium was found as 1236 mg/L in Lar Bala city of Zahedan.

The average value of magnesium ion was calculated to be below 50 mg/L, which is within the permitted range and the maximum value was observed in a village in Chabahar. The residual chlorine was obtained as zero in 85% of the places where the sampling from distribution networks took place. Considering the strategic position, immigration, and prevalence of

water-borne diseases, this is a highly important issue.

The values of fluoride also lie within the permitted range and below 0.8 mg/L. As a conclusion, it may be expressed that, significant chemical parameters of the water resources of Sistan and Baluchistan are not problematic from health point of view, however, due to low quality of the obtained water from underground resources, it has to be combined with other existing water resources to achieve the desirable standards, before consumption.

Table of all the investigated parameters are provided below as well as geographical distribution picture of chloride, sodium, sulfate, and calcium ions, in addition to hardness, TDS and type of the water in ground water resources of Sistan and Baluchistan using GIS software.

Table 1: Descriptive statistics parameters of the quality of groundwater resources for each city

Total number	800	Statistical amount of sodium (mg/L)				Statistical amount of magnesium (mg/L)				Statistical amount of residual chloride (unit)				Statistical amount of fluoride (mg/L)			
city	number	min	average	max	STDEV	min	average	max	STDEV	min	average	max	STDEV	min	average	max	STDEV
<u>Iranshahr</u>	106	40	318.69	1165	223.94	5.8	19.32	65.4	12.71	0	0.35	4	0.67	0.16	0.72	1.74	0.32
<u>Chabahar</u>	60	68	273.17	691	52.74	11.56	42.78	269.6	54.74	0	0	0	0	0.055	0.55	1.67	0.26
<u>Khash</u>	69	23	238.61	702	151.98	8.68	36.18	98.96	31.33	0	0.24	1.5	0.44	0.21	0.72	1.63	0.26
<u>Zahedan</u>	50	46	415.69	1228	295.30	13.92	46.71	125.40	34.47	0.3	0.89	1.5	0.21	0.27	0.89	1.64	0.34
<u>Zahedan-Zabol</u>	25	67	116.94	548	114.56	12.40	31.50	56.28	16.74	0	0.55	1.3	0.64	0.31	0.45	0.78	0.25
<u>Saravan</u>	210	06	216.17	619	128.64	5.12	28.85	65.84	17.60	0	0.20	2	0.35	0.21	0.56	1.3	0.24
<u>Sarbaz</u>	70	42	109.01	420	65.38	6.64	19.29	41.68	6.35	0	0.11	2	0.35	0.16	0.42	0.92	0.11
<u>Konarak</u>	35	190	239.76	320	59.69	12.44	31.37	119.92	31.59	0	0.14	1	0.26	0.23	0.56	0.72	0.18
<u>Nikshahr</u>	175	15	159.04	376	85.76	10.6	22.66	54.36	9.81	0	0.006	0.80	0.072	0.12	0.46	1.41	0.23

Table 2: Descriptive statistics parameters of the quality of groundwater resources for each city

Total number	800	Statistical amount of Ca^{+2} (mg/L)				Statistical amount of Mg^{+2} (mg/L)				Statistical amount of Cl^- (mg/L)				Statistical amount of SO_4^{+2} (mg/L)			
city	number	min	average	max	STDEV	min	average	max	STDEV	min	average	max	STDEV	min	average	max	STDEV
<u>Iranshahr</u>	106	40	318.69	1165	223.94	5.8	19.32	65.43	12.71	0	0.35	4	0.67	0.16	0.72	1.74	0.32
<u>Chabahar</u>	60	68	273.17	691	52.74	11.56	42.78	269.6	54.74	0	0	0	0	0.05	0.55	1.67	0.26
<u>Khash</u>	69	23	238.61	702	151.98	8.68	36.18	98.96	31.33	0	0.24	1.5	0.44	0.21	0.72	1.63	0.26
<u>Zahedan</u>	50	46	415.69	1228	295.30	13.92	46.71	125.40	34.74	0.3	0.89	1.5	0.21	0.27	0.89	1.64	0.34
<u>Zaha- zabol</u>	25	67	116.94	548	114.59	12.40	31.50	56.28	16.74	0	0.55	1.3	0.64	0.31	0.45	0.78	0.25
<u>Saravan</u>	210	6	216.17	619	128.64	5.12	28.85	65.84	17.6	0	0.20	2	0.35	0.21	0.56	1.3	0.24
<u>Sarbaz</u>	70	42	109.01	420	65.38	6.64	19.29	41.68	6.35	0	0.11	2	0.35	0.16	0.42	0.92	0.11
<u>Konarak</u>	45	190	239.34	320	59.69	12.44	31.37	119.32	31.59	0	0.14	1	0.26	0.23	0.56	0.72	0.18
<u>nikshahr</u>	175	15	159.04	376	85.76	10.6	22.66	54.32	9.81	0	0.006	0.80	0.072	0.12	0.46	1.41	0.23

Table 3: Descriptive statistics parameters of the quality of groundwater resources for each city

Total number	800	Statistical amount of Alkalinity (mg/L)				Statistical amount of pH				Statistical amount of TDS (mg/L)				Statistical amount of Turbidity (mg/L)			
City	number	min	average	max	STDEV	min	average	max	STDEV	min	average	max	STDEV	min	average	max	STDEV
<u>Iranshahr</u>	106	40	318.69	1165	223.94	5.8	19.23	65.23	12.71	0	0.35	4	0.67	0.16	0.72	1.74	0.32
<u>Chabahar</u>	60	68	273.17	691	52.74	11.56	42.78	269.6	54.74	0	0	0	0	0.05	0.55	1.67	0.26
<u>Khash</u>	69	23	238.61	702	151.98	8.86	36.18	98.96	31.33	0	0.24	1.5	0.44	0.21	0.72	1.63	0.26
<u>Zahedan</u>	50	46	415.69	1228	295.30	13.92	46.18	125.40	34.67	0.3	0.89	1.5	0.21	0.27	0.89	1.64	0.34
<u>Zaha- zabol</u>	25	67	116.69	548	114.56	12.40	31.50	65.28	16.74	0	0.55	1.3	0.64	0.31	0.45	0.78	0.25
<u>Saravan</u>	210	6	216.17	619	128.64	5.12	28.85	65.84	17.60	0	0.20	2	0.35	0.21	0.56	1.3	0.24
<u>Sarbaz</u>	70	42	109.01	430	65.38	6.64	19.20	41.68	6.35	0	0.11	2	0.35	0.16	0.42	0.92	0.11
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<u>Nikshahr</u>	175	15	159.04	376	85.76	10.14	22.66	54.36	9.81	0	0.006	0.80	0.072	0.12	0.46	1.41	0.23

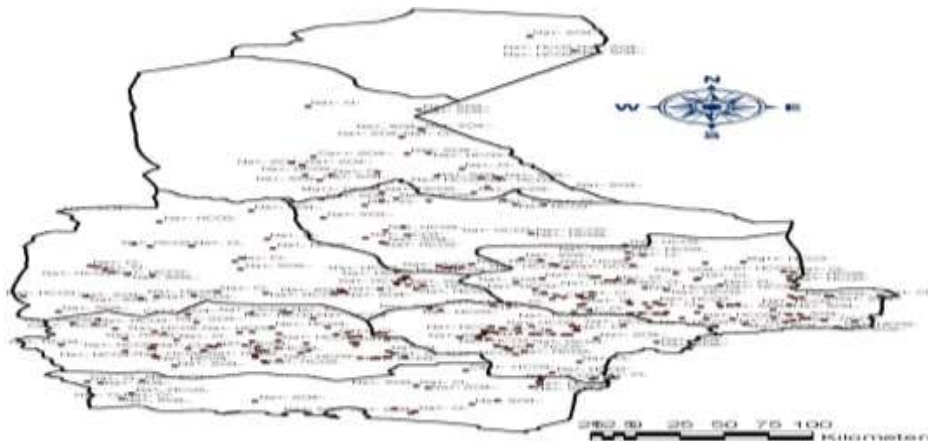


Fig 2: The quality of groundwater resources of Sistan and Baluchistan province on the basis of the biggest anions and cations

In this work, the qualities of ground water resources of Sistan and Baluchistan province were investigated in 2015.

The results demonstrated that, all parameters are within the permitted range in all cities of Sistan and Baluchistan province, except for sodium which was found to be greater than the permitted limit in majority of the cities. Among the studied cities, the quality of the ground water resources of Zahedan and Chabahar were found to be worse than the rest. Furthermore, the dominant types were determined to be sodium sulfate and then sodium bicarbonate in Sistan and Baluchistan. Considering the current situation of these underground resources of the cities, it is predicted that, their application is uncertain and they will be unusable in the future.

Conclusion

In this work, the dominant type of water and critical points by measuring the important and influential physical and chemical properties from different areas of the Sistan and Baluchistan province was investigated. the results demonstrated that, in all cities of the province, all parameters were within the limited range, except for sodium, which was revealed to be higher than the limited range in majority of the cities. Among these cities, the quality of the water in Zahedan and Chabahar was obtained to be comparatively worse. Furthermore, the dominant type in Sistan and Baluchistan province was detected to be sodium sulfate and then sodium bicarbonate.

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