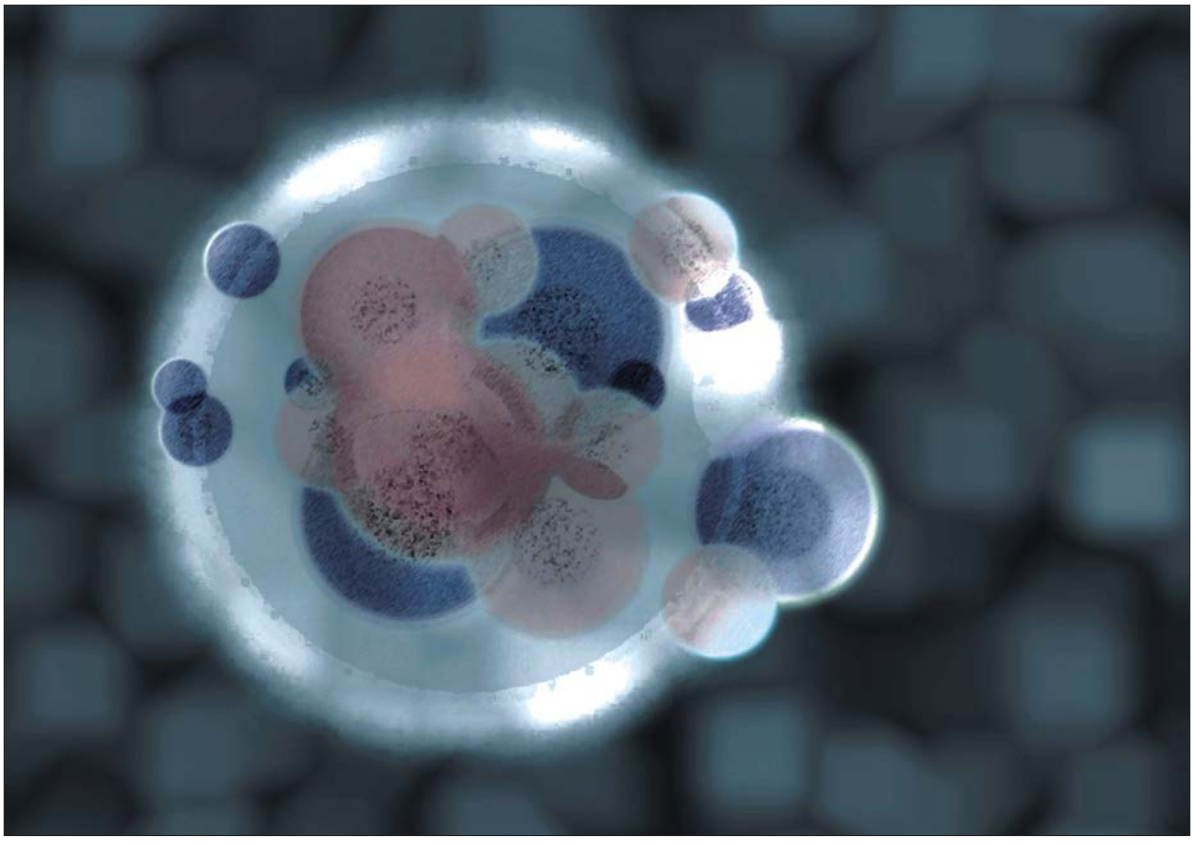

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Surface Water Suitability for Drinking Purpose in Cholistan Desert

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Abstract: The desert dwellers in Cholistan desert use surface water collected in natural depressions or dugout ponds 'Tobas' since the groundwater is brackish and not fit for human consumption especially for drinking purpose. The present study was conducted in cholistan desert to evaluate the quality of rainwater harvested in low lying areas or dugout ponds the only source of drinking water for humans as well as their livestock. Water samples were collected from 10 tobas of lesser Cholistan since most of the tobas were dried up due to the drought conditions. These samples were analyzed to quantify different parameters i.e. pH, H_T, TDS, Alkalinity, Ca, Mg, Na, K, Fe, Zn, Cd, Cr, Cu, Sr, Ni, Pb, Co, Cl, PO_4, SO_4, CO_3^{--}, HCO_3^{-} and NO_3 relating the water quality. The results showed that most of the parameters were found within the WHO recommended levels determining the suitability of this water for drinking purpose. However, Chemical Oxygen Demand (COD) concentration was found high indicating undesirable presence of organic matter. Higher concentration of Sr was found demanding future detailed study of drinking water in Cholistan.

Key words: Pollution, drinking water, brackish, rainwater, aeolian, alluvium

INTRODUCTION

The Cholistan desert, an extension of Great Indian Desert, is located in the southern part of the Punjab province between latitudes 27° 42' and 29° 45' north and longitude 69° 52' and 75° 24' east (Baig *et al.*, 1980 and Akbar, 1997). It comprises an area of about 2.6 million hectares (FAO, 1993 and Akbar *et al.*, 1996). The Cholistan desert has a length of about 480-km, while the width varies between 32 to 192 km (Khan, 1987 and Chaudhry, 1992). Based on the topography, parent material, soil and vegetation, the whole desert can be divided into two geomorphic regions. The northern region or Lesser Cholistan borders canal-fed irrigated areas and covers about 7770 km^2, while the southern region or Greater Cholistan is comprised of 18130 km^2 (Khan, 1987; Baig *et al.*, 1980; Ahmad *et al.*, 1992; Arshad and Rao, 1994). The Lesser Cholistan consists of saline alluvial flats (locally called 'Dahars'), alternating with low sandy ridges. The soils are classified as either saline or saline-sodic, with pH ranging from 8.8 to 8.4 and from 8.8 to 9.6, respectively (Khan, 1987; Baig *et al.*, 1980; Arshad and Rao, 1994).

The natural water deterioration is an emerging environmental issue throughout the world. The problem becomes more acute where natural pollutants are intensified by anthropogenic activities. Water is regarded as polluted when it becomes unfit for the given use or changed in its composition largely as a result of human activities and natural contamination. Cholistani people counting 1.2 million along with their about 300,000 animal heads are dependant on rainwater collected in tobas. Actually it is the scarcity of water that has made them nomads having no concept of quality in drinking water. They have only deepened their tobas and made 'Kunds' (dugout water tank) to raise the storage capacity of drinking water. The harvested rainwater carries different pollutants as soil particles, animal feces and decomposed plant material during runoff. The animal herds entering these tobas, to quench their thirst, pollute this water by adding their urine and feces. The desert dwellers, having no other choice, are forced to consume this unhygienic water at the cost of their health. Keeping in view this situation the present study was envisaged to check the quality of toba water in Cholistan desert by ascertaining the micro and macro elements.

Physiography and climate: Cholistan is a hot, arid and sandy desert. Annual rainfall is highly variable, both on temporal and spatial scales. The mean annual rainfall varies from less than 100 mm in the west to 200 mm in the east. Rain usually falls during monsoon (July through September) and in winter and spring (January through March) (Akbar *et al.*, 1996) (Fig. 2). Monsoon rains occur normally in heavy showers. The mean minimum and maximum temperatures being 20 and 40°C, respectively. The mean summer temperature is 34°C with high reaching nearly 51°C (Fig. 1). Aridity is the most striking feature of Cholistan desert with wet and dry years occurring in clusters.

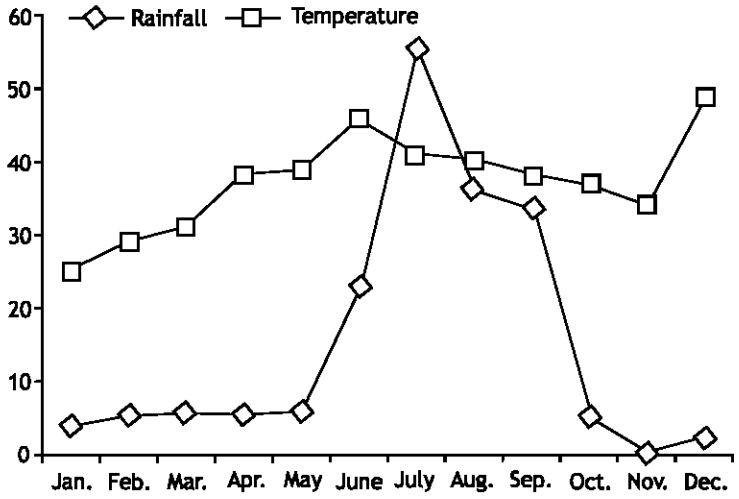

Fig. 1: Pattern of average rainfall (mm) and temperature (°C) in Cholistan desert

Geology and geomorphology: The Cholistan desert was formed predominantly by the deposition of aeolian sands or alluvial material. The source material for alluvial deposits was from the higher Himalayas containing granites, schists, gneises and slates. The soils in this desert are generally saline, alkaline and gypsiferrous. The dunes reach an average height of about 100 m (Baig *et al*., 1980; Anon, 1983; Baluch, 1983; Hashmi and Akram, 1984; Sanjrani *et al*., 1987; Mohammad, 1989; Abdullah *et al*., 1991; Bokhari, 1991; Rao and Arshad, 1991 and Akbar *et al*., 1996).This desert is a part of the Indo-Gangetic plain lying in a great tectonic trough originated in the mid-tertiary epoch as a result of upheaval of the Himalayas in the north and the concomitant receding of the sea in the south. The trough lying between the foothills of the Himalayan Mountains and the central core of the South-Asia was subsequently filled up with the thick mass of the alluvium derived from the Himalayas. The Indo-Gangetic system was responsible for this deposition resulting into a vast plain extending from Pakistan to Burma through India and Bangladesh. The deposition of this alluvium commenced after the final phase of the Siwalike (Middle Pleistocene) and continued all through the Pleistocene up to the recent (Wadia, 1966).

The northern part of the Cholistan desert was made of clayey alluvium, which was derived from the middle and lower Himalayas having predominantly calcareous sandstone, shales and clays. The central part of this desert was formed by sandy alluvium deposited by one or more of the eastern rivers i.e. Sutlej, Hakra and Sarswati. The source material was from the higher Himalayas containing gramites, schists, gneises and slates. The southern part was formed by aeolian sands transported inland from the Rann of Kutch and the western seacoast by the southwestern coastal winds. The debris of the Aravalli and its offshoots in Rajputana desert contributed a small portion of this sand. This sand is mainly comprised of rounded gains of quartz but feldspar and hornblende grains also occur alongwith a fair proportion of calcareous grains. (Wadia, 1966).

Hydrology: Detailed hydrogeological investigations have been carried by the WAPDA in 1986. According to the results of these investigations the groundwater occurs at a depth of 100 to more than 300 feet. The whole area is underlain by moderately to highly saline groundwater. The amount of TDS ranging from few hundreds to more than one thousand mg L^{-1} has been reported in the canal fed areas of Lesser Cholistan, more than 29000 mg L^{-1} has also been reported from Greater Cholistan (Muller and Ploethner, 1991). Generally the groundwater is saline however along the abandoned channel of river Hakra it is moderately saline that can be used for drinking purpose. Deprived of any perennial stream the entire area of this desert is rain dependent for its groundwater recharge and drinking water. The major source of fresh water is the rainwater harvested in the low-lying areas amongst the sandy ridges, locally called as 'Toba'. The sandy nature of the desert soils and irregular topography of the area leads to the collection of rainwater in the lower parts of these basins.

MATERIALS AND METHODS

The suitability of any drinking water depends upon the type and amount of some undesirable substances present therein. These undesirable substances are likely to harmfully affect the quality of water for the given use

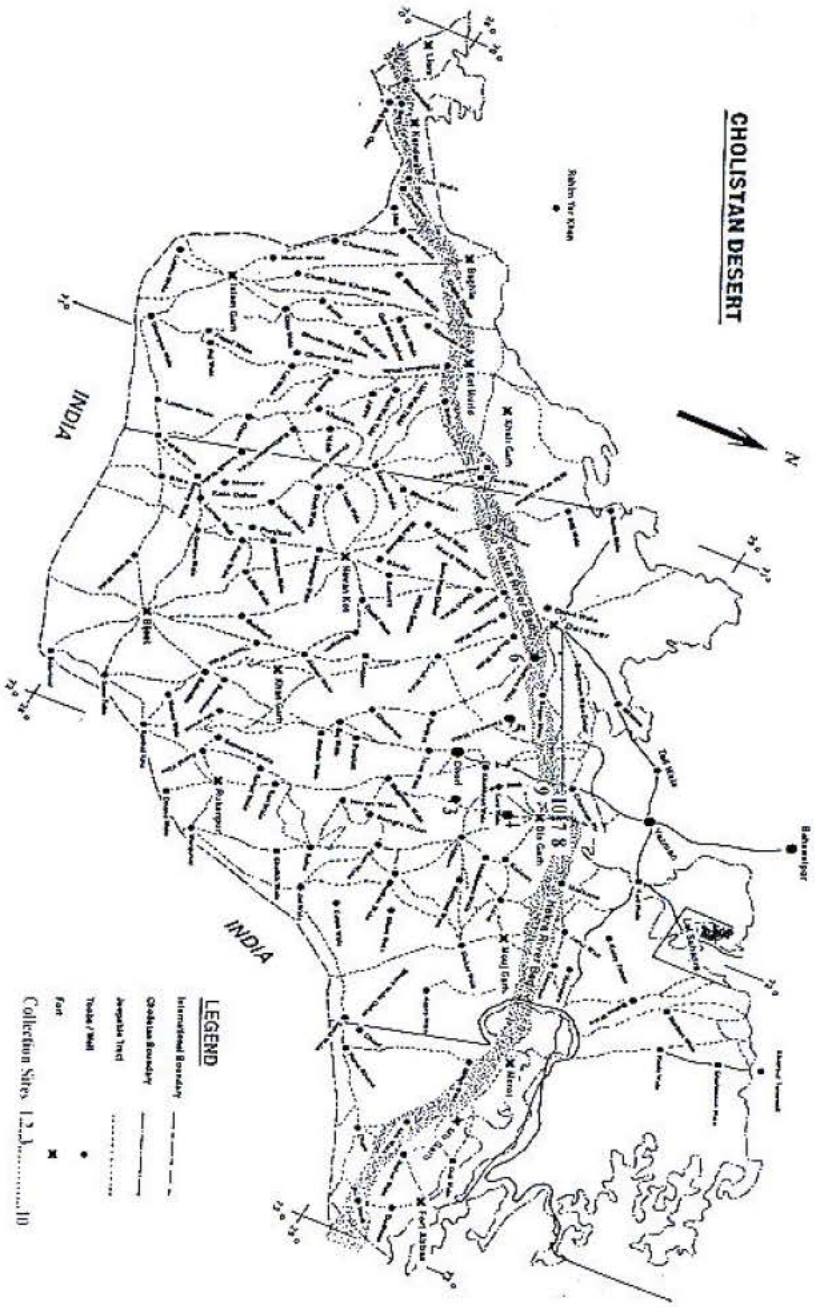

Fig. 2: Map of Cholistan showing the collection sites

as designated by pollution parameters. In the present study only the most important chemical parameters were considered for evaluating the suitability of this water for drinking purposes.

These parameters were compared with the given standards of World Health Organization and United States Environmental Protection Agency (WHO, 1993 and USEPA, 1975).

A preliminary survey was conducted to check the quality of the toba water in Cholistan desert and water samples from 10 different sites (Tobas) were collected (Fig. 2). The samples were collected in the plastic canes and standard methods were followed as per American Public Health Association, (Eaton *et al*., 1985). These samples were carried back to the laboratory of Cholistan Institute of Desert Studies, Islamia University

Bahawalpur. The samples were filtered and refrigerated prior to chemical analysis especially for Atomic Absorption Spectroscopy. The water samples were analyzed to determine the pH, alkalinity, hardness, TDS, Chemical Oxygen Demand (COD), silica, calcium, magnesium, sodium, potassium, Cd, Cr, Cu, Sr, Ni, Pb, Co, Fe, Zn, Cl, PO_4, SO_4, $CO_3^{=}$, HCO_3^{-} and NO_3. The pH and EC levels at 25°C were measured electrochemically immediately after collecting the samples following the standard method (Tandon, 1985). Alkalinity, hardness, TDS, COD, Cl, SO_4, PO_4, SiO_2, $CO_3^{=}$, HCO_3^{-} and NO_3 were determined by standard methods (Greenberg *et al*., 1985). Ca, Mg, Na, k, Fe, Zn, Cd, Cr, Cu, Sr, Ni, Pb, Co, were determined by standard methods of Atomic Absorption Spectroscopy (Marr and Cresser, 1983).

RESULTS AND DISCUSSION

The concentration of cations and anions and other computed parameters are incorporated in Table 1 to 3. It is evident from Table 1 that the concentration of Na was maximum i.e. (89.0 mg L^{-1}) in the sample collected from Trawaywala and Dingarh-4 while minimum concentration was noted i.e. 24.0 mg L^{-1} for Dadaywala sample. The high concentration of Na may be attributed to the presence of saline dahars in the catchment area of these "Tobas". The concentration of potassium was maximum (43.1 mg L^{-1}) in the water of Sawanwala toba and minimum (9.2 mg L^{-1}) at Dingarh-2 toba. Overall the concentration of Potassium was found low as compared to the Na concentration. The concentration of Ca was found maximum (76.5 mg L^{-1}) in the water collected from Kaniwala toba and minimum values (30.05 mg L^{-1}) in the sample collected from Dingarh-4. These values are well within the limits set by the WHO for drinking water. Maximum concentration (35.5 mg L^{-1}) of Mg was recorded at Nasuwala toba and minimum (14.0 mg L^{-1}) in the sample collected from Gadhenwala toba. The maximum value of Mg is close to the highest desirable limit given by the WHO. The concentration of Fe was maximum (2.0 mg L^{-1}) in Dingarh-3 sample and minimum (0.16 mg L^{-1}) in the water from Sawanwala toba. The maximum limit of Fe is almost two times high as compared to the maximum permissible limit set by the WHO. The exact reason is not known, however, it is being contributed by some natural source. Zinc concentrations, both maximum and minimum, were 0.05 and 0.01 mg L^{-1}, respectively and are quite within the limit prescribed by the WHO. The Sr concentration was found maximum (4.61 mg L^{-1}) in the Dingarh-3 water sample and minimum in the (0.40 mg L^{-1}) in the sample of Gadhenwala toba. Samples from Sawanwala and Dingarh-3 having Sr concentrations 2.06 and 4.61 mg L^{-1}, respectively were beyond the WHO recommended limit.

Table 1: Cation concentrations (mg L^{-1}) in toba water

Location	Ca	Mg	Na	K	Fe	Zn	Sr
Kaniwala	76.50	25.50	87.00	15.00	0.54	0.05	1.20
Tarawaywala	34.00	20.00	89.00	24.70	0.42	0.01	1.04
Khokhranwala	31.80	18.90	47.00	18.30	0.84	0.01	1.34
Gadhenwala	69.30	14.00	24.00	10.10	0.87	0.01	0.40
Nasuwala	49.50	35.60	39.00	09.30	0.36	0.01	0.68
Sawanwala	34.00	14.80	65.50	43.10	0.16	0.01	2.06
Dingarh -1	35.96	19.60	38.00	17.00	0.78	0.02	1.98
Dingarh-2	35.25	16.00	60.00	09.20	1.00	0.03	1.48
Dingarh-3	53.17	19.50	67.00	23.50	2.00	0.02	4.61
Dingarh-4	30.05	18.20	89.00	10.00	0.85	0.02	0.59
* LQD mg L^{-1}	00.10	00.05	00.01	00.05	0.05	0.05	0.10

Table 2: Anion concentrations (mg L^{-1}) in toba water

Location	HCO^{-}_3	NO_3	Cl	PO_4	SO_4	SiO_2
Kaniwala	409	27	031.95	5.60	0.57	4.40
Tarawaywala	403	32	124.25	8.40	0.69	9.40
Khokhranwala	391	22	026.62	5.45	0.95	3.60
Gadhenwala	348	50	105.97	6.20	1.25	3.25
Nasuwala	610	17	026.62	5.10	1.005	6.45
Sawanwala	470	51	035.50	4.00	0.95	7.80
Dingarh -1	671	27	028.40	2.00	0.28	5.65
Dingarh-2	421	17	026.62	1.10	0.44	8.46
Dingarh-3	488	26	092.30	8.45	0.75	4.65
Dingarh-4	432	18	031.95	2.30	1.17	2.60

The anion values, given in Table 2 showed that the concentrations of HCO_3^{-} remained apparently high while the $CO_3^{=}$could not be recorded. The concentrations of HCO_3^{-} ranged between 391 and 610 mg L^{-1} in water from Khokhranwala and Nasuwala tobas, respectively. The variation was found substantial. Natural waters may contain up to 1000 mg L^{-1} of HCO_3^{-} in dry regions (Durfer and Becker, 1964; Ebens and Schaklette, 1982 and Sparks, 1995). The maximum value of Cl (124.25 mg L^{-1}) was found in water sample from Trawaywala toba and minimum (26.62 mg L^{-1}) was estimated in samples from Khokhranwa toba, Nasuwala toba and Dingarh-2 toba. The range of Cl values is quite low as compared to the WHO recommended values. The SO_4 concentrations were found between 0.28 and 1.25 mg L^{-1}, those are quite low as compared to the WHO drinking water standards. The PO_4 concentration was minimum (1.1 mg L^{-1}) for Dingarh-2 sample and maximum (8.4 mg L^{-1}) in water sample from Trawaywala toba. The maximum value of PO_4 is quite high as compared to the standards given by the WHO. SiO_2 concentrations were maximum (9.4 mg L^{-1}) for the water from Trawaywala Toba and minimum (2.6 mg L^{-1}) in water sample from Dingarh-4 toba. The NO_3 concentrations were maximum (50 mg L^{-1}) in water from Gadhenwala Toba and minimum (17.0 mg L^{-1}) in samples from Nasuwala Toba and Dingarh-2 Toba. The maximum of NO_3 concentration is beyond the maximum permissible limit set by the WHO. The trace metals Cu, Pb, Ni, Co, Cr were found absent or

Table 3: Physico-chemical parameters of toba water

Location	pH	TDS mg L^{-1}	Alkalinity mg L^{-1}	Hardness mg L^{-1}	COD mg L^{-1}	EC μScm^{-1}
Kaniwala	8.76	800	220.00	295.80	13	1130
Tarawaywala	8.61	608	345.00	167.00	09	890
Khokhranwala	8.66	774	217.50	156.99	14	1080
Gadhenwala	8.52	700	258.75	230.65	20	990
Nasuwala	8.45	1160	267.50	269.71	08	1370
Sawanwala	8.77	840	453.75	145.68	12	1260
Dingarh -1	8.04	600	292.00	170.26	16	820
Dingarh-2	8.23	1100	175.00	153.73	09	1330
Dingarh-3	8.94	1400	170.00	212.87	07	2050
Dingarh-4	8.69	800	224.00	149.75	11	1160

with such negligible quantities those could not be recorded. Only Ni was found in Dingarh-1 water sample having .08 mg L^{-1} concentration that is within the set standards of WHO.

The other physicochemical parameters given in Table 3 showed that the maximum (8.94) value of pH was found for Dingarh-3 sample and minimum (8.04) for Dingarh-1 sample. However, all the samples were having pH values more than 8 indicating alkaline nature. The overall range of pH value is not beyond the maximum permissible limit set by the WHO. The total alkalinity was found maximum (453.75mg L^{-1}) for Sawanwala Toba sample and minimum (170.00 mg L^{-1}) for Dingarh-3 sample. The maximum value of Alkalinity as compared to the WHO standards is a bit high. The TDS were 600 to 1400 mg L^{-1} in water samples from Dingarh-1 toba and Dingarh-3 Toba, respectively. Its maximum value is quite high against the limit set by the WHO especially for surface water. The high value of TDS may be due to the presence of saline dahars in the catchment area. The EC value is minimum (820 μScm^{-1}) from Dingarh-1 water sample while maximum value (2050 μScm^{-1}) is from Dingarh-3 water sample. Total hardness was found maximum (295.8 mg L^{-1}) in Kaniwala Toba sample and minimum (145.68 mg L^{-1}) in Sawanwala Toba sample. The COD was found minimum (7.0 mg L^{-1}) in the Dingarh-3 sample and maximum (20.0 mg L^{-1}) was recorded in Gadhenwala Toba. The values of COD are well beyond the WHO recommended limit, indicating the presence of undesirable excessive organic matter.

Suitability of toba water for drinking purpose: The quality and suitability of waters have mainly been delineated in the light of drinking and domestic usage. The pollution parameters viz., pH, alkalinity, hardness, TDS, Chemical Oxygen Demand (COD), silica, calcium, magnesium, sodium, potassium, Sr, Fe, Zn, Cl, PO_4, SO_4, $CO_3^{\frac{1}{2}}$, HCO_3^- and NO_3 are discussed in according to WHO (1993). The pH values of the collected samples were within the maximum permissible level determining their suitability for drinking purpose. With respect to TDS no sample was found within the highest desirable level whereas all the samples were found within the maximum permissible level. Total hardness (H_T) of water is an important criterion for the assessment of the suitability of drinking water and only sample no. 1 and 5 were found out of the highest desirable level and these two samples were within maximum permissible level. The water of these tobas can be considered as suitable for drinking purpose as far as TDS and Ht is concerned. Ca and Mg concentrations of water samples are very important to determine the water quality as they have direct bearing on the H_T and alkalinity. The concentrations of these elements were found well within the limits set by the WHO indicating its suitability for drinking purpose. The Fe concentrations were also within the maximum permissible level except sample no. 9, which was out of limit. All the water samples were found well within required limit as far as Zn concentrations were concerned. However, the Sr ion concentrations were found too high that is alarming. The SO_4, Cl and NO_3 ion concentration was also within the highest desirable level except sample no. 4 which was having a bit high concentration of NO_3 but not a challenge to the overall quality of the water. The PO_4 concentrations were found quite high in all the samples and were out of the maximum permissible level except sample no. 7 and 8.

It is evident from the results described above that no serious threat to the desert dwellers is there as far as the presence of trace element in toba water is concerned. However, high concentrations of Sr suggest a detailed study of the toba water in Cholistan desert to save the health of the local people and their livestock. The presence of calcrete bodies in the Cholistan desert also demand special investigation regarding the Sr and radionuclides. High concentrations of COD in toba water is also threatening and indicate the presence of undesirable amount of organic matter. This situation demands bacteriological study of the toba water.

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