INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 20, No. 3, p. 1-8, 2022
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Hydro-chemical and statistical assessment of ground-water quality of mithi area of Tharparkar District, Sindh, Pakistan

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Article published on March 10, 2022

Key words: Water analysis, Ground water, Fluoride content

Abstract

An analytical examination of ground-water samples from various areas of Mithi area of Tharparkar District in the Thar Desert was carried out and the data obtained has been compared with WHO standards. Most of the analyzed samples don't meet WHO standards with respect to sodium, chloride nitrate and fluoride ions. Sulfate, calcium and magnesium ions have also been found in higher concentrations. Presence of above indicated ions make the water contaminated and unfit for human consumption in most of these places.

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Introduction

Water is the most fundamental substance forever and wherever living creatures are available, it is perpetually found with them. The human body contains about 70 percent water. The nature of water utilized for various reasons for existing is of crucial significance for humankind as it is straightforwardly connected with human survival.

The desert of Thar forms the south-eastern part of the Tharparkar district in Sindh province of Pakistan. It possesses rich cultural heritage and availability of drinking water has remained decisive role in the life of its habitants. The land area is spread over about 22000 square km and has a population of more than ten lakh. The socio-economic conditions of Thari's people are such that they live in small villages with limited assess to water whereas their main source of earning is agriculture and cattle farming based on rainfall. The people of this area rely on the ground water for drinking as well as for livestock purposes and this is available at a depth of 20 to 200 ft and is obtained through wells. The conductivity of ground water available in the desert varies b/w 100-35000 µS/cm while its recharge is slow due to short rainfall and long spells of drought. This leads to the terrible increase in the concentration of sodium, potassium, calcium, magnesium and their salts. The inhabitants of the areas consuming this water for drinking purposes often suffer from a variety of illnesses which include dental and skeletal fluorosis, kidney stones, dysentery etc, the prevalence of which could partly be due to the quality of drinking water [Mallah, 1998, Rafique *et al.* 2004]. It is therefore, an urgent need to undertake detailed analytical investigations of the ground-water of the area and determine the water quality parameters in specific places. The purpose of this work is to investigate water quality parameters of this neglected area and then to suggest means for the improving its quality, so that it could be fit for human consumption.

Materials and methods

Climate

Tharparkar comprises of two words; Thar signifies 'desert' while Parkar means 'the other side'. Year back, it was known as Thar & Parkar however in this manner turned out to be only single word' Thar-parkar" for the two distinct parts of Sindh region (Province). On the western side, Parkar is the irrigated area though Thar, the eastern part, is known as the biggest desert of Pakistan with a rich multifaceted culture, legacy, conventions, people stories, and music because of its occupants who have a place with various religions, sects and casts. The alluvial stores of waterway Indus have shaped the Parkar region while Thar generally comprises of barren tracts of sand hills secured with thorny bushes.

The Thar zone has a tropical desert climate. The long periods of April, May and June are the most hottest ones amid the day. The normal least and most extreme temperatures amid this period remain 24 °C to 48 °C individually while December, January and February are the nearly coldest months with normal least and greatest temperatures 9 °C to 28 °C respectively. Rain-fall changes from year to year. The greater part of the rain falls in the monsoon months among June and September though the winter are insignificant.[Rafique *et al.* 2004].

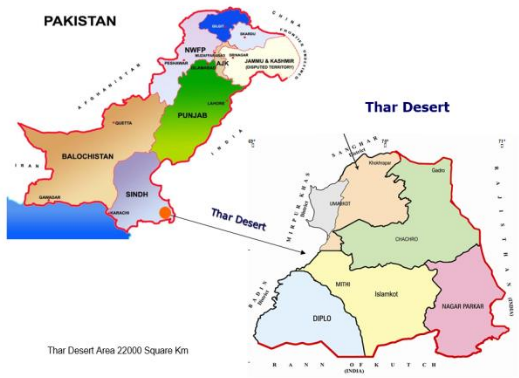

Fig. 1. The Map of Thar, Pakistan.

Methodology

During this study the visit for sampling was planned in Mithi area and 25 ground-water samples were collected from various places. The analysis of water samples were subjected to the quantitative determination of target anions and cations, which are responsible for salinity, hardness, and high conductivity of ground water i.e. Na^+, K^+, Ca^{2+}, Mg^{2+},

Cl^-, HCO_3^-, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}, NO_3^- and F^-. Standard methods were followed in collecting, handling and analyzing samples for aforementioned parameters [APHA, 1999, WHO, 1984]. All precautions were taken to collect the representative samples and to get reliable data by taking average readings of individual parameters, whereas other parameters such as pH, conductivity and temperature were also determined. The whole sampling area covers big and small dunes with thorny bushes with no road for transportation.

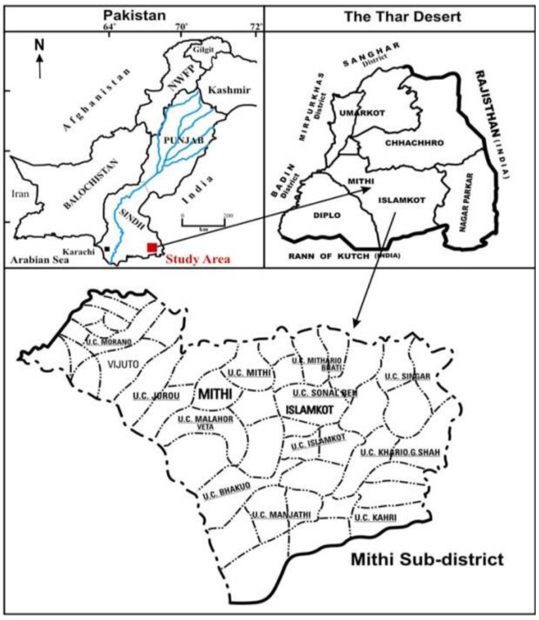

Fig. 2A. The Map of Thar, Pakistan.

Results and discussions

The detail analysis results of water samples collected are presented in Table 1 and Table 2. Twenty five (25) samples were collected from various selected villages of the area in order to get the representative results so that reliable base line data can be generated. Quoted results are the mean values of various drinking water quality parameters for each selected village. A detailed sampling profile has also been established for each village which describes the history of each well including name, location, water body, physical appearance, spot taste and status in terms of operational or non-operational. Attention has been paid to collect samples from wells which are in operation for drinking purpose but a few samples have also been taken from non-operational wells or wells which are now being used for cattle in order to identify the variation patterns responsible for water quality deterioration.

In general the depth of wells ranges between 100-170 ft and ground-water was found to be of saline taste. The highest values are for sodium and chloride ions followed by bicarbonate. Almost all villages were found affected with salinity problem except Seran, and Satar. The ground-water quality of these two villages was good. Mithi city especially was found much affected in terms of pH. Generally pH was ranged between 9.0-9.2 with specific alkaline slippery effect.

In areas where salinity is high, people fetch water for drinking purpose from far way places where water is of a better quality. The chemical analysis of ground-water is characterized by high sodium, high magnesium, high chloride and high sulfate ranges.

Besides the aforementioned ions, higher levels of fluoride and nitrate ion have also been detected. Calcium and magnesium are low in wells with high fluoride contamination as they are precipitated largely as carbonates. High fluoride concentration occurring in ground-wate2er of Thar Desert is mainly due to the fluoride containing minerals buried under sand dunes. The presence of fluoride in ground water used for drinking water is known to cause various health problems including dental and endemic fluorosis in humans and cattle. Because it is highly reactive, fluoride commonly exists in the ionic form as fluoride, and enters the human body by ingestion, inhalation and in extreme cases through skin. Water borne fluoride is absorbed more rapidly than food borne fluoride. In mild form, mottled teeth have little public health significance, apart from causing embarrassment to the affected. However, it may bring about excessive wear of the teeth, and mastication can be affected. Severe fluorosis makes teeth more susceptible to dental caries. In skeletal fluorosis, the skeleton increases in density and osteophytie outgrowth appear on the long bones, vertebrae and ribs [UNICEF, 2000, Hussain *et al.,* 2010]. Such adverse health effects are clearly visible in the areas visited by our team and do invite the attention of a separate investigation.

Table 1. Statistical-parameters of ground-water samples collected from "Mithi area".

Parameters	WHO Maximum permissible Limit	Minimum	Maximum	Mean	Median
pH	6.5 to 8.5	7.6	9.1	8.12	8.1
EC (µs/cm)		1436	11156	7139	7167
TDS (mg/L)	1000	1363	7825	5036	5025
Na^+ (mg/L)	200	274	2790	1604	1380
K^+ (mg/L)	30	40	125	85	85
Ca^{2+} (mg/L)	200	10	399	205	205
Mg^{2+} (mg/L)	150	6	143	75	75
CO_3^{2-} (mg/L)		132	6	132	132
HCO_3^- (mg/L)		232	519	376	376
Cl^- (mg/L)	600	2853	3656	3255	3255
F^- (mg/L)	1.5	0.05	8.87	4	4
SO_4^{2-} (mg/L)	400	82	270	176	176
NO_3^- (mg/L)	45	5.91	57.66	32	32
PO_4^{3-} (mg/L)		0.63	1.08	1	1

Table 2. Water quality parameters of analyzed ground-water samples collected from Mithi area. Results have been quoted in terms of mg/L except pH and EC.

Village	Av. Well Depth	pH	EC µS/cm	TDS	Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	F^-	SO_4^{2-}	NO_3^-	PO_4^{3-}
WHO Maximum permissible limits		6.5 - 8.5		1000	200	30	200	150			600	1.5	400	45	
Mithi City	110 ft	9.1	10600	7420	2750	53	10	6	132	519	3656	8.87	270	57.66	0.63
Seran	20 ft	8.3	4950	3356	1045	100	34	35	86	464	1364	1.87	201	77.8	0.28
Bajeer East	165 ft	8.1	5885	4126	1328	57	85	43	---	388	3388	2.02	165	88.7	0.34
Bageer West	130 ft	8.5	11156	7825	2790	55	20	21	198	939	2634	12.4	379	64	0.025
Jagotar	130 ft	7.6	6735	4759	1380	94	257	54	---	174	2774	7.6	102	105.8	0.33
Ghutsir	150 ft	7.8	7183	5040	1740	40	55	52	---	260	2710	6.2	160	59	0.033
Pabuhor	115 ft	8.1	9143	6412	1942	125	103	112	---	468	2502	3.28	1138	64.9	1.06
Satar	120 ft	8.0	1436	1363	274	105	39	50	---	290	488	3.16	102	31.1	0.34
Vijoto	110 ft	7.6	7167	5025	1186	116	399	143	---	232	2853	0.05	82	59.1	1.08

It may be noted that most of the water samples do not meet WHO standards with respect to sodium, chloride and fluoride and nitrate ions. All other anions and cations do not show regular pattern of variation therefore ground-water quality in these areas is attributed to the presence of above indicated ions and make the water unfit for human consumption in most of the places. Recently Thar has passed through extreme drought conditions as usually happen here after every three years. There is no substantial natural recharge due to scanty rainfall. There is no river passing in the desert except few areas irrigated by barrage water near Umarkot. Analysis results show that area is facing terrible situations of ever-rising ground-water quality problem where people won't have adequate access to safe drinking water.

Fluoride Health Impacts

Dental Fluorosis

- Generally, ingestion of water having concentration of fluoride above 1.5-2.0 mg/L may prompt dental fluorosis which is portrayed at first by murky white fixes on teeth.

- In advance phases of dental fluorosis, teeth show brown to black staining, trailed by pitting of teeth surfaces.
- Although not a perilous sickness, dental fluorosis can deliver impressive tooth crumbling and critical mental worry for influenced population.[Rafique, 2008]

Fig. 1B. Symptoms of Fluorosis among the children's of Study area. [Rafique, 2015]

Skeletal Fluorosis

- Skeletal fluorosis may happen when concentration fluoride in drinking water exceed 4-8 mg/L. The condition shows itself as an expansion in bone thickness prompting thickness of long bones and calcification of ligaments.
- Symptoms stage from mild arthritic pain in joints and muscles, to extreme distress in the cervical spine district alongside solidness and unbending nature of joints.
- Both dental and skeletal, fluorosis influences the body of an individual as well as renders them socially and socially crippled..
- Whether dental or skeletal, fluorosis is irreversible and no cure and treatment so far exists. The main cure is the counteractive action by protecting fluoride within safe-limits. [Rafique, 2015]

Fig. 2. Patient of Skeletal Fluorosis with premature aging effects. .[Rafique, 2015]

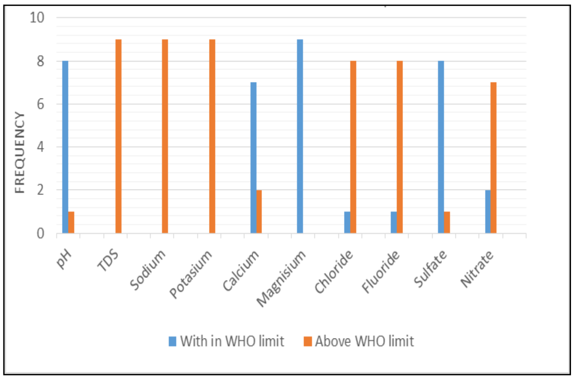

Fig. 3. Comparison of Groundwater quality of samples collected from various sites of Mithi Area with WHO permissible Limit.

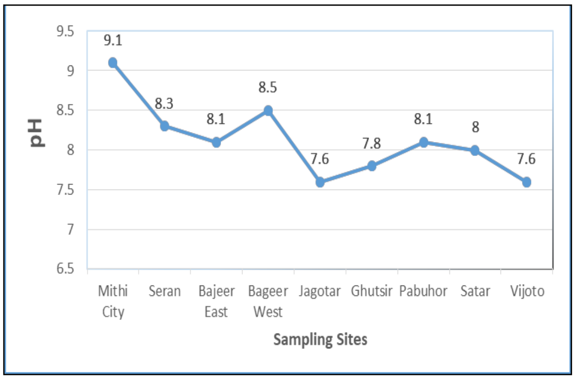

Fig. 3. Variation in pH with sampling sites of Mithi.

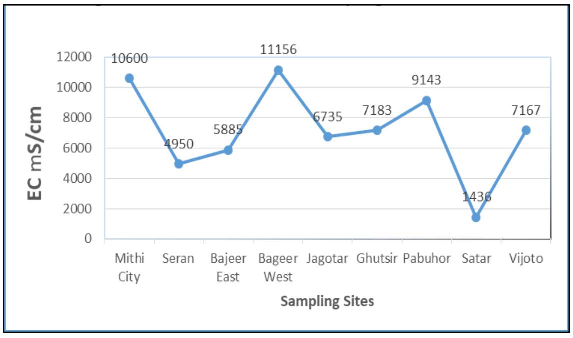

Fig. 4. Variation in EC with sampling sites of Mithi.

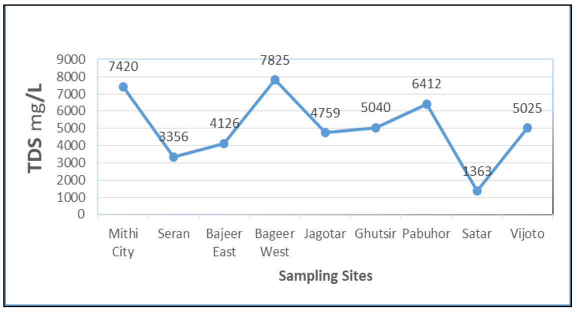

Fig. 5. Variation in TDS (mg/L) with sampling sites of Mithi.

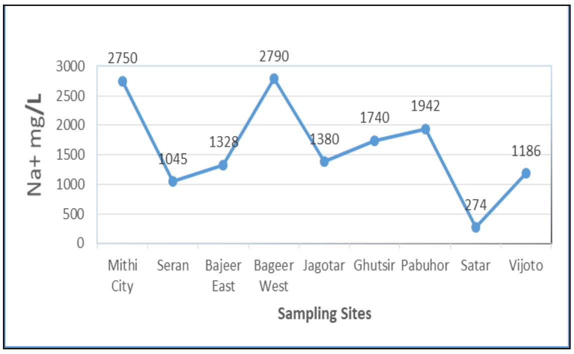

Fig. 6. Variation in Sodium ion (mg/L) with sampling sites of Mithi.

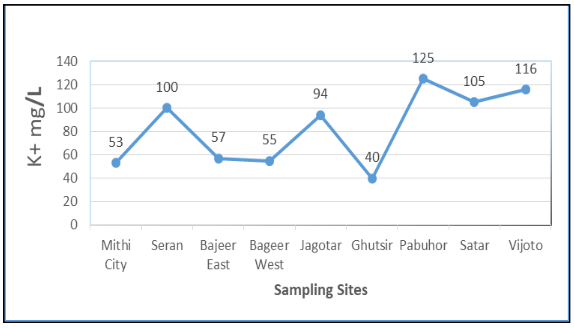

Fig. 7. Variation in Potassium ions (mg/L) with sampling sites of Mithi.

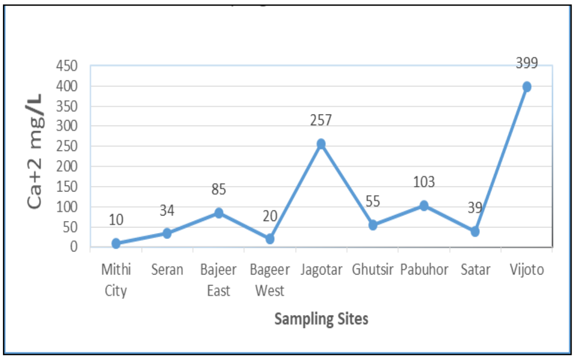

Fig. 8. Variation in Calcium ions (mg/L) with sampling sites of Mithi.

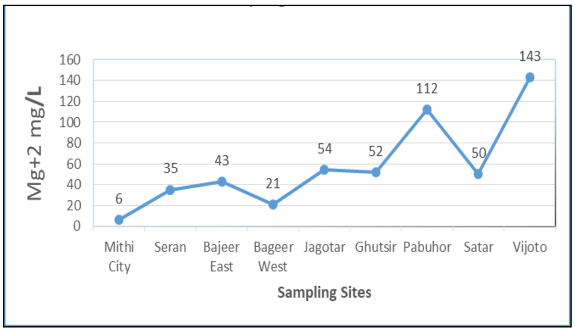

Fig. 10. Variation in Magnesium hardness (mg/L) with sampling sites of Mithi.

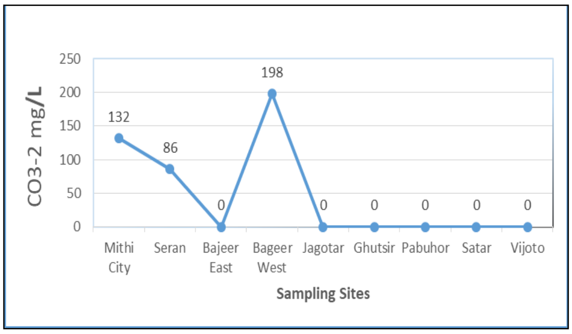

Fig. 11. Variation in Carbonate ions (mg/L) with sampling sites of Mithi.

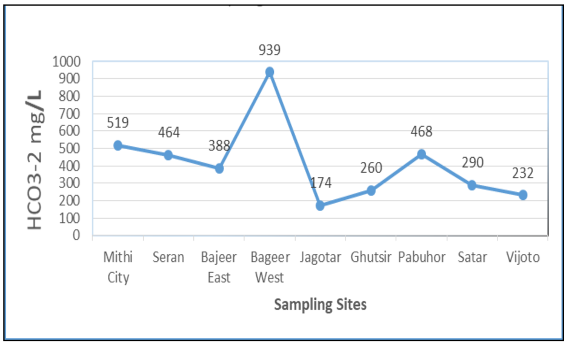

Fig. 12. Variation in Bicarbonate ions (mg/L) with sampling sites of Mithi.

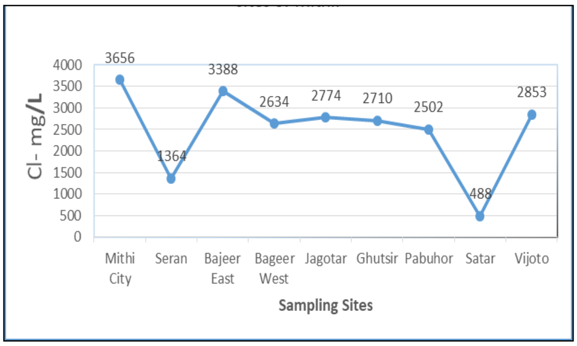

Fig. 13. Variation in Chloride ions (mg/L) with sampling sites of Mithi.

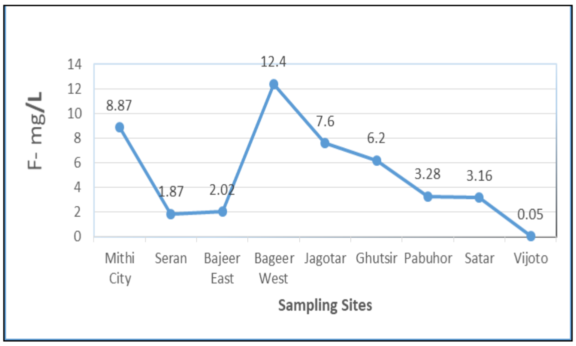

Fig. 14. Variation in Fluoride ions (mg/L) with sampling sites of Mithi.

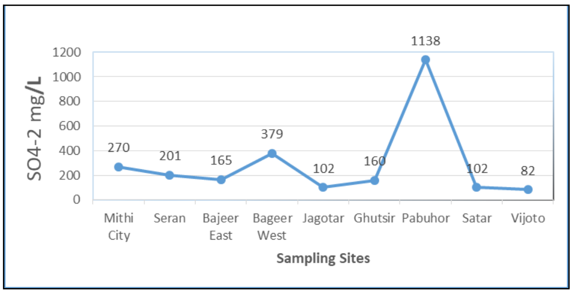

Fig. 15. Variation in Sulphate ions (mg/L) with sampling sites of Mithi.

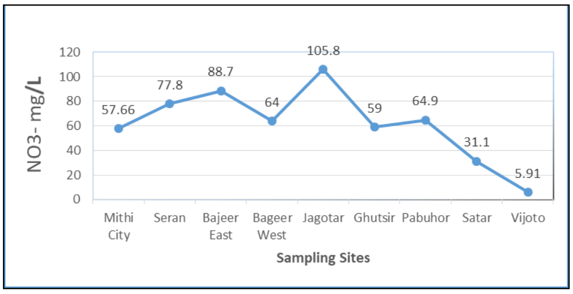

Fig. 16. Variation in Nitrate ions (mg/L) with sampling sites of Mithi.

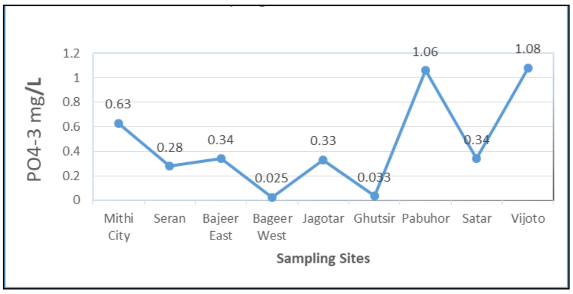

Fig. 17. Variation in Phosphate ions (mg/L) with sampling sites of Mithi.

Conclusion

It is evident that due to scant rainfall and long period of drought, the ground water in deserts increases its budget of salts therefore the studies should be carried out to prepare base line data on chemical composition of ground-water so that the NGO's and government authorities could be advised to take care of the salinity problem while digging and maintaining wells in desert areas. Adequate monitoring and evaluation of water quality should be carried out periodically for the understanding of the biogeochemical processes that largely affect the ground-water quality. Since ground-water movement is slow, and salts not only disperse considerably but also migrate far in advance in the bulk.

Thus, warning of ground-water contamination is possible if monitoring capability at very low concentrations and standards is available.

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