

Determination of Ground Water Quality for Agriculture and Drinking Purpose in Sindh, Pakistan

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Abstract: The study was conducted to assess the quality of ground water from different Talukas of district Tando Muhammad Khan for drinking and agriculture purpose. Water samples for determining the water quality were collected in one liter polyethylene bags by observing standard sample collection method. It was ensured that sample collection sites must be at least 500 feet away from each other. Physical and chemical parameters of ground and surface water samples such as pH, Electrical Conductivity (EC), Turbidity, Colour, Taste, Odour, Alkalinity as CaCO₃, Bicarbonate (HCO₃), Carbonate (CO₃), Calcium (Ca), Magnesium (Mg), Hardness, Sodium (Na), Potassium (K), Chloride (Cl), Phosphate (PO₄), Total Dissolved Solids (TDS) and Arsenic (As) were determined.

The study clarified that pH and odour was within the permissible limits in majority of samples whereas, Arsenic (As), Hardness, Sodium (Na), Total Dissolved Solids (TDS), Taste, Chloride (Cl) and turbidity were beyond the permissible limits set by WHO.

The groundwater status in Tando Muhammad Khan district, TDS in 50% samples, Chloride in 54.16% samples, Sulphate in 44.8% samples, Calcium in 38.5% samples, Sodium in 54.16% samples, hardness in 21.88% samples were beyond the WHO's permissible limits for human consumption.

Keywords: Ground water, physical composition, chemical composition.

1. INTRODUCTION

Groundwater is a vital source of drinking and irrigation water. It is estimated that water covers about 70 percent of the earth's total surface but only 0.3% of it can be used by human beings. This is increasingly the case due to the effects of population growth and climate change, which are causing severe stress to surface water supplies [1, 2] and due to lack of proper maintenance the water supply systems are incapable to run their full capacity [3] therefore, water quality monitoring program is necessary for preserving the fresh water resources [4] or otherwise the consumption of poor quality of water may cause the severe health related problems. It is estimated that about 5 million children died in developing countries due to intake of polluted water [5].

Groundwater is the major source of water for domestic, agricultural and industrial purposes in many countries. In Pakistan, water supply coverage through piped network and hand pumps is around 66% [6]. It is estimated that, in Pakistan, due to poor water quality all the diseases and the entire death ratio is reported as 30 and 40%, respectively [7]. Diarrhea and water borne diseases are reported as the leading cause of death in

infants and children in the country while every fifth citizen suffers from illness and disease caused by the polluted water [8]. Unluckily, very less attention is being paid to drinking-water quality issues and increasing of quantity remains the priority focus of water supply agencies. Country lacks the monitoring programs of drinking-water quality as well as surveillance programs. Weak institutional arrangements; lack of well-equipped laboratories in combination with absence of a legal framework for drinking-water quality issues have aggravated the situation. Moreover, the public awareness regarding water quality issues is dismally [9].

Unchecked and untreated disposal of Industrial and municipal waste, excessive use of fertilizers and insecticides is deteriorating the already low quality surface and groundwater. Pakistan's per capita water availability has declined from 5,600 cubic meters at the time of independence to 1,200 cubic meters currently and expected to reach the threshold level of 1,000 cubic meters before 2010 or even in 2007 due to lack of water quality monitoring and information management [10].

In Pakistan, water remains a critical resource for sustained wellbeing of its citizens. Water pollution is increasing because of competition for multiple usage practices which in turn is becoming the major cause of water shortage in Pakistan. Polluted water intake

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directly or indirectly is creating many health related diseases. Pakistan is in the list of the most water-stressed countries in the world, a situation which is going to degrade into outright water scarcity (WB) [11].

In recent years, an increasing threat to ground water quality due to human activities has become of great importance [12, 13, 14 and 15], therefore reliable analytical measurements for determination of quality of water are necessary before consumption by human and used in agriculture. Thus, analytical water quality parameters are utmost important and are playing a key role for water quality assessment. The analytical parameters for assessment of water quality include pH, EC, Turbidity, color, taste and odor. Among chemical parameters, the basic role in soil texture modification is played by Alkalinity, bicarbonate, carbonate, calcium and magnesium. The hardness of water is formed by sodium, potassium, chloride, sulphate, nitrate, methaemoglobinaemia, phosphorus and TDS, while among trace and ultra-trace elements; Lead, Arsenic, Iron, fluoride, chromium, manganese, molybdenum, nickel, Aluminum and selenium are determined [16].

The objective of this study is to determine the groundwater quality is suitable or unsuitable for drinking and agriculture purpose.

2. METHODOLOGY

2.1. Area of Study

According to the new government setup in June 2005, Taluka Tando Muhammad Khan is emerged as a new district on map of Sindh province with its Head

quarter located at Tando Muhammad Khan Town/ City. It is spread over a geographical area of about 1733.99 square kilometers (428469 acres). It is located at height of 55 ft above mean sea level and between 250 07' 28" N latitudes and 680 31' 59" E longitudes. In North of the district, Hyderabad and Tando Allahyar districts are located, Badin district lies on South and East, West boundary is shared by district Thatta and the river Indus flows through North-West (Figure 1).

The evaluation of water quality including Arsenic was carried out in each Union Council (UC) of District Tando Muhammad Khan, Sindh, Pakistan. Water samples for determining the water quality were collected in one liter polyethylene bottles by observing standard sample collection method. It was ensured that sample collection sites must be at least 500 feet away from each other. Before sample collection the bottles were washed and rinsed properly with distilled water so as to remove any possible contamination. Water samples were collected using one liter polyethylene bottles and standard methods for this purpose were adopted. After purging, the polyethylene bottles and their caps were washed with same water and then sample was collected in bottle for getting maximum accuracy in result.

The water quality parameters are mainly divided into following categories:

2.2. Physical and Aesthetic Parameters

Electrical Conductivity (EC), pH, Turbidity, Colour, Taste, Odour.

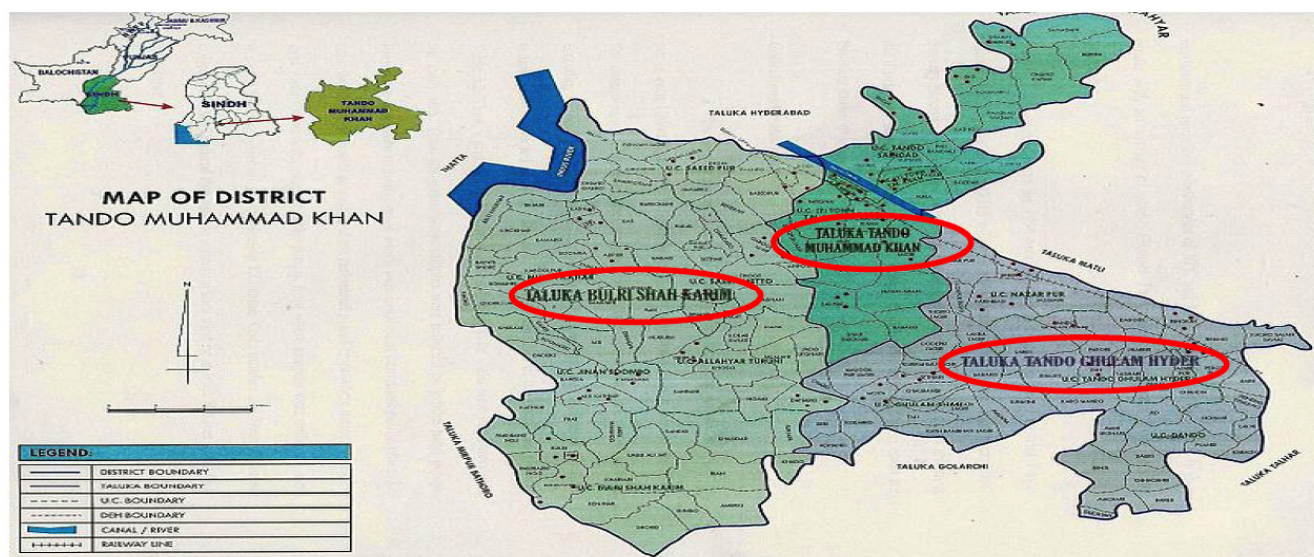


Figure 1: Tando Muhammad Khan ecological areas (Encircled the area of study: Taluka Tando Muhammad Khan, Taluka Tando Ghulam Hyder and Taluka Bulri Shah Karim).

2.3. Chemical Parameters

Alkalinity as CaCO_3 , Carbonate (CO_3), Bicarbonate (HCO_3), Calcium (Ca), Magnesium (Mg), Hardness, Sodium (Na), Potassium (K), Chloride (Cl), Phosphate (PO_4), Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC).

2.4. Method Used to Investigate the Water Quality of Samples

A detailed chemical analysis was carried out for each sample. In chemical analysis titration method was used for determining Anions (CO_3 , HCO_3 and Cl), Cation (Ca and Mg), Alkalinity as CaCO_3 and Hardness. Water quality parameters and methods used for analysis are given in Table 1.

3. RESULTS AND DISCUSSION

The quality of groundwater in Pakistan and particularly in Sindh province is deteriorating fast due to varied causes. The study embodied in this paper aimed at determination of ground and surface water samples for pH, Electrical Conductivity (EC), Turbidity, Colour, Taste, Odour, Alkalinity as CaCO_3 , Bicarbonate (HCO_3), Carbonate (CO_3), Calcium (Ca), Magnesium

(Mg), Hardness, Sodium (Na), Potassium (K), Chloride (Cl), Phosphate (PO_4), Total Dissolved Solids (TDS) and Arsenic (As).

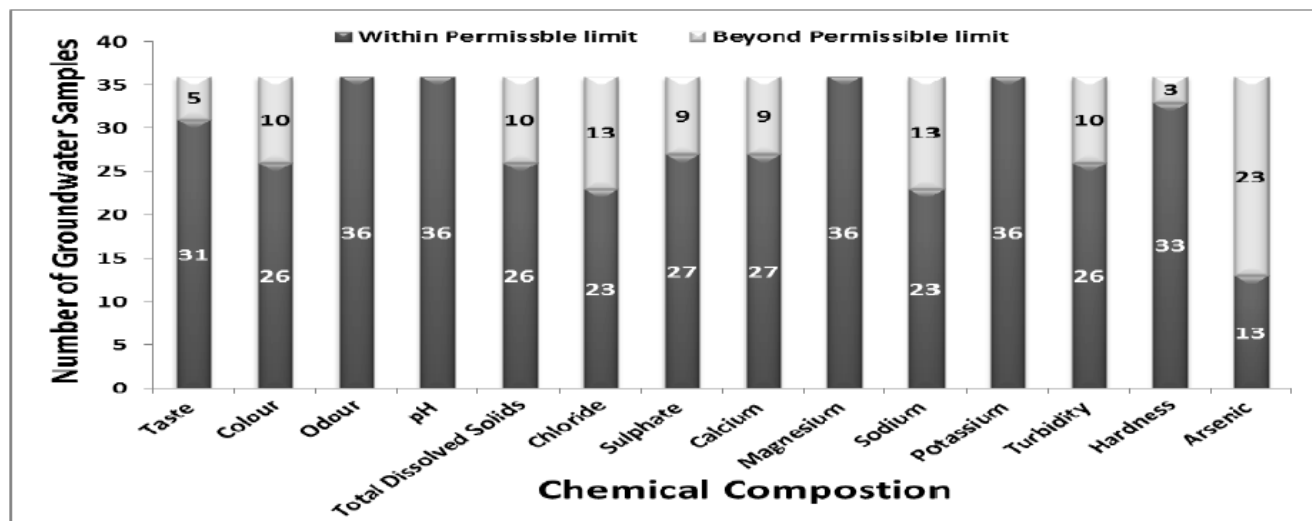
Number and percentage of groundwater samples with heavy metal levels and chemical composition beyond WHO's permissible limits in Taluka Tando Muhammad Khan is depicted in Table 2 and Figure 2. It was noted that TDS, Chloride, sulphate, calcium, sodium, turbidity, hardness and arsenic levels were higher than the WHO's permissible limit. Out of 36 samples of water TDS, Chloride, sulphate, calcium, sodium, turbidity, hardness and arsenic were observed higher in 10 (27.78%), 13 (36.11%), 9 (25%), 9 (25%), 13 (36.11%), 10 (27.78%), 3 (8.33%) and 23 (63.89%), respectively. Similar results have also been reported from the neighbouring country (India) [17], who found pH, EC, turbidity, TDS, alkalinity, total hardness, calcium, magnesium, sodium, potassium, chloride, nitrate, phosphate, sulfate and fluoride in excessive concentration and beyond the permissible limits of WHO. Taluka-wise position of groundwater samples determined for various heavy metals and other chemical composition showed relatively different trend [18]. In Taluka Tando Muhammad Khan odour, calcium and potassium were found within permissible limit of WHO in Taluka Tando Muhammad Khan.

Table 1: Water Quality Parameters and Methods used for Analysis

S. No.	Parameters	Test method
1	Colour (TCU)	15 units (WHO)
2	Odour	Odourless
3	Taste (bitter, salty, sour and sweet)	Unobjectionable
4	Alkalinity (m.mol/l as CaCO_3)	2320, Standard method (1992)
5	Arsenic (mg/l)	Merck Test Kit (0-0.5 mg/l) 1.17927.0001
6	Bicarbonates	2320, Standard method (1992)
7	Carbonates (mg/l)	Standard method
8	Calcium (mg/l)	3500-Ca-D, Standard method (1992)
9	Chlorides (mg/l)	Titration (Silver Nitrate), Standard Method (1992)
10	Electrical Conductivity (micro S/cm)	E.C meter, Hach-44600-00, USA
11	Hardness (mg/l)	EDTA Titration, Standard Method (1992)
12	Magnesium (mg/l)	2340-C, Standard Method (1992)
13	pH at 25°C	pH Meter, Hanna Instrument, Model 8519, Italy.
14	Phosphate (mg/l)	Method (Hach) 8190 & 8048
15	Potassium (mg/l)	Flame photometer PFP7, UK
16	Sodium (mg/l)	Flame photometer PEP7, UK
17	TDS (mg/l)	2540C, Standard method (1992)
18	Turbidity (NTU)	Turbidity Meter, Lamotte, Model 2008, USA

Table 2: Number and Percentage of Groundwater Samples with Heavy Metal Levels and Chemical Composition Beyond WHO's Permissible Limits in Taluka Tando Muhammad Khan

S. No	Source	Parameter	Safe limit	Total No. of Samples	No. of Samples beyond permissible limit	% age beyond permissible limit
1	Hand Pump	Taste (bitter, salty, sour and sweet)	Unobjectionable	36	5	13.89
2	-do-	Colour	15 TCU	36	10	27.78
3	-do-	Odour	Odourless	36	Unobjectionable	Nil
4	-do-	pH at 25°C	6.5-8.5	36	Nil	Nil
5	-do-	Total Dissolved Solids (TDS)	1000 (mg/l)	36	10	27.78
6	-do-	Chloride (Cl)	250 (mg/l)	36	13	36.11
7	-do-	Sulphate (So ₄)	250 (mg/l)	36	9	25
8	-do-	Calcium (Ca)	75(mg/l)	36	9	25
9	-do-	Magnesium (Mg)	150 (mg/l)	36	Nil	Nil
10	-do-	Sodium (Na)	200 (mg/l)	36	13	36.11
11	-do-	Potassium (K)	12 (mg/l)	36	Nil	Nil
12	-do-	Turbidity (NTU)	5 NTU	36	10	27.78
13	-do-	Hardness	500 (mg/l)	36	3	8.33
14	-do-	Arsenic (As)	10 (ppb)	36	23	63.89

**Figure 2:** Chemical Composition of ground water in District Tando Muhammad Khan.

□ Values above WHO Permissible Limits.

■ Values below/ Within WHO Permissible Limits.

Similarly, in Taluka Bulri Shah Karim the groundwater quality was not suitable for human consumption and particularly, the limits for taste, colour, TDS, chloride, sulphate, calcium, sodium, turbidity, hardness and Arsenic were well beyond the permissible limits of WHO for drinking purpose (Table 3 & Figure 3). The arsenic level in 10 of samples was higher than the WHO's permissible limit of 10 ppb.

In Taluka Ghulam Hyder, the groundwater quality was relatively better than Tando Muhammad Khan and Bulri Shah Karim Talukas. However, limits for taste, TDS, chloride, sulphate, calcium, sodium and hardness and Arsenic were beyond the permissible limits of WHO for drinking purpose (Table 4 & Figure 4).

The groundwater quality results of the present investigation are fully supported by Ilyas and Sarwar

Table 3: Number and Percentage of Groundwater Samples with Heavy Metal Levels and Chemical Composition Beyond WHO’s Permissible Limits in Taluka Bulri Shah Karim

S. No	Source	Parameter	Safe limit	Total No. of Samples	No. of Samples beyond permissible limit	% age beyond permissible limit
1	Hand Pump	Taste (bitter, salty, sour and sweet)	Unobjectionable	36	19	52.78
2	-do-	Colour	15 TCU	36	10	27.78
3	-do-	Odour	Odourless	36	Unobjectionable	Nil
4	-do-	pH at 25°C	6.5-8.5	36	Nil	Nil
5	-do-	Total Dissolved Solids (TDS)	1000 (mg/l)	36	24	66.67
6	-do-	Chloride (Cl)	250 (mg/l)	36	24	66.67
7	-do-	Sulphate (So ₄)	250 (mg/l)	36	22	61.11
8	-do-	Calcium (Ca)	75(mg/l)	36	18	50
9	-do-	Magnesium (Mg)	150 (mg/l)	36	Nil	Nil
10	-do-	Sodium (Na)	200 (mg/l)	36	24	66.67
11	-do-	Potassium (K)	12 (mg/l)	36	Nil	Nil
12	-do-	Turbidity (NTU)	5 NTU	36	11	30.55
13	-do-	Hardness	500 (mg/l)	36	13	36.11
14	-do-	Arsenic (As)	10 (ppb)	36	10	27.78

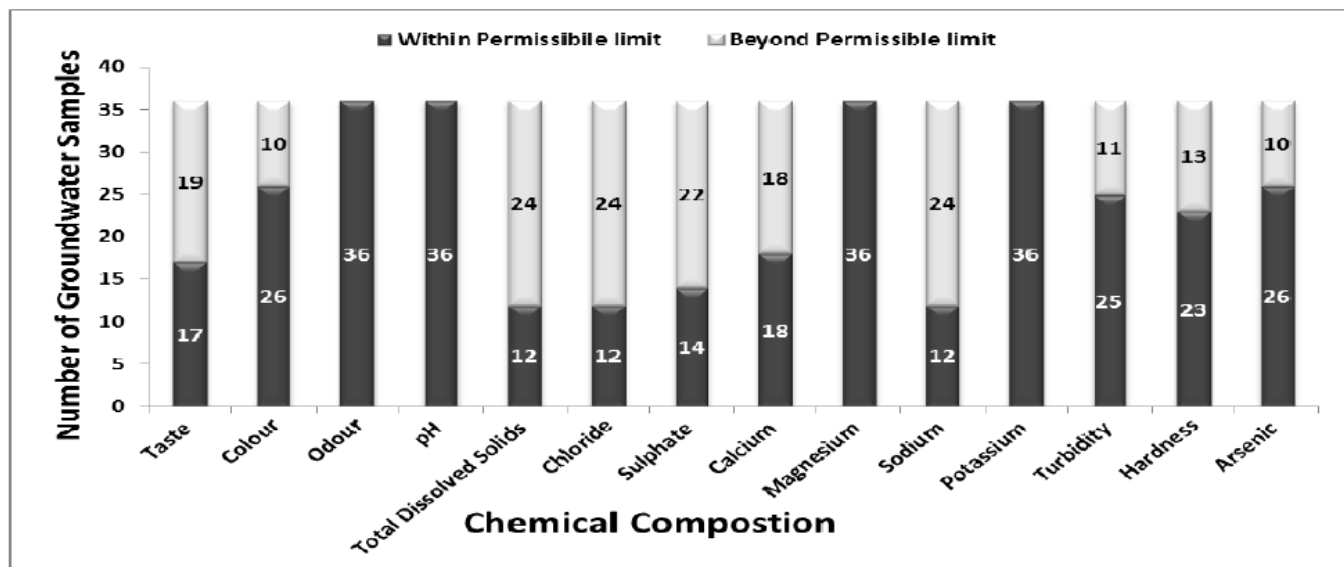


Figure 3: Chemical Composition of ground water in Taluka Bulri Shah Karim.

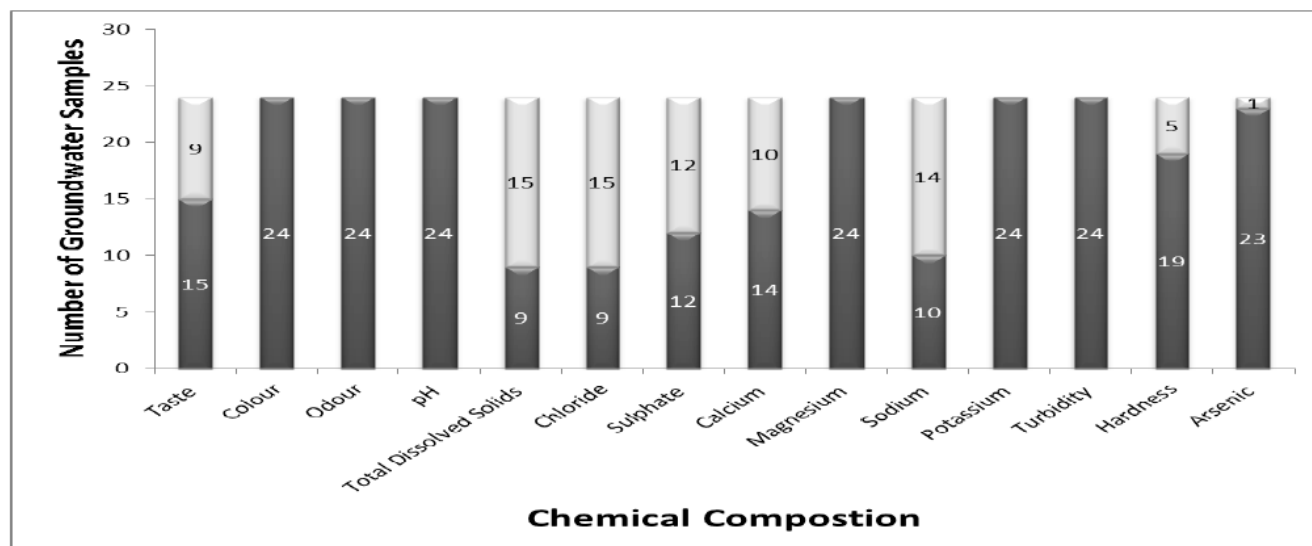
- Values above WHO Permissible Limits.
- Values below/ Within WHO Permissible Limits.

[16] from Peshawar (Pakistan), who reported that pH and EC of drinking water were 7.8 and 0.62 dS/m, drinking water had low turbidity and crossed the limit of WHO in some areas, while Ca and Mg (16.2 and 48.4 mg/l) were within the WHO limits. Similarly, in the present study, the odour, pH, magnesium (Mg) and Potassium (K) in majority of groundwater samples were

within unobjectionable limits, and found safe for human consumption and for agricultural use. Thirumathal and Sivakumar from India [19], analyzed groundwater quality and found total dissolved solids (86-1165 mg/l), iron (0.6-4.1 mg/l), nitrates (6.3-17.2 mg/l), sulfates (4.9-32.5 mg/l), chlorides (110-825 mg/l), calcium (60.0-185.3 mg/l), magnesium (33.2-140.0 mg/l),

Table 4: Number and Percentage of Groundwater Samples with Heavy Metal Levels and Chemical Composition Beyond WHO's Permissible Limits in Taluka Tando Ghulam Hyder

S. No	Source	Parameter	Safe limit	Total No. of Samples	No. of Samples beyond permissible limit	% age beyond permissible limit
1	Hand Pump	Taste (bitter, salty, sour and sweet)	Unobjectionable	24	9	37.5
2	-do-	Colour	15 TCU	24	Nil	Nil
3	-do-	Odour	Odourless	24	Unobjectionable	Nil
4	-do-	pH at 25°C	6.5-8.5	24	Nil	Nil
5	-do-	Total Dissolved Solids (TDS)	1000 (mg/l)	24	15	62.5
6	-do-	Chloride (Cl)	250 (mg/l)	24	15	62.5
7	-do-	Sulphate (So ₄)	250 (mg/l)	24	12	50
8	-do-	Calcium (Ca)	75(mg/l)	24	10	41.66
9	-do-	Magnesium (Mg)	150 (mg/l)	24	Nil	Nil
10	-do-	Sodium (Na)	200 (mg/l)	24	14	58.33
11	-do-	Potassium (K)	12 (mg/l)	24	Nil	Nil
12	-do-	Turbidity (NTU)	5 NTU	24	Nil	Nil
13	-do-	Hardness	500 (mg/l)	24	5	20.83
14	-do-	Arsenic (As)	10 (ppb)	24	1	4.17

**Figure 4: Chemical Composition of ground water in Taluka Tando Ghulam Hyder.**

□ Values above WHO Permissible Limits.

■ Values below/ Within WHO Permissible Limits.

biochemical oxygen demand (6.2-22.0 mg/l) and chemical oxygen demand (18-38.5 mg/l) in all the selected water samples. The findings of the present study are also in concurrence with Chaudhary *et al.* [20], who reported pH 7.2-7.8, salinity 224-674 mg/l, total dissolved solids (TDS) 1.0-1.96 mg/l, hardness 292-560 mg/l, chloride 124-373 mg/l, sodium 33-360 mg/l, potassium 30-165 mg/l, magnesium 31-97 mg/l

and sulfate 20.5-40.3 mg and levels were highest in hand pump water.

In a recent study carried out by Naeem *et al.* [21] in Lahore (Pakistan), it was found that about 10-20% samples of the study area crossed the maximum permissible limit for TDS, hardness, calcium, magnesium, sulphate and fluoride while 20-30%

samples crosses the limit for nitrate. The groundwater of the study area has also been classified to study various hydro chemical processes. Similarly, from Egypt, Saleh *et al.* [22] found that total dissolved solids (TDS) ranged from 390-8840 mg/l and the TDS, pH and water types with some minor differences between clusters.

4. CONCLUSION

It was concluded that TDS, Chloride, Sulphate, Calcium, Sodium, hardness and arsenic were beyond the WHO (PCRWR, 2002) permissible limits in majority of samples obtained from Taluka Tando Muhammad Khan, Bulri Shah Karim and Tando Ghulam Hyder. However, odour, pH, Magnesium (Mg) and Potassium (K) in the groundwater samples were within unobjectionable limits.

The groundwater with TDS, Chloride, Sulphate, Calcium, Sodium and hardness beyond WHO's permissible limits which may not be used for drinking and irrigating crops.

It is recommended that without testing from recognized soil and water testing laboratory, the groundwater may not be used for drinking and agricultural use.

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