

Groundwater Quality Analysis of Different Villages in Two Union Councils of District Tando Muhammad Khan

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Abstract

The groundwater quality of different villages located in two Union Councils, namely Shah Karim Bulri and Khokhar of district Tando Muhammad Khan used for drinking purpose were analyzed. The water quality parameters checked were pH, turbidity, electrical conductivity, total dissolved salts, hardness, sodium, potassium, nitrate, fluoride, turbidity, iron and arsenic by taking fifteen samples in triplicate. Some parameters were examined using instruments and others by titration method. The obtained results were within the range as; pH from 6.6 to 7.5, turbidity 0.0-3.0 NTU, electrical conductivity 675-4030 $\mu S/cm$, total dissolved salts 432-2579 mg/l, hardness 90-860 mg/l, sodium 32-388 mg/l, potassium 0.9-18.1 mg/l, nitrate 0.18-1.24 mg/l, fluoride 0.08-0.54 mg/l, and arsenic 5.0 ppb-20 ppb. It was revealed that out of fifteen groundwater samples nine samples were unfit due to high concentration total dissolved salts and five groundwater samples were found unfit due high concentration of hardness and in one sample the concentration of arsenic was more than international standards. It was concluded from the analysis that the groundwater samples taken from AHNa-06 location is unfit for drinking purpose due to higher concentration of maximum number of examined parameters than WHO guideline values.

Keywords—Water quality parameters, analysis, water characteristics

1 Introduction

CLEAN and safe water is a fundamental source for survival of human health and all creatures [1,2]. It is usually recognized as universal solvent because of its dissolving capability of different substances. Thus, it is hardly pure in nature. Population growth, fast urban development, industrial growth new means of living styles and economic advancements cause severe stress not only on the quantity but also on the quality of existing water resources, thus the water become contaminated [3-5].

The availability of unpolluted drinkable water is an emerging issue, if not tackled timely, can elevate severe water crisis not only in the world but also in Pakistan [6,7]. Water is being used for variety of purposes, like

consumption, food preparation, laundry, housework, farming, cultivation, industrial expansion and growth of plants. The manmade activities are the foremost source of water quality degradation. Although, these accomplishments can be managed by means of better organization, monitoring and taking controlling measures and by application of treatment technologies. The treatment of water may be carried out using unit operations or unit processes or combination of both. However, these treatment technologies are not widely implemented in developing countries [8-9].

The consumption of water has been increased with the increase of urban population. Meanwhile, the volume of municipal wastewater is also increased, which is being introduced into the canal without any treatment [10]. Such practice creates stern environmental problems to the people residing near the major cities and those living in the downstream areas of the canals [11]. It was discovered by PCRWR that around 84–89%

ISSN: 2523-0379 (Online), ISSN: 1605-8607 (Print)

DOI: <https://doi.org/10.52584/QRJ.1902.02>

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water quality of 23 big cities of Pakistan is not up to standards of human consumption [12]. Thus, there should be regular water quality monitoring program in the entire country to save the humans from anticipated water related illnesses [13]. The status of Pakistan in drinking water quality is 80 out of 122 nations [13,14], and just six persons out of ten can access potable water [15]. Although, there are many water treatment plants working in urban areas, but are not sufficient to fulfill the needs of even urban population, leaving behind rural people to manage water for their selves. Thus, the populations residing in rural areas live only on the groundwater. It is stated that about 40% deaths are happened due to water related diseases in Pakistan [16]. One of the reasons behind such poor quality of drinking water is due to release of 2000 MGD of sewage into the surface water bodies in the country [17-18]. Groundwater quality is as important as that of its quantity, because, it decides the suitability for its exploitation and application [19].

Various works have been carried out to see the level of water pollutants and develop effective techniques to treat water to be used of drinking purpose. Raza et. al. [19] revealed that the groundwater of Pakistan is extremely polluted and unsuitable for drinking purposes as the level of pollutants exceed WHO guideline value and NEQS. Hussain et. al. [20] established that the concentration of physicochemical characteristics, heavy metals, and trace metals in industrial wastewaters are more than Pakistan Environmental Protection Agency (PEPA) standards. Azizullah et. al., [13] and Mohseni-Bandpei and Yousefi [21] investigated the impact of industrial effluents, municipal sewage, fish ponds and agronomic runoff on river water quality, and found that not only surface but also groundwater in Pakistan is being contaminated with coliforms, toxic metals and pesticides. Samo et. al. [22] investigated the water quality of Gajra wah canal at Nawabshah Sindh, and the average values of pH, turbidity, TDS and EC in the examined water samples were found 8.4, 627 FTU, 435 mg/l and 654 $\mu S/cnm$ respectively. Lahgari et. al. [23] investigated the water quality of Rohri Canal at Nawabshah, and found that pH of samples were 8.4, turbidity 522.5FTU, TDS 47.2mg/l and EC 78.6 $\mu S/cnm$. Channa et. al. [24] analyzed the physical, chemical and biological properties of Phueli canal water Hyderabad, and discover that the level of EC and fecal coliforms were more than WHO standards. Jakhriani et. al. [25] analyzed the arsenic level in groundwater Taluka Sakrand, District Shaheed Benazirabad and found concentration of arsenic in groundwater with 60 ppb in Union Council Marvi. In other samples, the level of arsenic was in the

range of 20 to 60 ppb. Samtio et. al. [26] examined the groundwater quality of Taluka Dahili, Thar Desert, Pakistan. The average concentration of EC, TDS, Cl, HCO₃, NO₃ was higher than the maximum permissible limit of WHO guidelines. Pathan et. al. [27] evaluated the groundwater quality of Shahdadkot City and found that the level of E.C, hardness and TDS were exceeding WHO standards. Memon et. al. [28] investigated the physicochemical characteristics of groundwater on the left bank of the Indus River at downstream Kotri barrage. The maximum level of pH was found as 8.1, TDS 4011mg/l, total hardness 1320mg/l, chloride 2260mg/l and sulphate 777mg/l. Lanjwani et. al. [29] randomly collected and analyzed 40 groundwater samples from Taluka Dokri, district Larkana, and it was found that 27.5% samples were not suitable for drinking purposes as the level of TDS, EC and TH were above permissible limits. Jamali et. al. [30] analyzed groundwater quality of Taluka Larkana, and revealed that the level of pH in 53% of examined samples EC of 84%, TH of 21%, and TDS of 84% were beyond the WHO guideline values.

It is established from the literature review that quality of water resources are being contaminated in various part of Sindh province due to various anthropogenic activities and its quantity is also reduced due to lack of proper treatment facilities, supply systems and increasing demand due to increase of population. Thus, this study was conducted to examine the quality of water in different villages located in two union councils, namely Shah Karim Bulri and Khokhar of district Tando Muhammad Khan, Sindh.

The purpose of the study was to check whether the water quality of these villages is within international standards or not. If not, then suggest practicable solutions so save the villagers from any forthcoming vulnerability.

2 Materials & Methods

2.1 Study Area and Water Sampling

The water samples were collected from different villages of union councils, namely Shah Karim Bulri and Khokhar of district Tando Muhammad Khan. Samples were collected in transparent glass bottles with a capacity of 1liter. The collected samples were carried out in the morning time around 09:00AM Pakistan Standard Time (PST). Furthermore, sample bottles were stored at room temperature in thermopole container. The samples were collected in triplicate from the fifteen sampling points in the year 2021. The handling and transportation of water samples were being made as per standard methods adopted by

[31,32]. The location of each water sample and sample codes are given in Table 1.

2.2 Analysis of Drinking Water Quality

Instruments used for analysis of groundwater samples after their calibration as per World Health Organization (WHO) standards. The level of pH was measured using pH meter, model HANNA. It was calibrated with buffers of pH 4 and 9. The standard of values of pH should range from 6.5–8.5. Less than 4 value of and greater than 9 badly effect human health. Turbidity was tested with the help of turbidity meter. Electrical conductivity (EC) and total dissolved solids (TDS) were examined with conductivity meter HANNA, HI 9033 Multi range EC Portable meter. Hardness by using titration method, sodium and potassium with the help of flame photometer. Nitrate and fluoride were examined with DR 2800 colorimeter and arsenic by using Arsenic Testing Kit made by Merk. All the samples were analyzed at room temperature.

3 Results & Discussion

The results obtained from the examination of groundwater quality are given in Tables 2 and 3. A total of ten parameters namely pH, turbidity, potassium, arsenic, electrical conductivity, total dissolved salts, nitrates, fluorides, hardness and sodium were analyzed as per American Society for Testing and Materials (ASTM) methods. The level of pH in the samples KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were found as 7.0, 7.1, 6.9, 7.3, 7.0, 6.9, 6.8, 7.2, 6.6, 7.1, 6.7, 6.6, 7.5, 6.7 and 7.0 respectively as shown in Figure 1. The results were observed nearest to the neutral value and were within WHO guideline values. The maximum and minimum average of pH value of water samples were found at HUM-02 with 7.5 and 6.6 at KMR2-09 and MM-01 locations respectively.

The average level of turbidity in examined samples are presented in Figure 2. The average turbidity of samples KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were noted as 1.1, 1.1, 0, 0, 0, 0.3, 0, 1.0, 1.0, 3.0, 1.8, 0, 3.0, 2.0 and 0 respectively. The maximum turbidity was measured as 3 NTU from MKJ-10 and HUM-02 samples, and minimum 0 NTU from AMK-03, QMM-04, JB-05, YJ-07, MM-01 and HUM-02 samples. The turbidity of water samples were found low as these were taken from hand pumps and tube wells.

The average levels of potassium in water samples are given in Figure 3. The potassium concentration of KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were observed as 4.1, 2.8, 2.4, 2.5, 2.8, 18.1, 6.6, 4.8, 6.9, 2.5, 2.3, 2.0, 0.9, 3.0 and 8.0 mg/l respectively. The maximum and minimum concentration of potassium were observed as 18.1 mg/l and 0.9 mg/l from AHN-06 and HUM-02 samples respectively. Figure 4 shows the average values of arsenic in water samples. The arsenic level in KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were recorded as 10.0, 5.0, 0, 0, 0, 20.0, 0, 0, 0, 0, 0, 0, 0, 0 and 0 ppb respectively. The maximum level of arsenic were recorded as 20.0 ppb from AHN-06 sample. It was found from results that out of fifteen locations, the fourteen sampling locations were noted below the WHO level and only one location namely AHN-06 was found above the WHO permissible level.

The observed level of electrical conductivity and total dissolved salts in all water samples are presented in Figure 5. The electrical conductivity of KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were found as 2000, 1435, 1180, 1311, 2520, 4030, 3086, 1610, 3050, 1755, 1019, 952, 675, 2066 and 3060 $\mu S/cm$ respectively. The maximum and minimum values of electrical conductivity were found as 4030 $\mu S/cm$ and 675 $\mu S/cm$ from AHN-06 and HUM-02 samples. It was found that, all water samples were noted beyond the WHO guideline values. Similarly, the concentration of total dissolved salts in KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were noted as 1290, 925, 755, 839, 1613, 2579, 1975, 1030, 1952, 1123, 652, 606, 432, 1322 and 1958 mg/l respectively. The maximum and minimum values of total dissolved salts were found as 2579 mg/l and 432 mg/l from AHN-06 and HUM-02 samples. It was observed that, out of fifteen locations, the concentration of TDS in eleven samples were beyond the WHO standards. The large increase at AHN-06 could be attributed to the introduction of higher concentration of electrolytic salts from the open sewerage line. Since, the samples taken from AHN-06 location indicated higher values of TDS as compared to WHO standards. The nitrate and fluoride in all water samples are depicted in Figure 6. The level of nitrate in KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were noted

S. No.	Sample locations / villages	Union Council	Sample codes
01	Karnal Khalid	Bulri Karim Shah	KK-01
02	Saleh Muhammad Lashari	Bulri Karim Shah	SML-02
03	Ali Muhammad Khokhar	Bulri Karim Shah	AMK-03
04	Qabool Muhammad Magsi	Bulri Karim Shah	QMM-04
05	Jumo Burio	Bulri Karim Shah	JB-05
06	Abdul Hafiz Nizamani	Bulri Karim Shah	AHN-06
07	Yousif Jatoi	Bulri Karim Shah	YJ-07
08	Khan Muhammad Rind	Bulri Karim Shah	KMR1-08
09	Khan Muhammad Rind	Bulri Karim Shah	KMR2-09
10	Murad Khan Jatoi	Bulri Karim Shah	MKJ-10
11	Hussain Halepoto	Bulri Karim Shah	HH-11
12	Menoon Mallah	Khokar	MM-01
13	Haji Umar Mallah	Khokar	HUM-02
14	Yar Muhammad Mallah	Khokar	YMM-03
15	Sonolo Solongi	Khokar	KKR-04

TABLE 1: Selected names of villages and sample codes of groundwater

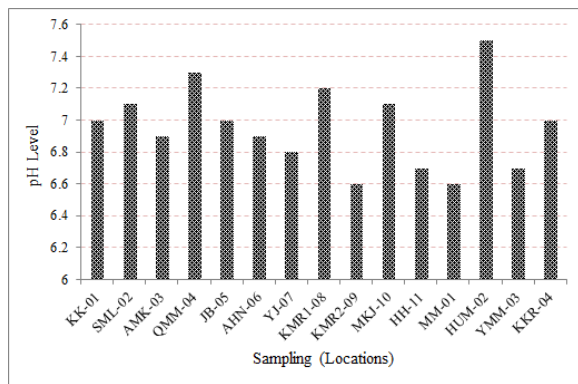


Fig. 1: pH in water samples

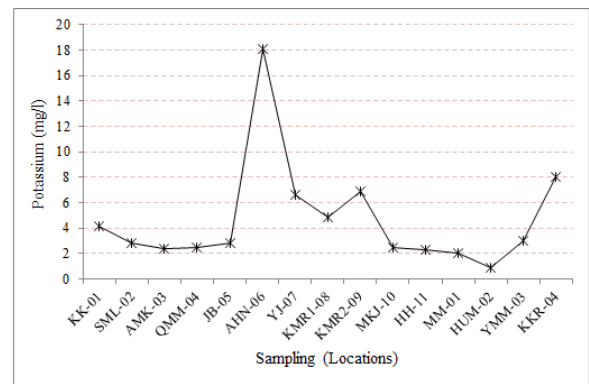


Fig. 3: Potassium in water samples

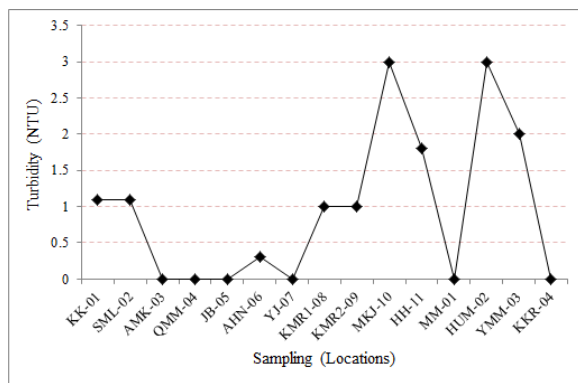


Fig. 2: Turbidity in water samples

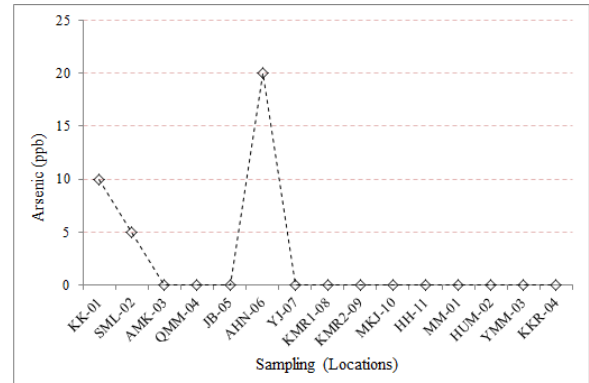


Fig. 4: Arsenic in water samples

as 0.8, 0.6, 0.42, 0.32, 0.86, 1.24, 1.0, 0.68, 0.69, 0.74, 0.49, 0.34, 0.18, 0.89 and 0.74 mg/l respectively. The maximum and minimum values of nitrate were found as 1.24 mg/l and 0.18 mg/l from AHN-06 and HUM-02 samples. The level of nitrate in all examined samples were within WHO standard of 10 mg/l. Likewise, the concentration of fluoride in KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-

09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were measured as 0.31, 0.11, 0.1, 0.19, 0.22, 0.54, 0.41, 0.31, 0.32, 0.16, 0.11, 0.23, 0.08, 0.11 and 0.23 mg/l respectively. The maximum concentration of fluoride was found as 0.54 mg/l and minimum 0.08 mg/l from AHN-06 and HUM-02 samples respectively. It was observed that the concentration of fluoride in examined water samples were within WHO standard.

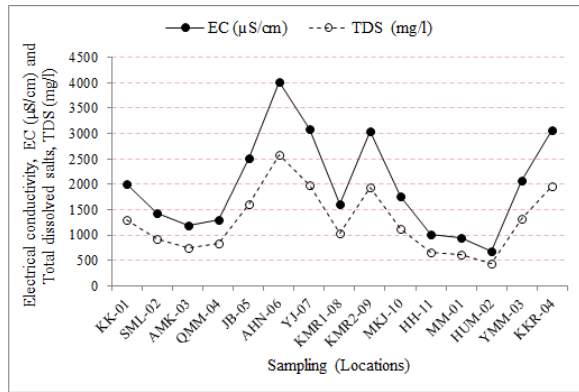


Fig. 5: Electrical conductivity and Total dissolved salts in water samples

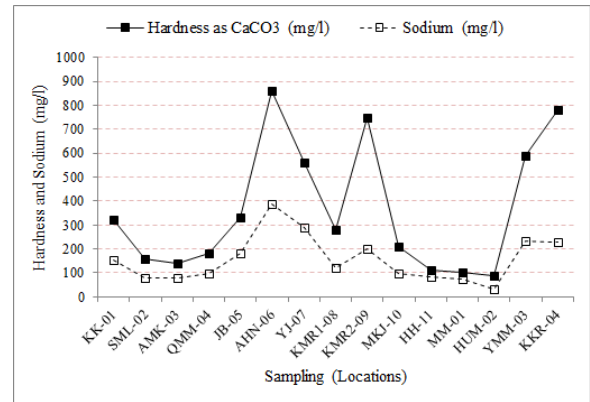


Fig. 7: Hardness and Sodium in water samples

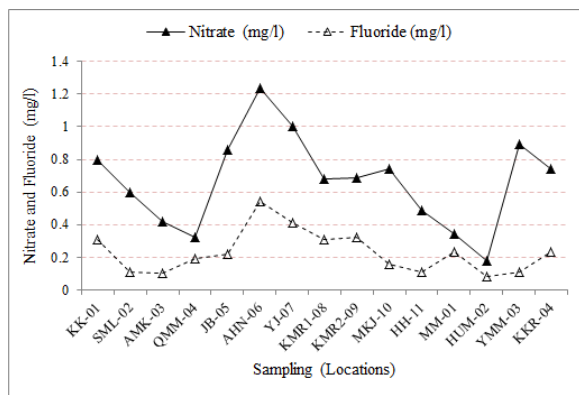


Fig. 6: Nitrate and Fluoride in water samples

The level of hardness and concentration of sodium in examined groundwater samples are illustrated in Figure 7. The level of hardness in KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were recorded as 320, 160, 140, 180, 330, 860, 560, 280, 750, 210, 110, 100, 90, 590 and 780 mg/l respectively. The maximum level of hardness was recorded as 860 mg/l from AHN-06 and minimum 90 mg/l from HUM-02 samples. It was found that the level of hardness in twelve number samples were beyond WHO guidelines. Similarly, the concentration of sodium in KK-01, SML-02, AMK-03, QMM-04, JB-05, AHN-06, YJ-07, KMR1-08, KMR2-09, MKJ-10, HH-11, MM-01, HUM-02, YMM-03 and K-4 were measured as 155, 77, 81, 99, 180, 388, 289, 123, 199, 98, 85, 76, 32, 233 and 230 mg/l. The maximum level of sodium was recorded as 388 mg/l from AHN-06 and minimum 32 mg/l from HUM-02 sample. It was found that the concentration of sodium of AHN-06, YJ-07, YMM-03 and KKR-04 samples were above the WHO standards.

4 Conclusion

It was found from the analysis that maximum and minimum average values of potassium were 18.1 mg/l and 0.9 mg/l from AHN-06 and HUM-02 samples respectively. The maximum and minimum values of arsenic were 20.0 ppb and 5 ppb at AHN-06 and HUM-02 water sample locations respectively. The maximum and minimum average values of electrical conductivity were found 4030 $\mu S/cm$ and 675 $\mu S/cm$ at AHN-06 and HUM-02 locations. The level of electrical conductivity in almost all samples were beyond the WHO guideline value. The maximum noted concentration of total dis-solved salts in the examined samples were 2579 mg/l and minimum 432 mg/l from AHN-06 and HUM-02 samples. It was observed that, out of fifteen samples, eleven numbers showed higher TDS values than WHO guideline value. The maximum level of hardness was recorded as 860 mg/l from AHN-06 sample. Since, in twelve water samples out of fifteen showed higher values of hardness than WHO guideline value. Whereas, the higher concentration of sodium was recorded as 388 mg/l from AHN-06 sample. In general, four water samples showed higher sodium concentration than WHO guideline value. It was found that the level of pH, turbidity, nitrate and fluoride in all examined ground-water samples were within WHO guideline values. It was revealed that out of fifteen groundwater samples nine samples were unfit due to high concentration total dissolved salts and five groundwater samples were found unfit due high concentration of hardness and in one sample the concentration of arsenic was more than international standards, whereas, the remaining parameters were within safe limits. It was concluded from the analysis that the groundwater samples taken from AHN-06 location is unfit for drinking purpose due to higher concentration of different physicochemical parameters

Sample Code	pH	Turbidity (NTU)	EC ($\mu S/cm$)	TDS (mg/l)	Hardness (mg/l)
KK-01	7.0	1.1	2000	1290	320
SML-02	7.1	1.1	1435	925	160
AMK-03	6.9	0.0	1180	755	140
QMM-04	7.3	0.0	1311	839	180
JB-05	7.0	0.0	2520	1613	330
AHN-06	6.9	0.3	4030	2579	860
YJ-07	6.8	0.0	3086	1975	560
KMR1-08	7.2	1.0	1610	1030	280
KMR2-09	6.6	1.0	3050	1952	750
MKJ-10	7.1	3.0	1755	1123	210
HH-11	6.7	1.8	1019	652	110
MM-01	6.6	0.0	952	606	100
HUM-02	7.5	3.0	675	432	90
YMM-03	6.7	2.0	2066	1322	590
KKR-04	7.0	0.0	3060	1958	780

TABLE 2: Groundwater quality of different villages of two union councils located in district Tando Muhammad Khan

Sample Code	Sodium (mg/l)	Potassium (mg/l)	Nitrate (mg/l)	Fluoride (mg/l)	Arsenic (ppb)
KK-01	155	4.1	0.80	0.31	10.0
SML-02	77	2.8	0.60	0.11	5.0
AMK-03	81	2.4	0.42	0.10	0.0
QMM-04	99	2.5	0.32	0.19	0.0
JB-05	180	2.8	0.86	0.22	0.0
AHN-06	388	18.1	1.24	0.54	20.0
YJ-07	289	6.6	1.00	0.41	0.0
KMR1-08	123	4.8	0.68	0.31	0.0
KMR2-09	199	6.9	0.69	0.32	0.0
MKJ-10	98	2.5	0.74	0.16	0.0
HH-11	85	2.3	0.49	0.11	0.0
MM-01	76	2.0	0.34	0.23	0.0
HUM-02	32	0.9	0.18	0.08	0.0
YMM-03	233	3.0	0.89	0.11	0.0
KKR-04	230	8.0	0.74	0.23	0.0

TABLE 3: Groundwater quality of different villages of two union councils located in district Tando Muhammad Khan

than WHO guideline values. It is recommended that continuous monitoring of water quality be carried out in regular intervals and the source contamination may be reduced to retard further contamination of water bodies.

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