Potable Water Quality Characteristics of the Urban Areas of Peshawar (Pakistan) Part 1: Tubewell Water

[1]AZIZ-UR-RAHMAN AND [2]A.R.KHAN
[1]Pakistan Council for Research in Water Resources (PCRWR) Peshawar (Pakistan)
[2]PCIR Laboratories, Jamrud Road, Peshawar (Pakistan)

(Received 9th March, 2000, revised 30th May, 2000)

Summary: Potable water quality of the urban areas of Peshawar was monitored for various physical and chemical parameters. The importance of this reference data, related to the water quality of Peshawar was felt after spreading of some water borne diseases, mainly diarrhea in one of the areas of Peshawar (Sufaid Dheri) during the summer 1999 in which a few people had died and several were hospitalized.

Forty three water samples from different tube wells of the urban areas of Peshawar were analysed for pH, TDS, TSS, electrical conductivity, turbidity, total hardness, calcium, magnesium, alkalinity, chloride, nitrate, sodium and potassium. The concentrations of these analytes were found in the ranges; pH (6.0-7.9), TDS (180.20-351.82 mg/1), TSS (1.05-4.21 mg/1), Electrical conductivity (200-390 mg/1), turbidity (0.3-2.1 NTU), total hardness (126.17-458.91 mg/1) calcium (21.81-90.90 mg/1), magnesium (12.50-80.72 mg/1),bicarbonates (132-244 mg/1), chloride (10.04-54.45 mg/1), sulphate (16.43-80.28 mg/1), nitrate (1.8-35.2 mg/l), sodium (7.9-74.6 mg/1), and potassium (1.6-6.2 mg/1), Mean concentration values of the different analytes of Peshawar water were also found. Average vales of; pH (7.06±0.45), TDS (284.57±51.16 mg/1), TSS (2.27±1.03 mg/1), Electrical conductivity (315.58±57.28 mg/1), turbidity (0.73±0.42 NTU, total hardness (306.23±70.64 mg/1), calcium (61.61±12.23 mg/1),magnesium (36.03±13.47 mg/1), bicarbonates (187.84±25.87 mg/1), chloride (31.41±10.55 mg/1), sulphate (49.43±16.15 mg/1), nitrate (19.21± 10.58mg/1), sodium (28.92±9.95 mg/1), and potassium (3.65±1.17mg/1), Alkalinity (due to hydroxide and carbonate) and nitrites were found absent.

All the analytes were found to be within the WHO permissible limits. This paper concludes that, waters of all the tube wells of Peshawar (under study) are safe for human consumption provided the supply lines and the storage tanks are prevented from being contaminated. A lowering trend in the pH of underground waters of Peshawar was seen, the reason to this was not found. The results presented in this paper also contradict the previous statement about the nitrate concentration in the tube well waters of Peshawar to have been decreasing.

Introduction

A number of diseases are caused by the consumption of poor quality water [1, 2]. It has been reported in a "Community Health Study" that 30% of all reported cases of illnesses and 40% of deaths in Pakistan, one way or another are related to water borne diseases [3]. This can be regarded as an alarming situation.

Previously, studies have been conducted to ascertain the suitability of water for human consumption in different areas of North West Frontier Province (NWFP). The water quality of District Abbotabad was studied by Hussain [4] who found that due to the bacterial contamination, the water was unfit for human consumption. Drinking water of Mardan District [5] was mostly polluted due to presence of higher COD level and nitrite concentration; some of the tubewell waters were however, found potable. The drinking waters of Districts Peshawar, Kohat and D. I. Khan were also investigated. The water samples of Peshawar and D.I. Khan were found polluted due to bacterial contamination [6]. The investigation based on the chemical composition of water samples from 15 plains, 9 hilly stations and 6 rivers/dams in NWFP, Akhtar *et al.* [7] concluded that half of the samples had higher concentration of Na^+, K^+ and . TDS while the hilly area samples were deficient in iodine. Nitrate content in the underground water in some areas of NWFP was investigated by Khwaja *et al.*

[8], Bangash [9] and Wasim [10]. The nitrite and nitrite contaminations of subsurface water of Charsadda, Peshawar and Mardan districts were reported by Khan *et al.* [11]. They concluded that the water samples collected from some areas of Peshawar, Mardan and Nowshera districts showed a very high nitrite concentration whereas, nitrate concentration was found to be with in the permissible limits. The subsurface water of Haripur, Hazara [12] was found potable. More recently, potable water quality of District Bannu was investigated by Khan *et al.* [13]. They concluded that wells and hand pumps water were more polluted as compared to that of the tube wells. Their study showed that the water of Bannu District were not fit for drinking purposes due to the higher levels of COD, nitrite and due to the synergistic effect of magnesium and sulphate [13]. Mushtaq *et al.* [14]. Studied water pollution in Rawal Lake, a reservoir which after necessary treatment is utilized and distributed for human consumption in the capital city Islamabad. They found that the river water was confronted with increasing pollution and leading to the growth of hydrophytes and gentrification in the lake.

It is evident that the data available on the quality of potable water of Peshawar is scattered with ample contradictions. The incident of water borne diseases in one of the areas of Peshawar during the summer 1999, which engulfed lives of few people and several hospitalized, necessitated the present survey. The aim of the present study is to provide the baseline data to the decision-makers in order to avert any on-toward incident.

Results and Discussion

Figure 1 shows the map of Peshawar where the sampling points have been located. Table 1 shows the names of sampling points, their state of surrounding and the general public opinion about the quality of potable water of the area. The general public opinion, as evident from the information contained in Table 1 suggests that no abnormality bout the quality of water was recorded during the survey. The water supply to the affected area, due to which few people died and several hospitalized was found to have been made to an overhead tank in Sufaid Dheri from the Abdara tube well (sample 33).

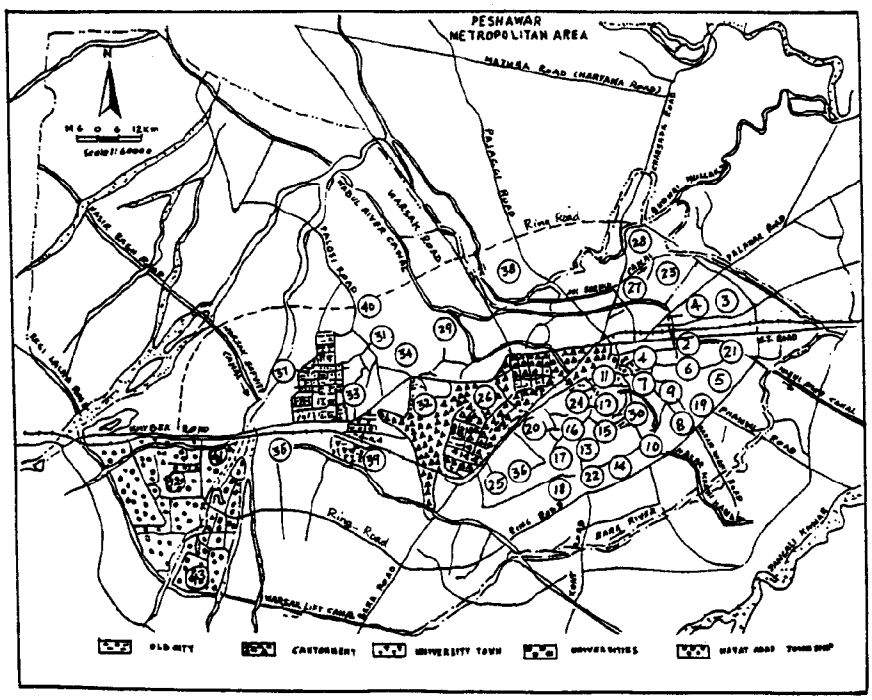

Fig. 1. Map of Peshawar showing the locations and the sampling points

Table 1: Details of sampling points, its surrounding and the public opinion

Sample No.	Location	State of surrounding	Public Opinion
1.	Sikander Pora	Populated area	Not objectionable
2.	Gulbahar	Mildly populated	No complaints
3.	Sheikh Abad/Dalazak	Populated area	No complaints
4.	Hashtnagri	Thickly populated	No objection
5.	Lahori	Thickly populated	No objection
6.	Rampura	Populated area	Not objectionable
7.	Karim Pura	Congested area	Not objectionable
8.	Kohati	Populated area	No complaints
9.	Gung Gate	Populated area	No complaint
10.	Gung Area	Open, grave yard	Not objectionable
11.	Jehangir Pura	Congested area	Not objectionable
12.	Andersher/Balahisar	Congested area	Not objectionable
13.	Din Bahar	Populated area	No complaints
14.	Kashkal-I	Populated area	No complaints
15.	Kashkal-II	Populated area	No complaints
16.	Assia Gate-I	Congested area	No objection
17.	Assia Gate-II	Thickly populated	No objection
18.	Wazir Bagh	Populated area	Not objectionable
19.	Landi Arbab	Populated area	Not objectionable
20.	Beri Bagh	Populated area	No objection
21.	Akhoon Abad	Open, grave yard	No objection
22.	Hazar Khawani	Populated area	Not objectionable
23.	Ahmad Abad	Populated area	Not objectionable
24.	Banamari	Populated area	Not objectionable
25.	Civil Quarters	Populated residential area	No complaint
26.	Nothia	Congested area	Not objectionable
27.	Zaryab Colony	Populated area	Not objectionable
28.	Afghan Colony	Populated area	Not objectionable
29.	Tehkal Payan	Open, grave yard	No complaints
30.	Dabgari (Anderoon)	Thickly populated	No complaints
31.	Tehkal Bala	Populated area	No objection
32.	Gulberg	Open area	No objection
33.	Abdara*	Open area	Not objectionable*
34.	Jehangir Abad	Open, grave yard	No complaints
35.	Danish Abad	Open area	No objection
36.	Yakka Toot	Populated area	No objection
37.	Engg. Univ. Peshawar	Mildly populated	Not objectionable
38.	Bashir Abad	Populated area	Not objectionable
39.	PCSIR Labs. Peshawar	Mildly populated	No complaints
40.	Palosi	Thickly populated	Not objectionable
41.	Hayat Abad (Phase-III)	Populated area	Not objectionable
42.	Hayat Abad (Phase-I)	Thickly populated	Not objectionable
43.	Hayat Abad (Phase-VI)	Less populated	Not objectionable

* Before and after the occurrence of the incident, water being supplied from this tube well to an overhead tank of the affected area.

Table 2 shows some of the characteristics of water samples. Most of the samples varied from 0.3 to 2.1 NTU, whereas, its average value as found 0.73±0.42 NTU (Table 2). Temperature of the water samples was found on the higher side, average value being 28.97±2.06. The highest value of dissolved solids was 351.82mg/l which is below the WHO permissible limit (Table-3). The average value of TDS was found to be 284.57±51.16mg/l in the area. The suspended solids were also below the 5.0mg/l of WHO permissible limits [15]. The average TSS value was found to be 2.27±1.03mg/l. pH and electrical conductivity were found with in the limits as suggested be WHO (Table 3), average values being 7.06±0.45 and 315.58±57.28 μ mhos/cm respectively.

Table 4 shows the chemical characteristics of water samples. Excessive concentration of hardness is associated with stomach disorders and difficulty in getting the clothes cleaned [13]. The average value of hardness was to be 306.23±70.64 mg/l. The total hardness values between 126.17 and 458.91 mg/l. WHO permissible limit being 500 mg/l. (Table 3). The presence of calcium in water within the permissible limit is useful for the body as a supplement of calcium as Ca^{++} in all water samples was found with in the WHO limits which is 250 mg/l. As $CaCO_3$ (100 mg/l as Ca^{++}). The calcium values were found in the range 21.81-90.90 mg/l. Whereas, its average value as 61.16±12.23 mg/l.

Sulphate concentration (Table 4) in all samples varied between 16.43 and 80.28 mg/l. Which is with in the limits, permissible limits being 250 mg/l. (Table 3). The average value of sulphate was found to be 49.34±16.15 mg/l. The magnesium concentration in all samples varied in the range 12.50-80.72 mg/l as Mg^{++} whereas, the permissible limits being 150 mg/l (36.0 mg Mg^{++}/l). The average value which was 36.82-13.63 mg Mg^{++}/l is above the WHO threashold limit. Khan *et al.* [13] have reported 30-50 mg/l as the allowable limits of Mg^{++}. Magnesium in the presence of sulphate makes water laxative in nature causing gastro-intestinal disorders [13], therefore, its synergistic effect with sulphate is necessary to be considered. The magnesium concentrations in some of the samples (i.e. 12,24, 29, 33 and 39) were higher than the permissible limits, compared to the maximum allowable limit of 50 mg Mg^{++}/l, the sulphate concentrations of these samples were found less than 250 mg/l. Therefore, it can be argued that all these samples are within the permissible limits. This is in agreement to the published work [5, 13].

The total alkalinity and the bicarbonate alkalinity (Table 4) were found to be the same. It has been reported [16] that as pH lower than 8.3, both carbonate and hydroxide alkalinity become zero. At this point, p-alkalinity of a sample is also zero and therefore, total alkalinity becomes equal to bicarbonate alkalinity. The results in Table 4 show bicarbonate in the range 132-244, averaging 187.84 ± 25.87 mg/l. The maximum permissible limit is 500 mg/l as reported by Khan *et al.* [13].

Chloride is naturally occurring in water and its higher concentration is due to discharge of

Table 2. Physical characteristics of potable water of the urban areas of Peshawar

Sample No.	Turbidity (NTU)	Temp. °C	TDS (mg/l)	TSS (mg/l)	Taste & Odour	pH	Elec. Cond. (μmhos/cm)
1.	0.30	30	180.20	2.00	Normal	6.00	200
2.	0.40	30	270.52	1.10	Normal	6.70	300
3.	0.60	31	214.30	3.12	Normal	6.80	238
4.	0.80	32	270.26	4.10	Normal	6.70	300
5.	1.00	32	270.27	1.13	Normal	6.67	300
6.	1.10	32	297.25	1.13	Normal	6.60	330
7.	0.50	31	315.23	1.04	Normal	6.64	350
8.	0.90	30	342.60	2.05	Normal	7.60	380
9.	0.40	30	292.24	2.12	Normal	6.68	325
10.	0.50	30	351.62	2.09	Normal	6.68	390
11.	0.60	30	307.82	2.08	Normal	7.60	342
12.	0.50	30	234.73	3.12	Normal	6.55	260
13.	1.00	30	328.46	4.16	Normal	6.67	365
14.	0.50	30	234.52	4.14	Normal	7.20	260
15.	1.40	27	310.91	2.40	Normal	6.80	345
16.	1.20	29	225.23	3.13	Normal	6.70	250
17.	0.60	29	315.62	4.16	Normal	6.70	350
18.	0.30	29	297.19	3.13	Normal	6.90	330
19.	0.40	30	324.21	2.19	Normal	6.80	360
20.	0.40	29	351.13	2.23	Normal	7.10	390
21.	0.60	31	351.01	1.05	Normal	6.80	390
22.	0.99	30	279.62	2.16	Normal	7.37	310
23.	1.10	30	324.16	3.42	Normal	7.20	360
24.	0.50	30	342.17	4.19	Normal	7.36	380
25.	1.50	30	225.19	4.21	Normal	6.62	250
26.	0.60	28	288.28	3.16	Normal	6.68	320
27.	0.80	28	315.39	2.16	Normal	7.70	350
28.	0.70	28	225.83	1.09	Normal	7.90	250
29.	0.70	26	306.46	1.06	Normal	7.60	340
30.	0.50	26	324.59	1.17	Normal	7.70	360
31.	0.40	26	351.82	1.41	Normal	7.29	390
32.	0.80	26	225.08	2.13	Normal	7.45	250
33.	0.70	26	252.04	3.18	Normal	7.70	280
34.	1.10	25	333.31	2.12	Normal	7.58	370
35.	0.40	25	216.19	2.19	Normal	7.18	240
36.	0.30	26	315.42	2.21	Normal	7.20	350
37.	2.10	25	351.63	1.16	Normal	7.40	390
38.	2.10	30	288.15	1.13	Normal	6.80	320
39.	0.50	32	342.13	1.21	Normal	7.20	380
40.	0.40	32	252.48	2.16	Normal	6.10	280
41.	0.40	28	195.63	1.23	Normal	7.53	210
42.	0.50	29	198.19	2.10	Normal	7.49	215
43.	0.40	28	197.47	1.13	Normal	7.56	220
Average values	0.73 ± 0.42	28.97 ± 2.06	284.57 ± 51.16	2.27 ± 1.03		7.06 ± 0.45	315.58 ± 57.28

Table 3. WHO potable water quality standards

Analytes	Standards
Colour	Colourless
Odour	Odourless
Taste	Tasteless
Electrical Conductivity	400 μ mhos/cm
Temperature	12 °C
pH	6.5-9.2
Dissolved Oxygen	3 mg O_2/l
Total Dissolved Solids	500 mg/l
Total Suspended Solids	5 mg/l
Chloride as Cl^-	250 mg/l
Nitrate as NO_3^-	45 mg/l
Nitrite as NO_2^-	0.1 mg/l
Total Hardness as $CaCO_3$	500 mg/l
Calcium as $CaCO_3$	250 mg/l
Magnesium as $CaCO_3$	150 mg/l
Chemical Oxygen demand	10 mg/l
Sulphate as SO_4^-	250 mg/l
Sodium as Na^+	250 mg/l
Potassium as K^+	12 mg/l

sewage. The permissible limit is 250 mg/l as suggested by WHO [15]. Chloride concentration in all water samples (Table 4) si within the permissible limits, varying in the range 10.04-54.45 mg/l. The mean value of chloride was found to be 31.41 ± 10.55 mg/l. Nitrates are present in almost all waters but some of them are also produced microbiologically by the process of nitrification of NH_4^+ ions, nitrites being the intermediate species [17]. Nitrites are soon converted to nitrates. The presence of nitrites is therefore, considered not only to be an indication of bacterial activity but is also regarded as the recent pollution in water bodies. Nitrosomonas are the species that convert NH_4^+ into NO_2^-. This species are found in soil, sewage and in the digestive track [6]. The permissible limit of nitrite is 0.1 mg/l (Table 3). Water containing

Table 4. Chemical characteristics of the potable water of the urban areas of Peshawar.

	Concentrations in mg/l								
Sample No.	Total hardness as $CaCO_3$	Calcium as Ca^{++} (mg/l)	Magnesium as Mg^{++}	Bicarbonate as HCO_3^-	Sulphate as SO_4^-	Chloride as Cl^-	Nitrate as NO_3^-	Sodium as Na^+	Potassium as K^+
1.	171.76	47.27	13.09	244	25.12	18.68	16.5	20.8	3.2
2.	279.80	65.45	32.72	220	44.13	18.68	3.9	23.0	2.8
3.	261.77	58.18	28.36	190	28.19	31.14	9.5	18.6	3.1
4.	290.86	55.45	37.09	200	47.21	12.45	6.1	20.8	3.2
5.	333.95	72.72	37.09	220	40.13	24.91	30.0	26.3	5.2
6.	333.57	54.59	48.00	210	47.17	24.91	30.5	27.0	6.2
7.	317.85	69.88	34.90	180	51.51	24.91	30.0	7.9	5.8
8.	305.76	60.09	37.90	170	35.23	31.14	19.5	25.0	5.0
9.	319.14	65.45	37.90	160	60.16	18.68	3.7	26.3	5.0
10.	325.06	76.36	32.72	150	42.15	31.14	19.5	28.0	4.8
11.	375.56	90.90	36.18	140	57.24	24.91	31.0	29.9	5.6
12.	380.68	69.88	50.18	145	70.35	16.64	31.0	30.0	5.2
13.	369.80	72.72	45.81	145	70.12	37.36	30.0	34.2	5.2
14.	395.18	50.00	41.45	200	80.25	43.69	10.0	30.5	4.0
15.	325.18	65.45	39.37	200	42.36	37.36	32.0	25.0	5.6
16.	315.85	69.08	34.90	210	55.14	37.36	32.8	30.7	3.1
17.	251.27	61.16	24.00	180	39.16	36.37	25.0	25.3	4.8
18.	190.81	47.72	17.45	190	54.17	31.14	35.2	26.5	3.0
19.	225.79	69.90	12.50	200	35.23	49.82	30.0	55.0	5.6
20.	126.17	21.81	17.45	200	80.28	31.14	11.4	26.0	3.1
21.	297.72	61.81	34.90	180	55.16	31.14	12.5	74.6	3.6
22.	279.79	61.81	30.54	170	59.21	37.36	25.0	34.2	1.6
23.	315.69	61.81	39.27	180	60.05	24.91	13.0	36.5	4.2
24.	387.77	72.72	50.18	200	72.17	18.68	25.0	31.7	4.0
25.	360.95	76.36	41.45	210	60.21	37.36	12.0	31.6	3.0
26.	370.05	80.00	41.45	200	35.23	43.40	25.3	30.0	2.0
27.	301.79	72.72	29.27	190	44.08	37.36	22.0	31.0	3.5
28.	324.48	65.45	39.20	200	70.26	37.36	23.1	36.0	2.9
29.	387.45	69.00	52.36	200	65.31	43.59	25.1	37.6	4.0
30.	324.65	61.81	41.45	210	75.10	31.14	30.2	33.0	2.6
31.	458.91	50.90	80.72	210	60.16	24.91	6.1	28.3	2.1
32.	288.87	65.45	30.54	190	64.23	24.91	2.2	22.0	2.2
33.	414.66	72.72	56.72	180	65.12	54.45	2.9	26.9	2.2
34.	324.56	58.18	43.63	200	44.19	31.14	10.0	19.2	3.1
35.	225.47	43.63	28.36	200	40.23	43.59	11.1	28.8	3.0
36.	207.36	40.00	26.16	210	42.17	49.82	1.8	21.0	2.8
37.	267.42	68.09	23.72	220	29.23	43.59	30.9	26.2	3.0
38.	225.76	54.54	21.81	200	47.17	43.59	7.8	20.5	3.0
39.	430.36	54.54	71.57	190	30.19	31.14	32.0	25.5	3.2
40.	251.00	50.50	30.40	180	32.31	30.30	12.6	20.5	2.8
41.	222.56	44.51	26.71	134	16.43	10.04	-	27.8	2.8
42.	226.84	52.80	22.60	132	28.76	10.80	-	27.8	3.2
43.	278.20	65.91	27.22	137	24.65	29.70	-	35.6	3.0
Average value	306.23 ± 70.64	61.61± 12.23	36.03± 13.47	187.84± 25.87	49.43± 16.15	31.41± 10.55	19.21± 10.58	28.92± 9.95	3.65± 1.17

Nitrite was not detected in all samples

Table 5. Comparison of some analytes of the present studies with the reported results

Sampling points		Parameters							
		pH	Ca^{++} (mg/l)	Mg^{++} (mg/l)	Cl^- (mg/l)	SO_4^- (mg/l)	NO_3 (mg/l)	Na^+ (mg/l)	K^+ (mg/l)
Gulbahar	**Present study**	6.70	65.45	32.72	18.68	44.13	3.90	23.00	2.80
	Study [17]	8.26	35.18	10.00	30.68	20.00	20.00	22.00	4.00
Sheikhabad/ Dalazak	**Present study**	6.80	58.18	28.36	31.14	28.19	9.50	18.60	3.10
	Study [17]	7.85	50.40	50.00	103.4	30.00	8.50	20.00	3.30
Hashtanagri	**Present study**	6.70	55.45	37.09	12.45	47.21	6.10	20.80	3.20
	Study [17]	8.32	38.00	40.00	13.80	48.00	20.00	33.00	3.00
Hazar Khawani	**Present study**	7.37	61.81	30.54	37.36	59.21	25.00	34.20	1.60
	Study [17]	7.82	70.00	38.00	36.36	58.00	24.00	30.00	1.80
Nothia	**Present study**	6.68	80.00	41.45	43.40	35.23	25.30	30.00	2.00
	Study [17]	7.45	72.00	50.00	28.16	40.00	24.00	40.00	3.00
Andrsher/ Balahisar	**Present study**	6.55	69.88	50.18	16.64	70.35	31.00	30.00	5.20
	Study [17]	7.48	70.00	48.00	15.00	60.00	32.00	33.00	4.00

nitrite-nitrogen concentrations above 1 mg/l can be regarded as heavily polluted microbiologically [6]. The nitrite concentration in all samples was not detected. The nitrate concentration in samples varied between the range 1.8-35.2 mg/l. The mean value of nitrate was found to be 19.21±10.58 mg/l. It has been reported [11] that the nitrite concentration in Peshawar City was also absent previously and the nitrate concentration was showing a decreasing trend in Peshawar after 1987. Khan *et al.* [11] have reported the nitrate concentration in tube well waters in the ranges; Peshawar City area (1.50-8.60 mg/l), cantonment area (2.50-5.10 mg/l) and university area (2.50-5.20). Comparing the existing results with earlier study [11], it is apparent that the nitrate level in the underground water of Peshawar is not decreasing. The results of the present study are therefore, not in agreement to that of the published work [11]. Both sodium and potassium concentration in samples (Table 4) found to be far below the permissible limits. The mean values of sodium and potassium were found to be 28.92±9.95 mg/l and 3.65±1.17 mg/l respectivley. The permissible limits of Na^+ and K^+ are 250 mg/l and 12 mg/l (Table 3).

Some of the analytes of the present study (Table 5) were also compared with a study conducted almost 15 years back [18]. The data in Table 5 show a mixed picture; however, there is only one conspicuous trend showing a decrease in the pH of water of Peshawar with the passage of time. However, this trend needs to be investigated further. The pH values reported previously [18] were higher, compared to that reported in the present study. The reason to this effect is not known. Other parameters did not show any distinctive trend.

Experimental

Forty three municipality tube wells were selected randomly in Peshawar City including the Hayatabad area. The samples (about 2 litres) were collected directly from the source in new plastic containers cleaned with the same water several times. The sampling sites are located in Figure 1. The state of surrounding and the general public opinion about the quality of water were also recorded.

The taste and odour were checked on sport organoleptically. The temperature was measured on spot with the help of an ordinary centigrade thermometer. Electrical conductivity and pH were measured in the laboratory using a potable conductivity meter (Jenway) and a pH meter (Gallenkamp) respectively. Sodium and potassium were determined using flame photometer (Corning). Turbidity was measured with the help of a turbidity meter. Nitrate and nitrite concentrations were measured spectrophotometrically using a UV spectrophotometer (U-2000, Hitatchi, Japan). The standard methods were employed in all the analyses [16] and the chemicals utilized were of analytical grade and were used without further purification.

Conclusions

This paper examines the quality of tube well waters of Peshawar. All the samples were found to be with in the WHO limits. The incident of water borne disease in Peshawar could not be directly associated with the poor quality of the tube well water in the area. The distribution lines and the storage tank could be imparting a major role in the occurrence of this incident. It has been found that pH of the underground water of Peshawar is showing a decreasing trend, the reason of which is not known. The results also contradict the previous statement about the concentration of nitrate in the tube well waters of Peshawar to be decreasing.

References

1. H.M. Dix, "Environmental pollution," John Willey and Sons, 172 (1981).
2. R. Feachem, M. McGray and D. Mara, "Water, waste and health in hot climates," Wiley Interscience, 167 (1970).
3. T. Akhter, "Community health study," Pak. Med. Res. Council-Research Centre Peshawar (1981).
4. S. Hussian. M.Sc. Thesis, Botany Deptt. Govt. Post graduate College, Abbottabad, 55-60 (1989).
5. A.R. Khan, M. Ibrar, M. Viqar, Mumtaz Khan and M. Riaz, *J. Chem. Soc. Pak.*, (1999), in press.
6. K. Khan, M. Khan, M. Amin, M. A. Khattak and E.R. Khattak, *J. Phy. Chem.*, **12**, 77-90 (1993).
7. J.Akhtar, I. Khan and S.A. Khan, *Sarhad J. Agri.*, 11(3) 373 (1995).
8. M.A. Khwaja, J. Shah and Z. Ullah *Porc.*

National Chem. Conf. (II), University of Karachi, 161 (1990).
9. F.U. Bangash, M. Phil. Thesis, Centre of Excellence in Physical Chemistry, the University of Peshawar, Pakistan (1981).
10. M.A. Wasim, M. Phil Thesis, Chemistry Deptt., the University of Peshawar Pakistan (1995).
11. M. Khan, M.A. Khwaja and I. Ullah, *J. Chem. Soc. Pak*, 20(2), 110-113 (1998).
12. M.Khan and M.A. Khwaja, *J. Chem. Soc. Pak.* In press.
13. A.R. Khan, S. Ullah, F. Hussain, M. Khan and M. Riaz, *J. Chem. Soc. Pak.* **21** (2), 106-114 (1999).
14. WHO, "Guidelines for drinking water quality," 82, Geneva, Switzerland (1984).
15. M. Ahmad, M.I. Ali Khan, M. Nisar and M. Y. Kaleem, *J. Chem. Soc. Pak.* **21** (1), 47-49 (1999).
16. A.P.H.A. and A.W.W.A, "Standard methods for the examination of water and wastewater," 16th ed., American Public Health Inc. New York (1985).
17. Metcalf and Eddy, "Wastewater Engineering-treatment, disposal, reuse," 3rd ed., McGraw Hill Inc. New York, pp. 695 (1991).
18. I. Rahman, M.Sc. thesis, Chem. Deptt., the Univ. of Peshawar, pp. 70 (1985-86).