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Assessment of Physiochemical Parameters of Drinking Water from Different Sources of Palosi Maghdarzai, Peshawar, Pakistan

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Abstract

The present study was conducted using fifty samples (tube wells, bore wells, and hand pumps) to investigate both the physical and chemical parameters of drinking water in the village of Palosi Maghdarzai, Kandi Bala, Peshawar. The analysis was carried out according to the standard analysis procedures reported in the literature. Several analytical techniques, including titration and flame photometry were employed to assess the level of drinking water quality in the area under investigation. The results obtained for each parameter were compared with the standard guidelines of the World Health Organization (WHO). The findings indicated that parameters like pH, Total dissolved solids (TDS), total alkalinity, chloride, and sodium in drinking water were within the permissible limits given by the WHO, while Electrical conductivity (EC), total hardness, calcium hardness, magnesium hardness, and potassium exceeded the permissible limit in some samples. It is concluded that tube well water can be considered safe amongst bore water and hand pump water.

Keywords: Physiochemical parameters; Drinking water; Palosi Maghdarzai; Total dissolved solids; Electrical conductivity; Alkalinity.

1. Introduction

The Greek philosopher Pindar described water as the "best of all things" (Biswas, 2008). The most important substance for living things is water, and without water, life on earth is not possible (Rehman et al., 2017). Of the total water on the lithosphere, only 3 percent is freshwater, of which only 0.01 percent of this freshwater is available for human consumption (Hinrichsen and Tacio, 2002). However, according to the WHO, about 1.1 billion humans lack good quality water, and 2.4 billion do not have access to adequate sanitation. Each year, diarrheal diseases kill over 2 million people, primarily children under the age of five in developing countries with inadequate hygiene and sanitation. The water for human consumption must not contain organisms and chemical substances in concentrations sufficiently high to affect health (Toure et al., 2017).

Water is a very important aspect of life. Because water is the basic unit of every animal, human, and plant cell. Water is part of life because the protoplasm of living cells contains 80% of it. Most of the activity in the human body depends on water. Humans are using water for different purposes like drinking, air conditioning, bathing, washing, industries, etc. After usage, the water returns to the environment altered and perhaps contaminated. which alter the normal level of water and all other ecosystems. Pollutants are now also disposed of in water, which is especially concerning since it might cause unfavorable changes in its chemical or physical properties. Industrial discharge contains many hazardous substances; therefore, its discharge into environment should be control. Some customers are heating water and discharging wastewater into adjacent bodies of water, which raises the temperature of the water and has a positive effect on the aquatic ecosystem

since each aquatic species has a unique habitat (Hering et al., 1997). With predicted yearly losses of 48.29 MAF, Pakistan's current water availability at different canal head works is around 97.71 MAF. Pakistan has exceeded the safe yield limit and is currently extracting around 50 MAF from groundwater aquifers, according to the WAPDA. The amount of water available per person dropped from 1,299 m^3 in 1996–1997 to 1,100 m^3 in 2006, and by 2025, it is expected to be less than 700 m^3. It is now crucial to look for alternative non-traditional water sources for irrigation, such as wastewater (Kahlown et al., 2003; Abeer et al., 2020). As there was no such study conducted in this area and there was a need to determine the quality of water, we conducted our research in this area to analyze the physical and chemical parameters of drinking water from different sources and identify the best source of water for drinking purposes.

Generally speaking, access to clean drinking water is a fundamental human right and is necessary to safeguard the environment, public health, and local communities. Water becomes drinkable when its sensory, physical, chemical, and biological qualities are in balance. The current study aimed to examine the physio-chemical parameters to determine whether the village of Palosi Maghdarzai, Peshawar drinking water meets WHO water quality standards.

Peshawar is the metropolitan city of Khyber Pakhtunkhwa. With a Pashtun majority, it is the sixth biggest city in the nation. Situated on the border with Afghanistan in the large valley of Peshawar, east of the famous Khyber Pass, Peshawar is the oldest city in Pakistan and among the oldest in South Asia, with a known history dating back to at least 539 BCE (Ahmad et al., 2021).

The village of Palosi Maghdarzai lies between 33°44 to 35°15 north latitudes and 71°22 to 71°42 east longitudes. On the north side, it has a Warsak road; on the east side is the village Tehkal; and on the west, it is touched by village Regi. The study area is divided into two parts, namely, Kandi Bala and Kandi, Payan. This research has been conducted in Kandi Bala. Its area is about 3.297 square kilometres, and the number of houses is about 2450, which is identified through the GPS system.

2. Materials and methods

2.1. Sample collection and preservation

To digitize the current conventional map, several GIS techniques, such as geo-referencing, were used. Each sample that was collected for testing was precisely located using the Global Positioning System (GPS) (Fig. 1). Samples were collected randomly from 3 different sources: 20 samples from tube wells, 21 samples from bore water, and 9 samples from hand pumps for testing purposes. Samples collection was distributed based on the number of different sources. In the study area, number of bore water users and tube well water users are more than the hand pump users. Furthermore, there is a great difference in numbers of this source as well. Based on the quality and users of these sources, more samples were collected from bore and tube well while lesser from hand pumps. The water samples were collected in polyethylene bottles of 500ml capacity. During sample collection, the bottles were rinsed with fresh water and then washed three to four times with source water at the collection site. The samples were taken from the end of the pipe. The samples were coded, labeled and brought to the laboratory. Physio-chemical parameters like pH, TDS, and EC were analyzed within 4 hours after collection. Then, the samples were preserved in a healthy environment (Refrigerator) for further analysis.

2.2. Analytical methods

All the meters were calibrated before use like pH meter with pH 7 solution and Electrical conductivity meter with KCl. In order to keep the quality control during analysis, blank samples and control samples were used after analysis of each 5 samples. Electrical conductivity (EC), total dissolved solids (TDS), and pH were determined by benchtop meters. Total alkalinity was measured by titrating against H2SO4 and using a methyl orange indicator while EDTA was measured with an erich rome black tea indicator to measure hardness. Chloride (Cl), one of the

anions, was examined using a potassium chromate indicator in a titration against AgNO3. Titration against EDTA using the EBT indicator was used to determine the total hardness. To maintain the pH of the solution, a few drops of ammonium buffer pH 10 solutions were added. By subtracting the amount of magnesium from hardness, calcium (Ca) and magnesium (Mg) were assessed by titration against EDTA using murexide as an indicator. Furthermore, the flame photometer's standard method was used to quantify the amounts of sodium (Na) and potassium (K).

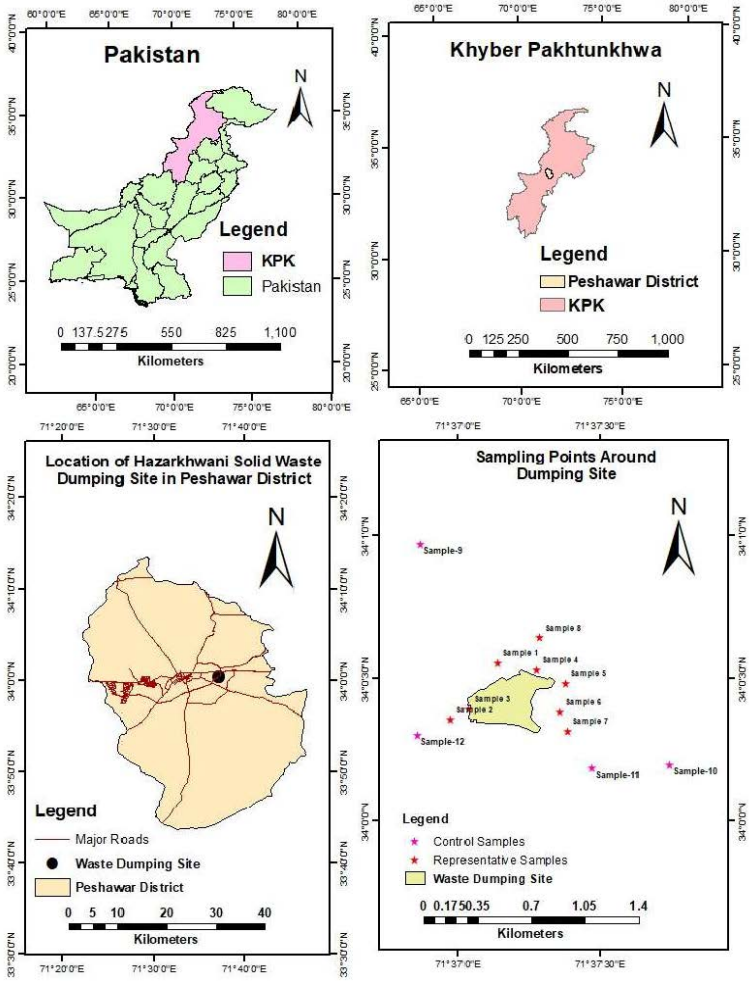

Fig.1. Location map and sampling points in the study area

3. Results

This section includes. the comprehensive analytical findings of the physiochemical parameters of tube well, bore water and hands pump water samples.

3.1. Physical parameters

The analytical data indicate that the pH and TDS of water samples ranged from 6.3 to 8.33 and 292 to 838, respectively, and were found within the acceptable range with the standards of drinking water reported by the WHO. The values of TDS in the majority of samples collected were found within the WHO acceptable limits ranging from 363 to 1617, except for 9 samples, which crossed the permissible limits as shown in Tables 1-3.

3.2. Chemical parameters

The total hardness concentration ranged from 244 to 448 mg/L and was measured within the acceptable limit in all samples except six samples. While, Ca^{+2} concentration in terms of hardness was reported in the range of 12 to 236 mg/L and from 28 to 252 mg/L, respectively, and considered within the permissible limit in the majority of the samples except a few samples, like 14 samples in Ca^{+2} and 7 samples in Mg^{+2} which did not fall within the permissible range. All samples' total alkalinity

readings, which ranged from 200 to 404 mg/L, were found within the WHO guidelines' allowed limit. The values of chloride ranged from 10.99 to 51.98 mg/L and were considered within the permissible limits except for one (n = 9 of hand pump water) sample. Potassium values ranged from 0.8 to 19.1 mg/L and were considered within the permissible limits except for 3 samples. Similarly, the values of Na ranged from 15.4 to 82.4 mg/L and were found within the WHO permissible limits in all water samples of the study area, as shown in Tables 1-3.

Table 1: Physiochemical parameters and descriptive statistics of tube well water samples.

S.No	PH	TDS [ppm]	EC [µS/cm]	T.Hard [mg/L]	Ca.H* [mg/L]	Mg.H* [mg/L]	M.Alk* [mg/L]	Cl [mg/L]	K [mg/L]	Na [mg/L]
WHO	6.5-8.5	1000	1000	500	200	150	600	250	12	250
1	6.75	393.90	606	332	144	188	216	24.99	3.50	31.9
2	6.73	400.40	616	304	132	172	224	23.99	3.50	32.0
3	6.85	406.25	625	280	156	124	226	23.99	3.90	33.1
4	8.20	299.00	598	224	136	88	244	25.99	3.60	32.6
5	8.33	408.20	628	324	176	148	236	21.99	3.50	32.3
6	8.08	518.05	797	316	164	152	240	37.98	3.40	32.6
7	8.12	436.80	672	404	152	252	240	15.99	3.40	31.6
8	7.80	474.50	730	324	132	192	252	29.99	3.40	32.3
9	8.05	429.60	661	340	136	204	244	25.99	3.50	32.8
10	8.29	452.40	696	308	116	192	248	25.99	3.40	31.7
11	7.40	470.60	724	312	148	164	236	43.98	19.10	32.5
12	7.38	413.40	636	256	128	128	236	19.99	3.00	30.1
13	7.07	404.90	623	280	128	152	232	15.99	2.90	30.7
14	7.11	741.00	1140	448	236	212	404	51.98	10.60	38.2
15	7.36	526.50	810	288	136	152	232	17.99	3.00	30.5
16	7.21	435.50	670	284	132	152	224	13.99	2.90	30.8
17	7.10	416.00	640	280	124	156	228	15.99	3.00	30.7
18	7.28	442.00	680	288	128	160	232	17.99	3.00	30.9
19	7.31	452.40	696	292	132	160	236	19.99	3.20	31.0
20	7.18	468.00	720	284	128	156	228	15.99	2.90	30.7
Mean	7.48	449.47	698.4	308.4	143.2	165.2	242.9	24.53	4.435	31.95
Std	0.51	81.84	116.46	47.61	25.56	34.27	37.94	9.71	3.73	1.67
Q1	7.10	406.73	625.75	281	128	152	228	16.49	3	30.725
Q3	8.07	469.95	723	324	151	191	243	25.99	3.5	32.575

*** M.AL** Methyl Alkalinity; **Ca.H** Calcium hardness; **Mg.H** Magnesium hardness

Table 2: Physiochemical and Descriptive statistics parameters of bore well water samples.

S.No	PH	TDS [ppm]	EC [µS/cm]	T.Hard [mg/L]	Ca.H [mg/L]	Mg.H [mg/L]	M.Alk [mg/L]	Cl [mg/L]	K [mg/L]	Na [mg/L]
WHO	6.5-8.5	1000	1000	500	200	150	600	250	12	250
1	7.3	299	600	270	156	114	200	19.99	1.6	16.8
2	7.6	436	873	392	264	128	300	19.99	1.8	19.2
3	7.4	414	828	378	428	118	260	29.99	12.8	39.1
4	6.3	381	763	340	164	196	240	27.99	3.2	28.9
5	7.0	375	751	300	176	124	220	31.99	3.5	30.2
6	6.7	419	838	392	264	128	272	33.99	3.8	31.1
7	6.7	356	751	324	232	92	248	35.98	4.5	36.8
8	6.8	600	935	556	264	292	352	35.98	4.2	39.3
9	7.0	585	982	512	224	228	404	25.99	6.9	37.2
10	7.4	550	888	484	192	292	392	39.98	13.6	38.2
11	7.2	480	800	440	196	244	292	31.99	4.5	37.7
12	7.37	712	1617	480	116	364	440	49.98	1.8	82.4
13	7.52	838	1128	532	12	340	512	87.97	9.6	59.2
14	7.94	305	597	260	120	140	268	19.99	1.3	15.6
15	7.50	360	1074	320	136	184	412	97.96	2.2	62.8
16	7.85	292	648	260	124	136	232	29.99	2.7	28
17	7.50	347	1162	332	216	116	364	49.98	4.1	35.1
18	7.60	300	1136	284	156	128	416	77.97	2.1	57.6
19	7.55	318	1250	298	152	146	480	45.98	5.3	72.4
20	8.30	668	861	428	120	308	364	25.99	0.8	24.5
21	7.56	610	921	448	124	324	436	35.98	2.1	19.8
Mean	7.33	459.28	923.95	382.38	182.66	197.23	338.28	40.74	4.4	38.66
Std	0.45	152.94	235.98	91.78	81.29	86.76	90.40	21.24	3.47	17.88
Q1	7	332.5	757	299	124	126	254	26.99	1.95	26.25
Q3	7.58	592.5	1101	464	228	292	414	47.98	4.9	48.45

*** M.AL** Methyl Alkalinity; **Ca.H** Calcium hardness; **Mg.H** Magnesium hardness

Table 3: Physiochemical and Descriptive statistics parameters of hands pump water samples

S.No	PH	TDS [ppm]	EC [µS/cm]	T.Hard [mg/L]	Ca.H [mg/L]	Mg.H [mg/L]	M.Alk [mg/L]	Cl [mg/L]	K [ppm]	Na [ppm]
WHO	6.5-8.5	1000	1000	500	200	150	600	250	12	250
1	6.92	546	841	384	184	200	356	34.98	16.9	30.5
2	7.66	235	363	244	76	168	188	10.99	0.9	15.4
3	6.95	601	925	392	224	168	336	48.98	4.6	50.6
4	7.10	460	708	284	256	28	272	24.99	4.2	34.1
5	7.33	638	983	280	156	124	176	42.98	2.4	30.5
6	6.80	792	1219	532	284	248	528	66.97	6.1	25.9
7	7.10	635	978	468	284	184	416	61.98	5.8	40
8	6.80	677	1043	488	280	208	380	57.98	4.2	53.4
9	6.75	646	995	498	284	214	378	468.85	4.7	46.8
Mean	7.04	581.11	895	396.66	225.33	171.33	336.66	90.96	5.53	36.35
Std	0.27	149.11	229.32	100.99	69.17	60.39	104.85	134.68	4.29	11.72
Q1	6.8	503	774.5	282	170	146	230	29.98	3.3	28.2
Q3	7.21	661.5	1019	493	284	211	398	64.475	5.95	48.7

*** M.AL** Methyl Alkalinity; **Ca.H** Calcium hardness; **Mg.H** Magnesium hardness

4. Discussion

4.1 Physical parameters

Overall findings showed that all samples taken from three sources (tube wells, bore wells, and hand pumps) met WHO requirements for drinking water quality in terms of their physical properties, including pH and TDS, while the EC was exceeded only in 9 samples. The WHO recommends that EC values should not exceed 1000 S/cm. In all physical parameters, pH plays a key role. A pH range of 6.0 to 9.0 appears to protect the life of freshwater fish and bottom-dwelling invertebrates (Hering et al., 1997). Total dissolved solids (TDS) refer to the materials that remain in water after the filtration of drinking water or suspended solid. The TDS is toxic as well as carcinogenic. Water salinity/total dissolved solids (TDS) is one of the principal factors affecting water quality (National Academies of Sciences, Engineering, and Medicine, 2021)

4.2 Chemical parameters

The total hardness of water mainly depends on the amount of Ca and Mg salts, or both. Seepage and runoff from soils, as well as polyvalent metallic ions from sedimentary rocks, are the main sources of hardness in water. The two main ions that cause water hardness are Ca and Mg, which are found in many sedimentary rocks (Akram and Rehman, 2018). The analyzed samples showed minimum values of 256 mg/L (n =12) for tube well water, 260 mg/L (n = 14) for bore water, and 244 mg/L (n = 2) for hand pump water, while the maximum values were 448 mg/L (n = 14) for tube well water, 556 mg/L (n = 8) for bore water, and 532 mg/L (n = 6) for hand pump water, respectively. Among the total samples, 44 were within the limits, while 6 samples (n = 8, 9, 13, 15, and 19 of bore water and n = 6 of hand pump) crossed the limits. Minimum concentrations of Ca and Mg or TDS in softened or demineralized could be established taking into account the characteristics of the water that enters these processes. The analyzed samples showed minimum values of 116 mg/L (n = 10) for tube well water, 12 mg/L (n = 13) for bore water, and 76 mg/L (n = 2) for hand pump water, while the maximum values were 236 mg/L (n =16) for tube well water, 428 mg/L (n = 3) for bore water and 284 mg/L (n = 6 and 7) for hand pump water. Among the total samples, 36 samples were within the permissible limits, while 14 samples (n= 14 of tube well water, n = 2, 3, 6, 7, 8, 9 and 17 of bore water, and n = 3, 4. 6, 7, 8 and 9 of hand pump water) were above the limits. The etiology of hypertension has been linked to magnesium insufficiency, as evidenced by several experimental and epidemiological research showing a negative relationship between blood pressure and serum magnesium levels (World Health Organization, 2010). The analyzed samples showed minimum values of 124 mg/L (n = 3) for tube well water, 40 mg/L (n = 3) for bore water, and 28 mg/L (n = 4) for hand pump water, while the maximum values were 252 mg/L (n = 3) for tube well water, 512 mg/L (n = 13) for bore water and 528 mg/L (n = 6) for hand pump water. Among the analyzed samples, 7 samples (n = 3, 5, and 12 of tube well water, n = 3 and 14 of bore water, and n = 4 and 5 of hand pump water) were within the limits, while 43 samples were above the limits.

Alkalinity is the capacity of water to neutralize acids. Alkalinity is primarily due to carbonate, bicarbonate, and hydroxide contents. It is used in the interpretation and control of water and wastewater processes (Kumar and Puri, 2012). The samples analyzed showed minimum values of 216 mg/L (n = 1) for tube well water, 200 mg/L (n = 1) for bore water and 176mg/L (n = 5) for hand pump water, while the maximum values were 404mg/L (n = 14) for tube well water, 512 mg/L (n = 13) for bore water and 528mg/L (n = 6) for hand pump water. All the samples were within the permissible limits. Because they are vital to the structure of human cells, chlorides are an essential part of the organism. Elevated amounts of chloride in groundwater aquifers in close proximity to the coast may indicate the occurrence of seawater intrusion into the aquifer. Chloride levels over 250 parts per million may have an impact on drinking water flavor (Fytianos and Christophoridis, 2004). The analyzed samples showed minimum values like 13.99 mg/L (n = 16) for tube well water, 19.99 mg/L (n = 1) for bore water and 10.99 mg/L (n = 2) for hand pump water, while maximum values were 51.98 mg/L (n = 14) for tube well water, 97.96 mg/L (n = 15) for bore

water, and 468.85 mg/L (n = 9) for hand pump water. Among the total samples, only one sample (n = 9 of hand pump water) crossed the permissible limits.

Plant and animal tissues contain potassium, an element that is necessary for life. For the general population, diet is the main source of K as it is present in all foods, especially fruits and vegetables (World Health Organization, 2021). The analyzed samples showed minimum values like 2.9 mg/L (n = 13, 16, 20) for tube well water, 0.8mg/L (n = 20) for bore water and 0.mg/L (n = 2) for hand pump water, while the maximum values were 19.1 mg/L (n = 11) for tube well water, 13.6 mg/L (n = 10) for bore water and 16.9 mg/L (n=1) for hand pump water. Among the total samples, 47 were within the limits, while only 3 samples (n = 11 of tube well water, n = 3 and 10 of bore water, and n=1 of hand pump water) crossed the limits. The non-hazardous metal sodium is primarily found as salts in natural water. The analyzed samples showed minimum values like 30.1 mg/L (n = 12) for tube well water, 15.6 mg/L (n = 14) for bore water, and 15.4 mg/L (n = 2) for hand pump water, while the maximum values were 38.2 mg/L (n = 14) for tube well water, 82.4 mg/L (n = 12) for bore water and 53.4 mg/l (n = 8) for hand pump water. The total samples were within the permissible limits.

5. Conclusion

The present study aimed to analyze both the physical and chemical parameters of drinking water from different sources in the village of Palosi Maghdarzai, Peshawar. After analysis, the findings of the study showed that some of the parameters were within the WHO acceptable limits, while some samples were exceeding the limits for some parameters. The samples showed permissible values for pH, TDS, total alkalinity, chloride, and sodium. While the exceeded values were shown by some samples for EC, total hardness, calcium hardness, chloride and potassium. The tube well water is considered safe among the bore water and hand pump water. It is recommended to investigate the potential health effects and develop strategies for public awareness and community involvement in water quality monitoring and protection.

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Authors contribution

Anis Safir proposed the main concept and involved in write up, and drafting of the manuscript, Saeeda Yousaf supervised the whole research and manuscript work, Muhammad Waqas and Azam Tariq provided basic facilities for the collection of samples and field data, Sabeela Ameen performed chemical analysis of the samples, Muhammad Ilyas revised the manuscript critically for important intellectual content and Waqas Safir read and approved the final manuscript.

Conflict of Interest

All authors declare no conflict of interest

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Data Availability Statement

The data sets generated and analyzed during the current study are available in the main body of the paper.

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