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Assessment of physiochemical characteristics of drinking water quality in Kohat Development Authority, NWFP, Pakistan

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Abstract

This study was conducted to investigate the physiochemical characteristics of drinking water in Kohat Development Authority (KDA). Water samples were collected from various point and non point sources located at different sectors of phase1 and 11 in the study area. Several analytical techniques including titration, flame photometer, spectrophotometer, and multi water quality checker were used to determine the quality of the drinking water in the area under investigation. The findings indicated that all physical parameters such as temperature, electrical conductivity, pH, total solid and total dissolved solid were within the permissible limits of WHO for drinking water. Whereas the values of total suspended solids in few samples were found beyond the permissible limit particularly collected from phase-11. The chemical parameters include sodium, potassium, sulphates, nitrates, nitrites and chloride contents were within their respective permissible limits set by WHO. The values of total hardness of all samples except one fall within the permissible limit. Whereas the calcium and magnesium values in terms of hardness were found higher in few samples as compared to WHO standards. The overall analytical data suggested that the higher values of calcium and magnesium contents and total suspended solid in few samples, particularly collected from phase-11, reflect the presence of dissolved bi-carbonates released into the water aquifer from sedimentary rocks such as limestone, dolomite and gypsum. Such type of hardness in the water is considered as temporary and non hazardous and can be removed easily by simple boiling or Clark's method (by adding Calcium Hydroxide) and filtration, respectively. It is concluded that the drinking water of KDA is safe in all respect for drinking purposes.

Keywords: Drinking Water quality; physio-chemical and biological characteristics; KDA

1. Introduction

Kohat Development Authority (KDA) is a medium size township scheme located in Kohat District at latitude 33°35' and 33°37' N and longitude 71°27' and 71°29' E with an altitude of 550 meters above the sea level. Geologically, the area is mainly comprised of sedimentary rocks consisting of Jurassic limestone, sandstone and clay. The limestone belongs to Kohat Formation of Eocene age. Whereas the sandstone and clay is part of the Muree Formation of Miocene age (Ahmad, 2003).

Kohat development Authority is divided into two phases i.e. Phase-1 and Phase-11, which are further divided into several sectors. There are total 10 sectors in phase-1 and 19 in phase 11. Majority of the covered area of Phase-11 is still under construction. Underground water is the main source for potable water in KDA. There are 6 operational tub wells, 4 in phase-1, and 2 in phase-11 (Fig. 1). Fresh water is initially stored into main reservoir and then pumped into 4 main tanks for further supply to the end consumers. But for drinking purposes, water is supplied directly from some tub wells to the end users. Initially construction of 4 tub wells in phase- 1 and 6 in phase- 2 with 0.75cusecs discharge was considered sufficient. But due to the population growth and high demand /consumption, 6 more tub wells were being installed in phase- 11.

Previous studies indicated that drinking water quality of the study area was generally satisfactory in terms of its physio-chemical and biological characteristics. But during the last one decade, a drastic increase in the population growth and consumption of water has adversely affected the quality and quantity of the water resources in Kohat District including KDA. The heavy discharge and low recharge in the aquifer have also disturbed the water table and the physical and chemical characteristics including total dissolved solid (TDS), total hardness and other related parameters (PCRWR, 2001; DCR, 1998-99).

Generally, safe drinking water is a fundamental human right and is essential for the protection of public health and environment and the communities. A correct balance in the sensory, physical, chemical and biological characteristics of water makes it drinkable. This study, therefore, aimed to examine the physio-chemical and biological characteristics to ascertain the drinking water quality of KDA, in compliance with the WHO water quality standards (WHO, 2004).

2. Materials and methods

2.1. Sample collection and preservation

Prior to the collection of samples, various GIS techniques such as geo-refrencing and spatial point and polygon overlays were produced to digitize the existing conventional map to select the point (Tub wells) and non point (main reservoir, user tap water) sources located in the study area. Global Positioning system (GPS) was used to record the precise geographic location of each sample collected for testing purposes (Fig. 1).

Total of 19 water specimens, 4 from tube wells located in phase 1 (Twp1.1-1.4), 2 from tube wells in Phase-11 (Twp2.1-2.2), 1 from main reservoir in phase-1 (MRP1), 10 from taps in phase-1 (TP1.1-10) and 2 from phase 11 (TP2.1-2) were collected for testing purposes.

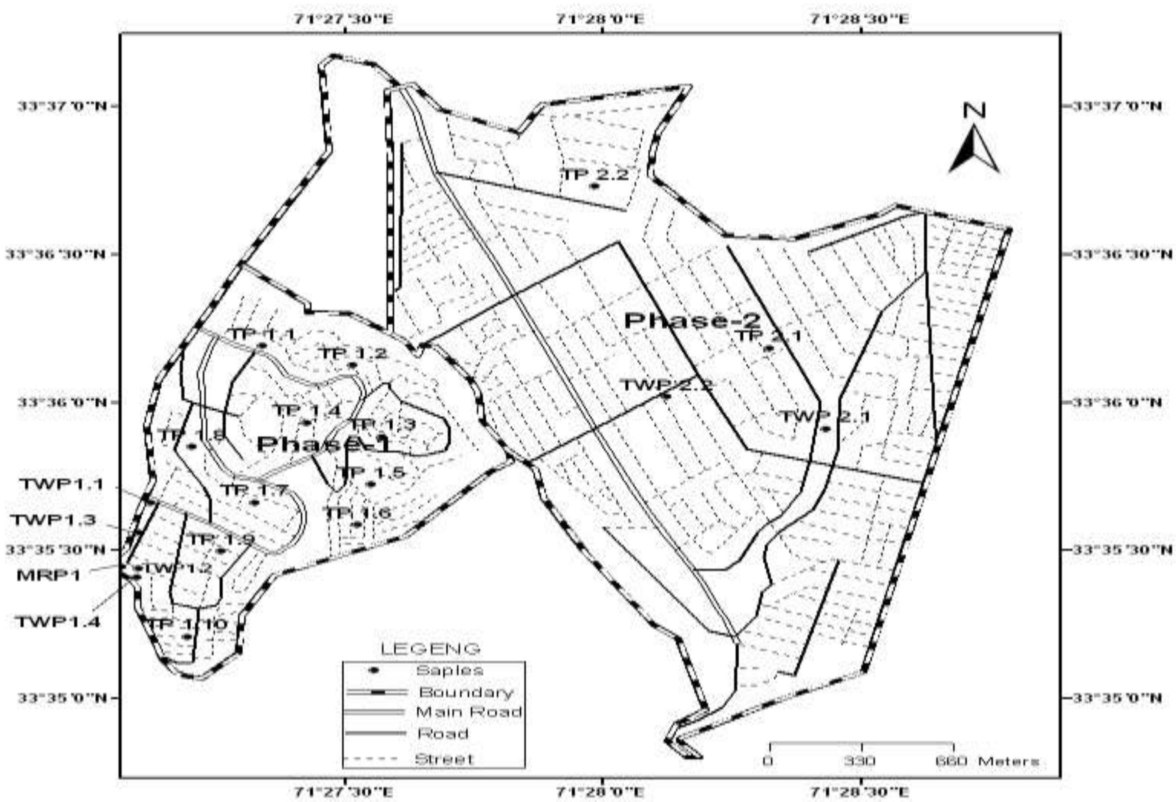

Fig.1. Location map and sampling points in the study area.

The physical parameters including color, taste, temperature, PH and electrical conductivity of all samples were tested on the spot by multi water quality checker. All the samples were stored in a Duran sterilized polystyrene bottle of 1.5 liter capacity and were transferred to laboratory within a recommended time for different physical and chemical analysis. All samples were precisely marked on the geo-referenced and digitized map of the study area.

2.2. Analytical methods

Temperature (T) and electrical conductivity (EC) were determined by water quality checker and PH by PH meter. The Total Solid (TS) and Total Dissolved Solid (TSS) and Total Suspended Solid were determined by titration methods. Alkalinity was determined by titration against H_2SO_4 using methyl orange indicator and hardness by titration against EDTA using erichrome-black tea indicator. Among the anions, Chloride (Cl) was analyzed by titration against $AgNO_3$ using potassium chromate indicator and sulphate (SO_4) by titration against EDT using erichrome-black tea indicator. Nitrite (NO_2) and nitrate (NO_3) were determined by the colorimetric method at maximum transmittance of 520nm and 275nm respectively. Among the cations, calcium (Ca) was determined by titration against EDTA using ammonium purporated indicator and magnesium (Mg) was determined by deducting the amount of calcium from hardness. Sodium (Na) and potassium (K) were determined by flame photometer. Moreover, coliform bacteria as maximum probability number (MPN) in water samples were measured using standard method (APHA, 1998).

3. Results

The detailed analytical results including physical and chemical parameters are presented in Tables 1-3. Table 1 summarize the physical parameters including temperature, pH, EC, TS, TDS and TSS of the water samples collected from different point and non point sources located in phase 1 and phase-11. The chemical parameters including alkalinity, hardness cations and anions are given in Tables 2 and 3 respectively.

3.1. Physical parameters

The analytical data indicate that all water samples were found colorless and tasteless. The temperature and pH values of all samples were ranging from 24-27 ^{0}C and 7.0-8.2 respectively and were found within the permissible limit of WHO (2004) standards for drinking water quality (Table 1). The values of total solid and total dissolved solid were also found within the range of WHO (2004) standards (Table 1). The values of total suspended solid in majority of samples collected from phase-1 and phase-11 were found within the WHO (2004) permissible limits except in water samples Twp1.2, Twp1.3, Tp1.7 from phase 1 and TWP2.1 and 2.2 from phase-11 (Table 1).

3.2. Chemical parameters

The values of total alkalinity in all samples ranged from 357-450mg/l and were found within the permissible limit of WHO standard. The total hardness concentration ranged from 356-512 mg/L and was considered within the permissible limit in all samples except one (Twp2.2) (Table. 2). While Ca and Mg concentrations in terms of hardness were reported in the range of 231-300 mg/L and 111-212 mg/L respectively and considered within the permissible limit in majority of the samples except in TWP2.1, 2.2 and TP1.5 and TP2.1 and TP2.2 (Table 2). Cations and anions concentrations in all water samples of the study area were found within the WHO permissible limit (Table 3).

Table1. Physical parameters of water samples collected from KDA.

Samples ≠	Temperature (^{0}C)	pH	E. Conductivity (μs/cm)	TS (mg/l)	TDS (mg/l)	TSS (mg/l)
Twp1.1	25	7.5	861	535	532	3
Twp1.2	26	7.5	849	516	507	9
Twp1.3	25	7.9	898	607	599	8
Twp1.4	25	7.1	872	528	738	4
Twp2.1	25	7.5	986	607	595	8
Twp2.2	25	8.2	1002	748	594	10
MRP1	25	7	867	552	550	2
Tp1.1	24	7.7	853	598	595	3
Tp1.2	27	7.7	836	595	594	1
Tp1.3	25	7.2	819	469	464	5
Tp1.4	25	7.3	848	530	528	2
Tp1.5	26	7	857	561	558	3
Tp1.6	25	7.5	868	541	536	5
Tp1.7	25	7.8	86	585	579	6
Tp1.8	25	7.4	824	538	536	2
Tp1.9	26	7.3	870	587	583	4
Tp1.10	26	7.5	862	545	541	4
Tp2.1	25	7.5	976	590	585	5
Tp2.2	27	7.9	998	585	683	2
PL	25-30	8.5	250	1000	1000	5

PL: WHO Permissible Limit

Table 2. Concentration of total hardness, alkalinity and Ca and Mg hardness in mg/L in water samples collected from KDA.

Samples ≠	T. hardness	Alkalinity	Ca hardness	Mg hardness
Twp1.1	388	400.0	244	144
Twp1.2	381	371.0	238	143
Twp1.3	412	386.0	280	132
Twp1.4	356	382.0	231	125
Twp2.1	456	372.0	264	192
Twp2.2	512	450.0	300	212
MRP1	388	390.0	248	140
Tp1.1	395	392.0	248	147
Tp1.2	393	400.0	245	148
Tp1.3	362	370.0	251	111
Tp1.4	380	359.0	244	136
Tp1.5	398	381.0	259	139
Tp1.6	374	385.0	238	136
Tp1.7	379	381.0	253	126
Tp1.8	385	362.0	245	140
Tp1.9	392	357.0	246	146
Tp1.10	389	372.0	250	139
Tp2.1	424	400.0	260	164
Tp2.2	494	435.0	287	207
PL	500	500	250	150

PL: WHO Permissible Limit

Table 3. Cations and Anions concentration values in mg/L in water samples collected from KDA.

Samples ≠	**Na**	**K**	**SO_4^-**	**Cl^-**	**NO_2^-**	**NO_3^-**
Twp1.1	21	8.4	198	68	0.084	8.2
Twp1.2	27	6	181	53	0.08	7.1
Twp1.3	26	7.1	225	72	0.093	8.2
Twp1.4	25	6.2	203	59	0.071	6.2
Twp2.1	26	4.4	239	112	0.086	8.4
Twp2.2	25	8	200. 1	126	0.095	18.3
MRP1	23	8	207.4	68	0.085	9.1
Tp1.1	21	5.9	200.1	57	0.082	9.2
Tp1.2	28	6.8	196	48	0.079	5.4
Tp1.3	24.3	7	195	75	0.086	7.1
Tp1.4	30	7.5	193	49	0.082	6.6
Tp1.5	27	6.5	208	65	0.08	8.8
Tp1.6	32	5.9	189	47	0.078	6.4
Tp1.7	22	8.3	206	61	0.079	9.4
Tp1.8	25	7	210	64	0.083	6.5
Tp1.9	29	8.2	199	55	0.078	8.6
Tp1.10	22	9	200	71	0.085	7.3
Tp2.1	23	4.2	224	112	0.082	7.7
Tp2.2	26	6	234	121	0.089	17.7
PL	200	75	250	250	0.1	45

PL: WHO Permissible Limit

4. Discussion

The overall results revealed that the physical characteristics including temperature, turbidity, pH, TS, and TDS of all samples either collected from the source (tube wells) or the end users (Tape water) located in phase-1 and 11 were found within the permissible limits set by WHO for drinking water quality standards. The pH and turbidity of drinking water are usually dependent on the quantity and nature of TS including the dissolved and suspended solids. The interpretation of analytical results of the current study suggested that TSS occurred mainly in the form of carbonates and bi-carbonates and may have been released from the host sedimentary rocks, mainly limestone and dolomite, into the water aquifer in the study area. Such type of dissolved solids were mainly found coarser in size and caused suspension but no turbidity. As a result the pH and turbidity values of all samples in the present study fall within the WHO permissible limit, The pH of drinking water has no immediate direct effects on human health but has some indirect health effects by bringing changes in other parameters such as solubility of metals and survival of pathogens (Ho et al., 2003). In sensitive individuals gastrointestinal irritation may also occur, however, occasional pH changes may not have any direct impact on consumers.

The chemical parameters including hardness and alkalinity are closely related with each other. The alkalinity of water is a measure of its buffering capacity. The higher the value, the more acid can be neutralized i.e., the more the water can resist a change in pH). Alkalinity of natural water is primarily the result of bicarbonates, but mostly expressed in terms of calcium carbonate. The results of the current study show that the pH values of all the samples were recorded below 8.3 and the total hardness and alkalinity values were recorded more or less in the same range. Therefore, it was assumed that the total hardness of the drinking water particularly in samples collected from phase-11 is due to the presence of carbonates and bicarbonates which causes alkalinity as well as temporary hardness. Apart from this the geological environments of the study area also support this assumption. However, the higher values of hardness in few samples as compared with the alkalinity reveals that permanent hardness may also exists in traces in the form of SO_4^- and Cl^-.

Hardness in water is of two types i.e. Ca-hardness (when Ca is combined with other constituents) and Mg-hardness (when Mg is combined with other constituents). The degree of hardness of drinking water may be classified in terms of its calcium carbonate concentration as: soft, 0 to <60 mg/L; medium hard, 60 to <120 mg/L; hard, 120 to < 180 mg/L; and very hard, 180 mg/L and above (Environment Canada, 1977). The principal natural sources of hardness in water are sedimentary rocks and seepage and runoff from soils. In general, hard waters originate in areas with thick topsoil and limestone formations and hardness levels up to several thousand milligrams per liter can result (Sawyer and McCarty, 1967).

The cations and anions concentration values in all samples collected from the point and non point sources located in phase-1 and 11 were in the range of WHO standards limit. Because the host environment of ground and underground water aquifer in KDA is free from such contamination. The contamination of NO_3 mainly occurs due to overusing of fertilizers, sewage disposal, manure applications and wastewater of livestock farms (Chowdary et al., 2005). The primary health problem associated with high intake of NO_3 in drinking water is methemoglobinemia (blue baby syndrome) (Gupta, et al., 2000). However, the adult individuals can tolerate high levels of NO_3 with little or no documented adverse health effects and may be able to drink water with nitrate concentrations considerably greater than the 10 mg/L with no acute toxicity effects (Bruning-Fann and Kaneene, 1993).

The values of Na and K concentrations were found within the permissible limit in all specimens. Sodium is the nontoxic metal and mostly exists in natural water in the form of salts. Analytical comparison of results of the studied area samples pointed towards their combination with SO_4^- and Cl^- Possible combination of SO_4^- and Cl^- with Ca and Mg for hardness is already discussed.

5. Conclusions

It can be concluded from the analytical results that the physio-chemical characteristics of drinking water in the study area are within the permissible limit of WHO standards except the TSS and hardness in terms of Mg and Ca contents in few samples specifically collected from phase 11. The overall interpretation of analytical data reveals that the type of hardness exists due to the host sedimentary environment and is considered temporary that can be removed easily by boiling and filtration. Overall it is concluded that drinking water of KDA is safe for drinking purposes.

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References

Ahmad, S., 2003. A comparative study of structural styles in the Kohat Plateau, NW Himalayas, NWFP, Pakistan. Unpublished PhD thesis, University of Peshawar.

APHA., 1998. Standard Methods for the Examination of Water and Wastewater, 19th Edition. American Public Health Association, Washington DC, USA.

Bruning-Fann, C.S., Kaneene, J.B., 1993. The effects of nitrate, nitrite, and N-nitroso compounds on human health: a review. Veterinary and Human Toxicology, 35, 521-538.

Chowdary, V.M., Rao, N.H., Sarma, P.B.S., 2005. Decision support framework for assessment of non-point-source pollution of groundwater in large irrigation projects. Agriculture Water Management, 75, 194-225.

DCR. 1998-99. Kohat District Census report, Government of Pakistan.

Environment Canada, 1997. Surface water quality in Canada: an overview. Water Quality Branch, Inland Waters Directorate.

Gupta, S.K., Gupta, R.C., Seth, A.K., Gupta, A.B., Bassin, J.K., Gupta, A., 2000. Recurrent acute respiratory tract infections in areas with high nitrate concentrations in drinking water. Environmental Health Perspective, 108, 363-366.

Ho, K.C., Chow, Y.L., Yau, J.T.S., 2003. Chemical and microbiological qualities of the East River (Dongjiang) water, with particular reference to drinking water supply in Hong Kong. Chemosphere, 52, 1441-1450.

KDA. 2006. Kohat Development Authority, KDA annual report.

PCRWR, 2001. Report of "National Water Quality Monitoring Program", Available at: http://www.pcrwr.gov.pk/water_quality.htm.

Sawyer, C.N. and McCarty, P.L. 1967. Chemistry for sanitary engineers. 2nd edition. McGraw-Hill Series in Sanitary Science and Water Resources Engineering, McGraw-Hill, Toronto.

Tamasi, G., Cini, R. 2004. Heavy metals in drinking waters from Mount Amiata (Tuscany, Italy). Possible risks from arsenic for public health in the Province of Siena. Science Total Environment, 327, 41-51.

WHO, 2004. Guidelines for drinking water quality, 2nd Ed. World Health Organization.