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CHARACTERIZATION OF SPRING WATERS OF MURREE REGION

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Ten samples of water from springs located in different parts of Murree region of Pakistan were collected and evaluated for the drinking quality. The chemical analysis showed that all samples are of the same type and are fit for drinking, domestic or industrial purposes as these fall within the WHO permissible limits of drinking water. Two samples were better than others due to low hardness and alkalinity whereas one sample had the highest hardness and alkalinity.

Key words: Spring water, Murree region, Chemical composition.

Introduction

A spring is a concentrated discharge of ground water appearing at the ground surface as current of flowing waters (Todd 1959) or below the hydraulic gradient in an artesian aquifer from which the water can escape (Bryan 1919). However for drinking purposes, all waters should be free of microorganisms which cause various ailments like typhoid, jaundice, hepatitis B, cholera etc. and chemically, their cations and anions levels should fall within the World Health Organization permissible limits, specially the amounts of trace metals like iron, zinc, copper, chromium, lead and cobalt etc. In very small amounts, they are beneficial to human body but above a certain limit, they are harmful (WHO 1958). For example copper up to 1 mg l^{-1} is good for the functioning of several enzymes and haemoglobins synthesis but above this limit it is injurious for health (Snell and Biffen 1964). Similarly iron upto 1 ppm in water is permissible for human consumption. Its deficiency causes anaemia and many other metabolic disorders (Mertz *et al* 1977). Zinc is associated with a number of enzyme systems and its deficiency retards the growth. WHO has suggested a limit of 5 ppm for zinc. Chromium and lead are both toxic to man if their concentration is more than 0.05 mg l^{-1} in potable water (Oberleas *et al* 1966). Concentration of cadmium in water above 0.01 mg l^{-1} is toxic to man and other invertebrates. The concentration of nitrate above the permissible limit of 10 ppm is toxic, specially to infants (Greenberg *et al* 1992).

A lot of research has been carried out upon the quality and characterization of spring water of various areas such as Saudi Arabia (Peverly and Kopka 1991), south regions of Albama (Ghorai *et al* 1991), sedimentary rocks of Southern Caspian area of USSR(Balakishieva 1988), Bahrain (Madany and Akhtar 1990), Adriogole Israel (Lim *et al* 1991), Ustave Czechoslovakia (Musil 1990) and Edenkoben West Germany (Andl 1982), using various methods.

There are a number of springs in Pakistan but very few studies have been made for characterizing the water of these springs for drinking or industrial purposes (Lim *et al* 1991; Beg et al 1984; Ashraf *et al* 1987). The present studies were carried out to characterise the water of various springs located at different places in Murree for public and industrial use.

Experimental

Ten samples of water were collected in December, 1996 from various springs of Murree Region of Pakistan as shown in Table 1.

The samples were collected from the sources in plastic bottles, after rinsing them with the water being sampled and securely corked. The samples were numbered and the location of spring, colour, odour and taste of water was recorded immediately after sampling (Aman et al 1992).

Reagents. All reagents were of analytical grade and were prepared according to the International Standards for the Analysis of Drinking Water (WHO 1958).

Apparatus. pH meter (Backmen Zerometric Germany); Conductometer (KT4, Karl Kolb, Germany); spectropho tometer (Spectronic 20); flame photometer (Corning EEL Model 1000 Evens Electron Selenium Ltd., Halstead Essex England); atomic

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absorption spectrophotometer (Hitachi, Model ITO-10, Japan).

Procedure. Physical measurements and chemical analysis of all the ten spring water samples were carried out according to the recommended standard procedure (Anon 1972; EPA Report 1979). Detailed chemical analysis of the samples is shown in Table 2.

Results and Discussion

Physical properties. All the samples were colourless and had no significant turbidity (in the range of <5 NTU), suspended solids or settleable solids (Table 1) The taste of 5 samples i.e. 2,4,6,7 and 10 was sweet while the rest were tasteless. However, all the samples were odourless. Temperature recorded at the source indicated all the springs to be cold springs. The taste of sweet water samples corresponds to their respective conductivity and the total solid (TDS) which are less than the other samples. Soluble salts found in ground water originate primarily from rock material (Froster 1942).

pH. The pH of all the samples ranged between 7.1 to 7.5, the average value being 7.29, indicating neutral characteristic, which is satisfactory. and within WHO permissible limits of 7.00-8.5. Moderately high pH values are common for water having high bicarbonate content.

Electrical conductivity. Conductivity measurements show that sample 1 had the highest conductivity i.e. 990 micro mhos cm^{-1} and sample 10, the lowest i.e. 381 micro mhos cm^{-1} at 250 °C. This was due to the presence of high total dissolved solids (634 ppm) in sample 1 and the lowest TDS (244 ppm) in sample 10. However, there is no standard for electrical conductivity as the water quality depends on TDS and the WHO standard for TDS is 500-1500 ppm.

Chemical properties. Alkalinity. Total alkalinity, estimated as calcium carbonate, lies in the range of 134 ppm (sample 7) to 409 ppm (sample 1). There was zero phenolphthalein alkalinity showing the absence of carbonate in all the samples (Table 2). The methyl orange alkalinity was greater than twice the phenolphthalein alkalinity which also indicates the absence of caustic alkalinity (Snell and Briffen 1964). Thus the total alkalinity is mainly due to the presence of bicarbonate of calcium and magnesium.

Hardness. Total hardness (Table 2), estimated as calcium carbonate, lay in the range of 168 ppm (sample 10) and 450 ppm (sample 1) but the calcium content as calcium carbonate was the highest in sample 5 (290 ppm) and the lowest in sample 6 (108 ppm) whereas in sample 1, the hardness as magnesium content was highest i.e. 296 ppm and lowest in sample 9 (32 ppm). Again these values lie within permissible limits of WHO for total hardness i.e. 500 ppm.

Total dissolved solids. (TDS). The amount of total dissolved solids was found to be in the range of 244 ppm to 634 ppm. The lowest TDS, 244 ppm was found in sample 10 which had sweet taste and the highest TDS 634 ppm was in sample 1 which was tasteless.

Anion and cation contents. Table 3 shows the anion and cation contents of the spring water under investigation . These

Table 1
Springs of Murree regions

Sample No.	Name of spring	Location	Local usage
1.	Margala Hill (cold spring)	At the foot of the Hill, Islamabad.	Drinking, house hold and for cleansing.
2.	Pini Pir (cold spring)	100 km upwards from the basis of the Hill, Islamabad	Drinking, house hold and for cure of skin diseases and stomach disorders.
3.	Ghora Gali (cold spring)	Ghora Gali, Murree	Same purpose as above
4.	Patriata (cold spring)	Patriata, Murree	Same purpose as above
5.	Sehare Gharan (cold spring)	Sehare Gharan, Murree	Drinking, house hold and for skin diseases
6.	Ayubia (cold spring)	Ayubia	Drinking and house hold
7.	Murree Hill (cold spring)	Centre Point, Murree	Same purpose as above
8.	Murree Hill (cold spring)	Pindi Point, Murree	Same purpose as above
9.	Murree Hill (cold spring)	Kashmir Point Murree	Same purpose as above
10.	Murree Hill (cold spring)	Murree Hill Proper	Same purpose as above

Table 2
Quality of various spring waters

Sample No.	Taste	Colour unit	Odour	Turbidity (N.T.U.)	pH	Electrical conductivity at 25°C	Total dissolved solids (ppm)	Alkalinity as $CaCo_3$			Hardness As $CaCO_3$		
								Phenol phthalein alkalinity	Methyl orange alkalinity	Total alkalinity	Total hardness	Mg hardness	Ca hardness
1.	Tasteless	<5	Odourless	<1	7.5	990	634	Nil	409	409	450	296	154
2.	Sweet	<5	Odourless	<1	7.3	719	460	Nil	283	283	302	154	148
3.	Tasteless	<5	Odourless	<1	7.4	844	540	Nil	331	331	364	230	134
4.	Sweet	<5	Odourless	<1	7.1	772	494	Nil	303	303	332	188	144
5.	Tasteless	<5	Odourless	<1	7.1	869	536	Nil	320	320	358	68	290
6.	Sweet	<5	Odourless	<1	7.4	611	391	Nil	240	240	252	144	108
7.	Sweet	<5	Odourless	<1	7.2	421	269	Nil	134	134	180	46	134
8.	Tasteless	<5	Odourless	<1	7.3	581	372	Nil	175	175	246	94	152
9.	Tasteless	<5	Odourless	<1	7.3	774	495	Nil	270	270	312	32	280
10.	Sweet	<5	Odourless	<1	7.3	381	244	Nil	136	136	168	38	130

Table 3
Concentration of anions and cations in spring water samples

Sample No.	CO_3''/ HCO_3 (ppm)	Cl' (ppm)	SO_4'' (ppm)	NO_3' (ppm)	NO_2' (ppm)	Ca^{++} (ppm)	Mg^{+} (ppm)	Na^{+} (ppm)	K^{+} (ppm)	Fe^{++} (ppm)	Zn^{++} (ppm)	Cu^{++} (ppm)	Co^{++} (ppm)	Cr^{+++} (ppm)	Cd^{++} (ppm)	Pb^{++} (ppm)
1.	Nil/499	15	40	1	<0.0	62	71	9	1	0.00881	0.0631	0.00723	0.01474	0.00569	0.0079	Nil
2.	Nil/345	16	25	1	<0.0	59	37	13	1	0.00295	0.00653	Nil	0.04573	0.00018	0.00643	Nil
3.	Nil/404	28	29	1	<0.01	54	55	16	1	0.00395	0.01941	Nil	0.01436	0.00077	0.00901	Nil
4.	Nil/370	17	33	1	<0.01	58	45	13	1	0.00146	0.01719	0.00518	0.01224	0.01415	0.00736	Nil
5.	Nil/390	18	40	1	<0.01	116	16	13	1	0.00386	0.01414	Nil	0.01544	0.00374	0.00677	Nil
6.	Nil/293	16	20	1	<0.01	43	35	14	1	0.01689	Nil	0.00749	Nil	0.00523	0.00484	Nil
7.	Nil/163	20	29	1	<0.01	54	11	5	1	0.01879	0.10522	0.00261	Nil	0.01129	0.00412	Nil
8.	Nil/214	42	37	1	<0.01	61	23	12	1	0.00466	0.00525	0.02213	0.00346	0.00374	0.0043	Nil
9.	Nil/329	40	29	1	<0.01	112	8	18	1	0.00543	0.01726	Nil	0.01156	0.01564	0.00754	Nil
10.	Nil/166	14	19	1	<0.01	52	9	3	1	0.00604	0.00571	0.01211	Nil	0.00729	0.00212	Nil

soluble salts found in the ground water originate primarily from rock materials (Bourdon *et al* 1987).

Chlorides. The chloride contents of the samples ranged between 14 ppm (sample 10) and 42 ppm (sample 8). However, all the samples had chloride contents far below the WHO permissible limit which is 250 mg l^{-1}. Because of low chloride contents, the spring waters were tasteless or sweet. Consequently, it is the chloride content and not the bicarbonate concentration which determines the taste of these waters (McGraw Hill 1960) e.g. sample 1 had the highest bicarbonate content but is tasteless.

Sulfates. Sulfate ion concentration of the spring water samples ranged between 19 ppm (sample 10) and 40 ppm (sample 1). Sample 1 and 10 also had the highest and the lowest concentration of TDS respectively but not chloride ions. The source of sulfate in the spring water was mainly calcium sulfate and sodium sulfate, but the latter, to a limited extent.

Carbonate and bicarbonates. Carbonate content was zero in all the ten samples of spring water, however, bicarbonates were present in each sample in the range of 166 ppm (sample 10) to 499 ppm in sample 1. All sweet water samples were found to contain significantly high bicarbonate concentration than the chloride and sulfate ions. Thus it was chloride and not bicarbonate concentration which determined the taste of these spring waters.

Nitrate and nitrite. Nitrate and nitrite contents of all the spring water samples was 0.01 ppm which is below the standard of 20 ppm; excess of this limit causes methemoglobineamia in infants (Greenberg *et al* 1992).

Calcium. WHO standard for calcium is 75 mg l^{-1} in drinking water and the observed concentration of calcium ion in the spring water samples varied from 43 ppm (sample 6) to 116 ppm (sample 5). Natural waters carry quantities of calcium bicarbonate when derived from upland sources up to 200 to 300 ppm as $CaCO_3$ than those supplies derived from underground or lowland spring because the ground water, in contact with sedimentary rocks of marine origin derives most of its calcium from the calcite, aragonite, dolomite gypsum mixtures (Davis and Dewiest 1966). All the samples except sample 5 and 9 were within the WHO standards.

Magnesium. The concentration of magnesium ion in the spring water samples varied from 8 ppm (sample No.9) to 71 ppm (sample 1), whereas the WHO standard is 50 mg l^{-1} for drinking water. All samples except sample 1 was within this range. Generally magnesium is contributed to spring waters by dolomite (Davis and Dewiest 1966).

Sodium. The concentration of sodium varied from 3 ppm (sample 10) to 10 ppm (sample 9) thus closely following the variation pattern of chloride and sulfate. High concentration of sodium and chloride ions render saline taste to the spring water. Other than the taste, high sodium content in water can lead to cardiovascular diseases and high blood pressure (Greenberg *et al* 1992; Peverly and Kopka 1991).

Potassium. The potassium content in spring water was less than that of sodium, calcium, and magnesium. All water samples contained 1 ppm of potassium except for sample 9 which contained 7 ppm. In the descending order for amount of anions and cations, potassium ion content was always the lowest. However, all the samples lay well within the range of WHO standard (Table 4).

Iron. The WHO permissible limit of iron in drinking water is 1.0 mg l^{-1}. Highest iron content was found in sample 7 (0.018799 ppm) and lowest in sample 4 (0.00146 ppm).

Table 4

WHO standards for drinking water

Sr.No.	Parameters	WHO desirable levels	WHO max permissible levels	Remarks
1.	Temperature °C			
2.	pH	7.0-8.5	6.5-9.2	
3.	Odour	Unobjectionable	Unobjectionable	
4.	Colour	5 units	50 units	
5.	Taste	Unobjectionable	Unobjectionable	
6.	Turbidity ppm Silica units or N.T.U.	5 units	25 units	
7.	Total dissolved solids mg l^{-1}	500.00	1500.00	
8.	Calcium mg l^{-1}	75.00	200.0	
9.	Magnesium mg l^{-1}	50.00	150.00	
10.	Total hardness mg l^{-1} as $CaCO_3$	100.00	500	
11.	Total alkalinity mg l^{-1} as $CaCO_3$		30-500	
12.	Sulfate mg l^{-1}	200.00	400	Laxative effects at 750 mg l^{-1}
13.	Chloride mg l^{-1}	200.00	600.00	
14.	Iron total mg l^{-1}	0.1	1.00	
15.	Conductivity um cm^{-1} or us cm^{-1}			
16.	Copper mg l^{-1}	1.0	1.0	Body needs 1mg day^{-1}; health hazard in large doses
17.	Zinc mg l^{-1}	5.0	5.0	Beneficial in small quantities; above 675 mg l^{-1} emetic
18.	Chromium mg l^{-1}	0.05	0.05	Carcinogenic when inhaled
19.	Lead mg l^{-1}	0.05	0.05	Cumulative body poison
20.	Cobalt mg l^{-1}	1.0	1.0	
21.	Cadmium mg l^{-1}	0.01	0.01	13-15 ppm cause illness
22.	Nitrate mg l^{-1}	20	45	Excess, health hazard to infants

Ground water which is classified as spring water consists essentially of the seven component aqueous system i.e. ions of calcium, magnesium, sodium, potassium, bicarbonate, sulfate and chloride. The dissolved matter in water although originating from the minerals in an aquifer has no relation with the composition of the rocks, because many soluble impurities present in the rocks can also affect the water quality (Hem 1959). Besides the seven components of water, traces of some cations can be found in spring waters which are toxic if they exceed the WHO standards of potable water (Table 4).

Trace elements. Copper ion is present in traces. It was absent in samples 2,3,5 and 9. It ranged between 0.02213 ppm (sample 8) and 0.00261 ppm (sample 7). All the samples lay well below the range of WHO standards which is 1.0 mg l^{-1}. (Table 4).

The WHO standard for the trace element zinc in the drinking water is 5.0 mg l^{-1}. It was absent in sample 6, highest in sample 7 (0.10522) ppm) and lowest in Sample 8 (0.00525 ppm). Excess concentration of copper or zinc can cause health hazards specially zinc which is emetic in high doses (Table 4).

Cobalt ion was absent in samples 6,7and 10 but was present in trace amounts in the rest of the samples. The standard amount is 1 mg l^{-1}. Cobalt is a constituent of vitamin B_{12}, necessary for normal red blood cell formation, but its excess amount causes toxic side effects like polycythemia and vaso-dilation (Mertz *et al* 1977).

The WHO standard for chromium is 0.05 mg l^{-1} and 0.01 mg l^{-1} for cadmium. All the ten samples lay well below these concentrations. Lead was totally absent in all the spring water samples. WHO standard for lead is 0.05 mg l^{-1}. Excess of chromium, cadmium and lead can lead to cancerous hazards (WHO 1958).

Conclusion

The results of the chemical analysis of the spring waters carried out on samples collected from different localities of Murree region show that all samples are of the same type with little variation and lie within the WHO limits of drinking water and so are fit for drinking and house hold use. Two samples (7 and 10) were better than the others due to low hardness and alkalinity, whereas one sample (1) had highest hardness and alkalinity. This may be due to the location of the spring at the foot of the Margala Hills.

In sedimentary rocks, fresh water is located in silicious sands and sand stones formed of quartz. All the ten samples are true carbonate rock water as they conform to the category $HCO_3' > SO_4'' > Cl'$ on the basis of their ionic composition (Hem 1959). These waters are either sweet or tasteless and are not only palatable but also fit for house hold use.

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