Ground Water Quality of Surrounding Areas of Peshawar City

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(Received 25th October, 2003, revised 28th February, 2004)

Summary:Ground water samples from 28 tubewells in the surrounding areas of Peshawar city were collected and analyzed for physiochemical parameters viz., total hardness, chloride contents, pH, specific conductance, alkalinity, ammonia, nitrate, biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The results obtained were compared with the limits recommended by WHO and Pakistan Council of Research in Water Resources (PCRWR). Specific conductance of 19 out of 28 water samples was found to be above the WHO permissible limit indicating the presence of high content of total dissolved solid. All the water samples had total hardness above the PCRWR desirable limit of 200 mg dm^{-3}. COD level of nine samples out of 28 were above the WHO permissible limit, which may be due to seepage of domestic sewage and industrial effluents. The significance and implications of the levels of all the parameters determined have been discussed.

Introduction

For every living system the presence or provision of water is of cardinal importance. Biological processes can continue on the earth as long as water is available. The two main sources of potable water are surface water and ground water. Rivers and streams are the important surface water sources, while springs, deep and shallow wells are the common sources of ground water. It is generally pure when drawn from greater depths as in the case of deep tube wells except that the water may be hard.

The main sources of ground water are precipitation (snow, rain, dew etc) and underground (phreatic) water. The water delivered by precipitation penetrates the ground. In grounds that consist of coarse particles and thus have big pores, the water penetrates rapidly and sinks into porous stratum. In this way salts are dissolved in the upper layer of earth and build up in the lower layer. Those particularly involved are sulfates, chlorides and carbonates. According to the quantity of the rainfall and the strength and nature of the ground, the salts dissolved will sink into the underground water and leave the solid phase or form so-called enrichment layers lower down. Owing to the absence of sunlight there is no green plant life in ground water. Consequently all the organisms that live in groundwater depend on the provision of organic matter from outside, that is, from earth's surface [1, 2].

Public water supplies from groundwater sources are economical as well as less complicated. In many cities of Pakistan tube wells are the main sources of drinking water. Some of the ground water sources may be contaminated and render unhygienic because of the seepage of waste water and industrial effluents. Water is said to be polluted when its condition or composition or both are changed. The major pollution sources are domestic and industrial wastes from urban, rural and industrial areas, discharged in the natural water bodies. The menace of water born diseases and epidemics looms large on the horizons of developing countries [3]. According to WHO survey, 60% diseases in the Asian countries are water born [4]. Water pollution is also a big problem in Pakistan. It is necessary to examine the quality of water from time to time, in order to have a check upon the level of inorganic, organic, microbial and bacterial pollutants. Studies have already been made to ascertain the suitability of water for human consumption in different cities of Pakistan. The ground water of Mardan city, Bannu district, Dera Isamail Khan, Malir valley Karachi, Bahawalpur, Rahim Yar Khan, Sadiqabad, urban areas of Peshawar city, and many other areas had been characterized by different peoples [5-8]. This paper represents the research work conducted with the aim to characterize and examine the ground water of surrounding areas of Peshawar city, as the contamination from the sewage system and industrial effluents seems to be largely possible.

The information gained will be helpful for creating awareness in the people and will provide

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guidelines for controlling pollution of the potable ground water. The levels of physicochemical parameters like total hardness, pH, conductivity, alkalinity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), free ammonia and nitrate were determined. These parameters are generally considered helpful in determining the level of contaminants due to seepage of sewage and flow of wastes generated by human activities.

Results and Discussion

The levels of different inorganic contents and other physiochemical properties determined in this research work have been presented in Table-1.

The range of pH recommended by WHO and Pakistan Council of Research in Water Resources (PCRWR) is 6.5-9.2, while the highest desirable level according to PCRWR is in the range 7-8.5. As observed from the Table-1, all the water samples were slightly alkaline and had pH in the range of 7.09-8.23, which was within the desirable range of WHO [9]. pH determination is useful in assessing the corrosivity of water to plumbing. It is the measure of the acidity or alkalinity (basicity) of water. Many of the processes involved in water treatment are pH dependent.

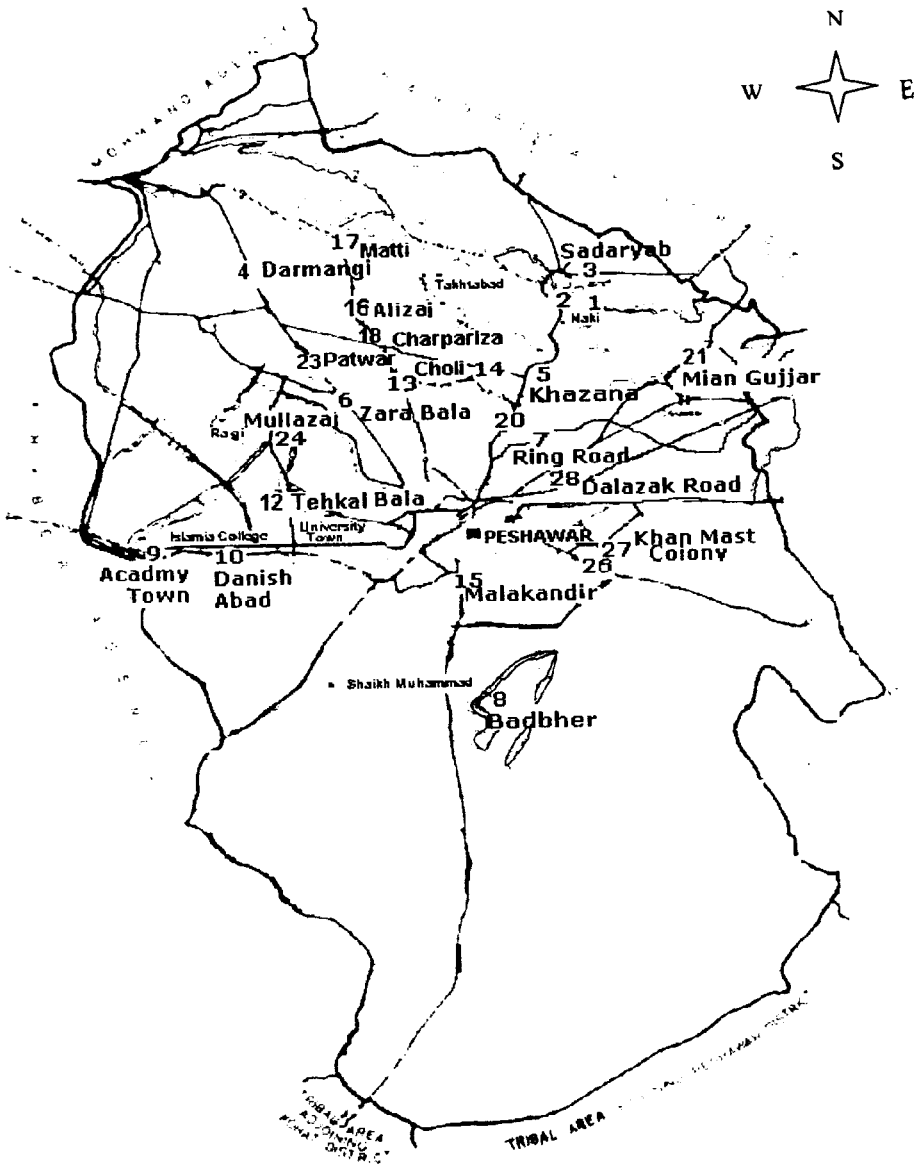
Conductivity is a measure of the ability of an aqueous solution to carry an electric current. As this ability is dependent upon the presence of ions in solution, hence a conductivity measurement is an excellent indicator of the total dissolved solids (TDS) in water. Generally natural water possesses low conductivity but contamination increases its level. The specific conductance of all the water samples except one varied in the range 247-786 $\mu S\ cm^{-1}$. The WHO limit of specific conductance is 400 $\mu S\ cm^{-1}$. It may be observed from the Table-1 that 19 out of 28 water samples had specific conductance above the WHO limits, indicating that the well water sample analyzed contain high level of dissolved salts. The ground water of Chagarmatti had very high level of specific conductance (1.16 $mS\ cm^{-1}$), of which people of the area should be informed.

Total hardness is defined as the sum of the calcium and magnesium concentration, both expressed as $CaCO_3$. Ground water is usually harder than surface water. There are two types of hardness, temporary and permanent. Temporary hardness is caused due to the presence of bicarbonate of calcium, magnesium and other bivalent metals. This is known as carbonate hardness. Permanent hardness is caused due to the presence of sulphates and chlorides of hardness constituting cations. This is also known as non-carbonate hardness. These salts are very corrosive and deposit scales in steam boilers and in distribution system. Hard water may cause inflammation of intestines. The WHO recommends a limit of 500 $mg\ dm^{-3}$ for total hardness, while the highest desirable level of PCRWR is 200 $mg\ dm^{-3}$. All of the ground water samples had total hardness above the PCRWR desirable level, while the total hardness of ground water obtained from the sites, near police chowki Sardaryab (Charsadda road),

Table-1. Inorganic contents and physiochemical properties* of ground water of surrounding areas of Peshawar city.

S. #	Sample Locations	pH	Sp. Cond. $\mu S\ cm^{-1}$	T. Hardness $mg\ dm^{-3}$	Alkalinity (HCO_3) $mg\ dm^{-3}$	Chlorides $mg\ dm^{-3}$	Nitrate $mg\ dm^{-3}$	BOD $mg\ dm^{-3}$	COD $mg\ dm^{-3}$	NH_3 $mg\ dm^{-3}$
1.	Mosque of Agra sardaryab, Charsadda road	7.79	479	461 ± 23	275 ± 8	24 ± 1	11.6 ± 0.5	6.2 ± 0.3	15 ± 0.7	0.10 ± 0.005
2.	Near Police Chowki Sardaryab, Charsadda road	7.70	786	570 ± 22	392 ± 11	72 ± 3	9.8 ± 0.4	3.3 ± 0.2	24 ± 0.9	0.10 ± 0.005
3.	Near Tariq Flour Mills Sardaryab, Charsadda road.	8.22	506	428 ± 12	274 ± 13	18 ± 1	5.4 ± 0.2	0.5 ± 0.1	1± 0.1	0.10 ± 0.005
4.	Darmangi Warsak Road	8.16	591	514 ± 8	308 ± 15	41 ± 2	13.2 ± 0.6	2.8 ± 0.2	18 ± 0.7	0.18 ± 0.008
5.	Khazana Sugarmill near main Charsadda road.	8.16	277	255 ± 10	187 ± 9	69 ± 3	6.6 ± 0.3	0.7 ± 0.1	11 ± 0.4	0.10 ± 0.005
6.	Zara Bala Warsak road	8.03	247	340 ± 17	180 ± 8	63 ± 3	3.2 ± 0.1	7.5 ± 0.3	16 ± 0.7	0.10 ± 0.005
7.	Ring road (Latif Abad)	7.10	325	532 ± 15	352 ± 10	71 ± 3	5.9 ± 0.2	0.2 ± 0.1	1 ± 0.1	0.10 ± 0.005
8.	Bada Ber, Kaga walla, Kohat road	7.85	310	447 ± 9	252 ± 12	125 ± 4	5.4 ± 0.2	3.4 ± 0.2	4 ± 0.1	0.05 ± 0.002
9.	Academy Town	7.81	553	351 ± 17	207 ± 11	72 ± 3	7.4 ± 0.3	4.3 ± 0.2	8 ± 0.1	0.05 ± 0.002
10	Danish Abad	7.92	529	386 ± 11	222 ± 14	72 ± 3	3.0 ± 0.2	2.7 ± 0.2	26 ± 0.3	0.10 ± 0.005
11	Nodey Walla	8.08	490	425 ± 19	310 ± 16	59 ± 2	3.3 ± 0.3	9.0 ± 0.4	12 ± 0.4	0.10 ± 0.005
12	TehkalBala (Mohammad Abad)	7.56	661	660 ± 17	109 ± 7	63 ± 2	3.1 ± 0.3	5.3 ± 0.3	11 ± 0.3	0.05 ± 0.002
13	Choly Bala(Bus Stand)	8.20	342	343 ± 11	118 ± 8	65 ± 2	4.5 ± 0.4	14.8 ± 0.6	20 ± 0.9	0.02 ± 0.001
14	Choly Bala(mid village)	8.24	423	353 ± 9	281 ± 13	66 ± 2	7.4 ± 0.6	1.0 ± 0.1	4 ± 0.2	0.02 ± 0.001
15	Professor Colony Malakander	8.36	508	468 ± 10	320 ± 15	31 ± 1	7.6 ± 0.6	1.0 ± 0.1	1± 0.1	0.05 ± 0.002
16	(Police Colony) Badazai	8.00	600	638 ± 19	360 ± 14	49 ± 1	1.9 ± 0.1	1.4 ± 0.1	2 ± 0.1	0.02 ± 0.001
17	Asohab Baba, Chager Matti	7.60	1116	1804 ± 54	672 ± 20	130 ± 4	1.8 ± 0.1	0.8 ± 0.1	1 ± 0.1	0.10 ± 0.005
18	Charpariza	7.76	718	412 ± 20	86 ± 4	11 ± 1	2.1 ± 0.2	2.0 ± 0.2	4 ± 0.2	0.10 ± 0.005
19	Choki Near Albela	8.23	418	279 ± 11	76 ± 3	92 ± 3	2.8 ± 0.2	1.6 ± 0.2	9 ± 0.3	0.10 ± 0.005
20	Khazana Sugermill, inside mill colony	7.77	663	419 ± 13	103 ± 4	71 ± 2	5.5 ± 0.3	0.4 ± 0.1	6 ± 0.2	0.10 ± 0.005
21	Mian Gujar	7.66	748	483 ± 20	126 ± 5	99 ± 3	6.3 ± 0.4	0.6 ± 0.1	8 ± 0.3	0.10 ± 0.005
22	Kharaka	7.87	700	312 ± 21	74 ± 3	63 ± 2	5.1 ± 0.3	1.6 ± 0.2	3 ± 0.1	0.10 ± 0.005
23	Patwar Payan Warsak road	7.09	693	376 ± 19	113 ± 4	72 ± 3	4.4 ± 0.2	0.5 ± 0.1	2 ± 0.1	0.15 ± 0.009
24	Mulazai University road	7.75	685	417 ± 16	109 ± 3	63 ± 2	7.4 ± 0.3	1.4 ± 0.2	3 ± 0.1	0.15 ± 0.009
25	Bairsiko Kohat road	7.09	677	473 ± 21	105 ± 4	65 ± 2	27.6 ± 0.9	1.6 ± 0.2	4 ± 0.2	0.10 ± 0.005
26	Hazar Khan	7.80	746	488 ± 16	76 ± 3	71 ± 3	7.5 ± 0.3	2.0 ± 0.2	5 ± 0.2	0.20 ± 0.010
27	Khan Must Colony	7.59	563	437 ± 20	94 ± 4	65 ± 2	9.00 ± 0.4	3.0 ± 0.2	6 ± 0.2	0.10 ± 0.005
28	Muncipal colony Dalazak Road	8.03	558	384 ± 16	59 ± 2	86 ± 3	8.3 ± 0.4	3.4 ± 0.2	8 ± 0.3	0.05 ± 0.002

* Mean of three readings ± Standard deviation.



Map of Peshawar and surrounding areas showing the location of sampling points No. 1-28

Darmangai (Warsak road), ring road (Latif Abad), Tehkal Bala (Mohammad Abad), Police colony (Badazai) and Asohab baba (Chagar Matti) were above the WHO recommended limit.

The level of chloride in the water samples was found in the range 18-130 mg dm^{-3}, which was below the limit recommended by WHO (250 mg dm^{-3}). In natural water, high level of chloride is regarded as an indicator of pollution because of organic matter of animal origin.

Alkalinity of water may be defined as its capacity to neutralize strong acid. It is primarily a function of carbonate, bicarbonate and hydroxide contents. Alkalinity measurements are used in the

interpretation and control of water and waste water treatment processes. Types of alkalinity depend on the pH at the end point of titration. "Phenolphthalein Alkalinity" is the term traditionally used for the quantity measured by titration to pH 8.3. When it is zero then carbonate and hydroxide alkalinities are absent and the bicarbonate alkalinity represents the total alkalinity. As all the water samples analyzed had pH less than 8.3, therefore only bicarbonate alkalinity was present. It may be observed from the table that it varied in the range 59-672 mg dm^{-3} (as $CaCO_3$). The WHO has recommended a maximum level of 500 mg dm^{-3} for alkalinity, therefore all the water samples had alkalinity within the WHO limit except that of Chagar Matti (672 mg dm^{-3}).

Ammonia nitrogen is present in variable concentrations in many surface and ground waters. A product of microbiological activity, ammonia nitrogen is sometimes accepted as chemical evidence of sanitary pollution when encountered in raw surface supplies. Its occurrence in ground supplies is quite general as a result of natural reduction processes. It is observed from Table-1 that water samples analyzed had ammonia well below the WHO permissible limit of 0.5 mg dm^{-3} as it varied in the range 0.02-0.2 mg dm^{-3}.

The maximum permissible limit of nitrate according to WHO standard is 45 mg dm^{-3}. The nitrate level of all the water samples was within this limit as it varied in the range 1.8-27.6 mg dm^{-3}. Blue baby syndrome or methemoglobinemia is a common symptom of excessive nitrate concentration. A limit of 10 mg dm^{-3} of nitrate has been imposed to prevent this syndrome. It is observed from Table-1 that ground water samples of sites, mosque of Agra Sardaryab, Darmangi warsak road and Bairsiko Kohat road had nitrate level above this limit. When nitrate level is higher than 10 mg dm^{-3}, it usually indicates pollution by human or animal wastes or fertilizer run-off.

The level of BOD of water samples analysed were in the range 0.2-14.8 mg dm^{-3}. Out of 28 samples three had exceeded the WHO permissible limit of 5.0mg dm^{3}.The sources of these three samples were tube wells located at mosque of Agra (Sardaryab), Zara Bala (Warsak road) and Choly Bala (bus stand). The level of COD of water samples ranged from 1-26 mg dm^{-3}. Out of 28 water samples 9 had COD level above the permissible limit of 10 mg dm^{-3} recommended by WHO. The samples exceeded COD limit of WHO were No. 1, 2, 4, 5, 6,10,11,12 and 13 (Table-1). High level of COD of water samples is indicator of the presence of significant amount of oxidisable organic matters, generally attributed to sewage contamination and flow of wastes generated by human activities to the water sources.

Experimental

Samples of water were collected from 28 tube wells in the areas surrounding Peshawar city, as shown in the map and Table-1. Representative sample was prepared at each sampling point by mixing water samples obtained at regular intervals through out the operational time of the tubewell. The representative sample was collected in a plastic bottle. Each bottle was rinsed with water sample several times before filling. After collection, the water samples were transported to the laboratory immediately.

All the stock solutions were made with distilled water. All the reagents used were of analytical grade (Merck & BDH) and were used with out any further purification. The instruments utilized were calibrated before each analysis.

Conductance of the water samples was measured by using conductivity meter [PC m3-Jenway]. pH of water samples was determined by pH meter [HI 8428, Hana]. Levels of ammonia and nitrate were determined at λmax 400nm and at λmax 410nm respectively, by using spectronic 20 [Milton Ray Spectronic 20D]. Total hardness was determined by EDTA titration method. Biochemical oxygen demand (BOD) and Chemical Oxygen demand were determined by 5-day incubation and open reflux methods respectively [10-11]. All the physical and chemical analyses were carried out in triplicate and the average values with standard deviations were calculated and presented in the Table-1.

Conclusions

In this study 28 samples of ground water of tube wells in the surrounding areas of Peshawar city were characterized. On the basis of the results obtained it may be concluded that the ground water samples analyzed were hard and had high level of total dissolved solids. Water in those areas should be treated or boiled before using for drinking and other

domestic purposes. The levels of other parameters such as nitrate, ammonia, chloride, pH, alkalinity and BOD of the majority of the samples were found within the permissible limits of WHO and PCRWR. Therefore if total hardness is controlled, those ground water sources may be considered fit for domestic use. Water of the nine tube wells had COD level higher than recommended by WHO which may be due to contamination of domestic and industrial origin. The inhabitants of those areas should be informed to take measures to control the COD level. The potable water in the thickly populated cities and in their surrounding areas should be analyzed regularly in order to have a check upon the seepage of the industrial effluents and sewage system, which is a serious environmental problem.

References

1. R. Thomas, A. Camp, L.M. Robert, Water and its impurities, 2nd Ed. New York, U.S.A, (1974).
2. S.E. Manahan, Environmental Chemistry, Willard Grant Press Boston, (1983).
3. H. Khan, M.H. Khan and I.M. Sheikh, *Engineering Horizons*, **19**,135(1999).
4. M. Shakirullah, K. Shabana. and A. Imtiaz, *Scientific Khyber*, **15** (2), 99 (2002).
5. A. R. Khan, S. Ullah, and F. Hussain, *Jour. Chem. Soc. Pak.*, **21** (2), 106 (1999).
6. M.K. Baloch, M. Ashfaq, and T. Ashour, *Pak. J. Anal. Chem.*, **2**, 48 (2001).
7. A.R. Khan, M. Akif, and R. Riaz, *Jour. Chem. Soc. Pak.*, **22** (2), 87(2000).
8. M.I. Qaimkhani, *Jour. Chem. Soc. Pak.*, **24** (2), 86 (2002).
9. World Health Organization (WHO). "Guidelines for drinking water quality" **82**, Geneva, Switzerland, (1981).
10. A. I. Vogel. Quantitative Inorganic Analysis. 3rd Ed, Mc Graw-Hill, New York, (1971).
11. American Public Health Association (A.P.H.A) and American Water Work Association (A.W.W.A). Standards Methods for the Examination of water and waste water. 18th Ed, American Public Health Association, Washington, D.C, (1992).