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ASSESSMENT OF DRINKING WATER QUALITY IN PESHAWAR, PAKISTAN

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Abstract

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Drinking water contamination is one of the core issues in many developing countries and of the challenges confronting scientists and planners. Need of water quality assessment in different parts of the country is thus imperative to analyze state of the water consumed for different purposes especially for drinking purpose. The present study took into account water quality assessment of 32 locations inside Peshawar. Groundwater samples were collected both from tube wells as well as from household ends and subjected to physical, chemical and bacteriological analysis as well as presence of heavy metals, to check their suitability for drinking purpose. Results revealed that physical and chemical characteristics of 96.87% samples were within the permissible limits. However, 84.35% of the samples collected from household ends were contaminated with coliform bacteria and could not be considered safe for human consumption. 31.2% of the samples collected directly from tube wells also showed suspicious results. Faulty distribution and storage infrastructure and their lack of maintenance are concluded main reasons behind drinking water contamination in Peshawar.

Key words: water contamination, bacteriological analysis, atomic absorption spectrophotometry, hard water, Peshawar KPK

Introduction

Pakistan is blessed with abundant water resources. However, due to lack of proper management strategy for water resources, the country faces problems of quantity and quality. Only limited population has access to public water supply (noteven clean), while the rest of population is dependent upon direct withdrawal of water from both surface and ground sources, where available, for its daily needs. Environment profile of Pakistan indicates that about 40 percent of deaths are related to water borne diseases resulting from the effluent added by different sources (MCP, 1997). Evidently, many studies carried out on in the country point toward the deteriorating quality of water supplies. A study conducted by Khalid et al. (2011) took into account analysis of water samples from 15 sources in Abbottabad Pakistan, has reported that drinking water of different areas in Abbottabad district was not suitable for human health due to microbiological issues. Similarly, Aziz (2005) also reported that most of the drinking water supplies were faecally contaminated, as coliform count was found to be in a range of 0 to 240. This study investigated that groundwater quality is deteriorating due to naturally occurring subsoil contaminants or to anthropogenic activities. The poor bacteriological quality of drinking water has frequently resulted in high incidence of waterborne diseases while subsoil contaminants have caused other ailments to consumers. Moreover, other studies have also highlighted the presence of exceeded amount of heavy metals and nitrate contents in drinking water supplies, and still considering unsafe for human consumption, e.g. Jan (2005) analyzed exceeded Mn and Pb quantities (8.26 and 2.97 mg/l) in ground water specimens collected from Peshawar city. Much of the quality problems in Pakistan are due to lack of waste disposal regulation, mismanagement of the water distribution infrastructure, non-availability of treatment facilities and due to lack of public awareness about water quality. If the present state of affairs continues, the result will be accentuated quality problems in future. Therefore, there is a need for integrated management of water resources, which takes into account the environmental concerns. Public water supply to Peshawar, which is the capital of Khyber Pukhtun khwa (KPK) province, depends on both surface water and ground water stored in overhead tanks and then distributed to households. However, this is limited to certain parts of the city while the sub-

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urban areas around the city are without proper water supply and sanitation systems. Contamination of drinking water because of many factors has lead to various outbreaks of water borne diseases. Thereby prompting detailed studies of drinking water quality and identification of the various sources of contamination affecting groundwater in Peshawar, the present study in this concern was conducted in different zones of Peshawar. The study was focused on evaluation of drinking water quality of the area with the following objectives.

To expose the water samples for bacteriological analysis; determination of physico-chemical parameters of water samples and to find out amount of trace elements/ heavy metals in collected samples and comparing results with World Health Organization (WHO) limits for drinking water.

Materials and Methods

Research Area

Peshawar is the provincial metropolis of KPK province and has a population of about 2.28 million. There are four important rivers flowing in Peshawar region. Kabul River is the biggest river, which enters Peshawar near Warsak in the west, and discharges into Indus River, 4km downstream of Jehangira. It divides Peshawar into the northern and southern part. Swat River enters Peshawar in the northwest near village Manda Qila and falls into Kabul River near Charsadda. Bara River flows from the south and enters Peshawar near Jhansi Post. It supplies Peshawar with drinking and irrigation water and discharges into Kabul River. It also drains large area of northern part of Peshawar and finally discharges in the Kabul River 5 km downstream of Nowshera. There are two main aquifers, the first extended to a depth of 60 m and the second lies at depth of about 180 meters, which contains water under artesian conditions. Ground water movement in both the aquifers is northeast towards the Kabul River. The depth of water table varies from about 2 meters to 45 meters. Presently, water need of Peshawar is mainly met by groundwater resources, which contribute to more than 95% of the total water supply by means of about 400 operational tube wells (Ilyas, 2002).

The Study was conducted at various places of Peshawar and the selection was made based on stratified random sampling method encompassing major communities of Peshawar. Diverse living conditions and variations in infrastructure and age of construction of infrastructure were taken into consideration while selecting points of collection of water samples. Major areas selected for sample are presented in Table 1.

Water Sampling and Analysis

For physical and chemical analysis, drinking water samples were collected in plastic bottles, whereas for bacteriological analysis, sterilized glass jars were used. They were filled with 5 ml of Sodium Thiosulphate and autoclaved before taken to the field. Samples were collected after sterilizing the taps' mouth and running them for 3 to 5 min. Replicated samples were then collected from the same location by "grab sampling" procedure. Water samples were collected directly from the tube wells (source) and from farthest tail endhouseholds fed by the same source. They are referred to

Table 1
Water sampling locations in Peshawar

Sampling point no.	Area	Location	Sampling point no.	Area	Location
1	Hayatabad	*Phase-II*	**17**	Kohat Road	*Tube well-II*
2	Hayatabad	*Phase-I*	**18**	Kohat Road	Tube well-III
3	Hayatabad	*Phase-III*	**19**	Peshawar City	*Hussein abad*
4	University campus	*Palosi*	**20**	Peshawar City	*Gulbahar*
5	University campus	*Administration block*	**21**	Peshawar City	*Nishter abad*
6	University campus	*Colony*	**22**	Walled City	*Karim Pura*
7	University Town	*UTC Office*	**23**	Walled City	*Sarki Gate*
8	University Town	*Circular Road*	**24**	Walled City	*Kohati Gate*
9	University Town	*J. Afghani Road*	**25**	Ittehad Colony	*Ittehad Colony*
10	Tehkal bala	*Zukum abad*	**26**	Ittehad Colony	*Ittehad Road*
11	Tehkal Payan	*Tehkal payan -I*	**27**	Ittehad Colony	*Latif abad*
12	Tehkal Payan	*Tehkal payan -II*	**28**	Bara road	Tube well-I
13	Peshawar Cantt	*Qasim Road*	**29**	Bara road	*Tube well-II*
14	Peshawar Cantt	*BMH tube well*	**30**	Bara road	*Tube well-III*
15	Peshawar Cantt	*Saddar Stadium*	**31**	Industrial area	*Karkhano tube well*
16	Kohat Road	*Tube well-I*	**32**	Kacha garhi	*Tube well-I*

"level one" and "level two" samples respectively in the discussions. Results obtained after subjecting water samples to selected laboratory analysis were compared with World Health Organization (WHO) standards for drinking water. Following analyses were performed:

A. Bacteriological analysis

B. Physico-chemical analysis: i. pH, ii. Electrical conductivity (EC), iii. Turbidity, iv. Total hardness and v. Calcium (Ca)

C. Trace elements/ Heavy metals: i. Lead (Pb), ii. Copper (Cu), iii. Iron (Fe), iv. Zinc (Zn) and v. Manganese (Mn)

Bacteriological Analysis

Microbial analysis of the water samples was performed by determination of most probable number (MPN) of coliform bacteria (indicator organisms) in 100ml of water sample. The standard of microbial purity for potable water is counted as total coliform/100ml of water sample (MacDonald and Kay, 1988). The coliform has gained widespread acceptance among water analyses as best measure of faecal contamination (HMSO, 1982). However their presence may not provide us the information about the type of pathogens in water. But it gives us an assessment of future risk of disease that a pathogen carrier may spread. The indicator test indicates the health risk, which should be investigated before the water supplied is consumed (MacDonald and Kay, 1988).

Bacteriological analysis is accomplished with the help of two tests; presumptive and confirmed. Presumptive test takes into account treatment of specimen samples with lactose broth solution and incubating them for 24 to 48 hours. Specimen test tubes showing gas are then treated with brilliant green bile broth solution for confirmed test. Concentration of coliform bacteria are most often reported as the Most Probable Number (MPN) per 100ml. Typically the MPN value is determined from the number of positive (lactose fermenting) tests in a set of five replicates made at three different dilutions (15 samples altogether). Estimation of the MPN is based on the poisson distribution for extreme values (Greenwood and Yule, 1917). MPN values can be determined directly by using probability tables.

Physico Chemical Parameters

pH, which is determination of water acidity or alkalinity was determined through pH meter. It was first standardized by using buffer solutions of known pH (4, 7 and 9), and then probe was dipped directly into the water sample to record the pH value.EC, measure of salt concentration, was measured using a conductivity meter. The EC meter was calibrated using standard solution at 25°C room temperature before the EC readings of water samples. Determination of turbidity (suspended particle load) was performed using Turbidimeter, which was standardized by using the solutions of known turbidities 9 and 10 Nephlometric Turbidity Units (NTU) respectively. Calcium, Magnesium and Hardness of the samples was ascertained through titration method, which takes into account sample with buffer solution and titrated with EthyleneDiamineTetraAcetic acid (EDTA). Nitrates concentration in the water samples was calculated with a photometer. The procedure for using this photometer consists of selecting required wavelength, placing blank tube in test chamber until it gives 100% transmission and then placing sample tube in test chamber, and displayed percentage of transmission reading then compared against appropriate calibration chart.

Heavy Metals/ Trace Elements

Trace elements and heavy metals can be classified into two categories; first those metals (such as Cu, Fe, Mn, and Zn) which are essential for living organisms, however, excessive levels of these elements can be detrimental to living organisms. Secondly, non-essential elements (such as Pb, Hg, Cd and Ni) are of particular concern in drinking water. Atomic absorption spectroscopy was used for the detection of selected heavy metals in water samples.

Results and Discussions

Bacteriological Analysis

The results of Figure 1 show a varied trend of bacterial contamination between level one and level two samples. Among samples collected from level one, 14 out of 32 (43.7%) samples showed 'excellent', 8 out of 32 (25%) samples showed 'satisfactory', and 10 out of 32 (31.2%) samples revealed 'suspicious' results. Samples collected at level two revealed that 2 out of 32 (6%) samples had 'excellent', 3 out of 32 (9.3%) samples had 'satisfactory', 17 out of 32 (53.1%) samples had 'suspicious', and 10 out of 32 (31.25%) samples had 'unsatisfactory' results. Most of the samples collected from level two, could hence be considered unsafe for human consumption, which is in conformity with similar studies conducted by Abdul Hussain et al. (2008) and Anwar Khalid et al. (2011). Suspicious and unsatisfactory results at both levels have been observed in the localities of Hayatabad Town, University Campus, University Town, Tehkal Payan, Peshawar Cantonment, Peshawar City, Walled City, Ittehad Colony, Bara road and Kacha Garhi.

Faecal contamination of drinking water, especially at household level, is very alarming and is attributed to certain obvious reasons. Type of construction, material used and management of water storage facilities and distribution lines are obvious reasons contributing significantly to water contamination. Unawareness about feacal contamination and household water handling also play important role in raised incidents of water borne diseases in Peshawar.

Physico-Chemical and Trace Elements Analysis

Table 2 shows that pH values measured at different locations were within the range of WHO standards. However, the range of pH values was from 6.6 and 7.75 with an average of 7at level one and from 6.7 to 7.68 with an average of 7.04 at level two. EC values were less than 1000 micro-mhos/cm, which means water has low concentration of salts; therefore, water can be categorized as non-saline. Range of EC was from 305 to 810 micro-mhos/cm with an average of 575 micro-mhos/cm at level one from 315 to 810 micro-mhos/cm with an average of 584.6 at level two. It has been observed that turbidity of the drinking water samples was in accord with WHO standard of 5 NTU that means water was free from particulate matter and organic matter that create turbid conditions. Turbidity in drinking water may hinder disinfections process during treatment, therefore, giving rise to risk of water born diseases. The data shows range of turbidity from 0.45 to 2.35 NTU with an average of 0.94 NTU at level one and from 0.65 to 2.45 NTU with an average of 1.07 NTU at level two. Hardness result shows average values of 559 and 552 mg/l at level one, levels two in Peshawar city, and was considered as hard water. A possible reason for the hardness of drinking water could be due to the drilling of rock materials for installing bore wells at many locations within Peshawar. Drilling of rock materials pose a threat of concentrating the ground water with salts. High hardness can cause lime build up in plumbing materials and can cause plugging of water piping systems. Scaling in water heaters and other equipment can also be a consequence of hard water.

As evident from Figure 2, Pb concentrations in the analyzed samples also show a diverse trend at level one and level two. At level one, 4 out of 32 (12.5%) samples, and at level two, 11 out of 32 (34.37%) samples had concentration exceeding WHO threshold of 0.01 mg/l. One of the perceived reasons for Lead contamination could be the use of substandard pipes and plumbing materials. Exposed water delivery system and substandard pipes are more prone to corrosion under diverse climatic conditions. Bakariji and Karajo (1999) stated that Pb is commonly used in plumbing materials. Natural water usually contains very little Pb. Concentrations occur in water distribution system or in pipes of a home or facility. Thus, it can be concluded that water on its way to the households carry lead through pipes and other distribution installations and so there is more pollution of Pb concentration at household levels.

Mn concentrations of the samples collected from level one were within the range of WHO threshold of 0.5 mg/l. Concentrations of three samples collected from level two were exceeding the WHO standards. Those samples were collected from Kohat road (sampling point no. 17 and 18), and Bara road (sampling point no. 28). All the other samples had concentrations in accord with the WHO standard. Sources of pollution rich in organic matter (e.g. runoff from landfills, compost, brush or silage piles, or chemicals such as gasoline) can add to the back ground level by increasing Mn release from soil or bedrock into ground water. In Peshawar, the increased Mn content in drinking water can be attributed to improper waste disposal. Municipal solid waste collection and disposal services in Peshawar are not adequate. Authorities responsible for disposal services manage to dispose only a part of the wastes generated, and much of the waste remains on the streets or in open plots. Leachate generated from these waste piles might possibly add to the increased Mn content

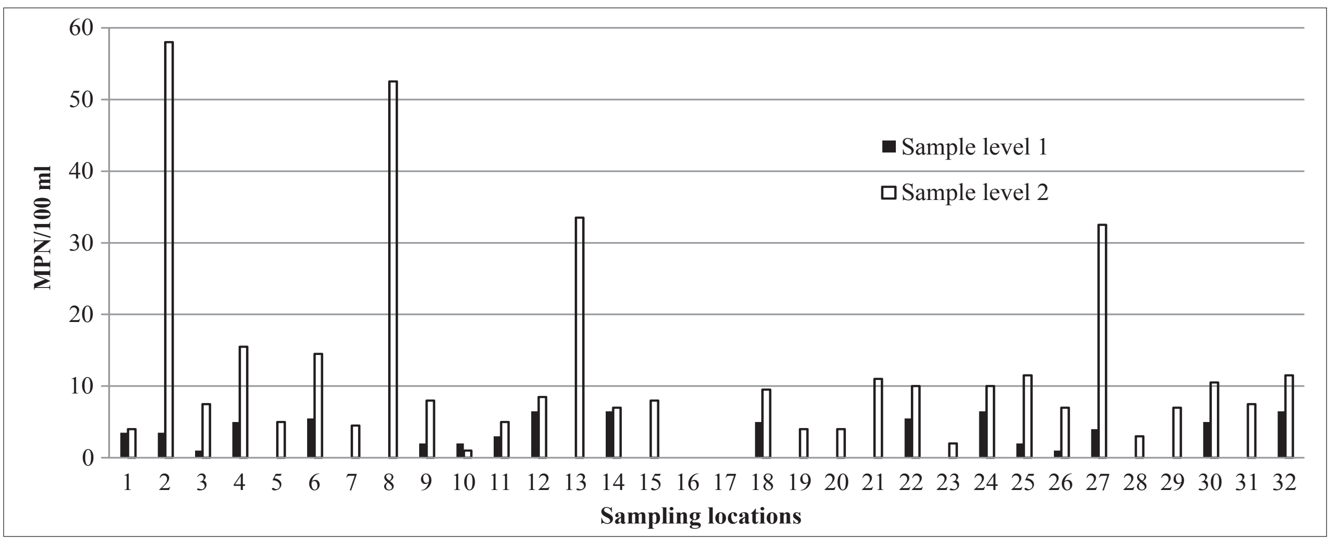

Fig. 1. Bacteriological Analysis of water samples at level one (tube wells) and level 2 (households)

Table 2
Descriptive analysis of physico-chemical parameters and heavy metals

Parameters	Levels	Average	S.Dev	Minimum	Maximum
pH	L 1	7.00	0.22	6.60	7.75
	L 2	7.04	0.19	6.70	7.68
EC, micro-mhos/cm	L 1	575.00	108.52	305.00	810.00
	L 2	584.60	109.35	315.00	805.00
Turbidity, NTU	L 1	0.94	0.36	0.45	2.35
	L 2	1.07	0.35	0.65	2.45
Hardness, mg/l	L 1	280.18	91.30	175.50	559.00
	L 2	285.29	89.13	179.50	552.00
Ca, mg/l	L 1	136.08	35.69	86.00	225.80
	L 2	138.99	35.99	80.50	223.95
Mg, mg/l	L 1	144.10	58.01	84.20	333.20
	L 2	146.19	56.12	88.00	328.05
NO_3-N, mg/l	L 1	0.37	0.28	0.02	0.95
	L 2	0.42	0.32	0.01	1.00
Pb, mg/l	L 1	0.03	0.08	0.00	0.36
	L 2	0.11	0.18	0.00	0.65
Cu, mg/l	L 1	0.27	0.20	0.00	0.65
	L 2	0.38	0.21	0.02	0.83
Fe, mg/l	L 1	0.27	0.19	0.00	0.65
	L 2	0.46	0.38	0.00	1.81
Zn, mg/l	L 1	0.93	1.02	0.02	3.61
	L 2	1.17	0.96	0.06	3.49
Mn, mg/l	L 1	0.15	0.14	0.00	0.43
	L 2	0.31	0.24	0.05	1.20

Note: S.Dev- Standard deviation, L1-source (tube well), L2-households, NTU-Nephlometric turbidity units

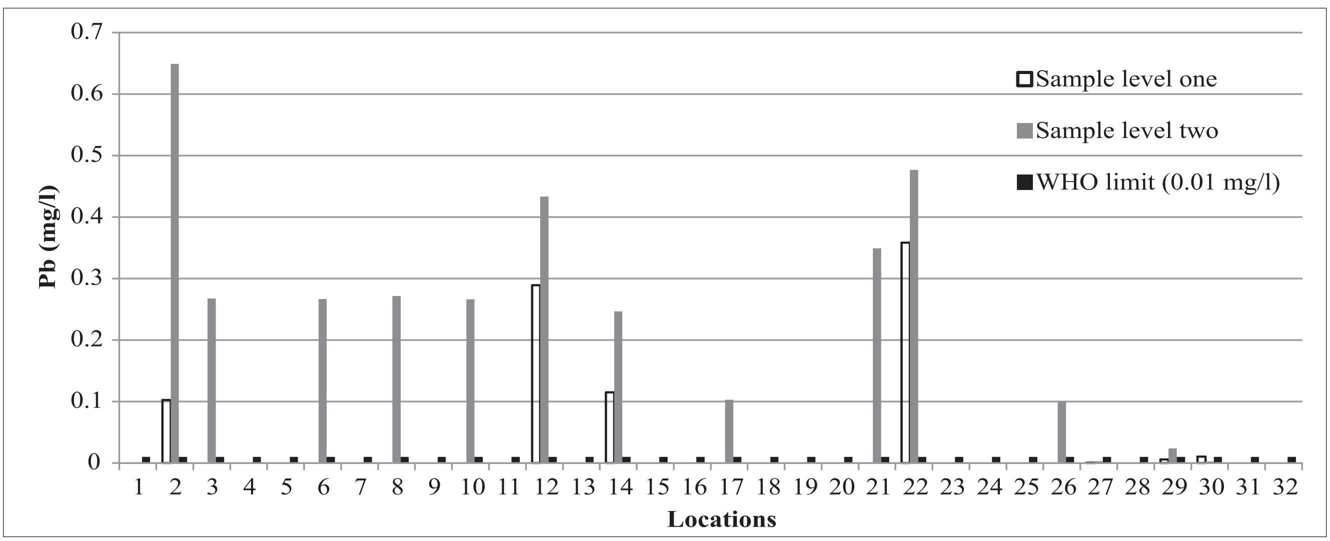

Fig. 2. Pb concentrations at level one (tube wells) and level two (households)

of ground water through increased Mn release from soil or bedrock.

Conclusion

The present study aimed exposing drinking water samples for bacteriological analysis; determining the physico-chemical parameters of water samples and to explore quantity of trace elements/ heavy metals in collected samples. Results were then compared with drinking water standards given by World Health Organization (WHO). It was found from the present study that most of the drinking water is contaminated before reaching households. About 84% of the samples collected from households were found feacally contaminated. Physico chemical parameters as well as heavy metals concentration were mostly found to be within permissible limits. However, Pb concentration in 34% household samples and Mn concentration of three household samples were exceeding the WHO limits. Moreover, water of one location was found hard because of exceeded amount of dissolved salts. Presence of coliform bacteria in drinking water provides us a good indication of health risk associated with faecal pollution.

Therefore, drinking water quality tests and continuous assessment should be conducted at regular intervals to check the quality of drinking water. Detailed studies should be undertaken along the distribution lines starting from the sources to the households to find out the actual points of contamination and their sources in the distribution networks. Consequently, distribution system should be enhanced and remedial measures be taken for proper installation of pipes and joints etc. Standardized materials should be ensured for construction of pipes and other storage facilities.

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