EVALUATION OF DRINKING WATER QUALITY AT ZOO AND VARIOUS PUBLIC PLACES IN DISTRICT LAHORE, PAKISTAN

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ABSTRACT

Fifty eight water samples in triplicate were collected from tap and filtration units from selected sites of various public places including universities and colleges in Lahore city. All collected samples were tested for status of physicochemical parameters (pH, turbidity, hardness and total dissolved solids, arsenic, nitrite and fluoride) and presence of indicator bacteria (total coliform and fecal coliform) and compared with World Health Organization (WHO) standards for drinking water. The results demonstrated that physicochemical quality of drinking water was satisfactory except arsenic and fluoride in few water samples. The microbial quality of water has breached the WHO standard limits. The statistical analysis using one way ANOVA, a non-significant difference was observed between various public places ($p>0.05$) irrespective of animal parks, recreational parks, historical places, public transport stations and Universities. However, a significant difference ($p<0.05$) was found when data of microbiological and physiochemical analysis was compared with WHO drinking water set standard values.

Key words: Microbial, physiochemical analysis, Public places, Water quality, ZOO,

INTRODUCTION

Water is one of the best gifts to all living creature, given by nature. Availability of safe drinking water is one of the basic human rights and is necessary to human and animal health. Drinking water quality is a public health concern for both developed and developing countries (Sulehriya *et al.* 2011). In developing countries huge human population suffers from health problems due to substandard quality of drinking water(Johnston and Holt 2014). Drinking water could be contaminated at any point from the source up to the level of consumers (Suthar *et al.* 2009). Normally drinking water becomes contaminated by leakage of pipe lines and causes different diseases like hepatitis, typhoid, dysentery, giardiasis and cholera (Azizullah *et al.* 2011).

According to the WHO and UNICEF reports, 2.6 billion people do not have access to safe drinking water in the world. In Pakistan,most of the water supply schemes didn't follow the WHO permissible limits that is one of the main public health concerns (Cabral, 2010). Water in the country is polluted with microorganisms and various toxic compounds (Azizullah *et al.* 2011). Living style along with mismanagement mostly contaminate drinking water (Gerba and Smith, 2005). Water purification units in big cities are in place but they are not working well leading to unsafe drinking water quality (Hisam *et al.* 2014).

Water related health problems are more common in over populated cities of Pakistan like Lahore, Karachi and Faisalabad etc. Among these cities, Lahore district has historical background. This city has number of public places for recreational purposes like Zoo and Safari park etc. Many people all over Pakistan visit these public places daily and drink water from government supplies without concerning its quality.

Therefore this study was designed to evaluate the quality of drinking water at various public places including parks, historical places, Universities and Colleges of Lahore city.

MATERIALS AND METHODS

Sample Collection and Transportation: A total of 28 Public places including animal parks (Lahore zoo, National bank Park, Safari Park, Pakistan Aviary and Jalo Park), recreational parks (Joyland, Bagh e Jinah, Race course, Ghushan e Iqbal Park and Model Town Park), historical places (Data darbar, Shahiqilla, Minar e Pakistan, Lahore museum and Badshahi Mosque), public transport stations (Lahore railway station, Lariada, Daewoo express, Niazi express and skyway bus service) and universities and colleges (University of Engineering and Technology (UE), CMH medical college, University of Veterinary and Animal Sciences (UVAS) and King Edward Medical University (KEMU), Punjab university (PU), Allama Iqbal Medical College (AIMC), Government College University(GC) and Lahore College for Women University (LCWU) were selected on the basis of most visiting places in district Lahore.

From each site, two water samples (200 ml each) in triplicate were collected aseptically in screw capped sterilized bottles. The first sample was taken from tap and second one from government installed filtration unit if available. The samples taken from tap were tagged as Tw and that taken from water purification unit as Pw. The labeled water samples were transported in a container at low temperature to the University Diagnostic Lab (UDL), UVAS Lahore for further analysis. Each triplicate of water sample was divided into two parts. Six water samples were subjected to microbiological analysis whereas other six were processed for physicochemical analysis.

Microbial Analysis: In the laboratory, water samples were processed for analysis of total viable, coliform and fecal coliform count**.** Total viable count (TVC) in the water samples were performed by spread plate method using Nutrient agar medium(Suthar *et al.* 2009).Coliform bacteria in water samples was checked using most probable number (MPN) methods(Rompré *et al.* 2002). All the samples were processed within 24 hours after collection. MPN method was used to determine the presence of gas producing lactose fermenting bacteria and probable number of coliform in the sample. For evaluation of Coliform bacteria, samples were inoculated into tubes of Lactose broth (LB) for presumptive test. The positive tubes were sub-cultured into brilliant green lactose bile broth (BGLB) for confirmation. Complete test was performed by inoculating confirmed samples into*E.coli* (EC) broth and checked for total count.

Physico-chemical Analysis: Physical analysis was carried out for various water quality parameters such as pH, turbidity, total dissolved solids (TDS) and hardness using standard methods ((Trivedy and Goel, 1984; Manivasakam, 2005). Chemical parameter such as arsenic, nitrite (NO3-) and fluoride was checked using commercially available Merck kits.

RESULTS

Microbiological and Physiochemical quality of drinking water in Animal Parks: All water samples collected from either taps or filtration units in animal containing parks were declared contaminated with coliform bacteria thus accepted as unfit for drinking purposes. Highest coliform load was found in both tap (240MPN/100ml) and filtration water (150MPN/100ml) of Jallo Park, while lowest (15MPN/100ml) in filtration water of Lahore ZOO Table 1).

Among coliform positives, not even a single park was found free from fecal coliforms (FC). Overall highest FC load was found in water samples taken from taps as compared to filtration unitsin animal parks. Highest percentage of FC load to total coliform was found in Jallopark (43/43 MPN/100ml), while lowest in Lahore Zoo (9.2/93MPN/100ml). Highest turbidity, total hardness, pH, total dissolved solid, arsenic, nitrite and fluoride in filtered water was found in safari park (1.50 NTU), Jalo park (150 mg/L), Safari (8.60), National bank park (664 mg/L, Lahore zoo (0.025 mg/L), Lahore zoo Jalo park (1.99 mg/L), respectively as shown in Table 1. Highest turbidity, total hardness, pH, total dissolved solid, arsenic, nitrite and fluoride in tap water was found in Pakistan Aviary (1.50NTU), Jalo park (190 mg/L), Safari and Pakistan Aviary (8.60), Jalo Park (1092 mg/L), Lahore zoo and national bank park (0.025 mg/mL), Lahore zoo (0.05 mg/mL) and Jalo park (1.91 mg/mL), respectively as shown in Table 1.

Microbiological and Physiochemical quality of drinking water in Recreational Parks: Water quality of recreational parks (n=5) on testing showed presence of coliform bacteria in all water samples either of tap or filtration units. Highest coliform was found in tap water of Bagh e Jinah (460PMPN/100ml) with lowest in Model Town Park (29MPN/100 ml). In tap water of Gulshan e iqbal park 100% (240/240 MPN/100ml) coliform was taken as fecal coliform (240MPN /100ml) while tap water samples of all other sites have found contaminated with coliform bacteria (Table 2). Highest FC load was detected in Joyland and Gulshan e Iqbal park (240MPN/100ml each) (Table 2).Highest concentration of turbidity, nitrite and fluoride in in both filtered and tap water of recreational parks was found in Gulshan e Iqbal park, race course and race course, respectively as shown in Table 2. Model town Park was found with highest concentration of total hardness, pH, and total dissolved solid as shown in Table 2.

Microbiological and Physiochemical quality of drinking water in Historical Places: Among historical places (n=5), none of the place was declared fit for drinking purpose, although as compared to animal containing and recreational parks, microbial load was found less in all selected historical places. Tap and filtration water of Badshahi mosque contained highest number of coliform (93MPN/100ml) and fecal coliforms (23MPN/100ml) while lowest coliform (11MPN/100ml) and FC load (3MPN/100ml) was detected in filtration water of Lahore museum. Complete data has been presented in (Table3).Among physical parameters, slightly high pH value was observed only in tap water of Lahore museum and Badshahi mosque (8.60).Filtered and tap water in historical places was found with highest concentration of turbidity and fluoride at Badshahi mosque and Data Darbar, respectively while Lahore museum was observed for highest concentration of total hardness, pH and TDS (Table 03).

Microbiological and Physiochemical quality of drinking water in Public Transport Stations: Situation in public transport stations was not found different from

parks and historical places. All samples originated from either tap or filtration units were found contaminated with coliform and fecal coliform. In this study, tap and filtration units water of all subject sites showed varied number of coliform bacteria. Tap water of Lahore railway station and Lariadda had highest number of total coiliform (93MPN/100ml) and fecal coliform (93MPN/100ml) count; although tap water samples of rest of sites have also exceeded the WHO drinking water permissible limits(Table 4).Filtration unit water of these places was also checked for total coliform and fecal coliform count, highest total coliform count (35MPN/100ml) was found in filtration water of Daewoo express. Highest fecal coliform was found in Lahore railway station (29MPN/100ml). Detail of data has been given in (Table 4).Physical parameters of water in public transport stations showed that filtered and tap water of Daewoo express, Niazi express, Skyways bus service, Niazi express, Lariada, Daewoo express and Lariada contained highest concentration of turbidity, total hardness, pH, arsenic, fluoride and nitrite, respectively as shown in Table 4.

Microbiological and Physiochemical quality of drinking water in Universitiesand Colleges: All water samples collected from either taps or filtration units of subject Universities and Colleges were declared contaminated with coliform bacteria. Highest coliform and fecal coliform load was found in both tap (240MPN/100ml) and filtration water (29MPN/100ml) of UOE. Comparatively high load of FC was evidenced in tap water samples than in filtration plants. The whole data has been presented in (Table 5 and 6).Physical parameter analysis showed that filtered and tap water of KEMU has highest concentration of turbidity as compared to other universities and colleges while CMH medical college and UVAS was found with highest concentration for total hardness. Both filtered and tap water off all universities was found alkaline more than 8.0 as shown in Table 5 and 6. Highest concentration of fluoride (1 mg/mL) was found in CMH and UVAS as shown in Table 5.

Table 1. Microbiological and Physiochemical quality of drinking water in Animal Parks.

Parameters	WHO Standards	Lahore Zoo		National bank park		Safari		Pakistan Aviary		Jalo park	
		T	F	T	F	T	F	T	F	T	F
Total Coliforms	0MPN/100ml	93	15	16	29	93	93	93	93	240	150
Fecal Coliforms	0MPN/100ml	93	9.2	1.5	11	93	43	93	43	43	43
Turbidity	5 NTU	1.20	1.10	1.30	1.10	1.10	1.50	1.50	1.30	1.30	1.10
T.hardness	500 mg/l	120	90	70	60	60	70	60	70	190	150
pH	6.5-8.5	8.50	8.50	8.50	8.50	8.60	8.60	8.60	8.60	9.0	8.50
TDS	1000mg/l	362	294	791	664	142	315	154	301	1092	612
Arsenic	0.01mg/l	0.025	0.025	0.025	0.010	0.010	0.010	0.010	0.010	0.0	0.005
Nitrite	3mg/l	0.50	0.15	0.15	0.15	0	0	0.0	0.05	0.15	0.15
Fluoride	1.5mg/l	0.54	0.49	0.88	0.98	0.39	0.37	0.44	0.15	1.91	1.99

Table 2. Microbiological and Physiochemical quality of drinking water in Recreational Parks

Parameters	WHO standards	Joyland		Bagh e Jinah		Race course		Gulshan e Iqbal park		Model town park	
		T	F	T	F	T	F	T	F	T	F
Total Coliforms	0MPN/100ml	210	240	460	75	93	15	240	240	29	21
Fecal Coliforms	0MPN/100ml	93	240	75	43	93	9.2	240	240	21	11
Turbidity	5 NTU	1.20	1.00	1.20	1.00	1.10	1.00	1.30	3.40	1.30	1.20
T.hardness	500 mg/l	160	90	60	70	90	80	100	80	240	200
pH	6.5-8.5	8.50	8.40	8.50	8.50	8.40	8.40	8.30	8.30	8.60	8.60
TDS	1000mg/l	452	329	315	308	315	280	298	264	872	686
Arsenic	0.01mg/l	0.010	0.010	0.025	0.025	0.025	0.025	0.025	0.025	0.010	0.010
Nitrite	3mg/l	0.0	0.0	1.0	0.50	1.0	0.50	0.0	0.0	1.0	0.50
Fluoride	1.5mg/l	0.52	0.55	0.09	0.11	1.45	1	0.54	0.57	1.0	1

Table 3. Microbiological and Physiochemical quality of drinking water in Historical Places

Parameters	WHO standards	Data darbar		Shahiqila		Minar e Pakistan		Badshahi mosque		Lahore museum	
		T	F	T	F	T	F	T	F	T	F
Total Coliforms	0MPN/100ml	21	23	21	6.2	15	9.2	93	93	9.2	11
Fecal Coliforms	0MPN/100ml	21	9.2	11	6.2	15	9.2	93	23	9.2	3
Turbidity	5 NTU	1.10	0.90	1.00	1.40	1.30	1.30	3.20	2.80	0.90	0.90
T.hardness	500 mg/l	130	160	170	190	280	200	190	190	320	290
pH	6.5-8.5	8.20	8.50	8.20	8.30	8.60	8.50	8.20	8.30	8.60	8.60
TDS	1000mg/l	220	609	227	231	727	609	315	287	695	828
Arsenic	0.01mg/l	0.025	0.025	0.025	0.025	0.05	0.010	0.010	0.010	0.025	0.025
Nitrite	3mg/l	0	1	0	0	0.50	0.50	0	0	0	0.05
Fluoride	1.5mg/l	0.79	0.79	0.31	0.27	0.59	0.67	0.51	0.47	0.05	0.03

Table 4. Microbiological and Physiochemical quality of drinking water in Public Transport Stations

Parameters	WHO standards	Lahore railway station		Lariadda		Daewoo express		Niazi express		Skyways bus service	
		T	F	T	F	T	F	T	F	T	F
Total Coliforms	0MPN/100ml	93	29	93	15	23	35	28	15	23	23
Fecal Coliforms	0MPN/100ml	93	29	93	15	23	15	15	15	23	23
Turbidity	5 NTU	1.30	1.20	1.10	1.30	1.10	0.90	1.30	1.50	1.10	1.10
T.hardness	500 mg/l	130	120	170	130	230	170	160	160	290	390
pH	6.5-8.5	8.40	8.50	8.40	8.30	8.40	8.50	8.70	8.70	8.50	8.60
TDS	1000mg/l	3338	279	303	230	919	686	280	266	840	578
Arsenic	0.01mg/l	0.010	0.010	0.025	0.025	0.010	0.010	0.025	0.025	0.010	0.010
Nitrite	3mg/l	0	0.15	0.15	0.15	0.05	0.05	0.025	0.25	0	0
Fluoride	1.5mg/l	0.19	0.21	0.49	0.44	1.30	1.41	0.31	0.32	0.28	0.29

Table 5. Microbiological and Physiochemical quality of drinking water in Universities and Colleges

Parameters	WHO standards	UOE		CMH medical college		UVAS		KEMU	
		T	F	T	F	T	F	T	F
Total Coliforms	0MPN/100ml	460	240	43	21	23	3.6	9.2	9.3
Fecal Coliforms	0MPN/100ml	240	29	15	9.2	23	3.6	9.2	3.6
Turbidity	5 NTU	1.10	3.20	1.10	0.90	1.80	1.20	1.20	2.90
T.hardness	500 mg/l	100	120	210	474	120	120	60	120
pH	6.5-8.5	8.20	8.30	8.60	8.50	8.60	8.30	8.50	8.30
TDS	1000mg/l	210	210	581	420	329	210	325	431
Arsenic	0.01mg/l	0.025	0.025	0.010	0.010	0.010	0.010	0.010	0.010
Nitrite	3mg/l	0	0	0.50	0.25	0.15	0.25	0	0
Fluoride	1.5mg/l	0.12	0.13	1	1	1	1	0.54	0.57

Table 6. Microbiological and Physiochemical quality of drinking water in Universities / Colleges.

Parameters	WHO standards	PU		AIMC		GC		LCWU	
		T	F	T	F	T	F	T	F
Total Coliforms	0MPN/100ml	9.2	23	9.2	11	23	21	9.2	3.6
Fecal Coliforms	0MPN/100ml	3.6	9.2	3.6	3.6	9.2	9.2	3.6	<3
Turbidity	5 NTU	1.10	1.40	1.10	0.90	1.30	1.20	1.20	1.10
T.hardness	500 mg/l	60	60	110	60	100	120	130	150
pH	6.5-8.5	8.60	8.30	8.40	8.60	8.60	8.60	8.60	8.60
TDS	1000mg/l	340	294	427	308	323	225	574	420
Arsenic	0.01mg/l	0.010	0.010	0.025	0.025	0.025	0.025	0.025	0.010
Nitrite	3mg/l	0	0	0.15	0.15	0	0	0.50	0.50
Fluoride	1.5mg/l	0.80	0.72	0.29	0.21	0.29	0.26	0.03	0

DISCUSSION

Generally,human health is influenced by many factors including access to proper sanitation, safe drinking water supplies and health services. The use of clean potable drinking water ensures the reduction of water borne illness leading to improved quality of life. Throughout the world, access to safe drinking water in public places has been challenge for many reasons. Quality of water is being compromised due to presence of microbes and physiochemical parameters. The utmost microbial risks are of faecal origin and these are principal apprehensions in setting health-based targets for microbial safety (Organization, 2006).Water related health problems are more common in over populated cities of Pakistan like Lahore, Karachi and Faisalabad etc. Among these cities, Lahore district has historical background. This city has number of public places for recreational purposes like Zoo and Safari park etc. Many people all over Pakistan visit these public places daily and drink water from government supplies without concerning its quality. Therefore the present study was conducted to evaluate the microbial and physiochemical quality of drinking water from selected areas of Lahore including recreational parks, Historical places, public transport stations and different public sector Universities and Colleges of Lahore.

Drinking water that is contaminated with human and animal excreta has maximum threat from microbes and is the main source of waterborne diseases like gastroenteritis, dysentery, diarrhea and viral hepatitis(Cabral, 2010). Microbiological safety of water supplies is monitored for the absence of the total coliform bacteria (Anderson *et al.* 2005) and these are used as indicators (Staradumskytė and Paulauskas 2012) and according to the WHO guidelines, fecal coliform should not be present in 100 ml water sample (Abdelrehman and Eltahir, 2011).

In the present study, among 5 selected recreational parks, not even a single park had potable drinking water quality as per WHO standards, although there was variation in the bacterial load. Tap water of Bagh e Jinah and Gulshan e iqbal parks had highest number of total coliforms and fecal coliforms respectively (Table 1).

When microbial quality of Filtration units installed in recreational parks was checked, it was found that similarly to tap water quality, all water samples were accepted as unfit for drinking purposes due to having high load of coliform bacteria. One of the possible reasons of poor quality of drinking water in recreation parks may be due to unhygienic practices on part of visiting people and management of these sites. People all over Pakistan visit these sites daily and number of them drinks water directly from water source using unhygienic hands or by touching their mouth with water supply leading to introduction of bacteria in water sources. Beside this, it was also observed during study that pipe lines of water supply were very old that need to be replaced as soon as possible. In comparison to recreational park, no animal park, historical place, public transport station and University or college was found free of total and fecal coliforms that may be due to unhygienic practices in the premises, possibilities of mixing sewage water in drinking water due to any leakage and old pipe lines of water supplies in the area.

Our study findings are in agreement with results of previous who reported high load of bacteria in drinking water in various areas of Capital of Pakistan and its twin city Rawalpindi (Mehmood *et al.* 2013).

Such studies have also been conducted in Africa where drinking water quality failed to meet the WHO drinking standards hence declared unsuitable for drinking purposes(Wright *et al.* 2012). On the basis of this study, it was found that quality of all drinking water sampled from selected areas was not fit for drinking purposes. These findings are in concordance with the data of study conducted in Lahore (Anwar *et al.* 2010). All the water samples of Lahore was contaminated with bacteria and was unfit for drinking pupose due to presence of colifrom

bacteria(Gerba and Smith 2005). In another study higher number of coliforms and fecal coliforms were detected in urban and semi urban areas in Islamabad (Jadoon *et al.* 2012). The poor quality of drinking water in selected sites may be due to over burden on the sites under subject. Poor sanitation and unawareness about personal hygienic practices (Suthar *et al.* 2009) are some of the other contributing reasons of poor quality of water.

In the present study the pH level in the water samples ranged from 8.2-9, higher pH was observed in Animal park (Jallo park pH 9.0) and public transport stations (Niazi express pH 8.7), but mostly water samples had pH within the WHO permissible limits (6.5-8.5). The high level of pH reflects the effect of pollution due to the discharge of municipal and industrial effluents and agricultural wastes it may be due to free availability of heavy metals as a result of their precipitation in hydroxide form.

The previous data showed that pH of water in all the water samples (7.1-7.5) met the WHO requirements and considered safe for drinking purpose in Islamabad (Mehmood *et al.* 2013). pH ranging from 6.75-8.45 was observed in areas adjacent to Hudiara industrial drain, Lahore (Khattak *et al.* 2012). Another study that was conducted to check the ground water quality in 18 districts of Karachi, showed that all the water samples had pH within the WHO acceptable range (Ul-Haq *et al.* 2011).

In the present study turbidity of all water samples ranged between 0.9-3.4, water from recreational parks was more turbid, lowest turbidity was observed in water samples that were collected from public transport stations. However turbidity of all the water samples falls under the WHO permissible limits.

In the present study, highest value of TDS was observed in water samples that were collected from animal parks. TDS of all water samples ranged between 163-1095. Besides animal parks all the water samples fulfill the WHO requirement. The higher value of TDS may be due to contamination from urban, sewage, agriculture runoff and industrial waste water. Sometimes cemented storage tanks are used to store drinking water which may also attribute to increase TDS in these areas.

Same results have also been reported in another study that was conducted in industrial area of Sheikhupura, out of twelve sites, five sites indicated high level of TDS (Total Dissolved Solids) (Gilani *et al.* 2013). In a study that was conducted in different schools of Ghulam Mohammad Abad, Faisalabad, indicated that WASA water as direct supply, water stored in tanks and that available in school coolers had total hardness, total dissolved solids and nitrate within the safe limits, whereas ground water had total dissolved solids and nitrate above than the WHO permissible limits (Ilyas *et al.* 2008).

In the present study, regarding status of T. Hardness, public transport stations had the highest value of T. Hardness which may be due to contamination of inorganic materials while the animal parks had the least value. In another study highest hardness value (584mg/l) was found in collected water samples in 1-9 sectors Islamabad (Mehmood *et al.* 2013). Another study that was conducted to check water quality in Railway Stations in India, showed appropriate value of hardness in water which is hazardous to human health (Shahezad, 2013).

Contrary to our study, another study that was conducted in Thatta, Badin, and Thar to access the drinking water quality of canal, shallow pumps, dug wells, and water supply schemes, indicated that all four water bodies exceeded the WHO permissible limits for turbidity, TDS and Hardness (Memon *et al.* 2011). Similarly chemical quality of drinking water that was conducted in industrial area, Sialkot, indicated that water has pH, TDS and Total. Hardness more than the WHO permissible limits and ground water of the study area cannot be considered of good quality as it was highly turbid (Ullah *et al.* 2009) and 10- 20% water samples of the study area in Lahore exceeded the maximum permissible limits for TDS, hardness while 21% samples crossed WHO permissible limits for nitrate(Khattak *et al.* 2012).

In the present study, chemical analysis showed that, mostly water samples had higher value of arsenic than WHO set values, while all the rest water samples had arsenic, nitrite and fluoride within the WHO permissible limits.

The data obtained in this study when analyzed statistically using one way ANOVA, a non-significant difference was observed between various public places ($p>0.05$) irrespective of animal parks, recreational parks, historical places, public transport stations and Universities. However, a significant difference ($p<0.05$) was found when data of microbiological and physiochemical analysis was compared with WHO drinking water set standard values. On the basis of these study findings, it is recommended that microbial quality of water may be improved to safeguard the health of people visiting these sites.

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