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Research Article

Evaluation of microbial load in drinking water from different areas of Peshawar

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Abstract
Houses, office buildings, commercial businesses, markets, and schools all have water reservoirs. This drinking water has the capabilities to produce waterborne epidemics, particularly in vulnerable and immune-compromised individuals. The aim of this study is to determine the water quality of different localities in district Peshawar. Water pollution may result from water pipe leaks with sewage, a close proximity of septic tanks or any of a number of other factors like runoff, infiltration of waste water and direct deposition of waste through leaks. For this purpose, 120 different sites at Peshawar were selected for sampling of drinking water. The bacteriological quality assessment study is carried out by determining Total Plate Count (TPC), Total Coliform (TC) and Fecal Coliform (FC). Data reveals that out of 120 samples, due to high TPC, TC, and FC levels, 44 No of samples were contaminated. Total coliforms were found in 37 percent of the samples, while fecal coliforms were found in 22 percent of the samples. TPC concentrations ranged from 20 to 1060 cfu/ml. TC were found in the range 1.1 - 9.2 MPN / 100ml. The data shows that 66 samples have higher TPC values than the permissible limits of WHO standards for drinking water. The findings highlighted the need to take sewerage contamination of drinking water seriously as an issue for both the environment and human health.

Keywords: CFU; Drinking water; FC; MPN; TC; TPC; WHO

Introduction

Water contamination is the degradation of water quality caused by agricultural, residential, or industrial contaminants to the point where it interferes with any useful use of water but does not necessarily pose a health risk. Wastewater released into natural water bodies as a result of urbanization and industry which causes substantial ground water contamination **[1]**. A limited percentage of Pakistan's population has access to safe drinking water, which is a basic requirement. In impoverished countries like Pakistan, mismanagement, poor municipal circumstances, and natural disasters all contribute to a high rate of underground water contamination **[2]**. Pathogenic organisms are the world's most dangerous pollutants in terms of human health. The main source of these infections is untreated or badly handled by human waste **[3]**. In Pakistan, 40 to 60 percent of the population has access to safe drinking water. Waterborne infections are caused by pathogenic microorganisms. As a result, determining the bacteriological status of drinking water becomes critical **[4]**.

In Pakistan, poor health is reflected due to high child mortality rate i.e 12.6% and low fertility rates i.e 7% [5]. Many of the disorders are caused by water-borne bacteria, meaning that contaminated water causes a large amount of morbidity in Pakistan, according to the restricted hospital statistics. Diarrhea is a frequent gastrointestinal infection in both children and adults, accounting for 25% of patients treated in clinics and hospitals [6, 7].

Many parts of our existence, including growth and development, require water. It is crucial in all aspects of our existence [8]. As a result of technological improvements, drinking water may contain a range of physical, biological, and chemical pollutants. The biological impurity is the most dangerous, as it causes health issues or death in humans [9]. A lot of pollutants are transmitted from one location to another in the form of nutrients and bacteria [10]. Microorganisms and hazardous chemicals from household trash and industry come into water bodies, run off, or leak into the ground or freshwater supplies, resulting in water pollution [11]. The contamination of animal and human fecal indicates presence of coliform bacteria [12]. As a result of drainage in water bodies such as rivers, lakes, and streams, bacterial growth and dispersion are at their peak during the rainy season. Waterborne infections spread due to inadequate treatment infrastructure. The drinking water sanitation system and drainage pipelines in Pakistan run at the same time, resulting in leaks and intermixing, reducing the water quality [13].

As a result, frequent checks of the source water is required, especially if no water treatment is available. Water available to the people in Pakistan is mostly contaminated and very little population is consuming clean drinking water. In a developing country like Pakistan where floods and other natural calamities occur, damages the infra-structure of the urban areas in general and rural and far-flung areas in particular, so the drinking water sources are not usable. Therefore, it is the need of the day to analyze the drinking water both on source points and at the consumer ends to know the status of water in Peshawar district.

Materials and Methods

Site description and sample collection

One hundred and twenty (n=120) drinking water samples were collected and transported using standard methods from various parts of Peshawar city [14]. Sources of drinking water were tap water, tube well water and hand pump water. A random sample strategy was used in the investigation. The Laboratories The water samples were examined in Food Microbiology Laboratory of PCSIR Complex Peshawar. All of the samples were taken in sterile vials that were tightly packed, carried in ice packs, and analyzed within six hours of collection.

Sample preparation

Bacteriological tests were performed on each sample type. Under strict aseptic conditions, the samples were opened one by one in a laminar airflow chamber. For the Total Plates count, the samples were diluted up to $1/1000^{th}$. For the microbiological analysis, the chamber offered a sterile environment.

Bacteriological Analysis

Total plate count (TPC)

Pour plate method was used for determining the Total Plate Count. An aliquot of 1ml were inoculated in duplicate plates from sample and each serial dilution (1ml to 10^{-3}). Each Petri dish was filled (15-20ml) with molten Plate Count Agar (PCA) at 45°C and incubated at 35°C for 48±2 hours upon solidification. After incubation, colonies were counted using a Colony Counter and the result was expressed as cfu/ml [14].

Total coliform (TC)

Multiple tube fermentation technique was used for the MPN of total coliforms.100ml of LT Broth in double strength were inoculated

with a 100ml of sample in 10 test tubes with inverted durham tubes and incubated at 35 °C ± 0.5 °C for 24 and 48 ± 2 hours. After incubation the tubes were observed for the development of gas, which is measured by the media (Broth) movement from the inverted vial and also the effervescence formed when the tube was gradually shaken. Positive tubes with gas development and turbidity were sub-cultured into BGB (Brilliant Green Bile Broth) broth and incubated at 35 °C for 48 hrs. Total coliforms were calculated from MPN tables as MPN/100ml considering the positive BGBB tubes after confirmation [14].

Fecal coliform (FC)

Tubes with 10 ml E.C broth and inverted Durham tubes were inoculated with a 3mm loop from the positive fermentation tubes that produced gas & turbidity and incubated at 44.5 °C for 24 hours in water bath. After incubation the E.C Broth tubes are examined for gas production and Fecal coliform is calculated from tables as MPN/100ml [14].

Results and Discussion

This study is carried out for the microbiological quality assessment of drinking water samples from different localities of Peshawar. In (Table 1) the total number of water samples analyzed are 42. The tested parameter includes Total plate count, Total Coliform and Fecal Coliform bacteria. Among the analyzed samples 16 samples were found unfit for drinking, while 26 number of samples were found fit for drinking propose. The Total Plate Count in 23 number of samples were above the permissible limits while the remaining are in the permissible limits of WHO. The TPC value of sample S NO-11, sample ID A B has the highest value of 1060cfu/ml, while that of sample S NO-39, sample ID T P-II has the lowest value of 20cfu/ml. The coliforms MPN/100ml of 17 number of samples are above the limits and that of 25 number of samples are in the limits of WHO. For the coliforms bacteria the sample S NO 3&41, sample IDs MD & TC-II has (5.1MPN/100ml) highest contamination. The fecal coliforms bacteria are detected in 13 number of samples and the remaining 29 number of samples were found free from it.

Table 1: Bacteriological analysis of drinking water from localities of University of Peshawar

S. #	Sample ID	TPC (CFU /ml) *	TC (MPN/100ml) **	FC (MPN/100ml) ***
1	U T	130	< 1.1	< 1.1
2	B B-I	155	2.2	1.1
3	M D	890	5.1	2.2
4	C C	248	2.2	2.2
5	N B T	210	< 1.1	< 1.1
6	R T	150	< 1.1	< 1.1
7	R A	280	3.6	2.2
8	A R-I	71	< 1.1	< 1.1
9	R R H- I	155	1.1	1.1
10	A P A	130	1.1	1.1
11	A B	1060	3.6	2.2
12	P P	123	< 1.1	< 1.1
13	P C C	152	1.1	1.1
14	P K	133	2.2	2.2
15	G B	390	3.6	2.2
16	R B	280	2.2	1.1

17	F B	77	< 1.1	< 1.1
18	T P-I	270	< 1.1	< 1.1
19	R-III	74	< 1.1	< 1.1
20	T C-I	210	2.2	< 1.1
21	A R-II	57	< 1.1	< 1.1
22	P U-I	29	< 1.1	< 1.1
23	P U-II	36	< 1.1	< 1.1
24	A U B	27	< 1.1	< 1.1
25	F I	41	< 1.1	< 1.1
26	P C	24	< 1.1	< 1.1
27	J A	290	3.6	< 1.1
28	T-I	79	< 1.1	< 1.1
29	T-II	180	< 1.1	< 1.1
30	T-III	21	< 1.1	< 1.1
31	P-I	41	< 1.1	< 1.1
32	P-II	210	< 1.1	< 1.1
33	P-III	170	2.2	2.2
34	L S	84	< 1.1	< 1.1
35	M C	160	2.2	< 1.1
36	R-I	67	< 1.1	< 1.1
37	R-II	44	< 1.1	< 1.1
38	M-II	52	< 1.1	< 1.1
39	T P-II	20	< 1.1	< 1.1
40	S T	53	< 1.1	< 1.1
41	T C-II	82	5.1	< 1.1
42	B B-II	120	1.1	1.1

In (Table 2) the bacteriological analysis of drinking water from the localities of Ring Road/Hayatabad area of Peshawar. In Total 27 number of samples 10 samples were in the permissible limits and 17 numbers of samples were outlier from the permissible limits of WHO standards. In these samples the total plate count in 17 number of samples are out of standard limits and 10 number of samples are within the limits. The Total coliforms in 11 number of samples are out of limits and 16 were within the limits. The fecal coliforms in only 3 number of samples were outlier and 24 number of samples were within the limits of WHO standards.

Table 2: Bacteriological analysis of drinking water from localities of Ring Road/Hayatabad Peshawar

S. #	**Sample ID**	**TPC** (CFU /ml) *****	**TC** (MPN/100ml) ******	**FC** (MPN/100ml) *******
1	H P-I	135	< 1.1	< 1.1
2	H P-II	110	< 1.1	< 1.1
3	H P-III	89	< 1.1	< 1.1
4	H P-IV	87	< 1.1	< 1.1
5	H P-V	147	2.2	1.1
6	H P-VI	46	< 1.1	< 1.1
7	H P-VII	190	3.6	2.2
8	I E	37	< 1.1	< 1.1

9	K M	140	2.2	< 1.1
10	L A	82	< 1.1	< 1.1
11	N K	170	< 1.1	< 1.1
12	S D	182	2.2	1.1
13	S D-I	340	< 1.1	< 1.1
14	S D-II	410	2.2	< 1.1
15	S D-III	360	1.1	< 1.1
16	RRH-II	74	< 1.1	< 1.1
17	RRH-III	86	< 1.1	< 1.1
18	A P-I	290	5.1	< 1.1
19	A P-II	510	1.1	< 1.1
20	A P-III	430	9.2	< 1.1
21	A B-I	630	5.1	< 1.1
22	A B-II	490	2.2	< 1.1
23	A B-III	78	< 1.1	< 1.1
24	P P-I	600	< 1.1	< 1.1
25	P P-II	190	< 1.1	< 1.1
26	H M C	80	< 1.1	< 1.1
27	K P M	95	< 1.1	< 1.1

The (Table 3) illustrates the bacteriological analysis of drinking water from different localities of Main City of Peshawar. The table consists of a total 29 number of samples analyzed for Total plate count, Total coliforms and Fecal coliforms. In these 29 number of samples 14 number of samples are found fit for drinking while 15 number of samples are unfit for drinking propose. The Total plate count of 16 numbers of samples is in the range of drinking quality while that of 13 number samples are out of range. The total coliforms bacteria in 21 numbers of samples are in the limits and 8 numbers of samples are out of limits, while the fecal coliforms bacteria in 24 numbers of are in the limits and 5 numbers of samples are out of limits from WHO standards.

Table 3: Bacteriological analysis of drinking water from different localities of main city Peshawar

S. #	Sample ID	TPC (CFU /ml) *	TC (MPN/100ml) **	FC (MPN/100ml) ***
1	C H C	490	2.2	1.1
2	G-I	84	< 1.1	< 1.1
3	G-II	130	< 1.1	< 1.1
4	G-III	72	< 1.1	< 1.1
5	G-IV	61	< 1.1	< 1.1
6	H C A	97	< 1.1	< 1.1
7	C-I	77	< 1.1	< 1.1
8	F A-I	120	< 1.1	< 1.1
9	F A-II	320	2.2	1.1
10	C R S	240	1.1	< 1.1
11	C A	62	< 1.1	< 1.1
12	L G	87	< 1.1	< 1.1
13	N A	91	< 1.1	< 1.1
14	G A	138	< 1.1	< 1.1

15	M T	57	< 1.1	< 1.1
16	Sh B	81	< 1.1	< 1.1
17	D B	67	< 1.1	< 1.1
18	F S	410	3.6	2.2
19	W R-I	46	< 1.1	< 1.1
20	W R-II	220	< 1.1	< 1.1
21	B G	74	2.2	1.1
22	P B	82	< 1.1	< 1.1
23	C C	140	3.6	2.2
24	J R	90	1.1	< 1.1
25	K B	88	< 1.1	< 1.1
26	Q K B	170	< 1.1	< 1.1
27	C Y	280	2.2	< 1.1
28	B C	360	< 1.1	< 1.1
29	K C	280	< 1.1	< 1.1

The (Table 4) shows the bacteriological analysis of drinking water from the various localities of Cantt area of Peshawar. This table consist of total 22 number of samples, among them 9number of samples are fit and 13 number of samples are unfit for drinking purposes. The TPC of 9 number of samples are found in the limits and that of 13 number of samples are out of the standard limits, Total coliforms of 14 number of samples are in limits and 8 number of samples are outlier, the fecal coliforms for 17 number of samples are within the limits and that of 5 number of samples are out of the standard limits of WHO.

Table 4: Bacteriological analysis of drinking water from different localities of Cantt area Peshawar

S. #	Sample ID	TPC (CFU /ml) *	TC (MPN/100ml) **	FC (MPN/100ml) ***
1	S R	39	< 1.1	< 1.1
2	S B	180	< 1.1	< 1.1
3	G-I	26	< 1.1	< 1.1
4	G-II	61	< 1.1	< 1.1
5	C K	47	< 1.1	<1.1
6	N B	310	2.2	< 1.1
7	C Q	490	3.6	2.2
8	D G	370	2.2	1.1
9	K R C	290	5.1	< 1.1
10	G B	66	< 1.1	< 1.1
11	C-I	77	< 1.1	< 1.1
12	KC	113	< 1.1	< 1.1
13	R D	41	< 1.1	< 1.1
14	C-II	131	< 1.1	< 1.1
15	D C	310	2.2	1.1
16	H G	64	< 1.1	< 1.1
17	B A	32	< 1.1	< 1.1
18	C-III	180	5.1	3.6
19	C-IV	350	2.2	1.1

20	C-V	190	< 1.1	< 1.1
21	S C	270	2.2	< 1.1
22	Q S	190	< 1.1	< 1.1

* TPC CFU/ml = Total Plate Count, Colony forming unit / ml, ** TC MPN/ml = Total Coliform, Most Probable Number / ml *** FC MPN/ml = Fecal Coliform, Most Probable Number / ml

Out of the 120 samples collected from various areas of Peshawar i.e. University of Peshawar, Ring Road, Main City and Cantt area 66 number (55.00%) of samples were found unfit for drinking purposes being greater part is from University side i.e. 23 number of samples (54.76%) while 54 number (45.00%) of samples were found fit for drinking purposes. As a whole our results are similar to that of [15]. TPC is a commonly used indicator of drinking water quality. TPC is regarded as a biofilm forming parameter in water systems. The TPC of 45% of samples are in limits and 55% are above the WHO limits. So our results are in stream line with [16, 17] reported TVC for tap water of different areas of Lahore ranged from 1.05 $x10^4$ to 7.0 $x10^5$ CFU/ml (Fig. 1).

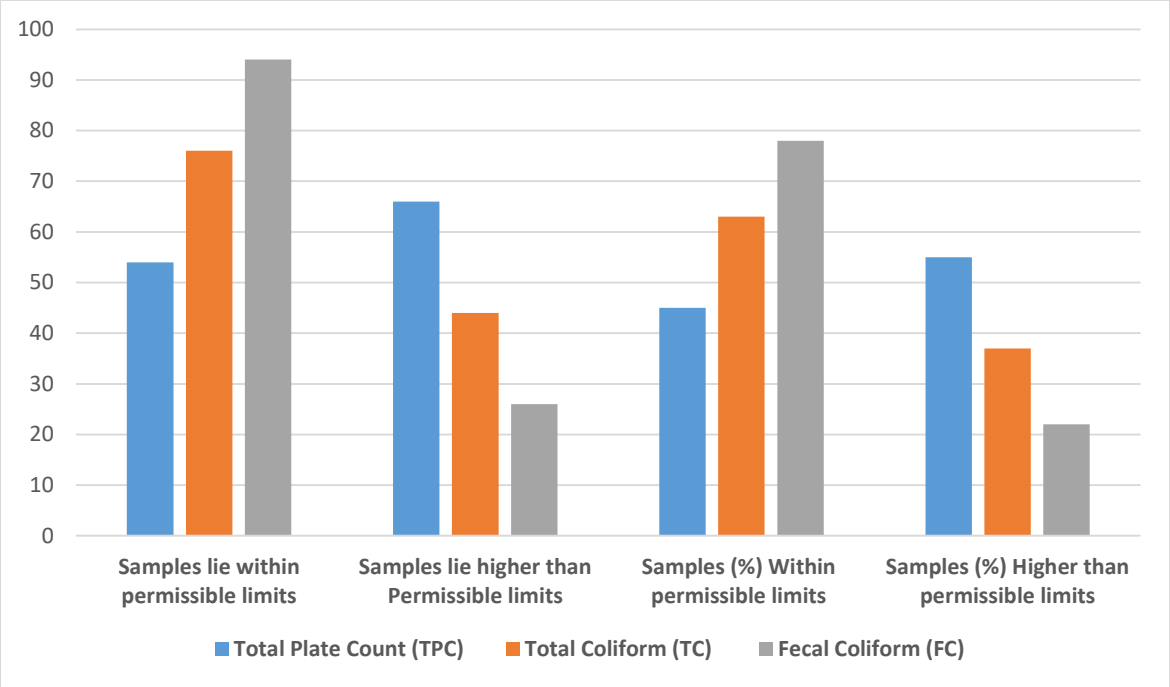

Figure 1: Summary on bacteriological analysis of drinking water samples

Bacteriological standards of drinking water in WHO guidelines [20]

Standard	Total Plate count (cfu / ml)	Total Coliform bacteria (MPN/100ml)	Fecal Coliform bacteria (MPN/100ml)
	< 100	< 1.1	< 1.1

One of the key difficulties in water portability is microbiological contamination, which is primarily associated with fecal contamination from wastewater or landfills. Diarrheal diseases account for 80% of all water-related diseases and 1.5 million deaths occur each year, in children under the age of five. Pakistan has one of the highest mortality rates for children under the age of five in the world, with 101 fatalities per 1000 children.

Water and sanitation-related diseases account for 60% of the disease in children under the age of five in the country, with diarrheal disease killing over 200,000 children under the age of five each year [18, 19].

In the current study 63.33 % of samples were free from total coliforms, and are similar (72.2 %) to the study of Taghiloo *et al*. [20] in Zanjan University of Medical Sciences, Zanjan, Iran. The presence of fecal coliforms, on the other hand, is of great concern because it directs the relationship between water and fecal pollution. Out of total samples analyzed the 21.67% were positive for fecal coliforms, which is better than the study (80%) of Ali *et al*. [21]. It indicates that the water has been contaminated by human or animal wastes. Diarrhea, cramps, nausea, headaches, and other symptoms may be caused by diseases causing microorganisms in these wastes. Infants, young children, and persons with extremely weakened immune systems may particularly vulnerable to these microbes.

In our study the fecal contamination was found in 26 No of samples (22%) and the 94 No (78%) of samples were found fit while Shar *et a.l* [22] indicated that total and fecal coliform bacteria were found in all samples (100%) of Khairpur city drinking water; the source was surface water (municipal water) [22]. Because of its poor quality, inadequate water supply and the impact of urbanization in urban informal settlement centers pose health risks to the consumers. Water contaminated by faeces is a major cause of waterborne illnesses. According to the community health report, in Pakistan, almost 30% of all the diseases and 40% of deaths are related to the water-borne diseases [23]. Numerous research studies about water quality contamination have been carried out in different parts of Khyber Pakhtunkhwa province and across the Pakistan. The potable water quality characteristics of District Bannu was evaluated and found that 85% of potable water samples were found contaminated [24]. Ahmad and Ahmad *et al*. [25] carried out research on the potable water quality characteristics of the rural areas of District Hangu and concluded that 63% water samples were contaminated bacteriologically [25].

Conclusion

The results of some samples are concerning, indicating that water quality is essential in terms of disease prevalence and other health issues. Some samples were found contaminated with bacteria. Lack of drainage, old rusted water supply pipes, placing of water supply pipes too close to main drains, and a lack of drinking-water quality monitoring are some of the causes of bacteriological contamination. The situation has been made worse by weak institutional arrangements and the lack of a legal framework for drinking-water quality issues. Water contamination may be due to leakage in pipes, cross contamination with waste water, short distance between water supply and sewage supply lines, construction of septic tanks near with drinking water supply lines. Runoff, infiltration of waste water, direct deposition of waste water through leakage is some of the major problems. The results drew attention that sewerage contamination with drinking water must be considered as an important environmental and health issue.

Authors' contributions

Conceived and designed the experiments: A Hussain & ZU Rahman, Performed the experiments: ZU Rahman & S Iman, Analyzed the data: A Hussain & ZU Rahman, Contributed reagents/ materials/ analysis tools: A Hussain, ZU Rahman & S Iman, Wrote the paper: A Hussain & ZU Rahman.

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References

1. Amin R, Zaidi MB, Bashir S, Khanani R, Nawaz R, Ali S & Khan S (2019). Microbial contamination levels in the drinking water and associated health risks in Karachi, Pakistan. *J of Water, Sanit and Hyg for Devel* 9(2): 319-328.
2. Rasheed F, Khan A & Kazmi SU (2009). Bacteriological analysis, antimicrobial susceptibility and detection of 16S rRNA gene of Helicobacter pylori by PCR in drinking water samples of earthquake affected areas and other parts of Pakistan. *Malaysian J Microbiol* 5(2): 123-127.
3. Aziz MM, Masood I, Yousaf M, Saleem H, Ye D & Fang YJPO (2018). Pattern of medication selling and self-medication practices: A study from Punjab, Pakistan. *PloS one* 13, e0194240.
4. Hannan ABDUL, Shan S & Arshad UM (2010). Bacteriological analysis of drinking water from 100 families of Lahore by membrane filtration technique and chromagar. *Biomedica* 26(Jul-Dec) 152-156.
5. Awan MA, Siddiqui MT, Khan RA & Shah AH (2002). Combined effect of salinity and industrial effluents on the growth of Eucalyptus camaldulensis dehnh. *Pak J of Agric Sci*.
6. Bekuretsion H, Hailekiros H, Niguse S, Asmelash T, Abdulkader M, Saravanan M, Brindhadevi KJJOWSR & Technology-Aqua (2018). Bacteriological assessment of drinking water from hand-pump-fitted borehole sources in Kola Tembien, Central Tigray, northern Ethiopia. *J of Water Suppl: Res and Technol-Aqua* 67(8): 790-799.
7. Daud M, Nafees M, Ali S, Rizwan M, Bajwa RA, Shakoor MB, Arshad MU, Chatha SAS, Deeba F & Murad WJBRI (2017). Drinking water quality status and contamination in Pakistan. Bio-Med Research International, 2017.
8. Hameed U, Muhammad A, Jahngeer A & Haq IJB (2015). Determination of Microbial load of Drinking Water from different areas of Lahore. *Biol (Pak)* 61(1): 151-156.
9. Panhwar A, Bhutto S, Rashid U, Begam R, Yasir M, Jalbani N & Jhatial GH (2019). Effects of historic floodonwater qualityof fresh water reservoir keenjhar Lakeofsindh, Pakistan. *Asian J Sci Technol* 10(11): 10499-10505.
10. Itah A & Ekpombok MUM (2004). Pollution status of swimming pools in south-south zone of south-eastern Nigeria using microbiological and physicochemical indices. *Southeast Asian J of Trop Med and Pub Health*, 35: 488-493.
11. Gulumbe BH, Aliyu B & Manga SS (2016). Bacteriological and physicochemical analyses of aliero dam water. *PARAMETERS* 1(2): 3.
12. Ashraf R & Ali TA (2007). Effect of heavy metals on soil microbial community and mung beans seed germination. *Pak J of Bot* 39(2): 629.
13. Patoli AA, Patoli BB & Mehraj V (2010). High prevalence of multi-drug resistant Escherichia coli in drinking water samples from Hyderabad. *Gomal J of Med Scie* 8(1).
14. Federation WE & Aph Association (2005). Standard methods for the examination of water and wastewater. American Public Health Association (APHA): Washington, DC, USA. pp. 21.
15. Shidiki A, Bhargava D, Gupta RS, Ansari AA & Pandit BR (2016). Bacteriological and Physicochemical Analysis of Drinking Water in Tokha, Kathmandu, Nepal. *J of Nat Med Coll* 1(1): 15-18.
16. Hameed U, Muhammad AB, Jahngeer, A & Haq I (2015). Determination of

Microbial load of Drinking Water from different areas of Lahore. *Biol* (*Pak*) 61(1): 151-156.

17. Farhadkhani M, Nikaeen M, Adergani BA, Hatamzadeh M, Nabavi BF & Hassanzadeh A (2014). Assessment of drinking water quality from bottled water coolers. *Iranian J of Pub Health* 43(5): 674.
18. Khan AU *et al*. (2013). Impact of Urbanization on Potable Water Quality: A Bacteriological Case Study of Bannu City. *Sci Inter (Lahore) J* 25(4): 559-564.
19. Rahman MA, Islam MM & Ahmed F (2015). Physico-chemical and bacteriological analysis of drinking tube-well water from some primary school, Magura, Bangladesh to evaluate suitability for students. *Inter J of Appl Sci and Engin Res* 4(5): 735-749.
20. Taghiloo, S., Hassanzadazar, H., Chamandoost, S., & Aminzare, M. (2017). Bacteriological Quality of Water Cooler Dispensers of Educational Settings in Zanjan University of Medical Sciences. *J of Human Environ and Health Prom* 2(2): 105-111.
21. Ali J, Hussain A, Abid H & Rahman Z (2011). Bacteriological quality assessment of drinking water from Khyber agency and its impacts on public health. *Pak J Biochem Mol Biol* 44: 73-76.
22. Shar AH, Kazi YF, Zardari M & Soomro IH (2007). Enumeration of total and faecal coliform bacteria in drinking water of Khairpur city. *Bangl J of Microbiol* 24(2): 163-165.
23. WHO/UNICEF Joint Water Supply, & Sanitation Monitoring Programme. (2015). Progress on sanitation and drinking water: 2015 update and MDG assessment. World Health Organization.
24. Ahmad M, Ahmad N, Rahman ZU & Ali S (2014). Bacteriological Assessment of the Potable Water Quality in the Urban Informal Settlement Centers of District Bannu, Khyber Pakhtunkhwa. In Proceedings of the First International Conference on "Emerging Trends in Engineering, Management and Sciences (ICETEMS-2014), Peshawar, Pakistan. pp. 28-30.
25. Ahmad, M & Ahmad N (2012). "Potable Water Quality Characteristics of the Rural Areas of District Hangu, Khyber Pakhtunkhwa – Pakistan. *Inter J of Multidis Sci and Engin* 3(10): 7-9.