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Assessment of water quality for drinking purpose from water coolers of different teaching institutes in Lahore

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Abstract: *Water coolers are common source of drinking water in teaching institutes of Lahore. Drinking water from water coolers has the potential to cause waterborne diseases to consumers due to contamination with different microbes and chemicals. Present study aimed to assess cooler water quality from different teaching institutes in Lahore city. A total of 55 water samples were taken in sterile polyethylene bottles according to standard water collection techniques (APHA). Physicochemical and bacteriological parameters were tested for each sample and values compared with World Health Organization (WHO) guidelines for drinking water. Laboratoryanalysis of water established that physicochemical quality of water samples was satisfactory as values were within the permissible limit established by WHO while 44 samples (80%) showed positive results for bacterial contamination. The faecal coliform (E. coli) was found in 17 of the total samples yielding a percentage of 38.63%. Amongst the positive samples 8 (18.18%) of the samples had E. coli O157: H7 present in them which is very alarming as this enterohemorrhagic strain of E. coli having a low infectious dose. Leakage and cross contamination between sewage pipes and drinking water pipelines or may be due to leaky and worn out pipes may be one reason for this contamination. Another reason may be improper disinfection (chlorination), biofilm development and improper working of the filtration. It is concluded here that water quality of Lahore teaching institutes is unsatisfactory and deteriorating. Consequently, the study recommends regular chlorination and monitoring of water quality from coolers to avoid microbial contamination.*

Keywords-*Lahore; Public universities; Tap water; Water cooler; Water quality.*

I. Introduction

Water is an extremely essential life sustaining commodity which may cause serious public health issues, waterborne diseases mainly owing to contaminated reservoir, poor sanitation and unhygienic conditions which result in extraordinary increase in infectious diseases, serious health issues high mortality rate worldwide and especially in developing countries [1-3].Since, more than 5 million people die due to waterborne illness, additionally 4 billion diarrhea casesare reported annually[4, 5].

During last few years Water coolers and dispensers as a source of healthy and pleasant drinking water are being used at public places like schools, parks, shopping malls, offices and health centers in most part of world [6-8]. Instead of popularity and immense use of cooler drinking water concern about these devises as a potential source of water born out brakes has been raised,recent studies have revealed the presence of infectious microorganisms like *Escherchia coli, Pseudomonas, Staphylococcus, Salmonella,Shigella, Mycobacterium* in cooler water [9-15]

International and local agencies have established parameters to determine biological and physicochemical quality of drinking water[16]. Like other developing countries drinking water quality is major issue in Pakistan and it stands at 80th position among 120 nations[17]. Studies related to drinking water quality have been conducted in major cities of Pakistan [18].Untilnow, only a few studies related to cooler drinking water have been conducted globally [18, 19] but none in Pakistan. Therefore, this study was carried out with the aim to investigate different physicochemical and microbiological parameters of public cooler drinking water in second largest city of Pakistan.

II. Materials And Methods

The study was conducted on filtered water collected from water coolers of teaching institutes in different areas of Lahore during the period between May 2013 and July 2013. Each sample was analyzed for qualitative microbiological parameters, and chemical parameters of organic contamination. A total of 55 water samples were collected according to standard water collection techniques [21]**.** Samples were collected separately for microbiological examination and physiochemical analysis. For microbiological examination 120 ml per sample was collected in 300 ml polyethylene bottles having 0.1 ml of a 3% solution of sodium thiosulphate to stop the bactericidal activity of residual chlorine during transportation of sample to the laboratory so that the exact microbial load at the time of sampling can be determined. For physiochemical analysis 500 ml water was collected per sample in polyethylene bottles. All the samples were transported to the laboratory within an hour of collection for analysis.

1.1. Microbiological examination

The microbiological parameters included: Heterotrophic plate count, enumerating the number of viable heterotrophic bacteria and qualitative identification of fecal coliform, *salmonella* and *shigella*spp and pathogenic *E. coli* species O157:H7. The indicative fecal organism targeted was *E. coli* as proposed by WHO [22]. All the tests were conducted according to the standardized procedures outlined by APHA (2005) [21]. For all the tests spread plate method was employed and 0.1 ml of 10^{-4} dilution of samples was dispensed and spread evenly with the help of glass spreader in all cases. For heterotrophic plate count tryptone glucose yeast extract agar was used and the incubation was done at 35 ^{o}C for 48 hours as per standards. Most probable number (MPN) gives an appropriate estimation, giving the highest probability of bacterial load thus requiring additional laborious procedures for checking the presence of fecal indicative organism, *E. coli.* Hence, for this purpose selective and differential medium, eosin methylene blue (EMB) agar, was used and plates were incubated at 37 ^{o}C for 24 hours**.** For the qualitative analysis of salmonella and shigella spp., the selective medium used was salmonella shigella agar (SS agar) and plates were incubated at 37 ^{o}C for 24 hours. The pathogenic strain O157:H7 of *E. coli* was plated on sorbitol MacConkey agar (SMAC) and incubated at 35 ^{o}C for 24 hours.
Sterility of all the plates were pre checked. Positive and negative controls were run along the samples. Plates having 30 – 300 colonies were selected for calculating bacterial count per milliliter. On EMB agar only those colonies were counted which gave a green metallic sheen, typical of *E. coli*. On SS agar colonies having pin pointed black centre were taken into account for salmonella spp., manifesting the production of hydrogen sulfide, whereas colorless colonies were depictive of shigella spp. For the qualitative analysis of E. coli O157:H7 on SMAC the presence of colorless colonies was noted, indicating the inability of O157:H7 strain to ferment sorbitol.

1.2. Physiochemical examination

Physiochemical parameters that were used to determine the physical and chemical characteristics of water were pH, conductivity, total dissolved solids, hardness, bicarbonate, nitrate, chloride, sulphate and sodium ion concentration. The results were then analysed and compared with WHO standards[22].The pH was determined electrometrically by using the technique recommended in the Standard Methods (2005). Perkin-Elmer Atomic Absorption Spectrometer (Model 3110) was used for the determination of metal ions [23]**.**

III. Results And Discussion

1.3. Physiochemical examination

The findings of Physiochemical parameters, as shown in Table 1, were within the range of permissible values established by WHO [22]. For instance, among physical parameters, Electrical conductivity (EC) of water samples ranged from 185-362 µS/cm and was well within the permissible limit of WHO guideline of 400 µS/cm. Electrical conductivity of water is determined by dissolved salts in water.

High level of TDS and hardness can be an indication of industrial or commercial waste water contamination. It can be seen in Table 1 that TDS and Hardness values were less than WHO guideline values of 1000 and 500mg /l, ranged from 660-780 and 380-450 mg /l respectively (WHO,2004)**.**Consumers can tolerate water with excess levels of total hardness but excess soap is required for cleaning purposes while TDS above 1000mg/l can affect the taste of water. In the same way, the pH values of water samples were within WHO desirable limits (6.5-8.0). Alkaline pH (>7) of water can hinder effective disinfection while acidic pH (<7) can leads to enhance deterioration of water pipeline system[22].The results of present study are in line with study reported previously[23].

The values of bicarbonates (HCO3) of water samples ranged from 355-420 were within WHO desirable limits of 500 mg/l. Bicarbonates compounds of water are the main source of hardness. The hard water can cause indigestion and hence not good for consumers.

On the other hand, Sodium (Na), chloride (Cl), sulphate (S) and nitrite (N) levels ranged from160-180,130-220,153-187 and 3-6 mg/l (as shown in Table 1) which are below than WHO standard of 200, 250, 250 and 10 mg/l respectively. High chloride level in water can lead to corrosion of iron pipes and can also put adverse effect on the growth of plants by damaging the roots of plants [22]. High level of Nitrate in water can pose a serious threat to young babies' particularly blue baby syndrome[3].

1.4. Microbiological examination

Although HPC is not an index of pathogen presence nevertheless high HPC values are indicative of the ineffectiveness of the water treatment process, faults in the distribution and filtration system and biofilm formation [24]. HPC besides telling us the variety of normal microflora present in water also tells us the possibility of the presence of organisms derived from various polluting sources that may contain pathogenic and opportunistic organisms. The results obtained in the present study, as shown in Table 2 & 3, are very alarming demanding immediate actions as they depict high level of bacterial load, indirectly revealing the presence of microbes whether pathogenic or having low sanitary importance. In the present study the Heterotrophic Plate count was considerably high ranging from 0CFU/ml to a maximum of $2.9x10^6$ CFU/ml (Table 2). WHO permissible limit for HPC is <100 CFU/ml for drinking water [22]. Overall 80% of the samples had viable bacteria present in them exceeding the permissible limit and out of those positive samples, 18.18% of the samples have load more than 10^6 indicating inefficient disinfection. Such high values of HPC clearly show that the water is misfit for consumption, not only the water distribution system but the filtration systems are also highly impaired. Such high loads may contain pathogenic organisms harmful to health.

The faecal coliform (*E. coli)* was found in 17 of the total samples yielding a percentage of 38.63% thus giving a rough picture of waterborne diseases that might arise from this much high count, as about 90% people in Punjab suffer from such ailments [25]. Amongst the positive samples 8 (18.18%) of the samples had *E. coli* O157: H7 present in them which is very alarming as this enterohemorrhagic strain of *E. coli* having a low infectious dose i.e. < 100 cells, can have serious health effects causing bloody diarrhea progressing to hemolytic uraemic syndrome in humans and may cause acute kidney failure in children**.** This much high percentage of *E. coli* totally violates the limit determined by WHO which states that *E. coli* should not be present in drinking water. This shows that the water available for drinking purpose in teaching institutes is misfit for use and can lead to major epidemics if left untreated. The presence of *E. coli* in water shows fecal contamination which may have resulted due to amateurish layout design of distribution system resulting in the blending of sewage pipes with drinking water pipelines or may be due to leaky and worn out pipes. Another reason may be improper disinfection (chlorination), biofilm development and improper working of the filtration plants installed at consumer ends as all these factors contribute to such high load [26], whatever may be the source and reason behind such high loads, a serious risk of an epidemic sprouting cannot be overlooked as the results revel that the water is totally unhygienic for consumption. However, *selmonella* and *shigella* was not detected in any sample.

Overall only 20% of the samples met the WHO requirements for drinking water as they did not reveal any bacterial contamination. As far as HPC is concerned apart from the 11 negative samples not even a single sample fell under WHO requirement of < 100 cfu /ml, all of the rest have bacterial loads way up the desired limit. It is interesting to note that amongst those 80% (44/55) positive samples 56.82% (25/44) of samples had fecal contamination as they showed growth of *E. coli* the rest 43.18% (19/44) of the samples had bacterial contamination other than *E. coli.* These may include opportunistic pathogens like Acinetobacter, Aeromonas, Klebsiella, Flavobacterium, Moraxella, Pseudomonas, Serratiaetc. which were not analyzed presently. Another thing that is worth mentioning is the total absence of *E. coli* in 7 of the samples where the HPC counts were the highest, this may have resulted due to suppression of coliform detection due to high HPC densities as evidences are there showing that the frequency of coliform detection decreases when HPC reaches to 10^4 to 10^5 CFU/ml. Hence more research is required regarding the interaction between *E. coli* and other aquatic microorganisms so that a greater precision in judging the true bacteriological quality of potable water can be achieved.

The present study reveals high bacterial contamination in the drinking water of teaching institutes. Several studies conducted in different area of Pakistan on the same topic show similar scenario. A study conducted regarding the microbial quality of water and food in school and colleges of Islamabad revealed that about 50% of the samples were above the limit[27], which is relatively lower than the one obtained during the present research, however *E. coli* was detected in 40% of the samples reaching a close approximation to the value of 45.45% indicated by the present study.

This depicts that the water quality in the teaching institutes of Pakistan is highly defective. It is also worth mentioning that the drinking water in Lahore is not up to the standards whether in the educational institutes or in households as discussed by different studies conducted for this purpose. Different studies in Lahore reveal bacterial loads of 42.85%, 75% and 37.2% showing a lack of proper distribution system[23, 28]. Hanan*et al.* (2010) also reported that the water samples taken from filters had 41.2% E. coli contamination [25]. The picture is really gloomy in other parts of Pakistan as well like a study conducted by Hashmi *et al.* (2009) regarding the bacteriological quality of drinking water in Peshawar gives the HPC counts reaching a maximum of 10^6 [29]. The present data shows that about 43.18% of the samples are in the range of 10^4 which correlates with another study conducted on drinking water quality in Sindh [30], where major proportion of HPC was in the range of 4 log cfu. Studies conducted by PEP in Islamabad and Rawalpindi show that 60% and 53.85% of the filtered samples were contaminated with E. coli. Similarly studies in Peshawar, Karachi and Sukkur show that 43.28%, 100% and 82% of the samples were having fecal contamination respectively[26, 31].

IV. Tables

Table 1: Hydro-chemical data of water samples taken from dispensers of teaching institutes in Lahore

Characteristic	Min	Max	Mean	SD	CV	WHO permissible limit
pH	7.2	7.8	7.4	0.56	0.075	6.5 to 8.0
Conductivity (μS/cm)	185	362	328.25	88.82	0.270	400 (μS/cm)
Hardness (mg/L)	380	450	410.39	49.06	0.119	500 mg/L
TDS (mg/L)	660	780	733.65	387.31	0.527	1000 mg/L
Bicarbonates (mg/L)	355	420	385.25	131.31	0.340	500 mg/L
Chloride (mg/L)	130	220	187.38	39.54	0.211	250 mg/L
Sulphate (mg/L)	153	187	162.5	11.93	0.073	250 mg/L
Sodium (mg/L)	160	180	156.70	41.23	0.263	200 mg/L
Nitrates (mg/L)	3	6	5.8	3.2	0.551	10 mg/L

SD= standard deviation, CV= coefficient of Varience

Table 2 Heterotrophic plate count (HPC)/ml ranges of water samples

HPC range / ml	Water samples
0 - <10	11 / 55 (20%)
> 10 - <10^3	6 / 44 (13.64%)
>10^3 - <10^4	19 /44 (43.18%)
>10^4 - <10^5	6 / 44 (13.64%)
>10^5 - <10^6	5 / 44 (11.37%)
>10^6 - <10^7	8 / 44 (18.18%)

Table 3 Results of microbiological study of water samples (%)

Samples type	Positive samples	Percentage
Contaminated water samples	44/55	80%
Non contaminated water samples	11/55	20%
E.coli (faecal coliform)	17/44	38.63%
E.coli (O152:H7)	8/44	18.18%
Bacteria other than *E.coli*	19/44	43.18%

V. Conclusions And Recommendations

Depending upon the results obtained only 11% of the samples were within the recommended limits laid down by WHO as far as bacterial quality is concerned. This is of great concern as potentially pathogenic microorganisms pose an obvious health risk to all the consumers. HPC values were particularly high clearly indicating the lack of proper water treatment not only from main distribution supply system but the improper functioning of the filters installed at the consumer's end as well. Also the presence of E. coli and the potentially lethal strain O157:H7 is very distressing as it can cause severe diseases in children. Based on the conclusion drawn, following recommendations are proposed to ameliorate the current condition:

1. The treatment plants should be highly focused upon giving prime importance to regular maintenance and supervision of all the water resources as well as all the treatment methodologies employed to purify water intended for drinking purpose. Proper monitoring of HPC and E. coli load in water should be undertaken while it is still in the treatment plant and also immediately after it leaves the treatment plant. These values will surely help in judging the proper working of the treatment plant.
2. Proper disinfection should be carried out at the water purification plants by means of standard disinfection procedures like chlorination, UV or Ozone disinfection.
3. Water in the distribution system may also get contaminated to the flaws in the layout design so proper sanitary surveys regarding the layout designs should be carried out in order to prevent the proximity of sewer pipes to the water pipes. In addition to that leaky, rusty and worn out joints and pipes should be timely changed.
4. The filters installed at the water coolers should be replaced according to the manufacturer's recommendations. Water coming out of their faucets should be monitored on a regular basis and whenever contamination is observed proper remedial measures should be taken immediately to avoid major catastrophe.
5. The UV lamps for the sterilization of water should be in working condition and must be replaced according to the manufacturer's recommendations and the dosage efficacy of the lamps should be according to the standards and must be monitored routinely as even functional lamps may not be providing the required disinfection dose.

Such amendments at the managerial as well as the consumer end can help rectify the present situation. The present study concludes that generally the drinking water quality in teaching institutes lack routine monitoring and hence is unsatisfactory for potable purposes. As the teaching institutes receive scholars coming from different regions of the country, therefore, such medical conditions can spread nationwide if left untended.

Hence it is anticipated that the present study would serve as a reference to initiate more meritorious research in this regard. This research may also enable the concerned authorities to take appropriate remedial actions to improvise the prevalent problems regarding the drinking water quality in the institutes by setting up effective programs.

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