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Chlorine Status and Drinking Water Quality in Public Institutions of Karachi, Pakistan

[1]Kanza Abid, [1]Aamir Alamgir, [1]Yashfeen Zahid, [1]Kiran Mahar, [1]Sidra Arif,
[1]Wara Zehra, [1]Omm-e-Hany, [1]Khalid Mehmood and [2]Sikandar Khan Sherwani

[1]Institute of Environmental Studies, University of Karachi, Karachi, Pakistan
[2]Department of Microbiology, FUUAST, Karachi, Pakistan

Abstract: This cross sectional study investigates the microbiological quality of drinking water and evaluates the status of chlorine in drinking water available in public institutions of Karachi. The quality of water was examined by Most Probable Number Technique (MPN) using standard methods and chlorine was analyzed through standard Merck kits. Water from all the sample stations failed to meet WHO guidelines for the micriological quality of drinking water and showed high bacterial water resource is grossly polluted with the organisms of public health importance that could be a potential threat to the people who consume water at these institutions.

Key words: Chlorine status · Water quality · Public institutions

INTRODUCTION

Water is one of the most imperative natural reserves found on earth. 70% of our earth is water regardless of the fact drinking water is not freely accessible to all parts of the world. 48 countries including Pakistan face chronic scarcity of water, which may be due to uneven dissemination of water and also the constant instabilities in the hydrological cycles. According to a report "*40% of the human populations do not have access to clean drinking water*" [1]. The apprehension for the safety of drinking water is very essential and is one of the supreme achievements of 20th century.

Developing countries are facing population explosion problem. Population growth rate is greater than agricultural growth rate resulting into continued shortage of food and water supply. In order to decrease gap between water supply and demand in developing countries the people mostly rely upon the under ground water resources [2].

Karachi being the largest and most industrialized city of Pakistan is facing a chronic shortage of water supply since decades as the water supply by the Government is insufficient to meet the requirements. Due to the fact people tempted to use the alternative water resources mostly the underground water to meet their requirements. The quality of water from Karachi Water and Sewerage Board as well as from alternate sources varies as much as the source themselves. Thus, the quality may vary from virtually the wastewater from sewerage system to bottled water [3].

Conventionally, the safety of potable water provisions has been controlled by disinfection, usually by chlorination and coliform population assessments. Chlorine is used for disinfecting drinking water at concentrations of 0.2–1 mg/liter. Potential benefit of chlorine becomes effective only when water turbidity is less than 5 NTU, even if enhanced dosage of chlorine is used. Adulterated water, comprising more than 100,000 coliforms per 100 ml, will not harvest safe drinking water [4]. This is accountable for the waterborne ailments caused by pathogens, including a variety of viral, bacterial and protozoan agents, which account for much of the estimated 4 billion cases and 2.5 million deaths from widespread diarrheal diseases each year [5]. Chlorination of drinking water for public supplies has assisted to eradicate these diseases, which may be regarded as a big accomplishment.

Chlorination proposes a number of benefits including reduction of foul tastes and odors, elimination of bacterial species and it also aids in the removal of chemicals of numerous categories which may cause hindrance in water

Corresponding Author: Aamir Alamgir, Institute of Environmental Studies, University of Karachi, Karachi, Pakistan.

Table 1: Sample Location and GIS Coordinates

Station No.	Area	Sample Code	GIS Co-ordinates
St-1	F-B Area	S-1	24°15'13.01"N 67°04'11.65"E
		S-2	24°55'48.69"N 67°04'34.77"E
		S-3	24°55'55.5?N 67°04'53.9?E
St-2	Metro Ville	S-4	24°56'35.12"N 67°06'20.66"E
		S-5	24°56'15.44"N 67°05'35.61"E
St-3	Orangi Town	S-6	24°57'42.34"N 66°59'20.90"E
		S-7	24°56'39.90"N 67°60'17.59"E
		S-8	24°57'04.51"N 66°58'50.91"E
		S-9	24°58'04.91"N 66°59'33.67"E
St-4	Nazimabad	S-10	24°06'54.00"N 67°02' 51.00"E
		S-11	24°55'14.94"N 67°02' 0.64"E
		S-12	24°55' 4.82"N 67°02'6.11"E
St-5	Gulshan-e- Iqbal Town	S-13	24°53'53.1?N 67°06'19.7?E
		S-14	24°53'21.4?N 67°04'22.8?E
		S-15	24°55'39?N 67°06'25.1?E
		S-16	24°56'09.5?N 67°08'04.2?E
		S-17	24°56'15.3?N 67°07'12.6?E
		S-18	24°53'53.1?N 67°06'19.7?E
		S-19	24°56'34.6?N 67°07'18.3?E
St-6	Shadmaan Town	S-20	24°57'25.9"N 67°4'7.8"E
St-7	Malir Town	S-21	24°53'20.39"N 67°11'34.36"E
		S-22	24°53'1.61"N 67°11'52.48"E
St-8	Saddar	S-23	24°51'37.6?N 67°01'26.2?E
St-9	Pehalwaan Goth	S-24	24°54'49.9?N 67°08'31.2?E
St-10	Shah Faisal Colony	S-25	24°52'48.94"N 67° 8'34.11"E

purification and treatment. In this regard present study evaluates the status of chlorine and microbiological quality in drinking water available in various public institutions of Karachi and therefore relate the high maicrobiological load to the low levels of chlorine.

MATERIALS AND METHODS

Sample Collection and Preservation: Twenty five (25) drinking water samples were collected from various public institutions present in ten different areas of Karachi (Table 1). After collection the sample bottle was labelled properly assigning a sample I.D number. Samples were collected in duplicate, one bottle used for bacteriological analysis contained 1 ml of sterile sodium thiosulphate to neutralize the effect of residual chlorine if any, another sample bottle was retained for determining residual chlorine. After collection of samples the bottles were placed in an ice-box maintained at temperature of 4-8°C and transported to the Institute of Environmental Studies, University of Karachi for analysis.

Microbiological Quality Assessment: The samples were processed in laminar flow hood using sterilized culture media (the sterility of media was checked prior to use) by Most Probable Number Technique (MPN) as per standard methods described in (APHA, 2005) [6]. Total Coliform and Faecal Coliform test were also performed, as per standard methods (APHA, 2005) [6] to check the quality of the water. Moreover, Flouorocult LMX broth was also used for simultaneous enrichment and detection of total coliforms and *E. coli* in water samples.

Chlorine Estimation: Residual chlorine was determined by Merck kits.

RESULTS AND DISCUSSION

The main objective of this study was to determine the status of chlorine and its influence on microbiological quality of drinking water available in various public institutions of Karachi, Sindh, Pakistan. The microbiological analysis of samples was performed by standard methods and level of chlorine in the drinking water samples was determined through Merck kits. Perusal of the results given in Table 2 it can be seen that the water quality of drinking water is deteriorating day by day,specially in government schools, colleges and other public places. This high pollution level in drinking water poses a serious threat to human health and the environment. Regular monitoring programs to assess the water quality at the treatment plants or in the distribution system is not practiced in Pakistan, except at a few major water treatment plants which may be associated with health risks for susceptible individuals

Table 2: Status of residual chlorine and bacteriological quality in collected drinking water samples

Sample code	Residual Chlorine (mg/l)	MPN Index / 100ml	Total Coliforms and *E. Coli* on Fluorocult LMX broth (24-48 hours incubation)
S-1	0	>2400	-ve
S-2	0	23	-ve
S-3	0	1100	-ve
S-4	0	460	-ve
S-5	0.15	23	+ve
S-6	0.2	9	-ve
S-7	0	210	-ve
S-8	0	43	-ve
S-9	0	43	-ve
S-10	0	1100	+ve
S-11	0.15	23	-ve
S-12	0.15	>2400	-ve
S-13	0.5	>2400	+ve
S-14	0	75	-ve
S-15	0	23	-ve
S-16	0	4	+ve
S-17	0.15	210	+ve
S-18	0	23	+ve
S-19	0	>2400	+ve
S-20	0.15	23	+ve
S-21	0.15	150	+ve
S-22	0	460	+ve
S-23	0.15	240	+ve
S-24	0.2	9	+ve
S-25	0.15	23	+ve

due to deterioration of microbiological water quality in the distribution systems [7]. According to a survey conducted by Pakistan Council of Research in Water Resources (PCRWR) around 84 - 89% of water supplies from around the country have water quality below the recommended standards for human consumption [8]. During a study conducted in 2013 it was found that more than 96% of water samples tested were contaminated with bacterial species, including *Bacillus spp., Corneybacterium spp., Acinetobacter spp., Pseudomonas spp., Enterobacter spp., Serratia spp. and Citrobacter spp.* which are potentially pathogenic and can cause serious as well as life-threatening infections in humans and animals [14].

Status of Chlorine (Cl_2) in Drinking Water: Chlorine is a chemical disinfectant that is added to the drinking water supply to kill bacteria, germs, parasites and viruses that can cause serious as well as life-threatening infections. It is administered either in liquid or tablet form. According to the US-EPA, the acceptable ratio of chlorine to water is four parts chlorine per million of water (or 4mg/l). Standard value for Pakistan of residual chlorine as described by the NSDWQ of Pakistan-EPA is 0.2-0.5mg/l at consumer end and 0.5-1.5mg/l at source [9], whereas the 1993 WHO Guidelines for Drinking Water Quality established a guideline value of 5 mg/liter for free chlorine in drinking-water [10]. During this study, it was observed that drinking water in schools has very little or no chlorine at all. Chlorine levels in our samples range from 0.15 mg/L being the lowest to 0.5mg/L being the highest. As a matter of fact, most of the samples have no chlorine at all which is very alarming since chlorination is essential to maintain good quality of drinking water.

Microbiological Quality of Drinking Water: According to Pakistan standards for drinking water and WHO guidelines all water intended for drinking (*E. coli* or Thermo-tolerant Coliform bacteria) must not be detectable in any 100 ml sample [2]. The study shows that the water quality in government institutions of Karachi does not meet the guidelines proposed by WHO since almost all of the samples were found to be fecally contaminated. Meybeck (1985) reported that the fecal coliform up to 10^6 /100 ml are commonly found in India, Pakistan and Indonesia [11] with respect to public health it should be made mandatory that water supplies should be free from contamination so that microorganism of any kind could not get a chance to grow.

It was likewise mentioned that the chlorine level is below the permissible limit which is not sufficient for the water purification until water gets to the consumer.

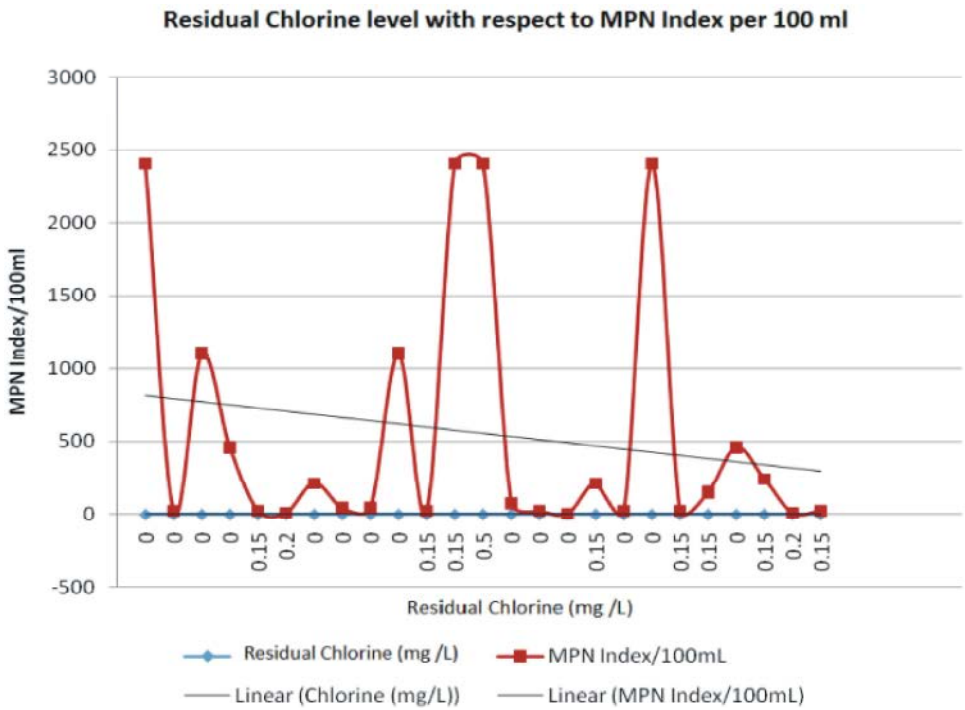

Fig. 1: Chlorine level corresponding to MPN Index/100 ml

Since it is an effective antimicrobial agent with the capacity to react destructively with the protein components of all types of organisms and even protecting water from contamination during distribution. Therefore, it is shown in Figure 1 that the low concentration of residual chlorine contributes to high loads of faecal coliform bacteria.These organisms are found in the intestinal tract of warm-blooded animals and in soil and their presence in water indicates pathogenic contamination. The standard for coliform bacteria in drinking water is "less than 1 coliform colony per 100 milliliters of sample" (< 1/ 100ml) [12].

Thus the results showed that the level of chlorine is not sufficient for the disinfection of drinking water in the distribution system thereby showing high microbiological loads in the sampling stations.

CONCLUSION

The aim of this study was to determine the status of chlorine and microbiological quality of drinking water available at various schools and colleges of Karachi. This study emphasizes on two major findings. First, chlorination is not adequate to reduce the microbial load of water. Second, microbial load at consumer's point area indicates that the water becomes contaminated when it is supplied to these areas. The possible reason of this may be the poor maintenance of water supply network due to which water may exposed to various microorganism. There is a probability that these microbes may endure the level of residual chlorine. When this polluted water is consumed it leads to various water borne diseases, abdominal problems etc [13]. Water supplies management sector is responsible to resolve this problem by complete monitoring and using enough chlorine so that no more water shall remain harmful for the health of citizens.

Recommendations: It is clear that both urban and rural drinking water supplies in Pakistan are chiefly tainted and pose grave health hazards to the users. To ensure safe water supplies for drinking, there is a need to articulate an operative management stratagem. Preventive measures must be taken from core level to prevent water contamination. As far as possible, water sources must be protected from contamination by human and animal waste, which can contain a variety of bacterial, viral, protozoan and helminth parasites. Protection of water sources should be the first line of defense. All personnel responsible for monitoring the quality of water should be educated and provided in-service training on a regular basis. A critical and objective review of existing national research data on the quality of drinking water should be conducted on a regular basis.

All critical parameters should be monitored. The sanitation of water reservoirs/tanks of users must be obligatory and chlorination should be ensured in the water tanks by using chlorine tablets or liquid chlorine. All institutions should be continuously scrutinized by the competent authorities.

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