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Original Article

# Impact of Seasonal Variation on Bacteriological Quality of Drinking Water

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**To assess the bacteriological quality 768 drinking water samples were collected from different locations in Khairpur City, Sindh, Pakistan over a period of two years from January 2006 to December 2007. The study reveals that out of 768 drinking water samples 567 (73.83%) samples were found to be contaminated with total coliform among them 85 (11.06%) found in the January-March period, 182 (23.70%) in April-June period, 188 (24.47%) in July-September, 112 (14.58%) in October-December period. Faecal coliform was found in 351 (45.70%) water sample, in which 49 (15.80%) occurred during January-March, 137 (17.83%) during April-June, 136 (17.71%) during July-September and 69 (8.98%) during September-December. It can be concluded from the results of the present study that bacteriological quality of two-third drinking water in Khairpur City is not safe as the water is the potential source of diarrhoeal disease agents.**

**Keywords: Drinking water, Khairpur City, Faecal pollution, Diarrhoea**

## Introduction

Assessment of seasonal variation in surface water quality is an important aspect for evaluating temporal changes of municipal water pollution due to natural or man made inputs of point and non-point sources[1]. Waste water pollution of drinking water sources is one of the most important environmental problems, which affects our lives[2]. The primary water pollution problem in the world today is the lack of clean drinking water. Each year in several countries people are exposed to waterborne disease whose effects vary in severity from an upset stomach to death. In 1990, epidemic of cholera, a serious waterborne disease, caused wide spread suffering and death in South America[3]. Water-borne diseases are very common in the developing countries and every year around 2.2 million people die due to basic hygiene related diseases like coliform diarrhoea. Much of the ill health, which affects the humanity in developing countries, can be traced to lack of safe and wholesome of water supply there can be no state of positive health and well being without safe water[4].

Contaminated water is an undisputed determinant of health, mentioned amongst 10 risks to the health in the World Health Report 2002. A hospital admissions data of WHO mentions 25-30% admissions connected with water-borne bacterial and parasitic conditions. According to Pakistan National Conservation Strategy report of 1992 about 40% of communicable diseases are water-borne. Major diseases linked to drinking water in Pakistan are diarrhoea, gastroenteritis, typhoid, *Cryptosporidium* infection, giardiasis intestinal worms and some strains of hepatitis. According to International Union on Conservation of Nature (IUCN) 60% of infant deaths are caused by water-borne diarrhoea in Pakistan[5]. The universal access to safe drinking water and sanitation has been promoted as an essential step in reducing these preventable diseases[6].

In Pakistan, there are potential sources to contaminate drinking water. Bacteriological contamination of drinking water has been reported to one of the most serious problems throughout the country in rural as well as urban areas. Such contamination is attributed to leakage of pipes pollution from sewage pipes due to problem within the system, intermittent water supply and shallow water tables due to human activities[7]. In Khairpur, Pakistan, a city of 150 million people, water quality is poor; the source of municipal water is surface water from river Indus, which is unprotected from the traditional sources of contamination, *i.e.*, human and animal activities, garbage disposal and disposal of untreated waste water of the city into source water (Mirwah Canal). Due to unsafe drinking water, water-borne diseases, *i.e.*, diarrhoea, dysentery and typhoid fever, are very common in the area. In 2006 and 2007, there were 18 cases of diarrhoea, 25 cases of typhoid fever and 7 cases of dysentery (Figure 1) reported in quarterly report of infectious diseases[8].

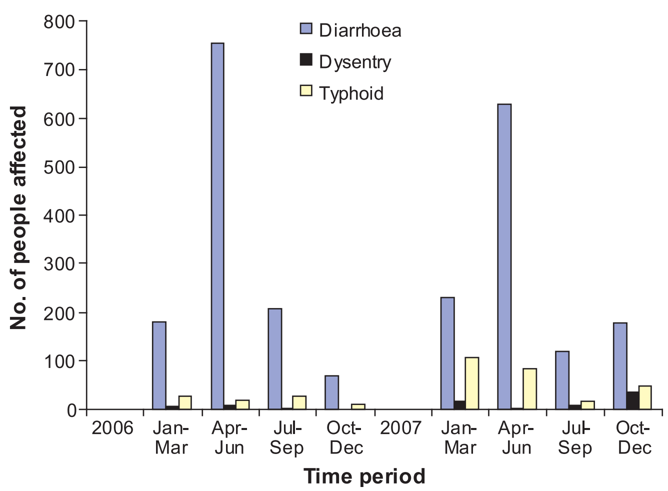


**Figure 1.** *Water-borne diseases reported during 2006-2007 in Khairpur.*

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To prevent the water-borne diseases it is imperative to provide the clean and safe drinking water to the people for this the development of an effective municipal water purification and delivery system and effective sanitary sewerage system is necessary. It has been realized that strong need to establish standard and guidelines for quality drinking water. In 2004, Pakistan council of research in water resources prepared a report related water quality in Pakistan with recommendation for establishing standards[7]. Looking at this significance of water-borne infections the present study on impact of seasonal variation on bacteriological quality of drinking water was undertaken to understand the pattern of water-borne infection according to various seasons.

## Materials and Methods

*Inspection of water treatment plant*

During informal inspection of water treatment plant following things were observed regarding storage, filtration and disinfections. Storage was observed during various informal inspections that a lot of algae were deposited in storage tanks, which may cause objectionable taste and odour. There were so many trespasses by human and animals in the vicinity of storage tanks for defecation. In filtration system, the development of vegetative growth like algae were also visible on sand filters like it was observed in storage tanks.

*Sampling techniques*

Water samples were collected from different sites, *i.e.*, households, hotels, hospitals, schools and waterworks. Duration of sampling was divided in four groups of time period months, *i.e.*, January-March, April-June, July-September and October-December 2006 and 2007. The drinking water was municipal water originating from surface water sources. The sampling was carried out fortnightly and the samples were collected in sterilized screw capped 500-ml white glass flasks (Pyrex) after a flow time of 5 min to eliminate any contaminant present. In order to neutralize the residual free chlorine, 10% solution of sodium thiosulphate was added the bottles. After collection the samples were placed in ice boxes and brought to laboratory. An analysis was carried out for drinking water samples keeping in view the standards of World Health Organization (WHO).

*Bacteriological analysis*

For bacteriological evaluation the samples were analysed within 4 h of collection by membrane filtration at three concentrations, undiluted and diluted 1:10, 1:100 and 1: 1,000 with 0.01 *M* sterile phosphate-buffered saline. Each dilution (100 ml) of water was first filtered through a sterile 0.45 µm membrane filter and each of the filters was transferred to a 47-mm Petri plate containing eosin-methylene blue agar (BioM, USA). The plates were incubated at 44ºC for 24 h and then examined for thermotolerant coliform and *Escherichia coli* colony counts. Blue-purple colonies with a greenish metallic sheen were selected as possible *E. coli* and inoculated them in a tube of MacConkey broth with a Durham tube and a tube of peptone water that were further incubated at 44ºC for 24 h. The colonies that fermented lactose (as indicated by a change in the colour of MacConkey broth) and produced gas and indole at 24 h were classified as *E. coli*. The countable range of colonies was 10-100. When the number of colonies in only one plate was within the countable range then this count was used to estimate bacterial density. When two or more plates had colonies within the countable range then we estimated bacterial density by calculating the arithmetic mean of the counts of these plates. When one or more filters had colonies too numerous to count and the more dilute filters had colonies below the countable range then the bacterial density was estimated to be at the maximum countable concentration of the most dilute filter that had colonies too numerous to count. When all the filters had colonies too numerous to count then bacterial density was estimated to be twice the upper limit of the countable range[9].

## Results

A total of 768 water samples were collected over a period of two years. In 2006, 384 drinking water samples were collected including 96 samples during January-March and same number of samples during April- June, July-September and October-December and the same number of drinking water samples collected in same way in 2007. Out of 768 drinking water samples, 567 (73.83%) samples were found to be contaminated with total coliform. It was observed that during summer months, 182 (23.70) samples in April-June and 188 (24.47%) samples in July-September were found to be contaminated, while in winter months, 85 (11.06%) samples in January-March and 112 (14.58) samples in October-December were found to be contaminated with total coliform bacteria. Out of 768 drinking water samples, 351 (45.70%) samples were found to be contaminated with faecal coliform bacteria. It was also observed that the faecal contamination was also increased in summer months, *i.e.*, during April-June 136 (17.71%) samples and during July-September 137 (17.84%) samples showed faecal contamination as compared to the winter months, *i.e.*, during January-March 49 (6.38%) samples and during October-December 69 (8.98%) were fond to be contaminated with faecal coliform (Figure 2).

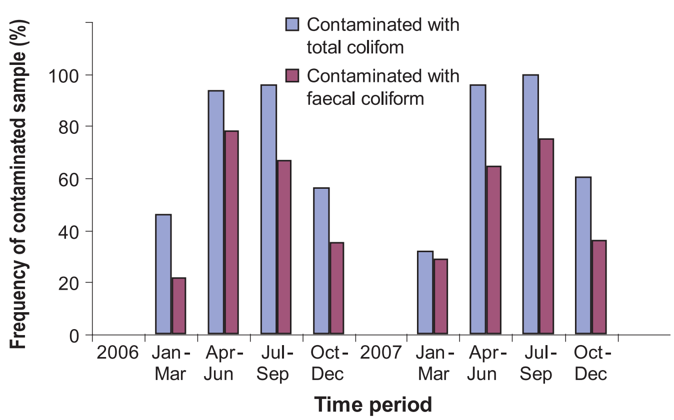


**Figure 2.** *Frequency of bacteriological contaminated drinking water samples from Khairpur City.*

The number of total coliform and faecal coliform bacteria per 100 ml was also impacted by the seasonal variation as it was observed that the bacterial count in 100 ml of drinking water samples was also high in the summer months than winter months. In 2006, 3.3 $\log_{10}$ cfu total coliform and 2.3 $\log_{10}$ ml faecal coliform in January-March, 5 $\log_{10}$ total coliform 3.78 $\log_{10}$ faecal coliform in April-June, 4.65 $\log_{10}$ cfu total coliform and 3.9 $\log_{10}$ cfu faecal coliform in July-September and 3.9 $\log_{10}$ and 2.78 $\log_{10}$ total and faecal coliform per 100 ml of drinking water samples were detected. In 2007, during January-March 3.7 $\log_{10}$ cfu total coliform and 2.7 $\log_{10}$ cfu faecal coliform bacteria, during April-June 4.67 $\log_{10}$ cfu total coliform and 3.7 $\log_{10}$ cfu faecal coliform bacteria, during July-September 4.84 $\log_{10}$ cfu total coliform and 3.6 $\log_{10}$ cfu faecal coliform, during October-December 3.9 $\log_{10}$ cfu total coliform and 2.47 $\log_{10}$ cfu faecal coliform per 100 ml water were found (Figure 3).

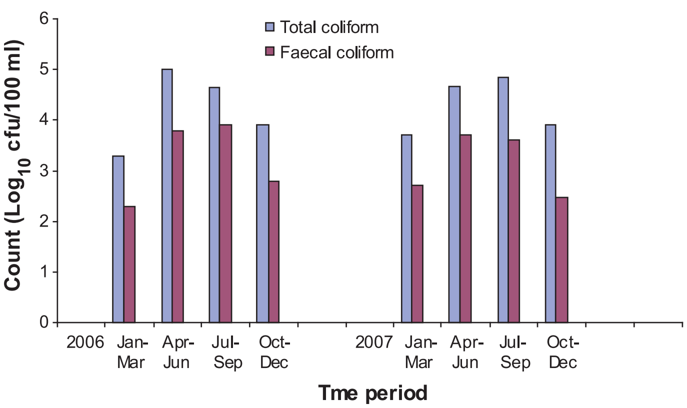


**Figure 3.** *Number of total coliform and faecal coliform bacteria per 100 ml of drinking of Khairpur City.*

## Discussion

The impact of seasonal variation on the quality of drinking water of Khairpur City was evaluated. The bacteriological analysis was carried out by membrane filtration method. A total of 768 samples were collected over a period of two years. The study was based on total number of contaminated samples in four sets of time period, *i.e.*, January-Mach, April-June, July-September and October-December. It was observed that in the summer months, *i.e.*, April-June and July-September the percentage of contaminated sample with total coliform as well as faecal coliform bacteria was higher than in the winter months, *i.e.*, in January-March and September-December. The number of total and faecal coliform bacteria per 100 ml sample of drinking water was also higher in summer months than in winter months. Our results are not in agreement with the results of Alkatib, as he reported that the bacteriological contamination was higher in winter months than in summer months in drinking water of Palestinian district Jenin[10].

In the months of peak of summer the cases of water-borne diseases were reported as higher than in winter months. This may be due to climate temperature, which favours the optimum growth of organism. Sisyphe *et al*.[11] reported that stream temperature change could be approximated by air temperature changes. Since the temperature ranges from 37-50°C, which supports mesophiles and pathogens come in the range means optimum temperature for their optimum growth, the contamination of drinking water in summer months has been reported as higher than in winter[4]. The source of microbial contamination in drinking water may be the human and animal activities in source water. In summer months, the consumption of water for different purposes increases and municipal has to supply more water to the consumer and, to clean the large amount of water urgently so it requires the treatment and thus the proper sedimentation can not be achieved. On the other hand, due to human and animal activities contamination in source water increases in summer months, which enhance the faecal contamination in the source of drinking water.

As surface water is the only source for many cities of Pakistan, it is not properly protected from the traditional sources of contamination. The results suggest that approximately all samples from consumer taps (households, hotel hospitals and schools) and from main storage reservoir (waterworks) were found to be contaminated with higher number of total and faecal coliform bacteria. As faecal coliform contamination was concerned then out of 768, 351 (45.70%) samples were found to be contaminated with faecal coliform. This situation also prevails in most cities of Pakistan; in Karachi the water quality was poor[9,12]. The drinking water of Peshawar was found contaminated with the total as well as faecal coliform bacteria[13].

The contamination of drinking water of the Khairpur City is attributed to the inadequate treatment facilities at the municipal level; there is overlooking of cleanliness of storage tanks and vicinity of storage area. The source of drinking water of Khairpur is surface water from Mirwah Canal, which originates from river Indus and is totally unprotected from the human as well as animal activities. The untreated sewage water of city is also ending up into the canal. This all increases the contamination load in the drinking water which in turn requires an adequate disinfection and treatment at water treatment plant. The distribution system is also old and badly damaged, which is vulnerable to cross contamination from sewage water and the consequently the faecal contamination increases at the point of uses than source. This deteriorated quality of drinking water has many impacts on the human health as in quarterly report it has been shown that in months of summer the cases of waterborne diseases, *i.e.*, infectious diarrhoea, dysentery and typhoid fever increased.

The bacterial contamination to some extent increases as drinking water enters the distribution system due to the leakages of pipes[7]. In its way the water gets faecal contamination from sewage water through cross contamination. For this, sufficient attention may not be paid towards this important health based issue for public betterment consequently people suffer much more and certain outbreak of waterborne diseases are very common in area.

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