Pak. J. Sci. Ind. Res. 2008 **51**(5) 272-275

Surveillance of Drinking Water of Karachi City: Microbiological Quality

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(received December 1, 2007; revised July 28, 2008; accepted July 31, 2008)

Abstract. In the analysis of 329 treated (tap) water samples and 30 well water samples of Karachi city, 94 (28.5%) tap water samples were found contaminated with faecal coliforms and had high heterotrophic plate count (HPC), 153 (46.5%) had very high heterotrophic plate count and only 82 samples were fit for human consumption. Out of 30 well water samples only 2 samples were fit for human consumption; 23 (76%) had high faecal coliform count and HPC, whereas, 5 (16.67%) were rejected owing to extremely high bacterial count.

Keywords: faecal coliforms, heterotrophic plate count, drinking water quality, Karachi

Introduction

In developing countries drinking water and sanitation related diseases are the major contributors of the disease burden (Pruss *et al*., 2002). The potential of drinking water to transport microbial pathogens to consumers causing subsequent illness is well documented in the countries throughout the world. One third of intestinal infections worldwide are caused by water-borne pathogens (Mead *et al*., 1999; Hunter, 1997). In France, most of the gastrointestinal illnesses are associated with the consumption of contaminated tap water (Collin *et al*., 1981). Several water-borne pathogens cause diseases of high mortality rate. Due to these reasons, faecal bacteria are selected as indicators of faecal pollution of drinking water (WHO, 2004).

Enumeration of the total coliform bacterial population as indicator of water quality has been in use for some 60 years (Geldreich, 1966). All the standards for drinking water quality do not allow presence of faecal indicators in drinking water (WHO, 1993). The cases of outbreaks of gastroenteritis in 2000 in Ontario, Canada involved *E. coli* 0157:H7 (BGOSHU, 2000). Mainly faecally derived coliforms, thermotolerant coliforms and *E.coli* are taken as indicators of faecal contamination and this criterion has led to significant improvement in drinking water quality worldwide (WHO, 2006).

The demand of water for more than 16 million population of Karachi city, the industrial hub of Pakistan, (Rahman *et al*., 1997) is presently 601 million gallons per day, whereas studies have shown that due to various reasons bulk supply to the town by the municipal authorities is 293 mgd; thus there is a shortfall of between 260 and 308 mgd potable water for the citizens (Rahman, 2007). Water supply system of Karachi city is 40 years old resulting in corroded and leaking pipes, whereas, wastewater treatment is almost non-existent in the city (Bridges, 2007). Due to shortage of water the supply is mostly intermittent in urban areas. Creation of vacuum in the water supply pipes due to intermittent water supply together with leaky pipes, lead to infiltration of sewage and industrial waste, into drinking water supply system and the drinking water become polluted (Mughal, 2008). The situation is further aggravated during rains and frequent epidemics of gastrointestinal diseases in the city are blamed on to consumption of polluted water. Estimates indicated that annually more then three million Pakistanis become infected with water borne diseases (UNDP-WSP, 2005). The water mainly contains *E.coli*, which is a faecal contaminant, besides the industrial, agrochemical and even radiological population.

In view of this situation of potable water of the Karachi city, microbiological analysis of the samples of consumable water from different localities is important for keeping a vigil on the possible contamination of water, whether at the water treatment plants of the city or elsewhere for taking timely action. Keeping this factor in mind, the present study was undertaken in which a survey of water samples from different sources and localities of Karachi were analyzed to determine the quality of water and present some solutions.

Materials and Methods

In the survey of water, a total of 359 samples of water were randomly collected from different localities of Karachi which included 329 samples of treated (tap) water supplied by municipal authorities and 30 well water samples which were collected from the open wells, usually used by the consumers within the housing localities for drinking purpose.

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Bacteriological analysis of water samples. ***Standard plate count.*** One ml and 0.1 ml of water was assayed, using pour plate procedure with standard agar medium (PCA; Merck) for heterotrophic plate count. A direct colony count was performed after the plate had been incubated for 48 h at 37 °C.

Total coliform count. Water sample (100 ml) was passed through a 0.45 µm cellulose ester nitrate membrane filter and carefully transferred to the surface of lactose triphenyl tetrazolium chloride (LTTC) agar plate and incubated at 36 °C for 24 h.

Orange to yellow colonies with yellow hallow on the back of the plate were counted as thermotolerant coliforms and faecal coliforms which were further streaked on PCA plates. The isolated colonies were examined for oxidase activity.

Thermotolerant coliform count. The same medium used to enumerate total coliforms was used, for the growth of thermotolerant coliforms except that incubation was carried out at 44 °C; after 24 h of incubation, characteristic colonies were counted and inoculated in E.C. medium for thermotolerant coliforms.

WHO standard for drinking water was used for the absence or presence of total coliforms, thermotolerant faecal coliforms and for heterotrophic plate count.

Results and Discussion

The results of the microbiological analysis of 329 treated water and 30 well water samples are given in Fig. 1.

Treated water samples. Out of 329 tap water samples, 94 (28.57%) indicated presence of faecal contaminants and high heterotrophic plate count; 153 (46.5%) had very high HPC and only 82 samples (24.92%) had low HPC with no faecal coliform or their number was within the permissible limit (Fig. 1) as per WHO Guidelines (1993).

Heterotrophic plate count (HPC) is important in assessing the efficiency of water treatment process and also helps in estimation of general hygienic quality of the water (WHO, 2003).

All the organisms that grow best at 37 °C are usually less frequently present in water and their presence in water system indicates their possible access from external source and is a sign of severe pollution (WHO, 2003; Report, 1982). In general, water utilities can achieve heterotrophic bacterial concentration of 10 colony forming units (CFU) per millilitre or less in finished water (Fox and Reasoner, 1999). Heavy fluctuations in HPC in the treated water samples indicate

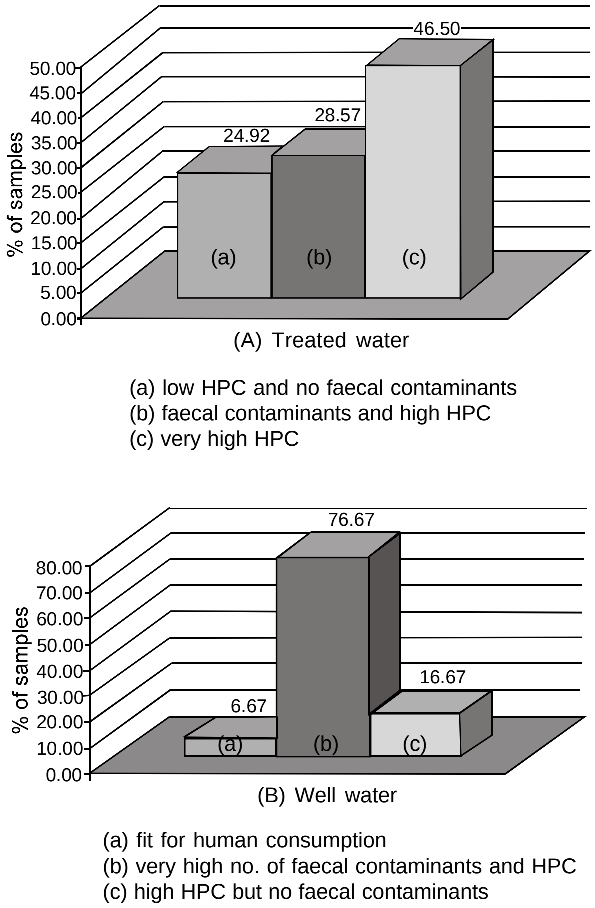

Fig. 1. Microbiological analysis.

severe ingress of faecal pollution in the treatment process (WHO, 2003).

Several species of pathogenic bacteria form part of HPC such as *Flavobacterium*, *Pseudomonas*, *Citrobacter*, *Staphylococcus*, *Aeromonas*, *Alcaligenes*, *Acinetobacter*, *Klebsiella*, *Chromobacterium*, and many others in addition to a range of unidentifiable microorganisms (Bitton, 1994). HPC tests recover a broad range of bacterial species, some of which may be opportunistic bacterial pathogens.

Pseudomonas aeruginosa is most frequently associated with many pathologies, such as urinary tract infections, respiratory diseases, ear and eye infections as well as a range of systemic diseases, such as bacterimia, osteomylites and meningitis (Pollack, 2000).

Aeromonas hydrophila, an additional heterotrophic bacterium that is capable of growing in a distribution system, has been placed on the U.S. Environmental Protection Agency's Contaminant Candidate List. Microorganisms listed on the Contaminant Candidate List are those that are potential health risks through drinking water and need to be evaluated for possible regulation (US EPA, 2005).

In the present study, 46% samples of treated water had high HPC indicating inadequate treatment of water at the treatment plants. It is therefore, important that such sources of contamination should be located and proper precautionary measures should be taken to avoid such heavy contamination of the drinking water supply.

The drinking water should be suitably treated to follow the accepted standards. Essential health standards do not allow *E. coli* or thermotolerant coliform bacteria to be detectable in 100 ml sample of drinking water (Adams *et al*., 2008). The presence of faecal pollutants in water indicates its inadequate treatment requiring immediate action (Dufour *et al*., 2005).

Microbial and other indicator analysis will be a major source of evidence for qualitative risk assessment. Enumeration of several specific pathogens such as detection of *E. coIi*, total coliforms in either source water or treated water indicates that the water is subject to contamination from human or animal faeces.

In the present study, analysis of treated (tap) water of Karachi city indicates the drinking water to be highly polluted. The presence of faecal coliforms in drinking water may be due to insufficien treatment of water at the plants or their ingress in the supply lines due to out-lived pipe system as indicated by the UNDP-WSP (2005). In any case the situation requires immediate investigation and corrective action.

A regular survey for the source of contamination and relevant monitoring programme should not only cover regular sampling but also be designed to examine high risk factors such as rainfall or the presence of vulnerable sites within the ground water abstracting system. As it is reported non-microbial parameters can also be used for ground water contamination monitoring and give information about the possible potential risk (Beaudeau, 2002; Dangendorf *et al*., 2002).

Well water samples. In the present study, well water samples were collected from different localities of the city, where people are using drinking water of wells due to nonavailability or insufficient supply of treated water. From the presented data in Fig. 1(B), it can be observed that among 30 well water samples only 2 (6.67%) were found fit for human consumption while 23 samples (76.67%) were rejected due to very high faecal pollution and high HPC. Five samples (16.67%) were rejected due to the high HPC only but in which faecal coliforms were not present.

There can be several reasons for groundwater contamination. In USA the most frequent reported source of ground water contamination in 1984, was the septic tank system which had high volume of untreated waste water, discharged into ground water (Hagedorn, 1984). Another active source of ground water contamination is the use of wastewater for crop irrigation. The potential risk of contamination of water source from sewage sludge disposal is well recognized (Mara and Cairncross, 1989). According to Rolland *et al.* (1983), the main source of ground water pollution are manures which mixed with surface water percolate to the ground water. These all may be the possible reasons for faecal contamination of ground water. Rejection of 76.6% samples of water due to high contamination with total coliforms and thermotolerant coliforms (faecal coliforms) and elevated HPC indicates the possible leakage of sewage in ground water.

The data of well water samples with such a heavy faecal contamination of ground water when correlated with the bacteriological analysis of treated water reflects the inadequate treatment given to the sourced water and also possible ingress of contaminated water into the drinking water at the site of treatment plant or into the supply system due to faulty lines. Such heavy contamination of drinking water poses severe health hazards due to consumption of highly polluted water especially by immunocompromised population (Aziz, 2005).

Mismanagement of water is also an important issue. It has been reported that in the third world countries, farmers are using more then required water for irrigation purpose resulting in loss of thousands of gallons of water in the irrigation process, further endangering the situation (PARC, 1982). It is further reported that there is an annual loss of 35 MAF in ground water seepage leading to the rise of under-ground water table and its mixing with the surface water and untreated water due to which several water related diseases have become very prevalent in the Sindh province of Pakistan. The meager health sector spending by the government is worsening the state of affairs which is bound to create havoc in terms of public health and safety.

Conclusion

On the basis of the data of bacteriological analysis of the treated water and well water samples of Karachi city, it can be concluded that the situation is alarming requiring immediate attention and investigation, pinpointing the causes and providing the solution. Adequate treatment should be given to drinking water in treatment plants; contamination of water during the treatment process should be checked and ingress of pollution in the system should be closely monitored and curative measures be introduced. Moreover, policies may be devised for proper management of water.

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