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*Full Length Research Paper*

# Drinking water quality in Rohri City, Sindh, Pakistan

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**Groundwater and surface water samples from Rohri city were analyzed for the presence of total coliform (TC), *E. coli* (Ec) and heterotrophic plate count (HPC). The samples were collected before and after storage. The bacteriological analysis was carried out by membrane filtration and spread plate count (SPC) technique. The pre-storage ground water samples were found to be contaminated with TC (25%), Ec (12.5%) and HPC (45%). All post-storage groundwater samples were found to be contaminated with TC (100%), Ec (41.6%) and with HPC (100%); the number of TC, Ec and HPC in post-storage groundwater samples was very high. The difference in number of colony forming units (cfu/100ml) between pre and post-storage groundwater samples was significant ($p$= 0.0001). The pre-storage surface water samples from main storage reservoirs and post-storage surface water samples from households were also found to be contaminated with TC (100%), Ec (100%) and HPC (100%). A significant ($p$= 0.002) difference in the number of cfu/ 100ml of ground water and in surface water samples was recorded. The quality of surface water was very poor as compared to groundwater in terms of microbial content and further declined after storage indicating lack of hygiene in the study population**

**Key words:** Groundwater, households, gastroenteritis and waterborne.

## INTRODUCTION

Coliform bacteria are natural part of the microbiology of intestinal tract of warm blooded mammals including, man. Coliform bacteria can also be found in water, soil, other animal and insect etc. The total coliform bacteria test is a primary indicator of ''potablity" that is suitability for consumption. This test measures the concentration of total coliform bacteria associated with the possible presence of disease causing organisms.

The primary concern of people living in developing countries throughout the world is that of obtaining clean water. In many places, this problem is made harder by the fact that many of the available water sources are unpotable without some forms of treatment (Joyce et al., 1996). Sewage pollution in tropical, Asian regions is a severe health risk to people that live near rivers and waterways. Direct discharge of domestic waste, leaking from poorly maintained septic water tanks and improper management of farm waste are suspected as the major source of waterborne diseases (Huttly, 1990). Poor water quality is responsible for the deaths of an estimated five billion children annually (Watson, 1996). Quality of drinking water has been debated throughout the world (Thurman et al., 1998; and Leoni et al., 2005). Indicator organisms (IOs), which reside in the gastrointestinal tract of humans and animals, are used in the United States and throughout the world to assess the microbiological safety of drinking water and recreational waters (Anderson et al., 2005). Many studies have been carried out for a suitable indicator of fecal pollution (Vilanova et al., 2004; Jones and Roworth, 1996). Studies have examined data from a large number (over 90) of water systems to determine the factors that contribute to the occurrence of coliform and HPC bacteria in drinking-water (LeChevallier et al., 1996; Volk et al., 2000). These studies have shown that the occurrence of coliform and HPC bacteria can be related to the following factors: filtration, temperature, disinfectant type and residual, assimilable organic carbon (AOC) level, corrosion control and pipe material selection. There have been very few epidemiological studies that have been designed to illustrate the association between HPC and

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human health effects; the only study was that of Ferley and colleagues (Ferley et al., 1986; Zmirou et al., 1987). This study was done in France from 1983 to 1984. The microbiological quality of drinking-water was monitored weekly. Physicians, pharmacists and primary school teachers recorded human illness due to gastroenteritis. The study was primarily designed to compare illness rates in people with and without point-of-use reverse osmosis filters on their tap water (Payment et al., 1991). The investigators found that there was an association between gastrointestinal illnesses and HPC at 35°C among people whose drinking-water had been through a reverse osmosis filter. Some members of HPC population are suspected opportunistic pathogens for immune-compromised individuals (Pavlov et al., 2004) Nevertheless, HPC is still considered a useful tool by national and international authorities (Burtscher et al., 2009). In many cities of Pakistan surface water reservoirs are main source of drinking water. In province of Sindh big cities like Karachi, Hyderabad, Sukkur and small towns like Khairpur and Rohri, 60-80% of drinking water is taken from surface water. Surface water bodies are presumed to be more vulnerable to fecal contamination than ground water due to the absence of natural soil protection and filtration and the possibly short distances between occurrence and water extraction.

It is argued that especially in heavy rainfall the microbial load of running waters may suddenly increase substantially and reach reservoir bodies very quickly (Kistemann et al., 2001).

## MATERIALS AND METHODS

### Sampling

A total of 96 samples (48 from groundwater) and (48 from surface water) were analyzed. This paper considers the pre-storage groundwater samples from selected hand pumps, post-storage ground water samples from households, the municipal water from main storage reservoirs and from households (surface water sources) of Rohri city Sindh Pakistan.

The ground water from hand pumps was collected and transported from outside the city and stored in houses in container and pitchers. The ground water samples were collected direct from hand pumps (pre-storage) and from households (post-storage). The municipal water (surface water) samples were collected from two sites; the main storage reservoir and households. The sampling was carried out fortnightly. Municipal water samples were collected from taps in sterilized screw cap 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 sodium thiosulfate was added in sterile bottles. After collection, samples were placed in ice boxes and brought to laboratory within 2 h of collection. Analyses were carried out for drinking water samples.

### Enumeration of bacteria

Total coliform were enumerated by membrane filtration on EMB agar medium. When necessary, the samples were diluted at the dilution of 1:100 and 1:1000 with 0.01 M sterile phosphate-buffered saline (Pettibone 1998). 100 ml of each dilution was filtered through a sterile (0.45 µm) pore size filter paper (Millipore) and each filter was transferred to (47 mm) Petri plate containing EMB agar (BioM USA). Filters were placed on surface of EMB agar at 37 and 44°C for *E. coli* for 24 h.

### Heterotrophic Plate Count (HPC) Enumeration

Water samples were also diluted in 0.1% (w/v) peptone water and 0.1 ml was spread onto nutrient agar plates in duplicate to determine the heterotrophic plate count. Plates were incubated at 37°C for 24 - 48 h. All colonies visible on the agar surface after incubation were counted and included in the calculation of HPC (Pettibone, 1998).

### Statistical analysis

All bacterial counts were log transformed statistical analysis. All statistical analyses were done using SPSS version 10 software.

## RESULTS

A total of 96 water samples; 24 pre-storage samples from hand pumps, 24 from post-storage samples from household (groundwater), 24 samples from main storage reservoirs of municipal water and 24 samples from different households (surface water) were found to be contaminated with TC, Ec and HPC. The study investigated: (1) pre-storage ground water samples from selected hand pumps from which the water venders collect the water and sell to consumers; (2) post- storage ground water samples stored in different containers in households; (3) treated water samples of municipal water from main storage reservoirs and (4) the municipal water samples from households. The pre- storage ground water samples from hand pumps were found to be less contaminated with TC (25%), Ec (12.5%) and HPC (45%) as compared to post-storage ground water samples contaminated with TC (100%), Ec (41.6%) and HPC (100%). The number of HPC in pre-storage ground water samples ranged from 1-1.60 log cfu/ 100 ml. The number of total coliform (TC) and *E. coli* ranged from 1.17-1.40 and 0-1 log cfu/ 100 ml in pre-storage ground water samples (Table 1). The post-storage ground water samples from households was found highly contaminated with TC, Ec and HPC; the ranges of counts were 1-2.60 log cfu, 1-1.39 log cfu and 2-2.60 log cfu/100 ml, respectively (Table 2). The municipal water samples from main storage reservoirs and from household were found highly contaminated with TC, Ec and HPC. In the samples from main storage reservoirs, TC, Ec and HPC counts ranged from 3.60-4.23 log cfu, 3-3.69 log cfu and 4-4.95 log cfu/100 ml, respectively (Table 3). In household water samples (surface water) TC, Ec and HPC counts ranged from3.90-4.25 log cfu, 3.17-3.51 log cfu and 4.17-4.77 log cfu/100ml,

**Table 1.** Bacterial count in 100 ml of pre-storage groundwater in Rohri City.

| S/N | Log CFU/ 100 ml | | |
|---|---|---|---|
| | Total coliform | Fecal coliform | Heterotrophic count |
| 1 | 0 | 0 | 1.30 |
| 2 | 1.17 | 0 | 1 |
| 3 | 0 | 0 | 1.17 |
| 4 | 0 | 0 | 0 |
| 5 | 1.25 | 0 | 1.4 |
| 6 | 0 | 0 | 1.43 |
| 7 | 0 | 0 | 0 |
| 8 | 1.17 | 1 | 1.47 |
| 9 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 |
| 14 | 0 | 0 | 1.60 |
| 15 | 1 | 0 | 0 |
| 16 | 0 | 0 | 1.23 |
| 17 | 0 | 0 | 1.25 |
| 18 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 |
| 21 | 0 | 1 | 0 |
| 22 | 1 | 0 | 1.60 |
| 23 | 1.40 | 1 | 1.4 |
| 24 | 0 | 0 | 0 |

respectively in drinking water (Table 4).

## DISCUSSION

The present study demonstrated the importance of proper management of hand pumps, municipal reservoirs and household storage points regarding drinking quality. Bacteriological quality of drinking water supplied from hand pumps was safe as the TC, Ec and HPC count was low and less number of samples was found to be contaminated. The analysis of ground water quality at selected sites in Rohri city has shown that the microbiological quality of drinking water deteriorated rapidly after collection and storage in the households. The significant difference in number of total coliform (TC), *E. coli* (Ec) and heterotrophic plate count (HPC) between the pre-storage and post-storage groundwater samples was observed at $p$= 0.0001. After storage in different container in households, the HPC, TC and *E. coli* counts per 100 ml was found to increase above the WHO and Pakistan guidelines of 0 cfu per 100 ml; resulting number of microbial contaminant is thus thousand times higher.

Various factors are currently considered as responsible for contaminations of drinking water at pre and post-storage level. First and probably most important is the selection of protected water sources. Most of the sources of drinking water in developing countries are unprotected from human, animal and environmental pollution. Secondly, the socio-economic conditions of developing countries, thirdly; the lack of awareness about importance of safe drinking water and diseases resulting from contaminated water and fourthly, the lack of knowledge about personal hygiene and general cleanliness among the population under study. These data suggest the vulnerability of ground water in Rohri city to fecal coliform contamination and rapid emergence of public health risk. Most observational changes in microbiological quality of water at source and point of use indicate decline in quality after collection.

The results in Tables 2, 3 and 4 suggest that there was significant contamination after collection. There were no instances where microbiological quality improved significantly after collection. The decline in water quality between source and point of use measured in terms of, TC, Ec and HPC count is proportionally greater where

**Table 2.** Bacterial count in 100 ml of post-storage groundwater in Rohri City.

| S/N | Log CFU/ 100 ml | | |
|---|---|---|---|
| | **Total coliform count** | ***E. coli count*** | **Heterotrophic Plate count** |
| 1 | 1.30 | 1 | 2.3 |
| 2 | 1.65 | 1.30 | 2 |
| 3 | 1.60 | 0 | 2.17 |
| 4 | 1.69 | 0 | 1.84 |
| 5 | 1.84 | 0 | 2.41 |
| 6 | 1.47 | 1.30 | 2.43 |
| 7 | 1.90 | 0 | 1.90 |
| 8 | 1.81 | 1 | 2.11 |
| 9 | 1.47 | 1.39 | 2.27 |
| 10 | 1.84 | 0 | 1.95 |
| 11 | 1.95 | 0 | 2.39 |
| 12 | 2 | 0 | 2.36 |
| 13 | 1.69 | 1.30 | 2.41 |
| 14 | 1.95 | 0 | 2.60 |
| 15 | 1 | 0 | 2.30 |
| 16 | 1.47 | 0 | 2.23 |
| 17 | 1.60 | 0 | 2.25 |
| 18 | 2.30 | 1.14 | 2.0 |
| 19 | 2.07 | 0 | 2.17 |
| 20 | 2.11 | 0 | 2.22 |
| 21 | 2.30 | 1 | 2.17 |
| 22 | 2.47 | 0 | 2.41 |
| 23 | 2.60 | 1 | 2.60 |
| 24 | 2.30 | 1 | 2.41 |

**Table 3.** Bacterial count in 100 ml of surface water in Rohri City (main storage reservoir).

| S/N | Log CFU/ 100 ml | | |
|---|---|---|---|
| | **Total coliform count** | ***E. coli* count** | **Heterotrophic Plate count** |
| 1 | 4.0 | 3 | 4.30 |
| 2 | 3.65 | 3.3 | 4 |
| 3 | 3.60 | 3.47 | 4.17 |
| 4 | 3.69 | 3.60 | 4.2 |
| 5 | 3.84 | 3.60 | 4.41 |
| 6 | 3.47 | 3.34 | 4.43 |
| 7 | 3.9 | 3.34 | 4.25 |
| 8 | 3.81 | 3.34 | 4.1 |
| 9 | 3.47 | 3.37 | 4.27 |
| 10 | 3.84 | 3.47 | 3.95 |
| 11 | 3.95 | 3.69 | 4.39 |
| 12 | 4 | 3.64 | 4.36 |
| 13 | 3.74 | 3.62 | 4.41 |
| 14 | 3.95 | 3.47 | 4.60 |
| 15 | 4.04 | 3.55 | 4.3 |
| 16 | 4 | 3.57 | 4.23 |
| 17 | 4.14 | 3.57 | 4.25 |
| 18 | 4.23 | 3.14 | 4.0 |

**Table 3.** Cont'd

| | | | |
|---|---|---|---|
| 19 | 4.09 | 3.23 | 4.17 |
| 20 | 4.13 | 3.62 | 4.22 |
| 21 | 4.07 | 3.60 | 4.17 |
| 22 | 4.14 | 3.3 | 4.30 |
| 23 | 4 | 3.23 | 4.32 |
| 24 | 3.95 | 3.17 | 4.36 |

**Table 4.** Municipal water samples from households.

| S/N | Log CFU/ 100 ml | | |
|---|---|---|---|
| | **Total coliform count** | ***E. coli* count** | **Heterotrophic Plate count** |
| 1 | 4.07 | 3.30 | 4.17 |
| 2 | 4.11 | 3.47 | 4.30 |
| 3 | 4.14 | 3.27 | 4.34 |
| 4 | 4.20 | 3.30 | 4.47 |
| 5 | 4.17 | 3.47 | 4.36 |
| 6 | 4.23 | 3.46 | 4.50 |
| 7 | 4.20 | 3.41 | 4.54 |
| 8 | 4.23 | 3.43 | 4.60 |
| 9 | 4.20 | 3.47 | 4.49 |
| 10 | 4.23 | 3.17 | 4.36 |
| 11 | 4.07 | 3.43 | 4.30 |
| 12 | 4 | 3.36 | 4.51 |
| 13 | 3.95 | 3.34 | 4.69 |
| 14 | 3.90 | 3.38 | 4.77 |
| 15 | 3.95 | 3.43 | 4.44 |
| 16 | 4 | 3.44 | 4.23 |
| 17 | 4.41 | 3.46 | 4.30 |
| 18 | 4.25 | 3.51 | 4.39 |
| 19 | 4.27 | 3.54 | 4.38 |
| 20 | 4.17 | 3.44 | 4.41 |
| 21 | 4.23 | 3.46 | 4.65 |
| 22 | 4.25 | 3.32 | 4.43 |
| 23 | 4.07 | 3.3 | 4.47 |
| 24 | 4 | 3.25 | 4.57 |

source was largely uncontaminated. Generally, the ground water at the source (hand pumps) was microbiologically of improved quality. For such sources aseptic storage in households may be a suitable supportive intervention to avoid bacteriological contamination of drinking water (Chidavenzi et al., 1998). The municipal water was found contaminated at the sources and in households. The HPC, TC and *E. coli* counts were higher at both sites. Nearly all samples of municipal water collected from main storage reservoirs as well as households were found to be contaminated. This reflects ineffective available water treatment facilities in Rohri city Sindh Pakistan.

The municipal water at the treatment plant (main-storage reservoirs) and at the household level was contaminated with TC, Ec and HPC which contained approximately similar numbers of bacteria. The heterotrophic population in potable water may include a wide range of micro-organisms including some opportunistic pathogens. Under some circumstances, however, these opportunistic pathogens within the heterotrophic flora can constitute a health risk for immuno-compromised persons. For example, some species of *Flavobacterium* as a primary pathogen for surgical patients and *Pseudomonas* can become serious secondary pathogens in post-operative infections

and in burn cases (Lowbury et al., 1970). Other opportunistic heterotrophs have received attention based on their ability to grow within drinking water distribution system. For example, *Aeromonas hydrophila* is capable of growing in distribution system which is included in the contaminant candidate list by United States Environmental Protection Agency (US EPA). Microorganisms listed on the contaminant candidate list are those that are potential health risk through drinking water and need to be evaluated for possible regulation (Hilborn et al., 2002).

The result of this study are evident that the drinking water quality of Rohri city was very poor with very high number of HPC in most of the water samples collected from municipal water. At present, measuring HPC level in water during treatment and immediately after leaving a treatment plant can be used by plant operators as useful tool to monitor plant operation. HPC can also be used as a measure of quality deterioration in distribution lines and reservoirs (Reasoner and Geldreich, 1985). The source of HPC, TC and E. coli in groundwater samples may be the water collecting individuals whose hands may be contaminated with these bacteria and during collection find their ways into the water body. The presence of HPC and other bacteria in municipal water sample may provide some indication of stagnation, residual disinfection concentration and availability of nutrient for bacterial growth in water under study (WHO, 2003). This study is also consistent with the results of earlier studies by Shar et al. (2008) during the enumeration of TC and FC from drinking water of Khairpur and in 2009, Shar et al reported that the bacteriological quality of drinking water of Sukkur City Sindh, Pakistan was very poor. The present study analyzed the changes in bacterio-logical quality of drinking water across the Rohri city.

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