

Bacteriological Analysis of Drinking Water along the Karakorum Highway (KKH)

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The present study was undertaken to assess the bacteriological quality of drinking water in Northern Areas of Pakistan. This study was comprised of total 32 water samples taken from river, water in distribution system and spring from different areas along the Karakorum Highway (KKH) from Thahkot to Khunjrab pass. Chlorination may affect the results, so its status was enquired from the local peoples and found that none of the 32 sample points in the residential areas were chlorinated. All the water samples were tested for contamination by H₂S strip Test. This study revealed that, according to WHO standard²⁵, all types of water supplies along KKH are unfit for human consumption.

Key words: Drinking water, KKH, Bacteriological analysis

A variety of human pathogens can be transmitted through contamination of drinking water¹¹. These human pathogens include bacteria (*Escherichia coli*, *Salmonella* species, *Pseudomonas* species, *Vibrio cholera*, *Campylobacter jejuni*, *Campylobacter coli* etc), Viruses (Hepatitis A, Hepatitis E, Adenoviruses, Rota Virus etc.) and parasites (*Entamoeba histolytica*, *dracunculus medinensis* etc.)^{12,27}. These pathogens are widely diluted in drinking water and so large number of peoples are exposed to relatively small numbers due to which the water infection rates are very low²⁷ but it also depends upon the immunity, state of living conditions, age and sex⁴. It is a well established fact that in developing countries, infectious diseases are transmitted through contaminated water due to inadequate sanitation and polluted water¹¹. It is estimated that in developing countries about 1200 million people don't have safe water for drinking¹⁸. More than 1200 children die every day from diseases caused by contaminated water¹¹. It is therefore, important that bacteriological quality of drinking water should be carried out frequently and thoroughly before supply to the public for consumption. In Pakistan, water microbiology is a neglected field though various researchers have studied the bacteriological quality of drinking water in different areas like Swat²⁸; Rawalpindi and Islamabad²⁰; Abbottabad¹⁴; NWFP¹; Lahore²³; Islamabad²¹ and Karachi²². However no study has been carried out in Northern Areas of Pakistan. The present study was planned to determine the bacteriological quality of drinking water in Northern Areas of Pakistan along the KKH.

Material and methods

The present study was carried out in Northern Areas of Pakistan. In this study three types of water samples were studied: i.e.

1. water in distribution system in urban areas
2. river water and
3. spring water.

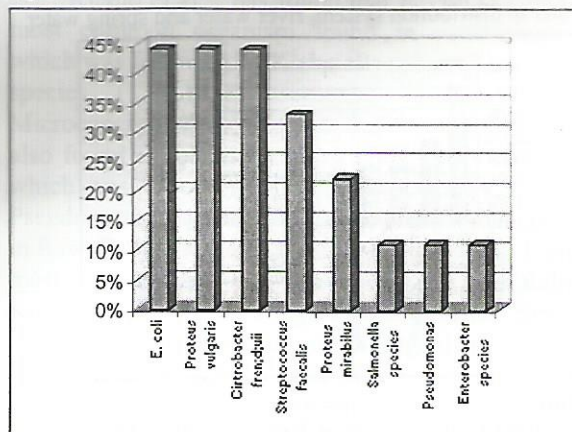
For this study a total of 32 water samples were collected from different localities of the Northern Areas starting from Thahkot and ending up at Khunjrab Pass. Out of these 32 samples, 18 samples were collected from water

in distribution system, 10 from rivers directly and 4 from different springs. Chlorination may affect the results of the study so its status was enquired from the local peoples and was found that none out of 32 samples were chlorinated. Water samples were obtained in sterilized small capacity (30ml) screw capped glass bottles which were prepared for H₂S strip test according to the procedure given by Manja et al¹⁶. Before getting the water samples, the cap of each glass bottle was heated for one minute to make it sterile. Then sterilized bottle was opened and filled with water leaving a small space behind for shaking. After that cap was screwed in place. Finally, all the water samples were transported to the laboratory for bacteriological examination by H₂S strip test.

Results

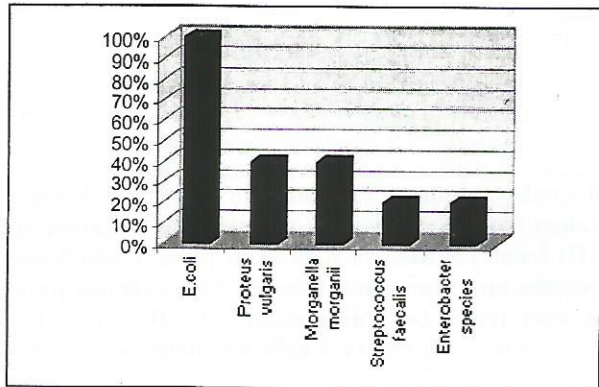
The water in distribution system was contaminated with *Escherichia coli* (44.44%); *Proteus vulgaris* (44.44%); *Citrobacter freundii* (44.44%); *Streptococcus faecalis* (33.33%); *Proteus mirabilis* (22.22%); *Salmonella* species (11.11%); *Pseudomonas* (11.11%); and *Enterobacter* species (11.11%); as show in Fig.1.

Fig.1: Water in distribution system



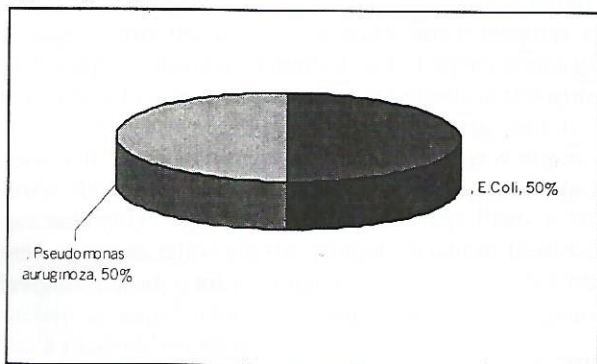
River water was contaminated with *Escherichia coli* (100%); *Protueus vulgaris* (40%); *Morganella Morganii* (40%); *Streptococcus Faecalis* (20%), *enterobacter* species (20%); Fig 2

Fig. 2. River water



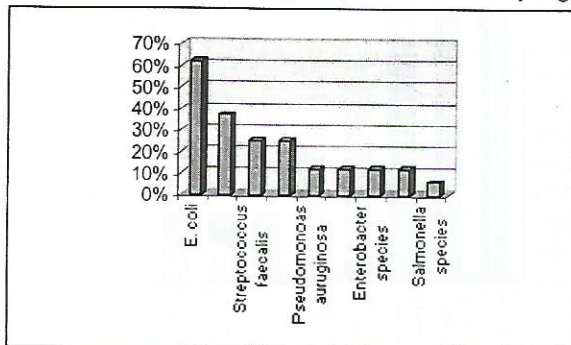
Spring water was contaminated with *Escherichia coli* (50%); and *Pseudomonas Auruginosa* (50%) (Fig 3).

Fig.3. Spring water



Collectively, the most common organism isolated was *Escherichia coli* (62.50%); followed by *Proteus vulgaris* (37.50%); *Streptococcus faecalis* (25%); *Citrobacter freundii* (25%); *Pseudomonas auruginosa* (12.50%); *Proteus mirabulus* (12.20%); *enterobacter species* (12.50%); *Morganella morganin* (12.50%); and *Salmonella Species* (6.25%); Fig 4.

Fig.4. Water in distribution system, river water and spring water



Discussion

Water is literally the source of life on earth. The human body is 70% water. People begin to feel thirsty after a loss of only 1% of body fluids and there may be death if fluid loss exceeds 10%. Human beings can survive for only a few days without fresh water.

The fresh water is emerging as one of the most critical natural resources issues facing humanity. 70% of the earth's surface is water but most of that is in oceans. By volume, only 3% of all water on earth is fresh water and most of this is largely unavailable. About 3/4 of all fresh water and most of this is largely unavailable. About 3/4 of all fresh water is in the form of ice caps and glaciers located in polar areas. Only about 1% is easily accessible surface fresh water. This is primarily the water found in lakes, rivers and the soil as under ground water. Only this amount is regularly renewed by rivers and snow fall. In all, only 100 thousand of 1% of world's total supply is considered easily accessible for human used. The earth hydrological cycle acts like a giant water pump that continually transfer fresh water from the oceans to land and back again. As the year 2000 approaches, the world's population is expanding rapidly yet there is no more fresh water now on earth than there was 2000 years ago when the population was less than 3% of its current size. Currently, 31 countries, mostly in Africa and the near East, face water stress and water scarcity. By the year 2025, 48 countries with more than 2.8 billions population, will be affected by water stress or scarcity. Another 9 countries, including China and Pakistan will be approaching water stress. Since 1940 annual global water withdrawals have increased by an average of 2.5% to 3% a year compared with annual population growth of 1.5 to 2%. In developing countries, over the past decade, water withdrawals have been increased by 4% to 8% a year. Yet in a growing number of places, people are withdrawing water from rivers, lakes, and under ground sources faster than they can be recharged.

Beyond the impact of population growth itself, the demand for fresh water has been rising in response to industrial development, increased reliance on irrigated agriculture, massive urbanization and rising living standard. Moreover the supply of fresh water available to humanity is shrinking because many fresh water resources have become increasingly polluted. In some countries, lakes and rivers have become receptacles for wastes including untreated or partially treated municipal sewage, toxic industrial effluents and harmful chemicals coming to the surface and ground water from agricultural activities.

It is difficult to estimate the amount of water needed to maintain acceptable or minimum living standards. According to Peter Gleick, President of the Pacific Institute for studies in Development, Environment and security; a range of 20 to 40 liters of fresh water per person per day is generally considered to be a necessary minimum to meet needs for drinking and sanitation alone. If water for bathing and cooking is included as well, this figure varies from 27 to 200 liters per day. Caught between finite and increasing polluted water supplies on one hand and rapidly rising demand from population growth and development on the other, many developing countries face uneasy choices. The lack of fresh water is like to be one of

the major factors limiting economic development in decades to come, warns the World Bank.

The people of both developed and developing countries are facing increasing problems for the procurement of good quality water due to release of domestic and industrial wastes into the environment⁹. Pakistan is also a developing country and is facing the same problems. In the north of Pakistan there are spectacular mountains like K2, Nangaparbat, Haramosh and Rakaposhi which are a great attraction for the tourists. Although the local population of the Northern Areas is very small but the civilian as well as military influx into this areas has increased now a days due to a number of factors. Due to this increased influx of tourists, scientists, trekkers and military personnel, large number of peoples have to stay there for a long time and at the same time they require soft and pure water for daily use. At the moment, apparently, the water being supplied to the peoples living in this area is neither according to the realistic standards as laid down by WHO²⁵ nor it is chlorinated as enquired by the local peoples. Hence pure water supply to the peoples of this area is scarce. In Pakistan, water microbiology is a neglected subject because generally relatively very small data is available and particularly in Northern Areas no previous work has been done so far regarding this public health problem. The main purpose of the present study was to assess the bacteriological status of the drinking water being used by the peoples of the Northern Areas and to make some positive suggestions for the safe water supply to provide better life for the local population and also the tourists.

In our study, a total of 32 water samples from different areas starting from Thakote to Khunjab Pass in Northern Areas were studied. Out of the 32 samples, 18 samples were from water in distribution system, 10 from river water and 4 from springs. Chlorination of water is an important factor because it may affect the results. It has found 48% reduction in childhood diarrhoea when chlorination was provided and it was found that 10.58% and 1.17% water samples were positive for total coliforms and faecal coliforms respectively in chlorinated water while 81.29% and 41.49% water samples were positive for total coliforms and faecal coliforms respectively in unchlorinated water samples. In our study when chlorination status was enquired from the local peoples it was found that none of the 32 water samples were chlorinated.

Various studies have been undertaken in different areas of Pakistan regarding the bacteriological quality of drinking water. In Karachi, Baqai and Zuberi^{3a} have reported that 36.43% water samples taken from different areas of the city were contaminated with bacteria and were unfit for drinking. Similarly in a study by Pakistan Medical Research Council, Karachi³, it was reported that about 86% water samples taken from taps were contaminated with bacteria. In a study by Sheikh et al²², it

was found that 53.33% ground water samples in Karachi were contaminated with bacteria. In Lahore, Waheed and Kausar²³ have carried out a study on various sources of water taken from urban and rural areas of Lahore for total and viable bacteria and found that more than 50% water samples were contaminated with bacteria and were unfit for drinking. In Rawalpindi and Islamabad, number of studies have been carried out Sami and Rehman²⁰ have reported that 52.37% of treated water samples were positive for coliforms. Similarly in a study Sami et al²¹ has reported that 35% treated water samples were unfit for drinking. Karamat et al¹³ have reported 56.2% positively in treated water. In NWFP, Akhtar et al¹ collected water samples from Mardan, Peshawar and Swat Valley and reported that all the samples were highly contaminated with bacteria.

In Swat, Zai and Akhtar²⁸ have reported that all water samples taken from different sources e.g. river, streams and taps were contaminated with faecal organisms. In Abbotabad, Khaliq et al¹⁴ have carried out a study in which they have reported that 57.2% water samples taken from springs, streams and wells were contaminated with E.Coli and were unfit for drinking.

Various researchers have also studied the bacteriological status of drinking water in other countries. Allen and Deldreich² have reported that ground water is usually free from enteric pathogens and so this water is usually of good bacteriological quality²⁴ because percolation of water through the soil results in removal of microbial pollution¹⁰. In India, Remteke et al¹⁹ have reported that 68.9% ground water samples were positive for faecal contamination. In Indonesia, Kromoredjo and Fujioka¹⁵ have reported that 45.7% water samples were unfit for drinking. In our study we have found that all the samples taken from water in distribution system, river and spring were contaminated with bacteria and are unfit for drinking.

Khaliq et al¹⁴ has found that E. coli (57.2%) was the most common organism found in contaminated water which was followed by Klebsiella species (14.3%), Proteus species (1.4%) Pseudomonas species (01%), and Micrococci (1.4%). Baqai and Zuberi^{3a} in Karachi have also found E coli as the most common isolated organism which was followed by Klebsiella species, Enterobacter, Pseudomonas and Streptococcus faecalis. Karamat et al¹³ in Rawalpindi and Islamabad, have also found E coli as the most common isolated organism which was followed by Klebsiella, Pseudomonas, and Acinetobacter. Similarly, in our study, the most common organism isolated from different water samples was also E coli (62.50%) which was followed by Proteus vulgaris (37.50%); Streptococcus faecalis (25%); Citrobacter freundii (25%); Pseudomonas auruginosa (12.50%); Proteus mirabilis (12.50%); and Salmonella species (6.25%) as shown in fig.4. The results of this study has revealed that E coli was isolated in higher number of samples from river water (100%) as compared to

water in distribution system (44.44%) and spring water (50%). This sharp difference is not seen in case of other bacteria (Fig.4).

This study revealed that according to WHO²⁵ standard, all the water samples taken from different sites is unfit for drinking. To control bacteriological quality of drinking water, there should be some realistic standards as laid down by WHO²⁵ which are neglected in developing and under developing countries. Cartwright et al⁵ have found that the bacteriological test is the most sensitive test to detect the recent and potential faecal pollution than chemical analysis²⁶. Contamination of water may be intermittent which may not be detected by the examination of a single sample so water should be examined regularly and frequently^{7,5}. It is therefore important to examine the drinking water regularly and frequently by a simple test rather than infrequently by a more complicated test. To cope with this problem, International Development Research Centre, Ottawa Canada started a new method of H₂S strip test, to control the bacteriological quality of drinking water⁶ which was introduced by Manja et al¹⁶ as the cheapest and simplest field test. Following Manja et al¹⁶, different researchers^{17,8,6} have used the same test to assess the bacteriological quality of drinking water and all of them found this test less sensitive to other conventional methods. So the H₂S strip test is the cheapest, simplest and reliable method for testing any sort of drinking water supply.

Conclusion

From this study it was concluded that:

1. Bacterial contamination of drinking water is a significant problem in Northern Areas of Pakistan which should be improved by regular chlorination of drinking water and also by monitoring of water supplies for bacterial contamination by H₂S strip test, regularly and frequently.
2. Entirely unhygienic and polluted water is being used by the peoples in Northern Areas of Pakistan.
3. To avoid water crises, particularly in water short countries with rapid growth, it is vital to slow population growth as soon as possible.

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