



Seasonal investigation of drinking water quality

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EIGHT THOUSAND CHILDREN around the world die from diarrhoea each day. That's one child every ten seconds, or three million every year who die from a preventable disease. According to WHO more than 80 per cent diseases in the world are attributed to un-safe drinking water or inadequate sanitation practices. (Microbiology Volume II, Monica). According to National statistics, 56 per cent of the total population of Pakistan enjoy safe drinking water and 24 per cent have sanitation. For the rural population the figures are 45 per cent and 10 per cent respectively. In theory, this might be the case. However, when factors such as accessibility, reliability, water quality and effective use of water and sanitation facilities are taken into account, the situation looks less promising. For example in northern Pakistan out of 502 existing water supply schemes only 86 can possibly be described as satisfactory (WSHHSP Issue paper 8). The number will be further reduced if continuity and quality of the water supply is taken into account.

Glaciers and snow deposits are the principal source of all water in the northern Pakistan. The melted water enters streams called nallahs, which subsequently feed man-made channels that bring water into the settlements for agriculture, live stock and domestic use. Almost every village in the Northern Areas and Chitral has a network of water channels. These channels are generally 2-4 feet wide and of similar depth. These channels are a symbol of the region's ancient history, indigenous art and collective efforts, since many of these were built centuries ago, cutting through rocks and difficult terrain.

Generally, a main channel carries water into a village, which subsequently divides into a network of smaller channels and streams covering the entire village. Traditionally, water for domestic usage is fetched from the channels flowing near the household. The villagers living at higher altitudes have freezing problems in winter. Under the mentioned conditions, people break the ice in the channels to carry water for re-filling the traditional water pits once a week or fortnight. Similarly, where available people rely on rivers or springs in these circumstances. A common practice in the area is of having water-pits, locally called as Gulko, Sardawai and Chudong. These pits are filled from the channels and are usually 2-3 meters deep and about 2 meters in diameter. Their benefits are multifold including, storing, cooling and reducing turbidity of water. Water from these pits is generally reserved for drinking and cooking purposes only.

Piped water system is becoming more common in the region. Since most of the settlements are established on

slopes, the systems operate by gravity. They are generally fed by manmade channels and consist of a storage reservoir and distribution network. Ground water is un-common in the area. Compared to the above sources river water is used by a small number of people for drinking purposes, and this practice itself is limited to the winter months only.

Objective of the study

The overall objective of the study was to make an assessment of the seasonal variation of drinking water quality of Northern Areas and Chitral. Specifically, the study aimed to:

- investigate the bacteriological and physical (turbidity) quality of drinking water in and at different points of the delivery systems from source to the point of consumption;
- investigate the bacteriological quality of water in household storage vessels; and
- study and define different drinking water sources and systems.

Methodology

The water sampling activity was initiated in June 1993. In total 105 villages in the project area were randomly selected for the study. Sampling in these villages was undertaken twice in 1994 i.e. in peak winter and summer seasons to judge the impact of seasonal variations on the water quality. All samples were collected at mid day to get the worst situation of water quality. Two seasonal categories were generated. The samples processed from October to February were categorized as winter samples, whereas those taken from May to September were considered as summer samples. For greater reliability and precision, all samples were processed in-situ. To do this, portable Del-Agua water testing kits were used. These employ membrane filtration techniques for bacteriological sampling. The samples from all selected points were taken in sterile sampling cups and were processed in duplicate. At the end of each cycle a control sample of sterile distilled water was processed to ensure the quality control of the process and consumables used. In summer season when processing highly turbid water or where high bacteriological contamination of the sample was suspected, different dilutions were made to obtain readable results. The turbidity of the sample was measured in Turbidity Units by using turbidity tubes provided with the water testing kit. These turbidity tubes are graduated with logarithmic scale that covered ranges from 5-2000 TUs. For pH phenol red tablets were used in

Table 1. Faecal coliform grading for unchlorinated rural water supplies

a colour matching comparator. The procedures recommended by the manual (Del.Agua) were adhered to.

When sampling water channels, three sampling locations were selected i.e. outside the inhabited area, in the middle of the channel and at the end point of the channel system in the village. The purpose of this selection strategy was to find out the trend of faecal contamination levels right from source to the end point of channel. Similarly for the piped system the sampling points included outside the habited area, the storage reservoir and a series of taps in distribution network.

Spring samples were generally taken at the spring outlet (also a collection point for domestic usage). Samples from the household containers were also taken. Before sampling, the water in storage container was mixed by sterile water sampling cup. The reason for doing this was to get a representative sample (uniform distribution of microbes) of the stored water. However a clear relationship of these samples with the specific source/s and the quality of water at the fetching time was not established, especially when the storage time varied from half an hour to about six hours in some cases.

Samples from the water pits were collected directly by using the sterile sampling cup by dipping it up to 1meter

depth. This exercise was repeated three to four time before collection of the final representative sample. For analysis the samples were graded into regimes A, B, C, D and E shown in Table 1. These gradings were recommended for the South Asian Regional Organization member states (WHO/SEARO,1996).

Results

It is alarming that none of the samples collected from traditional water channels, water pits, taps and storage vessels fell in A category.

- 93 per cent of the channel's summer samples were in high to very high health risk category (C,D,&E), whereas in winter 70 per cent samples fell in the same category. 30 per cent winter and 7 per cent summer samples were in low health risk category B. (See Table 2)
- Water pits samples were found grossly contaminated with 90 per cent winter and 97 per cent summer samples in category high to very high health risk (C,D,&E). Only 10 per cent winter and 3 per cent summer samples came under category B.
- The situation of tap water was slightly better with 51 per cent winter and 20 per cent summer samples in B category. The reaming samples were in the C, D, and E.

Table 2. Distribution of winter and summer samples in different grades of contamination (*E. coli*/100 mL)

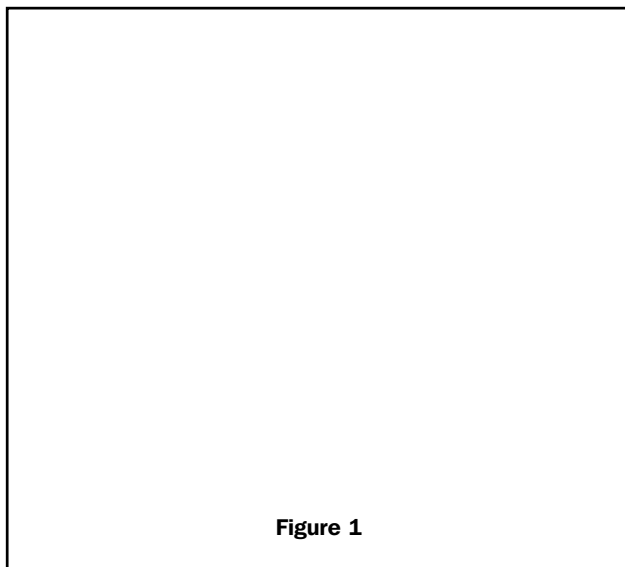


Figure 1

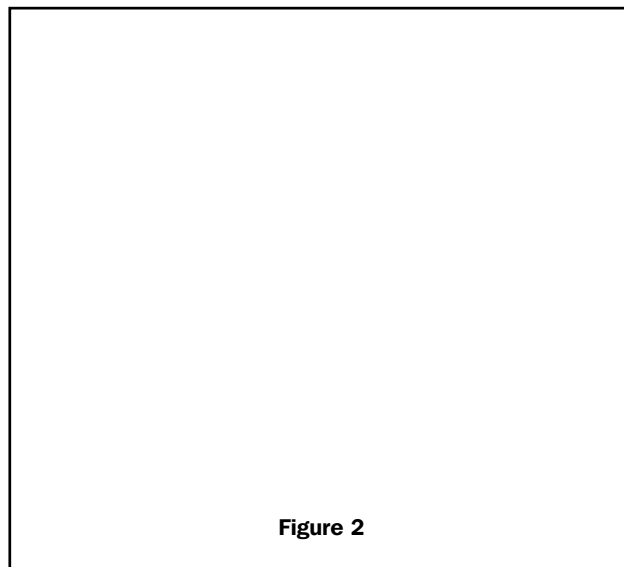


Figure 2

- As expected water quality analysis of springs showed low bacterial presence. 83 per cent winter and 63 per cent summer samples were in the Grade A category showing little or no health risk.
- Water quality analysis of storage vessels showed that 49 per cent winter and 80 per cent summer samples were in high to very high health risk category. Only 20 per cent summer and 51 per cent winter samples were in low health risk category.

Discussion

Results reveal that a considerable number of summer samples representing traditional and piped delivery systems exist in Grades which could be termed as “dangerous” for health. It is worth mentioning that the contamination levels observed in 23 per cent of water channel’s summer samples, 30 per cent of water pit’s summer samples as well as 25 per cent of storage container’s samples could be classified as “not fit for potable use” i.e. these samples were grossly contaminated i.e. Grade E.

Water samples collected from the traditional water channels show 5 to 10 times higher contamination levels compared to the source. Figure-1. The gradual increase in the contamination levels right from source to the end point of the channels is attributed to human and animal activities around the channels (actually observed during sampling). The absence of an appropriate drainage system for the agricultural fields and domestic run-off exacerbates the existing water quality situation of these channels. It is worth mentioning that in most of the villages the cattle sheds are situated near or above the water channels, which increases the likelihood of faecal contamination. During the process faecal droppings were seen near drinking water channels.

In summer the usage of water normally increases compared to the winter season and as such spread of diseases is higher in summer compared to winter. High incidence of diarrhoeal diseases in June, July and August has been reported by Aga Khan Health Service, Gilgit. Furthermore

the weekly water quality study confirmed that June, July and August are also the peak faecal contamination periods. This indicates possible linkage between drinking water and diarrhoeal diseases. (WSHHSP, Weekly water quality report 1996).

Improved water supply systems were found to be less contaminated compared to the traditional water channels, but the levels are significantly higher than the recommended WHO guidelines for drinking water. The reason for this increase is that majority of the water supply systems are being fed by the traditional water channels. The catchment area is not protected due to which the quality of source water deteriorates due to faecal ingress. In some cases water quality deteriorates in the distribution system itself, which indicates that ingress of faecal material has occurred. 7 to 9 times higher contamination levels were observed at mid and end points of the distribution compared to the inlet water (Figure 2).

The water pits was found to be highly contaminated with faecal coliforms (Although in practice water pits are filled early in the morning when the water quality is thought to be clean.). The reason for this high contamination is the poor superstructure and water handling practices. It was observed that poor water handling practices are the most important contributing factors for deterioration of water quality in pits. The space which is used for water collecting is highly contaminated, and during extraction water splashes from the containers and re-enters into the water pits with contaminants. Inappropriate location of water pits is another reason for higher contamination. It was observed that almost all water pits were situated near the cattle-sheds or paved pathways. Possibly in the rainy season the surface run-off enters the pits bringing with it surrounding pollutants. The potential role of these traditional water pits in causing diseases have been confirmed in 1996, when >30 water pits were found to be polluted with *Cryptosporidium* (WSHHSP: Issue Paper 15).

Water in storage containers was found to be less contami-

nated in winter, however contamination levels are higher as compared to the water collecting points. One possible reason for seasonal variation is that in summer water is collected from the traditional water channels which already have higher contamination levels. Whereas in winter most of the water channels get frozen due to extreme cold, and people have to collect water from different sources which possibly have low contamination levels. Also in winter storage time is lengthier, which produces an in-situ form of treatment thus reducing levels. Finally volumetric usage in winter is less and thus chances of contact and or contamination by water handling practices is reduced to some extent. Storage vessels which were kept with lids and were apparently clean had lower contamination levels than dirty and uncovered containers (as would be expected of course!).

Spring water was generally found to be safer compared to the other existing water sources, as majority of the summer and winter samples were Grade A category. The unprotected springs were found contaminated due to human and animal activities in the surroundings.

Though results indicate a seasonal contamination trend a few issues needed further examination namely; i) in which month of the year is contamination levels highest and how and why do levels increase and decrease? ii) Do contamination levels vary during the day and if so what is the pattern and the reason? To investigate these key unknowns an intensive weekly water sampling activity was conducted from January to December 1995. Results of two villages have been shown in (Figure 2). As can be seen contamination progressively increased in the channels.

The study patently highlighted the problems of water quality in villages. Even where water supply from source is relatively pure, at the point where water is drunk (ingested) the likelihood of contamination is high. It is therefore imperative that a programme of water and sanitation should encompass not only the supply component i.e. hardware, but should take into account the Knowledge, Attitude and Practices (KAP, software) and relevant intervention in this area as required. KAP issues have to be focused on with particular emphasis on women and children for likely interventions. Furthermore, regular monitoring to ascertain the causal relationship between turbidity, faecal contamination and disease need to be examined so that likely preventable strategies could be in place particularly for months where peak contamination occurs. WASEP, under its new integrated programme of water and sanitation is likely to focus on not only the technical issues but also on the software issues plus operational issues (which have not been discussed in this paper) as well.

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