PEOPLE-CENTRED APPROACHES TO WATER AND ENVIRONMENTAL SANITATION

Water quality monitoring of improved water delivery systems in Northern Pakistan

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The Water And Sanitation Extension program (WASEP) of Aga Khan Planning and Building Service Pakistan has been implementing water supply projects to improve the traditional water delivery systems for drinking purposes since 1998 aiming to reduce water borne diseases. In this connection 105 water supply systems have been implemented in rural communities of its program area with the financial assistance of KfW of Germany. Improved delivery systems were monitored for bacteriological quality through a series of sampling frequency from 1998 to 2002. The water quality monitoring program was developed locally consisting two phases, pre and post intervention. During pre intervention the Bacteriological contamination level was found to be very high in existing delivery systems with an average of 16% samples matching WHO Guidelines for developing countries (0-10 E.coli/100 ml). However during post intervention the bacteriological quality of water at system level significantly improved with 86% of samples matching WHO Guidelines for developing countries. Improvements in water, sanitation and hygiene behavior contributed to diarrhoeal reduction by more than 60%.

Keywords: delivery systems, rural communities, water quality, water borne diseases, hygiene, and diarrhoea.

Introduction

When considering how to improve water supply it is necessary to consider the quantity, access and quality of the water. According to WHO (Esrey 1999) 80% of all sicknesses and diseases in the world are caused by inadequate sanitation and polluted water. Children below 5 are most affected. Under-five mortality rate is 109 per 1000 live births due to diarrhoeal diseases in Pakistan (WASH, 2004). About 3 million children in the world die every year from diseases associated with lack of access to safe drinking water, inadequate sanitation and poor hygiene (WHO). Safe drinking coverage of rural areas in Northern Area of Pakistan is 34% (UNICEF 2002), and 38% of total population still lack safe sanitation in Pakistan. "As many as 76 million people mainly children will die from preventative water related diseases by 2020 even if current United Nations goals are reached', (Peter H. Gleick, President of the Pacific Institute, 2002).

Illness caused by chemical contamination of the drinking water supply system is negligible compared to the number caused by microbial pathogens (Galbraith et al. 1987, Harwarldt, 1992). However WASEP decided to look at water sources to ensure that they were safe from chemical contamination screening out of some selected heavy metals.

Membrane filtration technique was used as standard technique for detection of feacal coliform organisms in water samples using DelAgua field water testing kit. The presence of pathogenic organisms is a concern when considering the safety of drinking water. A useful way, therefore to determine whether a water supply is feacally polluted and could possibly contain enteric pathogens dangerous to health, is to test for the presence of feacal organisms. This is because sewerage from animal and human sources may contain the causative organisms of many communicable diseases such as typhoid fever, bacterial or microbial dysentery, giardiasis, infective hepatitis and poliomyelitis helminthiasis. Therefore water borne diseases are the major risks concerned with water quality.

Developing countries and rural communities are particularly vulnerable. Only by continual and costly attention to water quality control has it been possible to almost eradicate water borne diseases from developed countries with consequent reduction in mortality.

Coliform bacteria may not cause disease, but can be indicators of pathogenic organisms that cause diseases (Homes and Nicolls, 1195). They could cause intestinal infection, dysentery and other illnesses. This paper describes the strategies applied in monitoring the program and achieving comprehensive results and highlights the state of bacterial quality of drinking water in Northern Pakistan, before and after WASEP interventions.

The Northern Areas and Chitral is a mountainous region consisting of over 1200 villages. Traditionally each village has a separate dispensation in terms of water sources, and village geography. The majority of theses villages still does not have access to safe water and adequate sanitation facilities and therefore rely heavily on the traditional sources of water, including nullahs (water streams), springs, rivers, man-made channels and water courses running from distant sources.

Photograph:
An example of traditional way of fetching water for drinking and cooking purposes

Water is either collected directly from these sources or conveyed to individual or communal traditional water pits for storage and subsequent use. These traditional sources are grossly contaminated as in respect of bacteriological quality of water. Generally the piped water was also found to be highly contaminated in the area ranging 48 – 372 E. coli/ 100ml in winter and 191-417 E. coli/ 100ml in summer. In summer the channel water was significantly more contaminated with the levels as high as 462 – 3025 E. coli/ 100ml (H.Raza et al).

According to WHO for drinking water to be safe a 100 ml sample of water should not contain any coliform bacteria (Pillai et al., 1999). According to research findings of the Water Sanitation Health and Hygiene Studies Project (WSHHSP 1993 – 1997), through seasonal water quality monitoring monthly and intensive monitoring in randomly selected and representative sample villages in Northern Pakistan, the microbiological quality of drinking water was found to be highly polluted within the range of 1500 – 5000 E.coli per 100 ml in traditional delivery systems, 50 – 500 E. coli per 100 ml in existing pipe water (Intensive and Seasonal water quality sampling by WSHHSP,1993 – 1997).

Based on these findings, the Water and Sanitation Extension Program (WASEP) of the Aga Khan Planning and Building Service, Pakistan has been implementing water supply projects to improve the traditional water delivery systems for drinking purposes since 1998 aiming to reduce water borne diseases. 105 water supply systems have already been implemented in rural communities in its program area with the financial assistance of KfW of Germany. Most tap water is provided through gravity flow water supply systems. WASEP has developed a reputation in its program area for being a specialist in providing water treatment technologies for high turbid water. The engineering and environmental team has done extensive research on appropriate treatment methods. WASEP has chosen to use sedimentation, up flow roughing filtration and slow sand filtration systems to reduce turbidity levels and microbial contamination. As a result

of latrine promotion 80% of households build improved latrines. The bacteriological quality of water at system level significantly improved with 85% of samples matched with WHO guidelines for developing countries. Improvements in water, sanitation   and hygiene behavior contributed to over 60% diarrhoea reduction.

Improved delivery systems were monitored for bacteriological quality through a series of sampling frequencies from 1998 to 2002 in Northern Pakistan. Experience from both developing and developed countries has shown that surveillance of community managed supplies can be effective when well designed and the objectives are geared more towards a supportive role to enhance community management and in evaluating overall water supply strategies, rather than enforcement of compliance. In the case of evaluating strategies, the principal aim should be to monitor the water quality over all seasons for improving water safety for all community managed supplies, rather than monitoring performance for individual supplies. A water quality monitoring program was developed locally consisting two phases, pre and post intervention. During pre intervention the bacteriological contamination level was found to be very high in existing delivery systems with an average of only 16% samples matching WHO guidelines for developing countries (0-10 E.coli/100 ml). Whereas during post intervention the bacteriological quality of water at system level significantly improved with 86% of samples matching WHO guidelines for developing countries which indicates satisfactory achievement the target set in the logical frame analysis (LFA) developed by WASEP, which is that 75% of the total tap stands will meet the WHO guidelines i.e. 0 – 10 E. coli/ 100ml for developing countries.

Objective
The main objectives of water quality monitoring were the following:

• To identify safer sources for water supply systems.
• To create awareness among the communities involved in the implementation of the intervention.
• To take remedial actions if any health risks were found.

Test parameters and methodology
The test parameter selected as indicator for feacal contamination is the feacal Coliform, Escherichia coli (E. coli) which is detected by using the portable Del-Aguaâ water kit with standard Membrane Filtration technique. Pre and Post bacteriological water quality monitoring is one of the major activity of the WASEP.

Sampling area and collection of water samples

The water sampling was carried out in three different regions of the program area, Gilgit, Baltistan and Chital. 3 male microbiologists and 16 female Health and Hygiene Promoters

(who give health hygiene education to the communities and visit door to door to collect health data) were involved in doing the sampling and processing of water testing under supervision of the Program Coordinator Water Quality. The water quality monitoring program was carried out in 100 project villages out of 105. Water testing was done on site to make sure of reliable results, using 7 Del-Agua field water testing kits. Water samples were collected from representative sampling points. For example during pre intervention, samples were collected from collection points of existing delivery systems at the beginning of villages, mid and end of villages or from each representative points of scattered pocket villages. During post intervention samples were collected from representative points of improved delivery systems of WASEP intervention covering source, reservoir, treatment plants and distribution networks.

For collection of water samples from a water pit, river or channel, and from taps, sterilized sampling cups were used with the help of the steel rope provided with Del Agua kit. In the case of the pipe system, before taking water samples, the external fittings of the tap were removed and the nozzle of the tap was cleaned with a flame after which water was allowed to run for 3 to 5 minutes.

Through onsite observations, brief information regarding sanitary situation of the sampling site was noted before setting the sample volume and processing.

Method for counting colonies

The membrane filtration method was used to detect E.coli as an indicator for feacal coliform with the help of DelAgua water testing kit, which gives direct count of colonies present in the given sample of water with the help of required media, temperature and incubation time. The membrane filtration apparatus, including a base supporting a porous disc and a filter funnel having capacity of 100 ml, was used. Sterile filtration apparatus was connected to a vacuum source. The funnel was removed and a sterile membrane filter (dia. 47mm, pore size 0.45μm), grid side upwards was placed on the porous disc of the filter base. A vacuum was created in the flask to filter the required volume of water. After filtration the membrane was transferred carefully to the absorbent pad saturated with the medium, and incubated at 44°C. The colonies with the characteristic yellow color were counted on the membrane in good light. Enumerating the colonies of different sizes of samples the following equation was used to present the result per 100ml sample,

$$\text{Fecal coliform/100 ml} = \frac{\text{No. of colonies counted} \times 100}{\text{Volume of sample filtered}}$$

Media

Membrane lauryl sulfate broth, prepared by peptone yeast extract, lactose, phenol red and sodium lauryl sulphate dissolving in distilled water with pH 7.4 to 7.5 and autoclaved, was used as selective medium to isolate E. coli (Escherichia coli) as an indicator of fecal Coliform.

Comparative results of pre and post intervention

Water quality monitoring activities were carried out in two phases i.e. pre intervention water quality baseline survey and post intervention water quality monitoring on system level and household level. During pre intervention samples were tested from existing delivery systems as well as from household storage containers, while during post intervention samples were tested from source, reservoirs, treatment plants and distribution points as well as from household storage containers also.

System level

A total 354 water samples were tested during pre intervention from existing delivery systems out of which only 16% samples found matching WHO guidelines (0-10E. coli/100 mL). Whereas during post intervention 2620 water samples were tested from improved water supply systems, the results show a significant improvement with 86% samples matching WHO guidelines. (see table: 1)

Table 1. Consolidated microbiological result of pre and post Intervention of system level						
		Categories of contamination level (E.coli/100 ml)/% samples				
Phase	#. Samples	0-10	11-100	101-1000	>1000	WHO standard* matched
Pre Intervention	354	16	31	35	18	16%
Post Intervention	2620	85	12	3	0	85%

Results of post intervention show that a considerable variation in contamination occurred in project villages with nulla (watercourse) and spring sources. Nulla water is mainly glacial water, which becomes contaminated by animals and humans, thus it may vary with each sample depending on human or animal activities. Therefore, the contamination of such sources sometimes exceeds the recommended guidelines and is sometimes below recommended guidelines. According to the data of water quality monitoring, 76 projects with spring sources out of 100 were found to be 100% free of bacteria. However only two project villages with spring sources Ashrait and Balim in Chitral were found to be contaminated with feacal colifom. This was because of seepage of surface water from the surroundings of these spring sources. Remedial action was taken to improve of these sources. In the remaining 25 project villages the quality of water found was found to exceed WHO recommended guidelines where almost sources are nualla (stream) water. Taking remedial action in Hasis, a project village of 1998, the nulla source has been replaced by a spring source with extension of feeding pipe line to the supply system which resulted in the reduc-

tion of microbiological contamination to zero. For remaining projects further remedial actions could not taken due to lack of funds and an end of the program phase.

Water and Environmental Sanitation (WES), UNICEF Pakistan provided for and introduced the use of the H2S paper strip test for detection of fecal contamination of drinking water in Northern Pakistan. Water and Sanitation Operators found these easy to use to monitor water supply systems.

Household Level

During pre-intervention a total 1462 samples were tested from household storage containers. The over all result of post intervention shows a significant improvement, namely out of 728 samples, 63% samples result matched with WHO guidelines (see table: 2)

Table 2. Consolidated microbiological result of pre and post intervention of household level						
		Categories of contamination level (E.coli/100 ml)/% samples				
Phase	#. Samples	0-10	11-100	101-1000	>1000	WHO standard matched
Pre Intervention	1462	16	28	37	18	16%
Post Intervention	728	63	21	16	1	63%

It is necessary to mention here that 80% of villages were covered for household level sampling during the baseline survey pre intervention whereas only 40% villages were covered during post intervention water quality monitoring. 60% of villages did not store water in containers as they have quick access to tap in yards or kitchens. According to the comments made by the community women, because they have become aware of germs, they think that stored water might be contaminated therefore they preferred to fetch water directly from taps instead of storing it in containers. This indicates behavioral changes in water handling practices by awareness rising through hygiene education.

Conclusion and recommendations

It can be concluded through the findings of water quality monitoring and health impact study, that water borne diseases can be reduced through providing safe drinking water, appropriate sanitation and the changing of behavior through health and hygiene education. The risk of water pollution can be removed through providing safe drinking water. For community managed water supply systems, to ensure water safety, regular monitoring should be carried out through random visits by system operators using simple techniques like the H2S paper strip test (a product of Water Health Laboratories, Rorki India for bacteriological test). A proper surveillance system at regional level should be developed to make it sustainable and useful by taking remedial actions on the basis of sanitary observation and water quality reports. To ensure improvements where needed on the basis of water quality monitoring and sanitary observation, a special budget should be established by the responsible authorities. To ensure providing safe water through the existing piped systems in the area, water quality monitoring should be carried out to make it possible to take remedial action for improvement on the basis of sanitary and microbiological results.

A leading research study (Evaluation of a water, sanitation, health and hygiene education intervention on diarrhoea in northern Pakistan) published in the WHO March 2003 bulletin, concludes that the integrated approach taken by appropriate health and hygiene education and water quality monitoring is a useful example of how desired health benefits can be obtained.

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