Assessment of safety of drinking water in tank district: an empirical study of water-borne diseases in rural Khyber Pakhtunkhwa, Pakistan

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ABSTRACT

Access to safe drinking water is one of the basic human rights and essential for healthy life. The present study investigates the availability of safe drinking water and the effects of water-borne diseases on the health of the people of Tank District of Khyber Pakhtunkhwa Province, Pakistan. Data were collected from the field survey and secondary sources. Households meetings, focused group discussions and interviews with doctors were recorded in the field. Meanwhile, water samples were also collected from different sources to examine the prevalence of water-borne diseases in the study area. It was found that the use of unsafe drinking water and lack of basic sanitation were the main causes of diseases like hepatitis, cholera, typhoid, dysentery and diarrhea in the study area. However, the results also confirmed the presence of Giardia, Crypto, T. Gondi, Fasciola, B. Coli and Entamoeba in the water samples. The study concluded that due to acute shortage of water, people were oppressed to use unsafe drinking water. In order to reduce the health risk, it is necessary to immediately stop the use of unsafe drinking water from contaminated sources and government should supply treated/clean water with supply lines far away from solid waste and sewage sites. Moreover, health education and awareness can motivate people to improve and maintain their health, prevent disease and reduce risky behaviors.

Keywords: Factorial design, pollutants, stations, pH, B.O.D, dissolved oxygen.

1. Introduction

Safe drinking water and hygienic sanitation are prerequisites for health. Unfortunately, there are about 884 million people in the world who do not get their drinking water from improved sources, and about 2.6 billion people are living without adequate sanitation (WHO and UNICEF, 2010). Globally, the levels of availability and accessibility of safe drinking water are measured by standard indicators that depend on the presence of proper sanitary sources. These improved drinking water sources include household connection, public standpipe, borehole condition, protected dug well, protected spring, and rain water collection. Sources that may represent potentially contaminated drinking water include unprotected wells, unprotected springs, rivers or ponds, vendor-provided water and tanker truck water (WHO and UNICEF, 2004). Researchers and health experts usually explain that insufficient supply of clean and safe drinking water is the main cause of diseases in developing countries. In 1997, the United Nations Commission on Sustainable Development (CSD) concluded that about 2.3 billion people in developing countries suffered from diseases...
rooted in insufficient water provision and poor quality (CDS, 2015). The United Nations (UN) has estimated that approximately 1.8 million people in developing countries die each year as a result of cholera and other diarrheal diseases. Among of these people, 90 percent are children below the age of five years, and about 88 percent of diarrheal diseases are caused by consumption of high-risk water delivery, poor sanitation and lack of cleanliness (UN-Water, 2008).

Water-borne diseases in both epidemic and endemic forms continue to occur in both developed and developing countries. The main causes of water-borne diseases are pathogens transmitted by the fecal–oral route and by consumption of contaminated drinking water. Water-borne transmission also includes diseases transmitted by fecal droplet inhalation (e.g., some adenoviruses) and exposure through contact (e.g., recreational and occupational). It is important to place into context the magnitude and extent of the zoonotic component of water-borne disease. Consumption of water sources contaminated with human and animal excreta containing pathogenic organisms pose risks of water-borne and water-related diseases (URT, 2002). Water-borne zoonotic pathogens cause both gastrointestinal diseases such as diarrhea and other illnesses such as leptospirosis and hepatitis. Several water-borne zoonoses, such as cryptosporidiosis and giardiasis, occur regularly in a variety of countries; others, such as leptospirosis, occur more frequently in tropical countries.

In Pakistan, only 66 percent of the population is considered to have access to safe drinking water with huge disparities between urban and rural areas and among provinces/regions. Safe drinking water in rural areas is a precious commodity. Inadequate quantity and quality of the supply of drinking water results in a high incidence of water related diseases, which in turn, increase morbidity and mortality rates and pose a major threat to the survival and development of children (PES, 2010-11). International monitoring organizations define “access” to safe drinking water as the availability of at least 20 liters per person per day from an “improved” source within 1 kilometer of the user’s dwelling (Josephine, 2009), but such sources are rarely available in some areas. According to the Global Water Supply and Sanitation Assessment report (2000) by WHO and UNICEF, in Pakistan, around 30 percent of illnesses and 40 percent of deaths are attributed to inadequate water quality. Water quality in areas of poor sanitation and poor hygiene is related to the density of population – where, population is dense under such circumstances there is likely to be more contamination of water sources (WHO and UNICEF, 2000). It has been estimated that on yearly basis, more than 3 million people in Pakistan suffer from cholera and other diarrheal diseases caused by poor water quality and about 20 - 40 percent of hospital beds in Pakistan are occupied by patients suffering from water-borne diseases.

According to the Federal Bureau of Statistics (2010-11), in Khyber Pakhtunkhwa province, lack of access to safe water and poor sanitation are key contributors to under-nutrition. Both lead to a chronic cycle of illness and under-nutrition, and infants and young children are particularly susceptible. The province has marginally lower levels of safe water usage by household (70%) as compared to the national level (87%). Use of hygienic sanitation facilities is also slightly lower (62%) than the national level (66%). In January 2010, a survey by Khyber Pakhtunkhwa Provincial Reforms Program show that the water source situation in southern Khyber Pakhtunkhwa is inadequate because the land water aquifers are either quite deep (more than 500 ft) or the existing water is salty and hence unhealthy for drinking. As a consequence there is an elevated dependence on high-risk sources including ponds, insecure springs and/or local streams which are open to contamination. In another study, Khan et al., (2012) reviewed the physiochemical composition of the drinking water sources from district
Kohat of Khyber Pakhtunkhwa. Among 54 water samples from various sources, wells and tanks were highly contaminated with pollution while tube-wells were found to be suitable sources for drinking water and household consumption. Ayaz et al., (2011) also sampled water from different sources in three districts of Khyber Pakhtunkhwa province and found that in all the sources, water was contaminated with eggs, cysts or oocysts of the parasite. The Pakistan Safe Drinking Water and Hygiene Promotion Project report (2010) suggests that creating awareness about the importance of safe water and hygiene is an effective mechanism for engaging communities in safeguarding water infrastructure. The water quality testing in communities can prove an important educational tool to raise awareness about the need to treat water, since overall most Pakistani people believe that water that is clear and does not smell is good to drink. Moreover, engaging local NGOs as project implementation partners can prove to be a successful strategy for the government. The acquired knowledge and experience allow NGOs to be involved in similar government or donor-funded projects and capacity building for water, sanitation, and hygiene programs as these organizations have been the best advocates for creating awareness and behavior change for water, sanitation, and hygiene.

1.1 Purpose of the study

Tank is one of the less developed southern districts in Khyber Pakhtunkhwa province of Pakistan. Though there are number of social, political and economic challenges, the provision of clean drinking water has also constantly been one of the main troubles in the district. There has an acute shortage of drinking water problems as the water table is very low. Usually the water used for drinking is obtained from an open stream coming from Tank Zam and is stored near the city and later distributed to the people by different ways i.e. communal pipelines and provision of water tanker facility and people have to pay the fare by themselves in order to access safe drinking water. The situation of water delivery as well as of clean drinking water is worst in summer season because heat reaches to extreme high degrees and the rainfall is very low in the district. Tank is an arid area with certain features that restrict and limit healthy life practices as lack of freshwater, an abundance of heat and sunlight, extreme winters, short rainy season, saline soil or water, strong dry winds, poor soil structure, over-grazing and limited technological development. The monsoon rains averaging around 4.5 inches in July and August and almost nothing in June or September. People usually make their main livelihood by land ownership and farming by obtaining water from tube-wells, wells (manual), hand pumps, community tanks and rain water (Government of Khyber Pakhtunkhwa, 2015).

The purpose of this study was to estimate and analyze the importance of knowledge, awareness, practices and desire for safe drinking water. It is necessary to check quality of drinking water sources at regular intervals, because contamination of these sources can cause the population to suffer from various water-borne diseases (Basavaraja, et al., 2011). It is essential to improve the knowledge, attitude and hygiene practices of the community regarding safe sources and consumption of drinking water and their readiness to pay for clean drinking water. The findings of this study would be helpful for researchers, policy makers, and governmental and non-governmental organization who want to help improve the health of the community. Moreover, the findings are expected to create awareness and improve attitudes and practices regarding clean drinking water among the people in the district. For this purpose, the present study aims to explore the effect of water-borne diseases on the health of people with the following objectives:

1. To examine the sources of drinking water in the study area,
2. To quantify and investigate water-borne diseases in the study area,
3. To find out prevalence of zoonotic parasites in drinking water from different sources in the study area,
4. To suggest recommendations on the basis of study findings.

Figure 1: Map showing Tank District of Khyber Pakhtunkhwa Province

2. Methodology

2.1 Study area and sample size

According to the statistics of Government of Khyber Pakhtunkhwa province, the estimated population of Tank district is about 319,248, however, the district is divided into 17 union councils. The study under consideration deals with rural localities, therefore, 6 union councils were selected purposively because the villages in these union councils are suffering from a severe water scarcity caused by fast population enlargement that has caused land water levels to fall rapidly. Among the 107 total villages of the selected union councils, the study targeted only 600 households from 24 villages because majority of the residents have lower standard of life and poor housing conditions. By using random sampling technique, households were proportionally divided in all the villages. The following Table-1 provides information of selected unions councils and households from Tank district:

<table>
<thead>
<tr>
<th>No.</th>
<th>Union Council</th>
<th>Total Villages</th>
<th>Total Population</th>
<th>Selected Villages</th>
<th>Selected Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Amma Kheil</td>
<td>24</td>
<td>20568</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>2.</td>
<td>Ghara Baloch</td>
<td>17</td>
<td>16542</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>3.</td>
<td>Gul Imam</td>
<td>17</td>
<td>24724</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>4.</td>
<td>Jatatar</td>
<td>9</td>
<td>24037</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>5.</td>
<td>Pai</td>
<td>14</td>
<td>22791</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>6.</td>
<td>Ranwal</td>
<td>26</td>
<td>21089</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>107</td>
<td>129751</td>
<td>24</td>
<td>600</td>
</tr>
</tbody>
</table>

2.2 Key informants

According to the Intervention Report of Tank District by UNICEF (2012), the quality of ground water is regularly being reported contaminated in many areas of the district and highly threaten to the health of the local inhabitants. In order to understand further the health situation in Tank district, the study targeted a total of 10 doctors in the existing government hospitals, basic health units and civil dispensaries. The main purpose of the interviews with doctors was to identify the patients on the basis of water-borne diseases from the selected research area.

2.3 Collection of water samples

In order to assess the ground and surface water quality and its related diseases, a total of 450 water samples were collected from tube-wells, ponds and drain water in clean and sterilized bottles. The samples were labeled with date of collection, nature or source of water, the site of collection and were transported to the laboratory of Department of Soil and Environmental Science, the University of Agriculture, Peshawar for further process.

2.4 Processing of water samples

Samples were filtered through Filta-Max filters (IDEXX , USA) with a pump on the inlet side of the filter according to the recommendation of the manufacturer. The filter was taken out and processed with the aid of a Filta-Max Manual for further elution and concentration process which consisted of decompression of the filter, passing the sample through a membrane, and centrifugation. A sample pellet was obtained and mixed with 1ml buffer solution and kept at -200 C for further process.

2.5 Parasites detection and prevalence rate

Slides were prepared, stained and examined under a microscope (Olympus Japan) at 10X, 40X and 100 X magnifications. The prevalence rate of parasites in water samples was determined with the following formula:

\[
\text{Prevalence Rate} = \left( \frac{\text{Number of parasite detected in water sample}}{\text{Total number of water samples examined}} \right) \times 100
\]

2.6 Statistical analysis

Data were analyzed by using the SPSS software. P values less than 0.05 were considered to be statistically significant.

3. Results and discussion

3.1 Sources of drinking water

During survey in all the selected villages, it was found that about 40% of the households were using hand pumps as the main source of available drinking water. About 25% of the households reported that they obtain drinking water from the community tube-wells. Among the households, 16% were getting drinking water from the wells. However, 13% of the households explained that they obtain ground water by using pressure pumps at their houses while 6% use rain water as a source of their drinking water. The rain water collected in the
ponds was from the runoff of hills. The data revealed that in the majority of areas water distribution networks did not exist and people obtained the water from the above mentioned sources and stored in water tanks, open containers and pitchers etc. The following Figure-2 shows information about the various sources of drinking water in the study area:

![Figure 2: Sources of drinking water](image)

3.2 Time spent on fetching water

Water is very important for people’s health and also a key ingredient in domestic activities carried out mostly by women as part of their household chores. During interview, the head of households (who had not the facility of hand pumps and pressure pump at their houses) explained that they usually fetch water from tube-wells in the nearby of their residences. The majority 59% of the respondents reported that they spent about 15 minutes in fetching water from the tube-wells on a daily basis. About 26% replied that they spend about 30 minutes in bringing water to their houses while a few (15% of respondents) replied that they spent around 60 minutes to transport water to their houses on a daily basis. The Figure-3 below highlights the time spent in fetching water in the study area.

![Figure 3: Time Spent on Fetching Water](image)
3.3 Sewerage and drainage system

During survey, it was observed that the conditions of roads in the villages were not good and in many areas proper drains were not provided along the streets. However, the sludge drains in the streets were collecting the surface water along with the sewage in the study area. The existing open drains were not clean enough to be operational to its full capacity. However, the household survey was conducted regarding availability and type of latrines in the targeted areas. During the survey, it was reported that 58% of the study area population was using pit latrines and 39% of population was using flush type latrines. Other than that, 1% was using piped sewerage system and only 2% were facing the problem of a lack of latrines. Figure-4 provides a graphic presentation of the types of latrines is given in the region:

![Figure 4: Sewerage system](image)

3.4 Perception of people about safe drinking water

Perception is an expression of knowledge or belief based on observation or reading or other means of acquiring information about a subject or phenomenon. The following Figure-5 shows the perception of the targeted households as to whether they agree or disagree that the water is safe or unsafe for drinking and for other domestic purposes. As clear from the Figure-5, 78% of the respondents were of the opinion that water with no smell seemed safe to drink and use for other domestic purposes, while 32% believed that the water is unsafe and is not good for health.

![Figure 5: Perception about Safe Drinking Water](image)
3.5 People affected by unsafe drinking water

During interview, the doctors in the rural health units in each union council explored that in rural areas of district Tank, water for household use is mostly carried by women who often begin carrying small containers of water when they are very young. When water for household use is collected from a source away from the household, these women usually incur health damages resulting from the physical stress of carrying water. The doctors further described that the unsafe drinking water has been a major issue for the health of people. They reported that up to 34% of patients come to them with complaints of diarrhea, and 25% of patients have cholera, 19% have dysentery, 14% have typhoid and about 8% have hepatitis. Among these patients the majority are children who have been affected by the use of unsafe drinking water. The following Figure-6 illustrates the proportion of patients affected by different water-borne diseases in the study area:

![Figure 6: Effect of water-borne disease on the health of people](image)

3.6 Prevalence of Zoonotic parasites in drinking water

In the present study, the results of laboratory tests confirmed the presence of Giardia Spp and Cryptosporidium Spp in tap, pond and drain water in the selected union councils of district Tank. From all the samples, about 65.5% were contaminated with Protozoa, 18.5% with Giardia and 19.5% with Cryptosporidium. Both Giardiasis and Cryptosporidium are known to cause gastroenteritis and considered two leading causes of waterborne diseases in the United States (Richard, 1970; Bruce, et al., 2000). In the present study, T. gondii and Balantidium coli oocysts were found in all the water sources and were most numerous in pond and drain water. According to the recent report that water borne transmission of T. gondii is uncommon but a large human outbreak linked to contamination of a municipal water reservoir in Canada by wild felids and the widespread infection by marine mammals in the USA (Jitender, 2005). In the current study, Fasciola eggs and Entamoeba trophozoites cysts were also recovered from all the water sources. The recent longitudinal studies reported the finding of these parasites in the water sources throughout the year (Wallis, et al., 1996). According to the recent report which had shown Entamoeba histolytica, Giardia lamblia, and Cryptosporidium parvum are three of the major causes of protozoan-induced diarrheal disease (Robert, et al., 1977; Chapman, 1988) E. histolytica is responsible for approximately
100,000 deaths worldwide each year, making it second only to malaria as a cause of mortality due to a protozoan parasite (Walsh, 1986). In other studies, E. histolytica and E. coli was recovered from the sewage waters and stool (Chavarría and Avendendo, 2001).

Table 2: Prevalence of Zoonotic Parasites in Drinking Water from different Sources

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Union council</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ammen khel (n=75)</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Giardia</td>
<td>3</td>
</tr>
<tr>
<td>Crypto</td>
<td>2</td>
</tr>
<tr>
<td>T. Gondi</td>
<td>0</td>
</tr>
<tr>
<td>Fasciola</td>
<td>1</td>
</tr>
<tr>
<td>B. Coli</td>
<td>1</td>
</tr>
<tr>
<td>Entamoeba</td>
<td>4</td>
</tr>
</tbody>
</table>

Statistical Analysis: Tukey’s test and one way ANOVA, (P>0.05) non-significant

5. Conclusion and recommendations

Water samples collected from different sources of the study area showed bacteriological water contamination in the tube-wells, ponds and drains, and are likely to play an important role in the incidence of water-borne diseases. Tube-well sources were not widely associated with poor quality of water while cross water contamination in the distribution line had an important role as the storage tanks were found to be contaminated. The physical contaminants of all the water samples collected in all areas were found to be within WHO limits.

Based on a widespread lack of knowledge of inter-linkages between water safety and inadequate hygiene, the risk of water-borne disease was high, especially where there was lack of appropriate size narrow-mouthed containers, proper seal top cover to protect wells, and antibacterial soap for personal hygiene. The later interventions are effective ways to reduce such type of water-borne diseases.

Based on our findings, we recommended that the local government should address these issues in an effective and sustainable manner in order to protect, sources of drinking water. We also recommended that the government and non-governmental organizations collaborate to educate and inform the public about appropriate ways to collect, transport store and use water in households, including overall hygiene and awareness of inter-linkages between water safety and ill health.

5.1 Abbreviations

NGOs – Non-Governmental Organizations
UN CSD – United Nations Commission on Sustainable Development
UNICEF – United Nations International Children’s Emergency Fund
UN – United Nations
WHO – World Health Organization
B. coli – Balantidium coli is a parasitic species of ciliate protozoan that causes the disease Balantidiasis.
Crypto – Cryptosporidium is a microscopic parasite that causes the diarrheal disease cryptosporidiosis.
Entamoeba – Entamoeba histolytica, is a protozoan parasite responsible for a disease called amoebiasis.
Fasciola – Fascioliasis, is a parasitic infection typically caused by Fasciola hepatica, which is also known as the common liver fluke” or ”the sheep liver fluke.
Giardia – Giardia intestinalis, Giardia lamblia, or Giardia duodenalis is a microscopic parasite that causes the diarrheal illness known as giardiasis.
T. gondi – Toxoplasma gondii, is a microscopic protozoa that causes a disease called toxoplasmosis.
Zoonosis – Zoonotic disease that can be passed from animals, whether wild or domesticated, to humans.

6. References


