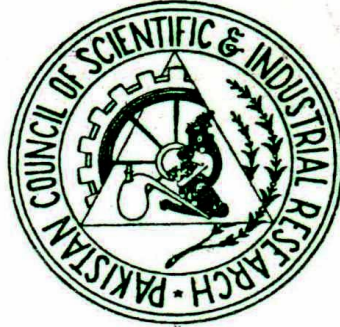


**PAKISTAN COUNCIL OF SCIENTIFIC AND INDUSTRIAL  
RESEARCH LABORATORIES COMPLEX, JAMRUD ROAD,  
PESHAWAR-25120**



**A report on the  
Bacteriological Investigations of Drinking  
Water of the Flood 2010 affected areas of  
Khyber Pukhtoonkhwa**

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**Submitted to:**

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- 2. Director Information, KPK Peshawar**
- 3. Director General, Provincial EPA Peshawar**
- 4. Provincial Disaster Management Authority, Peshawar**
- 5. UNICEF Peshawar Office**

**PCSIR LABORATORIES COMPLEX PESHAWAR**

A Report on the  
**Bacteriological Investigations of Drinking Water of the Flood  
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## **1. Background information**

The floods in Pakistan, started in the month of July 2010 after heavy monsoon rain fall, severely affected the Khyber Pakhtunkhwa, Sindh, lower Punjab as well as parts of Balochistan. More than that two thousand people along with about a million homes have perished so far. The United Nations reports that over 20 million people are suffering and homeless with over 160,000 square kilometers affected as a result of the floods, exceeding the combined total of the affected of 2004 Indian Ocean tsunami, the 2005 Kashmir earthquake and the 2010 Haiti earthquake. However, the death toll in each of those three disasters was much higher than the number of people killed so far in these floods. According to the BBC NEWS, about one fifth of Pakistan's total land area was underwater due to the flooding.

United Nations Secretary General Mr. Ban Ki-Moon requested for an initial of 460 million US Dollars for emergency relief, noting that the flood was the worst disaster he had ever seen. The Pakistani economy has been destroyed by extensive damage to infrastructure and crops (Dawn News). Structural damages are estimated to exceed 4 billion US Dollars and wheat crop damages are estimated to be over 500 million US Dollars. Officials estimate the total economic impact to be as much as 43 billion US Dollars (News Yahoo.com).

Khyber Pakhtoonkhwa was one of the worst affected Provinces of the country, where the highest number of deaths and displaced people were reported. The flood affected primarily the basic necessities of life such as food, shelter and clothing. Among the problems which broke out as a result of flood, unhygienic and contaminated drinking water was the most burning. World Health Organization reported that ten million people were compelled to drink unhygienic water (New York Times). There was an immediate increased risk of waterborne diseases like diarrhea, cholera, typhoid fever, shigellosis, hepatitis (A & E), skin and eye diseases which are related to unsafe drinking water and inadequate sanitation.

On 28<sup>th</sup> July 2010 flood in Khyber Pakhtoonkhwa water comes ashore, resulting in severe contamination of drinking water sources with pathogenic microorganisms. This

contamination of drinking water resources produced life threatening health problems in the affected area such as acute diarrhoeal diseases, cholera and other serious infections.

## **2. Scope**

In Khyber Pukhtoonkhwa immediately after the flood disaster, the Pakistan Council of scientific and Industrial Research scientists visited the affected coastal districts to find out health related issues of the coastal area population affected by the flood. In this report, results from the analysis of bacteriological contamination in drinking water samples collected from different affected areas of Khyber Pukhtoonkhwa are presented.

## **3. Identification of Villages**

In order to reach out the most vulnerable affectees in disaster hit districts, PCSIR Laboratories Complex Peshawar selected most affected villages and made a three days field assessment survey. The villages were identified on the bases that were completely inundated by floods. These villages are: Mulayan (Nisatta), Peeran (Nisatta), Parao (Nisatta), Kaker (Nisatta), Toor Khel (Nisatta), Mohallah Saddran, Sheikh Malee (Nisatta), Londa(Nisatta), Sore Pool Kooroona(Nisatta),Bhattai Kooroona(Nisatta), Peerano Masjid (Nisatta), Masjid Mala Khan, Chowk Bazar Sajid Khan, Chowk Bazar Kamil Shezad ,New Farid Khan, Masjid Darbar (Sheikhan), Khana Din, Hasan Khel, Hasan Khel(Nawaz House), Qazi Abad Tube well, Sheikhan (A.Raziq House), Munshi Kilay (Budhni), Qazi Abad (Budhni), Hashtnagr(Budhni), Saleem Town-I (Budhni), Saleem Town-II (Budhni), Shakarpura-1, Shakarpura-2, Shakarpura-3, Shakarpura-4 and Shakarpura-5.

## **4. Bacteriological Analysis**

### **4.1 Total Plate Count (TPC)**

Total plate count was determined by pour plate method. Serial dilutions ( $10^{-1}$  to  $10^{-4}$ ) of the water samples were made and aliquots of 1ml were added to each duplicate Petri dish. Total Plate Count Agar was added to each Petri dish for total plate count and incubated at

35 °C for 48 ± 2 hours. After incubation colony was counted by colony counter and results were expressed as cfu/ml (APHA 2001).

#### **4.2 Total Coliform Bacteria (TCB)**

The Most Probable Number (MPN) of total coliforms bacteria were determined by multiple tube fermentation technique (APHA 2001). 1ml from the previously prepared  $10^{-1}$ ,  $10^{-2}$  and  $10^{-3}$  dilutions were inoculated into three replicate tubes containing 10 ml of Lauryl Triptose (LT) Broth with inverted Durham tubes and incubated at 35 °C ± 0.5 °C for 24 and 48 ± 2 hours after inoculation. Tubes were examined for evidence of gas production at the end of 24 hours incubation. Gas production was measured by gas displacement in the inverted vial and also effervescence produced, when the tube was gently shaken. Negative tubes were re-incubated for additional 24 hour and again examined for gas production. Positive tubes with gas formation and turbidity were sub-cultured into Brilliant Green bile (2%) (BGB) broth and incubated at 35 °C for 48 hours. Total coliform were calculated from MPN tables as per 100 ml (APHA 2001).

#### **4.3 Total Fecal Coliform Bacteria (TFC)**

Tubes having 10 ml E.C. broth with inverted Durham tubes was inoculated by means of 3 mm loop from the presumptive fermentation tubes showing gas and incubated at 44.5°C for 24 hours and examined for gas production. Fecal Coliform were calculated from MPN tables (APHA 2001).

#### **4.4 *E. Coli***

Eosin Methylene Blue (EMB) Agar was used for the identification of *E. coli*. All the tubes of E.C. broth showing gas were subculture by streaking on EMB agar plates and incubated at 35 °C for 18-24 hours. Positive plates contained typical colonies with green metallic sheen were inoculated on PCA slants (plate count agar) and incubated at 35 °C for 18 – 24 hours. After 24 hours incubation the typical colonies were confirmed by biochemical tests and also by kits *E.Coli*O157:H7 latex test reagent kit Pro Lab. Canada (APHA 2001).

#### **4.5 *Pseudomonas aeruginosa* (PA)**

250 mL of sample was taken and filtered through a 0.45 µm cellulose membrane filter, placed on Pseudomonas Citranemide (CN) agar and plates were incubated at 37 °C for 48

hours, blue/green colonies were isolated on Plate Count Agar at 37 °C for 24 hours. After the oxydase test, the species identification was conducted using standardized identification Biochemicals tests (APHA 2001).

#### **4.6 *Vibrio cholerae***

*Vibrio cholerae* (VB) was detected by enriching the samples in 1% alkaline peptone water for 6 to 8 hours followed by isolation on Thiosulphate Citrate Bile salt sucrose (TCBS) agar medium (Collee *et al.*, 1996).

All colonies with different characteristics on M-Endo agar, Xylose Lysine Deoxycholate Agar (XLD) agar and Thiosulphate Citrate Bile salt sucrose Agar (TCBS) were sub cultured onto Nutrient agar (NA) for purification. Enteric bacteria isolated on respective selective or differential media were identified on the basis of their colonial, morphological and biochemical properties using Bergey's Manual of Determinative Bacteriology, 1994.

#### **4.7 *Salmonella* and *Shigella***

Detection of *Salmonella* and *Shigella* species were done by the enrichment of water samples on Selenite F broth, followed by isolation of the typical organism on selective medium Xylose Lysine Deoxycholate Agar (XLD) (Collee *et al.*, 1996).

#### **4.8 *Staphylococcus aureus***

The membrane Filtration Technique was employed for the enumeration of *Staphylococcus aureus* using 100 ml drinking water sample on Baird Parker agar as selective medium. After incubation the Baird Parker agar plates containing filter for 25-48 hours at 37 °C, circular bright gray to black colonies were picked, purified and sub-cultured on nutrient agar. The confirmed colonies were subjected to Gram-positive cocci in cluster, positive reaction catalase and coagulase test were considered as *Staphylococcus aureus* (Mihdhdhir AA. 2009).

## 5. Results and Discussion

### 5.1 Analysis of water samples from different areas of district Charsadda

Bacteriological analysis of bore water of District Charsadda (Nisatta) was shown in Table 1. The highest Total Plate Count (TPC)  $9 \times 10^6$  CFU/ml was found in Sheikh Malee (Nisatta). The lowest value of TPC  $9 \times 10^1$  CFU/ml was found in Mohallah Kaker (Nisatta). According to World Health Organization (WHO) drinking water standard for TPC is 100 CFU/ml; if this limit exceeds than the reported standard, the water become unacceptable for drinking purposes.

All the examined samples were found highly contaminated with Total Coliform Bacteria (TCB) and the results were reported that the highest TCB i.e. >1600 MPN/100ml were found in villages Mohallah Mulyan (Nisatta), Toor Khel (Nisatta), Mohallah Saddran (Nisatta), Sheikh Malee(Nisatta), Mohallah Londa (Nisatta) and Sore Pool Kooroona (Nisatta)..The WHO limit of TCB are <1.8 MPN/100ml. All analyzed samples were highly contaminated (100%) with Total Fecal Coliform Bacteria (TFC). The study of Khan *et al* 1999 on the fecal coliform contamination in the Kabul River and its tributaries showed that it was highly contaminated with these bacteria and this water can neither be considered safe for human consumption nor for irrigation purposes. *E. coli* was absent in Mohallah Mulyan (Nisatta) and Sheikah Malee. The other analyzed samples were highly contaminated showing positive results for the presence of *E. coli*. The bacterial species *Escherichia Coli* is one of the most common inhabitants of the human intestinal tract and is probably the most familiar organism in microbial world. Its presence in water or food is an indication of fecal contamination. It can cause urinary tract infections and certain strains produce enterotoxins that cause traveler's diarrhea and occasionally cause very serious food born disease (Tartora *et al* 2009).

**Table 1 Bacteriological analysis of bore water of District Charsadda (Nisatta)**

Name of village	<sup>1</sup> TPC	<sup>2</sup> TCB	<sup>3</sup> TFC	<sup>4</sup> EC	<sup>5</sup> PA	<sup>6</sup> VB	<sup>7</sup> S	<sup>8</sup> S	<sup>9</sup> SA	
Mulayan (Nisatta)		4.5 *10 <sup>2</sup>	>1600		+	-	+	+	+	60
Peeran (Nisatta)		2 *10 <sup>2</sup>	23		+	+	+	+	+	Nil
Parao (Nisatta)		2*10 <sup>2</sup>	23		+	+	+	+	+	Nil
Kaker (Nisatta)		9*10 <sup>1</sup>	14		+	+	+	-	+	Nil
Toor Khel (Nisatta)		3*10 <sup>4</sup>	>1600		+	+	+	-	+	4*10 <sup>1</sup>
Mohallah Saddran		4*10 <sup>4</sup>	>1600		+	+	+	-	+	1 * 10 <sup>3</sup>
Sheikh Malee (Nisatta)		9*10 <sup>6</sup>	>1600		+	-	-	+	+	1 * 10 <sup>6</sup>
Londa(Nisatta)		1.8*10 <sup>2</sup>	>1600		+	+	-	+	+	3 * 10 <sup>1</sup>
Sore Pool Kooroona(Nisatta)		4*10 <sup>2</sup>	>1600		+	-	+	+	+	2 *10 <sup>1</sup>
Bhattai Kooroona(Nisatta)		4*10 <sup>2</sup>	23		+	+	-	+	+	Nil
Peerano Masjid (Nisatta)		4.5 *10 <sup>2</sup>	920		+	+	+	-	+	1 * 10 <sup>1</sup>

Where as:

+	Detected
-	Not detected
<sup>1</sup> TPC	Total Plate Count
<sup>2</sup> TCB	Total Coliform Bacteria
<sup>3</sup> TFC	Total Fecal Coliform Bacteria
<sup>4</sup> EC	Escherichia Coli
<sup>5</sup> PA	Pseudomonas aeruginosa
<sup>6</sup> VB	Vibrio cholera
<sup>7</sup> S	Salmonella Spp / 25 ml
<sup>8</sup> S	Shigella
<sup>9</sup> SA	Staphylococcus aureus

All samples were contaminated with *Pseudomonas aeruginosa* except three samples (Sheikh Malee, Mohallah Londa and Bhattai Kooroona, Nisatta) in which *Pseudomonas aeruginosa* was absent. *Vibrio cholerae* results were more alarming. All water samples were contaminated except one sample from Bhattai Kooroona where *Vibrio cholerae* was absent. The samples collected from villages Mohallah Mulyan, Mohallah Peeran, Mohallah Parao, Sheikah Malee, Mohallah Lonada and Bhattai Kooroona have shown positive results of Salmonella and the samples from rest of villages i.e. Mohallah Kaker, Toor Khel, Mohallah sadran, Sore Pool Kooroona and Peerano Masjid were found free from Salmonella. The resulting data delivered that all the analyzed samples were contaminated with shigella. The highest *Staphylococcus aureus* contamination (1\*10<sup>6</sup>

CFU/ml) were found in Sheikh Malee and the lowest ( $1 \times 10^1$ ) were found in Peerano Masjid. The samples from Mohallah Peeran, Mohallah Parao, Mohallah Kaker and Bhattai Kooroona were found free of *Staphylococcus aureus*.

## **5.2 Analysis of water samples from different areas of district Nowshera**

Results from the bacteriological analysis of bored well water of District Nowshera (Akora Khattak) have shown in Table 2. The results from samples of Masjid Mala Khan showed that its TPC was  $1 \times 10^7$  CFU/ml, *Pseudomonas aeruginosa* was absent but TFC, *E. Coli*, *Vibrio cholerae*, Salmonella and Shigella were detected in the samples analyzed. Mohallah Hasan Khel TPC was  $3 \times 10^8$  CFU/ml which was the highest count in all the analysed samples of Akora Khattak. TCB was >1600 MPN/100ml, *Staphylococcus aureus* was 04 CFU/ml, *Pseudomonas aeruginosa* and Salmonella were absent but TFC, *E. coli*, *Vibrio cholerae* and Shigella were present. Hassan Khel TPC was  $4 \times 10^3$  CFU/ml, TCB >1600 MPN/100ml, and *Staphylococcus aureus* was  $8 \times 10^6$  CFU/ml. *Pseudomonas aeruginosa* was negative while TFC, *E. coli*, *Vibrio cholerae*, Salmonella and Shigella were present. TPC of samples from Qazi Abad Tube Well was  $8 \times 10^5$  CFU/ml, TCB was >1600 MPN/100ml and *Staphylococcus aureus*  $1.1 \times 10^7$  CFU/ml. Contamination of water from Hassan Khel with *Staphylococcus aureus* was highest among all the analysed samples of different locations of Akora Khattak. A leading cause of gastroenteritis is staphylococcal food poisoning, an intoxication caused by ingesting an enterotoxin produced by *Staphylococcus aureus*. Staphylococci are comparatively resistant to environmental stress. They also have a fairly high resistance to heat; vegetative cells can tolerate 60°C for half an hour. Their resistance to drying and radiation helps them to survive on skin surfaces. These bacteria are often an inhabitant of the nasal passages, from which they contaminate the hands.

**Table 2 Bacteriological analysis of bore water of District Nowshera (Akora Khattak)**

Name of village	<sup>1</sup> TPC	<sup>2</sup> TCB	<sup>3</sup> TFC	<sup>4</sup> EC	<sup>5</sup> PA	<sup>6</sup> VB	<sup>7</sup> S	<sup>8</sup> S	<sup>9</sup> SA
Masjid Mala Khan	1 * 10 <sup>7</sup>	240	+	+	+	+	-	+	06
Chowk Bazar Sajid Khan	1 * 10 <sup>3</sup>	23	+	-	-	+	-	+	48
Chowk Bazar Kamil Shezad	1 * 10 <sup>8</sup>	>1600	+	+	+	+	+	+	1 * 10 <sup>3</sup>
New Farid Khan	1 * 10 <sup>4</sup>	>1600	+	+	-	+	+	+	1 * 10 <sup>5</sup>
Masjid Darbar (Sheikhan)	1 * 10 <sup>5</sup>	>1600	+	+	+	-	+	+	1 * 10 <sup>6</sup>
Khana Din	7 * 10 <sup>3</sup>	>1600	+	+	-	+	+	+	1 * 10 <sup>7</sup>
Hasan Khel	3 * 10 <sup>8</sup>	>1600	+	+	-	+	-	+	04
Hasan Khel(Nawaz House)	4 * 10 <sup>3</sup>	>1600	+	+	-	+	+	+	8 * 10 <sup>6</sup>
Qazi Abad Tube well	8 * 10 <sup>5</sup>	>1600	+	+	-	+	+	+	1.1 * 10 <sup>7</sup>
Sheikhan (A.Raziq House)	8 * 10 <sup>3</sup>	240	+	+	+	-	-	-	Nil

Where as:

+	Detected
-	Not detected
<sup>1</sup> TPC	Total Plate Count
<sup>2</sup> TCB	Total Coliform Bacteria
<sup>3</sup> TFC	Total Fecal Coliform Bacteria
<sup>4</sup> EC	Escherichia Coli
<sup>5</sup> PA	Pseudomonas aeruginosa
<sup>6</sup> VB	Vibrio cholera
<sup>7</sup> S	Salmonella Spp / 25 ml
<sup>8</sup> S	Shigella
<sup>9</sup> SA	Staphylococcus aureus

They are also a frequent cause of skin lesions on the hands. From these sources it can readily enter into the food. If the microbes are allowed to incubate in the food, they produce and release enterotoxins into the foods. *Staphylococcus aureus* produces several toxins that damage tissues or increase the microorganism's virulence. The production of the toxin of serological type A (which is responsible for most cases) is often correlated with the production of an enzyme which coagulates blood plasma. Such bacteria are called coagulase positive. The toxin quickly triggers the brain's vomiting reflex center; abdominal cramps and consequently diarrhea is caused (Tartora *et al* 2009).

The village Sheikhan results were reported that TPC was  $8 \times 10^3$  CFU/ml, TCB 240 MPN/100ml, the *Vibrio cholerae*, Salmonella, Shigella and *Staphylococcus aureus* were absent while TFC, *E. coli* and *Pseudomonas aeruginosa* was present.

### **5.3 Analysis of water samples from different areas of district Peshawar**

Two areas were selected in District Peshawar for the assessment of bacteriological quality of drinking water of flood affected area. These areas were Budhni and Shakarpura and the results of bacteriological analysis of water samples from these areas are tabulated in Table3. The results of Munshi Kalay (Budhni) showed that TPC and TCB were  $2 \times 10^2$  CFU/ml and 79 MPN/100ml respectively. The TFC, *E.Coli*, *Pseudomonas aeruginosa*, *Vibrio cholerae*, Salmonella and *Staphylococcus aureus* were absent only Shigella was detected in the analyzed samples. The Qazi Abad (Budhni) TPC was  $4 \times 10^3$  CFU/ml and TCB was 49 MPN/100ml. The *Vibrio cholerae* and Shigella was found but the TFC, *E. coli*, *Pseudomonas aeruginosa*, Salmonella and *Staphylococcus aureus* were not found in the samples.

**Table 3 Bacteriological analysis of bore water of District Peshawar**

Name of village	<sup>1</sup> TPC	<sup>2</sup> TCB	<sup>3</sup> TFC	<sup>4</sup> EC	<sup>5</sup> PA	<sup>6</sup> VB	<sup>7</sup> S	<sup>8</sup> S	<sup>9</sup> SA
Munshi Kilay (Budhni)	2*10 <sup>2</sup>	79	-	-	-	-	-	-	-
Qazi Abad (Budhni)	4*10 <sup>3</sup>	49	-	-	-	+	-	-	-
Hashtnagr(Budhni)	8*10 <sup>1</sup>	<1.1	-	-	-	-	-	-	-
Saleem Town-I (Budhni)	3.6*10 <sup>2</sup>	4.5	+	+	-	-	-	+	+
Saleem Town-II (Budhni)	3*10 <sup>2</sup>	23	-	-	-	+	-	-	-
Shakarpura-1	4.7*10 <sup>1</sup>	<1.1	-	-	-	-	-	-	-
Shakarpura-2	3*10 <sup>3</sup>	79	-	-	-	-	+	-	-
Shakarpura-3	4*10 <sup>2</sup>	25	+	+	+	-	-	+	+
Shakarpura-4	7*10 <sup>4</sup>	280	-	-	-	+	+	-	-
Shakarpura-5	2*10 <sup>2</sup>	<1.1	-	-	-	+	-	-	-

Where as:

+	Detected
-	Not detected
<sup>1</sup> TPC	Total Plate Count
<sup>2</sup> TCB	Total Coliform Bacteria
<sup>3</sup> TFC	Total Fecal Coliform Bacteria
<sup>4</sup> EC	Escherichia Coli
<sup>5</sup> PA	Pseudomonas aeruginosa
<sup>6</sup> VB	Vibrio cholera
<sup>7</sup> S	Salmonella Spp / 25 ml
<sup>8</sup> S	Shigella
<sup>9</sup> SA	Staphylococcus aureus

Cholera is one of the most serious gastrointestinal diseases in the world. The causative agent of cholera i.e. *Cholera bacilli* is slightly curved, gram-negative rod with a single polar flagellum. *Cholera bacilli* grow in the small intestine and produce an exotoxin, cholera toxin that causes host cells to secrete water and electrolytes, especially Potassium. The result is watery stools containing masses of intestinal mucus and epithelial cells called rice water stools, named because of their appearance. As much as 12 to 20 liters (3 to 5 gallons) of fluids can be lost in a day and sudden loss of these fluids and electrolytes causes shock, collapse and often death. The blood lacking fluids may

become so viscous that vital organs are unable to function properly. Violent vomiting generally also occurs. The microbes are not invasive and a fever is usually not present. Untreated cases of cholera may have a mortality rate of 50%, although with proper supportive care it is usually less than 1% today. The diagnoses are based upon symptoms and culturing of *Vibrio cholerae* from feces (Tartora *et al* 2009). Two samples Hashnagar (Budhni) and Shakarpura-I was found fit bacteriologically as the results were within the range of WHO standards. Salim Town-I (Budhni) TPC was  $3.6 \times 10^2$  CFU/ml and TCB was 4.5 MPN/100ml. TFC, *E. coli* and Shigella was positive and *Pseudomonas aeruginosa*, *Vibrio cholerae*, Salmonella and *Staphylococcus aureus* were not identified in the analysed samples. Salim Town-II (Budhni) TPC was  $3 \times 10^2$  CFU/ml and TCB was 23 MPN/100ml. *Vibrio cholerae* and Shigella was identified while TFC, EC, *Pseudomonas aeruginosa*, Salmonella and *Staphylococcus aureus* was not found in the analysed samples. In water samples from Shakarpura TPC and TCB were  $3 \times 10^3$  CFU/ml and 79 MPN/100ml respectively.

Salmonella and Shigella were present while TFC, *E. coli*, *Pseudomonas aeruginosa*, *Vibrio cholerae* and *Staphylococcus aureus* resulted in negative. Species of Shigella are responsible for a disease called bacillary dysentery, or shigellosis. Unlike salmonellae, they are found only in humans. These organisms are second only to *E. coli* as a cause of traveler's diarrhea. Outbreaks are most often seen in families, day care facilities and similar settings. These bacteria are residents only in of the intestinal tract of humans. The toxin responsible is usually virulent and is known as the Shiga toxin. The infective dose required to cause disease is small and the bacteria are not much affected by stomach acidity. They proliferate to immense numbers in the small intestine, but the primary site of the disease is the large intestine. There the bacteria attach to certain epithelial cells. Membrane cells membranous cellular ruffles surrounding the cell, take the bacterium into the cell. The bacteria multiply in the cell and soon spread to neighboring cells, producing Shiga toxin that destroys tissue. Dysentery is the results of damage to the intestinal wall. Additional symptoms of the infection are abdominal cramps and fever. Shigella bacteria rarely invade the bloodstream. Macrophages not only fail to kill Shigella bacteria that they phagocytose, but they are killed by them. In severe cases of shigellosis, antibiotic therapy and oral rehydration is advised. Shakarpura-3 TPC was  $4 \times 10^2$  CFU/ml, TCB was

25 MPN/100ml. TFC, *E. coli*, and *Pseudomonas aeruginosa* resulted in positive while *Vibrio cholerae*, Salmonella, Shigella and *Staphylococcus aureus* were not identified in the analyzed samples. Detectable *E. coli* was found in 78% of all samples and the mean densities of *E. coli* varied from a minimum of 0 CFU/ml to a maximum of 15 CFU/ml in all samples. Malfunctioning septic systems and wildlife population appear to be the main source of *E. coli* contamination. Presence of *E. coli* in natural spring water indicators potential adverse health effects for individuals or population exposed to this water. The fecal contaminated spring water may present an unacceptable risk to pathogens. TFC, *E. coli*, *Pseudomonas aeruginosa* and Salmonella were not found in the Shakarpura-4 & 5, while *Vibrio cholerae* and Shigella was present. Salmonella was positive, TCB was 280 MPN/100ml and TPC was  $7 \times 10^4$  CFU/100ml in Shakarpura -4. TCB and Salmonella was absent and TPC was  $2 \times 10^2$  CFU/100ml in the Shakarpura-5. Salmonella are gram-negative, facultative anaerobic, non-endospore forming rods. Almost all members of this genus are potentially pathogenic. Salmonellae are common inhabitants of the intestinal tracts of many animals, especially poultry and cattle. Under unsanitary conditions, they can contaminate food. Typhoid fever, caused by *Salmonella typhi* is the most severe fever caused by any member of the genus salmonella. Typhoid fever is still a frequent cause of death in parts of the world with poor sanitation. The patient with typhoid fever suffers from high temperature of about 40 °C (104 °F) and continual headache. Diarrhea appears only during the second or third week and the fever then to decline. In sever cases which can be fatal, ulceration and proliferation of the intestinal wall can occur. Before antibiotic therapy was available, a mortality rate of 20% was common. With the treatment available now, the mortality rate is less than 1% today. A less severe gastrointestinal disease caused by other salmonellae is called salmonellosis. In this disease condition a moderate fever accompanied by nausea, abdominal pain, cramps and diarrhea. The mortality rate is overall very low, probably less than 1%. However, death rate is higher in infants and among the old aged people death is usually from septic shock.

## **6. Water Treatment**

There are several ways to treat water to make it fit for drinking purposes. The major types of water treatment used are;

### **6.1 Filtration**

Organisms such as protozoa and bacteria can be filtered out from water in sufficient numbers with an appropriate filter system i.e. Hand Pump Filters, Gravity Filters, Bottle Filters and Reverse Osmosis etc.

### **6.2 Heating**

Heat reduces all harmful organisms that may be present in water. It depends upon the temperature and duration of heat applied to water. It can be either sterilization (boiling water for 5, 10 or even 20 minutes to eliminate all bacterial spores that may be present in water) or pasteurization (65°C (149°F) for 5 minutes) to make it safe to consume. Sterilization of water involves boiling water to the point that all organisms in it are dead. Pasteurization involves heating it to the point that all harmful microorganisms are killed or inactivated. The disadvantage of using heat to treat water is the need for fuel and time needed to set up, heat and cool. It also does not remove sediment from your water.

### **6.3 UV Radiations**

UV radiations work by damaging the DNA in microorganisms. It has long been used in commercial and municipal water treatment.

### **6.4 Chemical treatment**

Chemicals such as chlorine (Chlorine Dioxide, Bleach, Superchlorination-dechlorination, Calcium hypochlorite Chloramine) and iodine (Concentrated Alcoholic Iodine, Tincture of Iodine, Povidone-Iodine, Tetraglycine hydroperiodide 16.7%) , have long been used against bacteria and viruses.

## **7. Observation**

The overall survey shows that there is an urgent need of water and sanitation facilities besides re-construct of houses. The houses are filled with a heavy bad smelly mud which must be removed on urgent basis as they are the main causes of diseases. During the

survey a total of 31 water samples taken randomly from different areas of District Peshawar, Chrasada and Nowshera were analyzed. All the samples from different water sources were found contaminated and not fit for human consumption according to the WHO drinking water standards except one sample which fit for human consumption. As the area is severely hit by flood and rain therefore ground water quality is affected by:

1. Direct flow of contaminated flood water into the water sources.
2. The openly dumped solid wastes were filled in the water sources through flood water.
3. As the water table rises due to floods which poses threat to the ground water as surface water may infiltrate easily and mix with ground water.
4. Most people have installed hand pumps in the middle of solid waste dumping which is due to lack of health hygiene awareness among the community.

## **8. Suggestions & Recommendations**

The results of the drinking water samples collected from the three most affected district of Khyber Pukhtoonkhwa showed that most the water samples were unfit for human consumption according to the WHO standards; therefore immediate action should be taken to prevent any bacterial diseases in the affected areas i.e.

1. The contaminated water sources should be dewatered with dewatering pump and proper chlorination of water sources should be done to attain 0.2mg/l to 0.5mg/l of residual chlorine level.
2. Hands pumps should be installed on open wells which will not only reduce chances of external contamination but also will enhance water quality in the area.
3. A systematic water quality monitoring system should be developed in the area to keep the water quality parameters with in WHO guidelines.
4. There is an urgent need of health hygiene awareness education among the people that these people properly take care of their health and water sources.

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