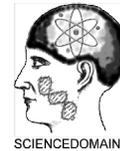




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Impact of Extreme Floods on Groundwater Quality (in Pakistan)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Case Study

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ABSTRACT

Study of long and short-term impact of hydro-meteorologically induced extreme flood on groundwater from well is a baby science, yet to grow and groom. This article focuses on the environmental impacts of the worst Pakistani floods on water quality of affected areas, Charsadda and Nowshera districts in Khyber Pakhtunkhwa province which experienced a disastrous flood in its record due to torrential monsoon rains in late July 2010. For this purpose, consuming water products from 10 main sources (tube wells), 10 intermediate points in water supply distribution system and 10 consumers' ends in 30 selected sites of flood affected areas were collected and analyzed for 12 key factors. Most of the parameters with respect to the standard limits of WHO guidelines indicated contamination in all samples that are directly available from tube wells as well as the one supplied through damaged pipe distribution system. This result becomes more fatal in the presence of microbial contamination and makes water risky for domestic consumption. A concrete policy addressing post-flood environmental effects on life and human health should be devised and strictly followed. Individual cases must be assessed from a basin-wide perspective in order to make sure that environmental concerns are judiciously and properly represented in flood planning and risk management decisions.

Keywords: *KP (Khyber Pakhtunkhwa); WHO; Nowshera; Charsadda; climatic; groundwater; tubewells; water sample.*

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1. INTRODUCTION

Water quality is of key importance to man and nature [1] and one can't deny the fact that it is one of the basic factors for the safe and healthy survival of humanity at large. A healthy society can't evolve in the absence of good quality water. It is quite clear from the previous examples that poor quality or contaminated water has led to the destruction of a whole community as the most tragic example is the 1972 flood in Buffalo Creek, West Virginia. A dam, layered with mine tailings over a period of time to raise its height from 20 feet and increase storage capacity, broke on February 26th, 1972 and discharged a violently fast stream of water contaminated with mine wastes on communities living downstream. More than 125 people were killed as the polluted water in the form of black wave of fluid containing more than two million tons of waste products coursed through streamside communities [2]. The community of Saunders met a dreadful destruction in a minute and the valley lay silent in shock, covered by a layer of sludge [1]. It is obvious that flooding causes a considerable reduction in water quality which then contributes to the adverse climatic impacts. The poor quality of water may be due to huge amount of man-made and natural contaminants and erosion. Man has altered low lying areas to farmlands by considerable removal of floodplain vegetation and wetland regions which serve as sediment intercept, hydraulic sponges, natural stilling ponds and erosion protection. Besides all these, overland flows have been a source of unwanted chemicals including heavy metals in the water on surface. Submerged municipal and industrial sites like wastewater treatment plants, chemical processing and manufacturing centers, and disposal or holding areas serve as point sources for chemical contamination of water [3] while runoff from agricultural land is the main non-point pollution origin. Large amounts of herbicides and nitrate were transported from urban and agricultural areas during the ruinous Mississippi River basin flood of 1993 [3]. 65 percent of the cropland in America is contained in the Mississippi River basin where an approximated one hundred thousand metric tons of pesticides and 6,300,000 metric tons of nitrogen fertilizers are utilized on annual basis. Goolsby et al. [3] compared 1992 and 1993 loads at the Mississippi mouth and noticed a 235 percent increase in the load of atrazine herbicide used in corn production and a 112 percent increase in the load of nitrate. Short- and long-term adverse climatic impacts can result from chemical loading and poor quality water. Goolsby et al. [3] cited Michael Dowgiallo of the National Oceanic and Atmospheric Administration in saying that the chemical loads were promoting primary production which caused an elevation in the levels of marine phytoplankton in the Gulf of Mexico. Zooplanktons, being a potent part of aquatic food chains, consume phytoplanktonic algae and provide a forage base for higher predators but this may cause adverse algal peaks.

Study of long and short-term environmental impacts of extreme floods is a baby science, yet to grow and groom. The quantitative impact analysis of these violent and short-lived environmental events requires reliable field data. The environmental impacts are complicated and unused in policy making. The focus of water management has recently changed from the need to dominate water resources to a more harmonious philosophy that seeks a balance between the structural flow control required to support and protect growing populations and environmental well-being [4-8]. Hickey et al. [1] identified status quo policy, the need for constant flood control and an incomplete understanding of environmental flood dynamics as hurdle for the implementation of this philosophy.

The nature and ingredients of flood flow are one of the important factors which define the quality of water of a specific area. Floods show diverse environmental and climatic impacts on water quality in case of different living beings; some are favored by these impacts while

others have to face a non-compensatory and irrecoverable loss. The adverse climatic impacts of floods are found in the form of widespread chronic epidemics in humans.

1.1 Case Study of Pakistan

A flood is a natural disaster and integral component of natural cycle which often happens in multitude of ways and inundates area and communities as well. This natural phenomenon as a part of the earth's bio-physical processes becomes devastating due to human activity such as clearing of vegetation, intervention in natural drainage lines, deforestation and permanent occupancy of wetlands in the buffer zones of riverbank ecosystem.

In late July 2010, hard monsoon rainstorms led massive deluge in Pakistan which left its disastrous widespread footprints in seven districts of Pakistan. The heavy rainfall due to monsoon patterns and excessive heat due to seasonal weather conditions melted the glaciers which were responsible for the flash floods in Pakistan [9]. Unwanted legal or illegal excessive deforestation and lack of storage dams in Pakistan also played an additional significant role in increasing the chances of intense and huge damages caused by such floods. The severe flood, resulting from heavy monsoon rains during the four day wet spell from 27 to 30 July 2010, broke a long standing, 100 years record flood in early 1900s and rapidly became devastating for the province of Khyber Pakhtunkhwa. These rains inflicted heavy damage in districts of Charsadda and Nowshera. Heavy rainfall of more than 200 millimeters (7.9 in) was recorded in Khyber Pakhtunkhwa based on data from the Pakistan Meteorological Department. Gulf News [10] reported that the flood affected more than 20 million people exceeding the combined total of individuals affected by the 2004 Indian Ocean Tsunami, the 2005 Kashmir Earthquake and the 2010 Haiti Earthquake. UN Secretary-General Ban Ki-moon noted that the flood was the worst disaster he had ever seen. The World Health Organization [11] reported that ten million people were forced to drink unsafe water. It was reported in Dawn News [12] that the Pakistani economy was harmed by extensive damage to infrastructure and crops. The United Nations rated the floods in Pakistan as the greatest humanitarian crisis in recent history with more people affected than the South-East Asian tsunami and the recent earthquakes in Kashmir and Haiti combined.

If one portrays the trail of devastations that took place due to 2010 flash floods in all over the country, the noticeable and serious damages can be seen in Khyber Pakhtunkhwa (KP) province. The people's lives, economy, agriculture, infrastructure, buildings and communication networks were badly affected in KP. Land contaminants, toxic chemicals from septic tanks and industrial effluents were transferred and propagated during surging and caused serious health issues to every age group of people. Serious flood casualties also occurred to the population residing along and near River Kabul and its tributaries.

The two districts Charsadda and Nowshera were the two main flood affected zones of KP as almost all the villages of these districts were horribly hit and damaged by the floods on a large scale (Figs. 1, 2, 7).

After the flood, many organizations had an immediate focus on human losses, damages to livelihoods, properties and infrastructures in response to the flood damages assessment, emergency rescue and rehabilitation but the environmental impacts on human life and nature were neglected. This worst flood triggered damages not only to the life of individuals and destroyed infrastructure but also most of the drinking and irrigation water sources i.e. tube wells got submerged that made it difficult for the flood affected population to find potable and safe water from tube wells for drinking and other domestic purposes. As majority

of the population of these areas is reliant on the consumption of ground water from the wells for drinking, cooking, preparation of food, washing cloths and utensils, hygiene and sanitation purposes, therefore, the need of safe and clean water in these areas was more and very immediate. The important environmental issue that people are experiencing nowadays due to hefty flooding in these areas of KP is the contamination of groundwater which is needed to be explored to provide safe and healthy water. The surface runoff created by heavy floods in these areas, when flowed over the ground, picked up and transmitted the natural and man-made contaminants with unsafe concentrations [13]. It also transmitted toxic materials and chemicals from the industrial effluents, pesticides and fertilizers to be used for the crop production. These contaminants finally deposited into water sheds and also subterranean rivers and polluted the whole aquifer making it unsuitable for use in daily routine.

The quality of water from tube wells in these areas was tested at three different points which are main source, intermediate point of the distribution line and the consumer's end. Selecting three significant points to determine the water quality from a single source was only because of the variation in the conditions of tube wells and distributaries in these areas. It was observed that few of the wells in the study areas had concrete lining. Some tube wells due to their substandard designs especially the private and the older ones which were not designed and maintained according to the design requirements increased the possibilities of polluting the subterranean water. It was also observed that 90 percent of the pipe lines were running through the open drains and were leaked from joints at many places ensured the contamination of water. Most of the inhabitants in these areas had installed small and cheap filter units at their homes which facilitate them in the availability of clean water. However, for this study the consumer's ends were selected at such areas where the people did not have the facility of filter units in order to get the clear picture of the quality of available water used by the majority of the population.



Fig. 1. Fully or partially submerged buildings in Nowshera under 15 feet of water, 2010



Fig. 2. In a flood-hit village near Nowshera, the rescue operation is in progress, 2010

The drinking water due to its sub-optimal quality may have serious adverse impacts on the health of population of all age groups causing high occurrence of water-borne diseases like diarrhea, liver disorder, cholera, giardiasis and abdominal viruses [14]. This polluted water also results in high chances of skin diseases during bathing and washing. Presence of some of the non-biodegradable heavy metals like lead, zinc, copper, manganese etc. in poor quality drinking water also causes chronic health issues such as weakness of neurological system, hair loss, liver cirrhosis and failure of renal system [13]. As most of the population in flood affected areas is reliant on ground water from the wells, the lack of the safe drinking water management practices in these areas specified the urgent need to ascertain if the water supply is suitable for human drinking purpose and for other domestic uses and whether it satisfies WHO guidelines or not.

In this study, water samples from 10 tube wells in the flood affected areas were collected and tested by routine techniques for 12 key parameters of water quality. The article evaluates the water quality of flood hit areas of Pakistan for human use and its climatic implications.

1.2 Study area

Charsadda, 34°09'N 71°44'E, at an altitude of 276 m and 29 km from the provincial capital Peshawar and Nowshera, 34°0'55'N 71°58'29'E, 27 miles due east of Peshawar are the focus of this research; shown in Fig. 3. Three rivers flowing in Charsadda: the River Jindi, the River Kabul and the River Swatmerge and join the River Indus.



Fig. 3. Map showing location of study areas in Pakistan (source: Wikipedia)

The local population in Charsadda and Nowshera faced the accumulated flood waters from Kabul and Swat rivers and from numerous flood channels flowing from the adjoining Malakand Division and FATA regions as can be seen from Fig. 4 and Fig. 5. River Kabul continued to flow much beyond its normal span (Fig. 4 and Fig. 5). Flood Monitoring Map in Fig. 6 identifies the areas hit by the river flood flow. Indus River had caused a massive flood water back flow resulting in extensive flooding in the southern parts of Nowshera district. The Kabul River is a 700 km long river that starts in the Sanglakh Range of the Hindu Kush Mountains in Afghanistan and ends in the Indus River near Attock, Pakistan. An extensive loss of standing sugarcane and other crops in particular along the eastern bank of River

Kabul was observed. Standing crops of maize, sugarcane and rice besides crops of various vegetables were destroyed and the lands, pastures and grazing areas got submerged under water. Nowshera was the worst hit out of the two districts as massive flooding along either banks of the Kabul River caused immense losses in habitats, standing crops and in livelihoods. The stagnant flood waters caused a major threat of water borne diseases in both the districts: diarrhea, AWT, malaria etc.

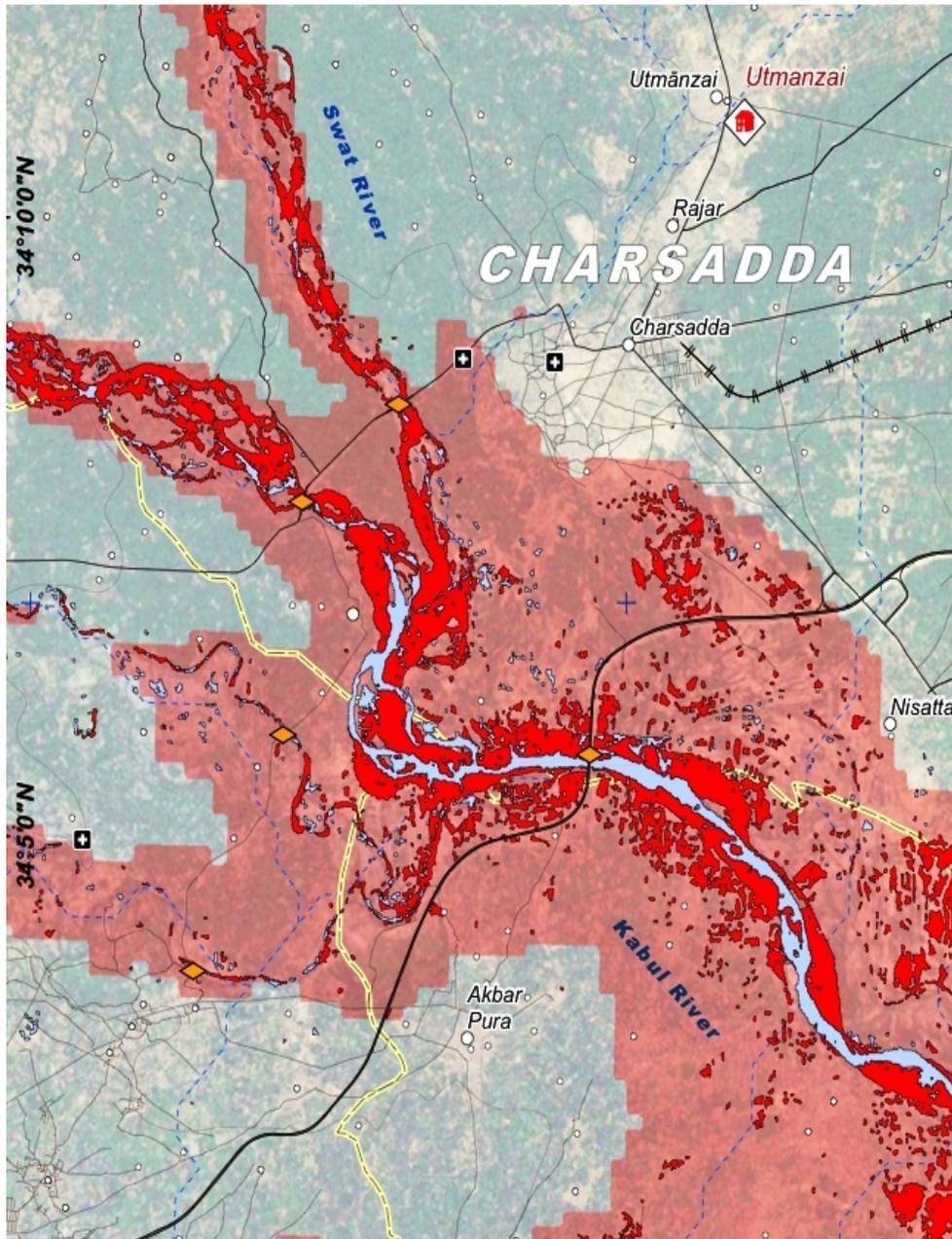


Fig. 4. Flooded River Kabul spreading and flooding Charsadda

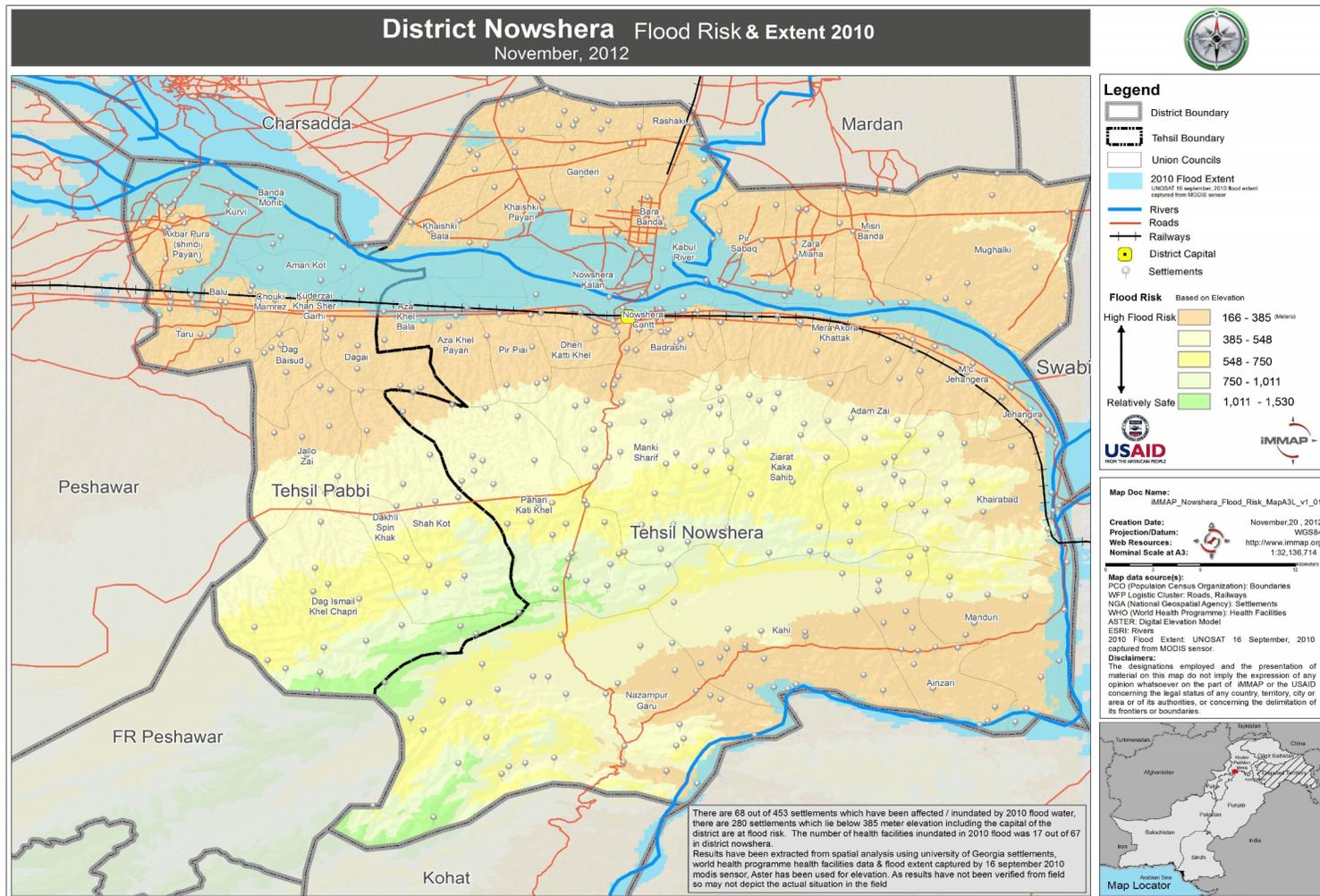


Fig. 5. Map developed by USAID to show the extent of Floods 2010 in District Nowshera

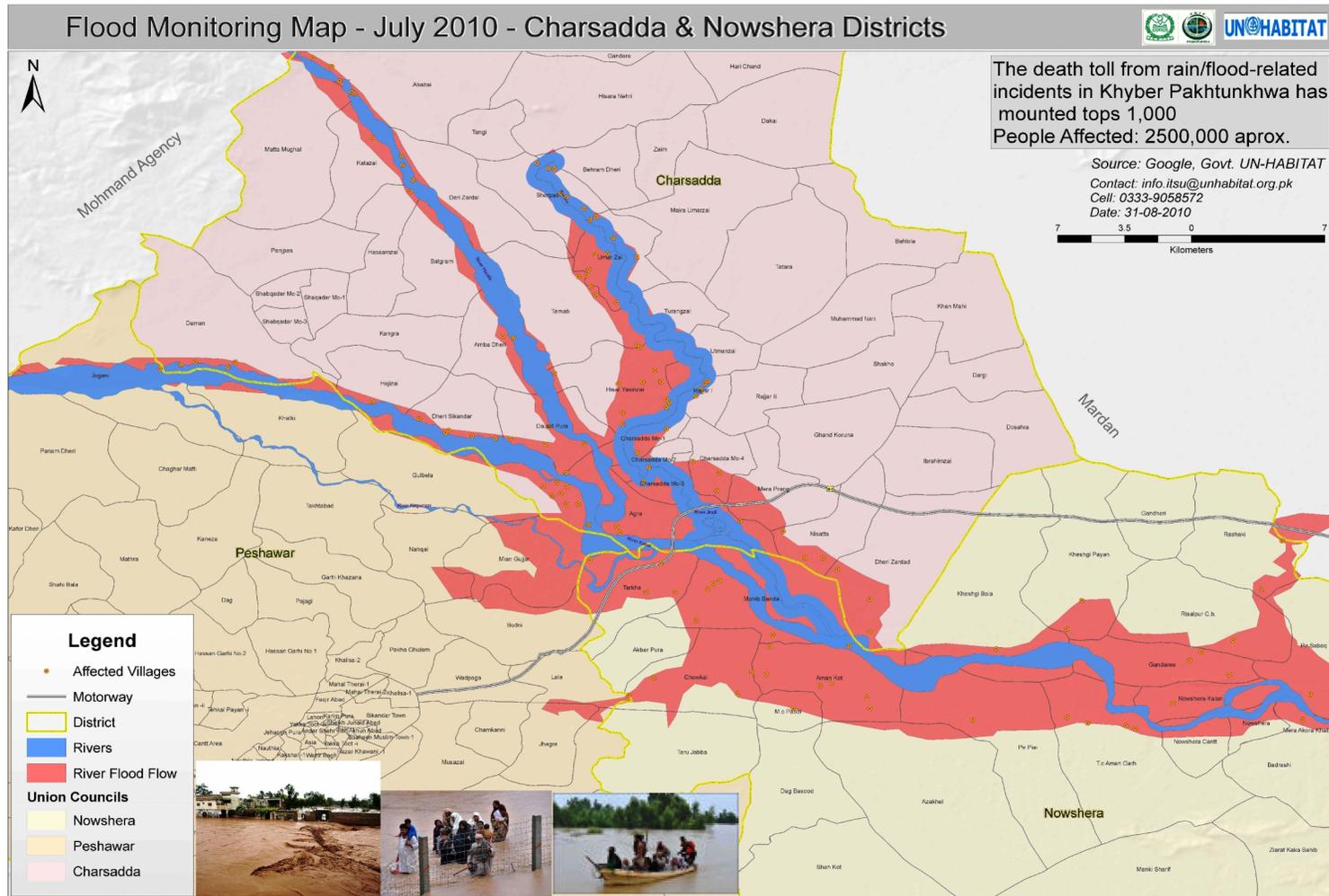


Fig. 6. Flood monitoring Map

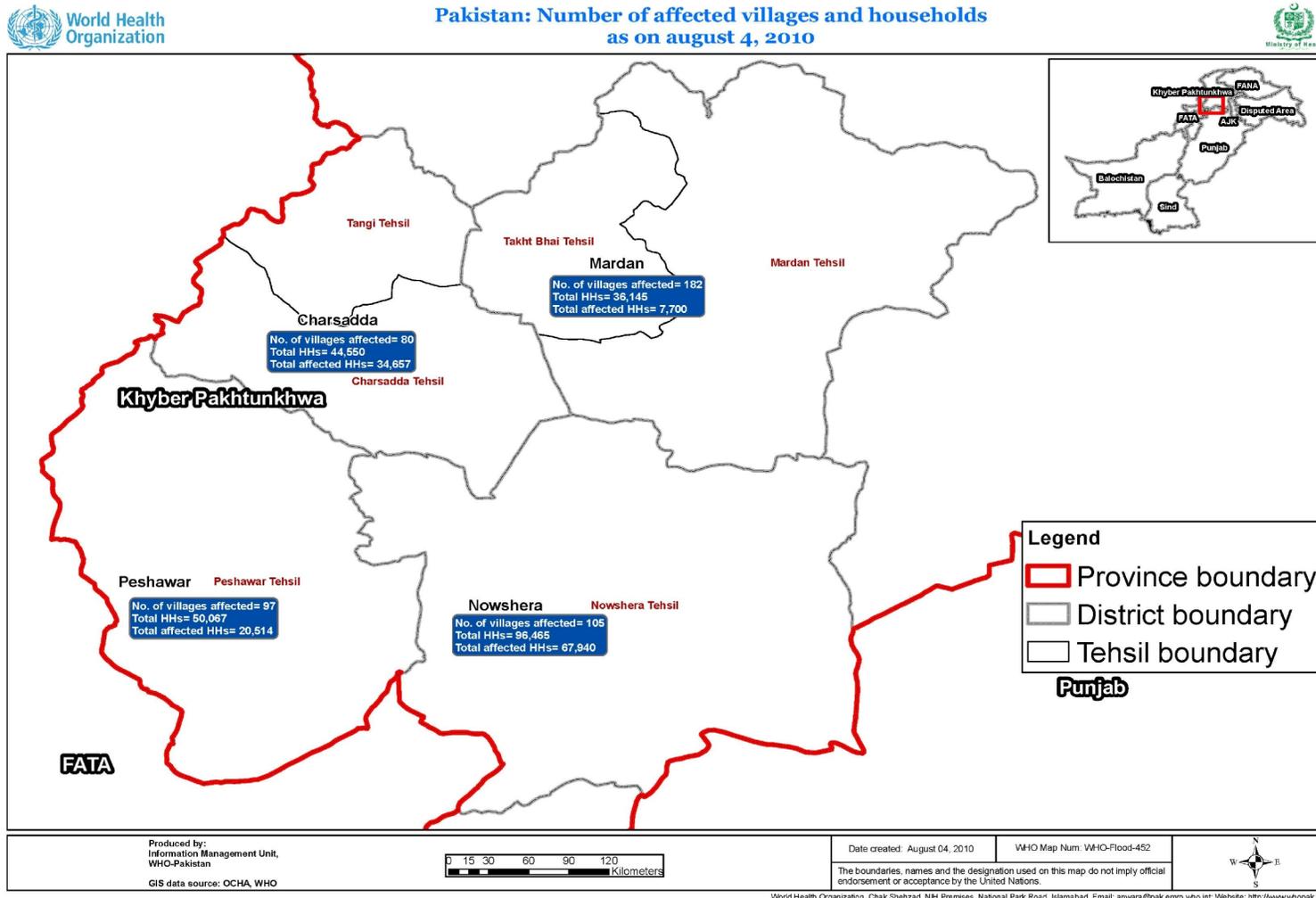


Fig. 7. Map developed by WHO to show the number of affected villages and households

The development of livestock and poultry sectors in Pakistan is dependent on promotion of maize crop. The crop, therefore, occupies high priority in agricultural development planning. The Kharif fodders include a number of crops as sorghum, millets and a variety of others. The damage of fodders caused very high discomfort to farmers, as fodders supply for livestock was restricted or cut in extreme cases. Tables 1, 2 developed by Pakistan Wetlands Programme [15] give the damage assessment of crops and area in the affected areas of Nowshera and Charsadda.

Table 1. Damage assessment of crops in Nowshera and Charsadda Districts

Crops	Area damaged (000 ha)	Damage (%)	Projected Production Loss (million tons)
Rice	5.5	47	0.02
Millet	0.9	80	0.3
Maize	16.7	-	-
Sorghum	0.9	80	0.3

Table 2. Damage to sugarcane and fodder crops in affected areas

Crops	Districts	Area Damaged (000 ha)	Yield Loss (tons/ha)	Damage Factor	Projected Production Loss (million tons)
Sugarcane	Charsadda	3.7	45	0.8	0.1
	Nowshera	2	50.4	0.5	0.1
Fodder crops	Charsadda	0.46	29.1	-	-
	Nowshera	1.64	24.9	-	-

2. MATERIALS AND METHODS

The two main districts of KP named Charsadda and Nowshera were the hardest hit by the unprecedented flood.

In order to investigate the water quality and climatic implications of floods, five water samples from the selected tube wells (main source), five from intermediate points and five from consumer's ends from each district were randomly collected in December 2010. A total of 30 samples from the areas were analyzed for water quality parameters where the majority of the inhabitants were dependent on ground water from the wells.

For the analysis of physical and chemicals parameters, each sample was collected in a fresh, clean and dry plastic bottle of 1.5 liters in capacity with air tight cap. Each bottle was marked with site name, time and date. Care was taken to avoid entry of external material in bottles during sample collection. Also, bottles were not absolutely loaded, so that they could be easily shaken before examination. Before sample collection, each well was pumped for about 5 to 10 minutes approximately. It was done to ensure that the collected water sample represented a clear picture of the properties of whole aquifer. Before collecting the water sample at the consumer's end, the tap was opened fully and ran for about 3 to 5 minutes. The faucet of the tap was sterilized with burner by putting it below the mouth of tap. It was done to avoid the entrance of the foreign matters during collection of water samples.

250 ml glass bottles were used for the analysis of bacteriological contaminants. First, the bottles were cleaned with detergents and rinsed with distilled water. Then 5 ml of Sodium thiosulfate in each glass bottle was taken and covered with air tight cap and was sealed with

aluminum foil tightly. These bottles were placed in an oven for about 45 minutes at 140°C. Bottles were finally sterilized. After collecting samples at the site, bottles were kept in ice coolers to transfer it to the laboratory. Table 3 shows the techniques and instruments used for finding various water quality parameters.

Table 3. Instrumental/Chemical techniques used for analysis of different water quality parameters

Sr. No	Water Quality Parameters	Techniques/Instruments used
1	Temperature	Celsius Thermometer for Field data
2	pH	pH Meter
3	Turbidity	Nephelometric Method
4	Electrical Conductivity	Conductivity Meter
5	Total Dissolved Solids	Gravimetric Method
6	Chloride	Titration Method
7	Nitrate	Colorimetric Method
8	Sulfate	Turbidimetric Method
9	Calcium	Titration method (using EDTA standard solution)
10	Magnesium	Titration method (using EDTA standard solution)
11	Coli form	Multiple fermentation tube technique
12	Fecal Coli form	Multiple fermentation tube technique

3. RESULTS AND DISCUSSION

The consuming water products from 10 main sources (tube wells), 10 intermediate points at pipe distribution system from main source and 10 consumer's ends from main source in 30 selected sites of flood affected areas were taken. Each sample was analyzed for 12 key factors. The results are presented in table 4 and each parameter is discussed in detail.

3.1 Temperature

Measurement of temperature is the most common physical parameter in assessing the quality of drinking water. It affects the chemical and biological characteristics of water. This study was carried out in December - January 2011. Table 4 shows negligible variation between the temperature of samples collected at intermediate point and its respective consumer's end while there is considerable variation between the temperature of the samples collected from tube wells and its respective sampling points.

3.2 pH

pH is a water quality parameter which is used to evaluate the level of acidity or alkalinity of drinking water. From the point of view of effective water treatment with chlorination, pH should be controlled and preferably be below 8. Generally, high pH value causes corrosion of metallic pipes which is associated with serious health problems due to the presence of heavy metals in drinking water leached inside the pipe distribution systems through which it passes. WHO guidelines [16] recommend a desirable limit of 6.5 to 8.0 for the pH of drinking water [17]. A little variation from this range is usually not associated to health issues but the value ranging from 10 to 12.5 have been documented to cause swelling of hair fibers and skin problems, and stomach disorders. While inflammation of eyes has also been reported with pH lower than 4. As given in Table 4, pH values for Charsadda district varies from 6.5 to 8.3 at main sources, from 6.8 to 8.7 at intermediate points and 6.7 to 8.9 at consumer's

ends. Whereas pH values for Nowshera varies from 5.6 to 9.2 at main sources, from 5.8 to 9.6 at intermediate points and 6.2 to 8.9 at consumer's ends. Tube wells # 1, 6, 7 and 10 should be regularly monitored for their pH increase against alkalinity and similarly tube well # 8 against acidity.

3.3 Turbidity

Turbidity is a measure of relative clarity and cloudiness of water. It is generally caused by the suspended and colloidal particles which are responsible for the obstruction of transmission of light through water. The WHO recommended value of turbidity should ideally be less than 1 NTU for effective disinfection. Table 4 shows that all the values are higher than the recommended value. For Charsadda its values varies from 11 to 16 NTU at main sources, 15 to 19 NTU at intermediate points and 18 to 22 NTU at consumer's ends. Similarly for Nowshera, its values vary from 13 to 16 NTU at main sources, 17 to 20 NTU at intermediate points and 19 to 25 NTU at consumer's ends, showing all the values are out of range and may lead to the rejection of drinking water by the inhabitants of the flood affected areas.

3.4 Electrical Conductivity and Total Dissolved solids

There exists a general relationship between Electrical Conductivity and Total dissolved solids (TDS) i.e. $[TDS (ppm) = Conductivity (\mu S cm^{-1}) \times (0.5 - 0.7)]$ [18]. In the present study, both tests were performed separately to get the precise values of both parameters. However, the approximated value of total dissolved solids can be found out by the above mentioned formula. The analysis of data for these two parameters showed that the conversion factor for overall samples was close to a value of 0.7.

The desirable value of 600 mg/l for TDS is proposed by WHO [14] on the basis of acceptability of drinking water. TDS with value higher than 1000 mg/l provide taste to the water and cause excessive scaling in pipes, heating units and boilers.

From Table 4, TDS at the consumer's ends and intermediate points for all samples is higher than that at the main sources. All samples show higher values than desirable limit. Samples from tube well #2 and #3 shows higher values of TDS than 1000mg/l. These high values may be because of the damaged pipe systems and leaked joints running through open drains and may affect the taste of water and can be rejected by the consumers.

3.5 Chloride

Chloride content for pollutants-free and fresh water is always less than 10 mg/l [19]. According to WHO guidelines, the chloride content less than 250 mg/l is considered good on the basis of acceptability for drinking since value higher than 250 mg/l imparts considerable taste to drinking water and consumers may reject use of such water. Table 4 shows that the chloride level for all samples are less than the desirable value for the samples obtained from Nowshera district but shows higher value for tube wells # 2, 3, 4 and 5 for Charsadda district. Chloride level increases remarkably approaching the consumer's ends for all samples may be due to the contact of leaked pipes with transmitted effluents from industries, human and animal wastes and highway salts during flooding. The higher chloride concentrations also causes corrosion of pipes and taps which may further contaminate water at intermediate and consumer's ends points.

Table 4. Water Quality Parameters for Main source, Intermediate points and End points

Parameter	Temperature (°C)			pH			Turbidity (NTU)		
Tube Well No.	Main source	Intermediate point	End point	Main source	Intermediate point	End point	Main source	Intermediate point	End point
1	18.0	18.8	18.8	8.30	8.70	8.90	11	15	18
2	19.2	21.0	21.2	7.24	7.5	7.7	11	15	19
3	18.5	18.8	18.5	7.01	6.80	6.70	13	16	19
4	20.2	21.0	20.7	7.40	7.90	7.10	15	19	22
5	17.0	19.6	19.6	6.50	6.90	7.01	16	19	21
6	20.5	22.5	22.2	9.20	8.90	8.80	13	17	20
7	17.6	18.8	18.2	8.70	8.95	8.90	14	17	19
8	18.3	21.0	20.9	5.60	5.8	6.20	17	20	25
9	19.2	23.5	23.2	8.20	8.00	8.00	13	16	20
10	21.5	24.4	24.1	9.10	8.90	8.7	16	20	24
Parameter	Electrical Conductivity (μScm^{-1})			Total Dissolved Solids (mg/l)			Chloride (mg/l)		
Tube Well No.	Main source	Intermediate point	End point	Main source	Intermediate point	End point	Main source	Intermediate point	End point
1	1133	1159	1265	793	800	873	221	208	208
2	1271	1307	1507	890	902	1040	275	305	322
3	1220	1351	1396	854	932.4	963.2	245	256	270
4	1299	1471	1562	909	1015	1078	268	299	312
5	1127	1249	1306	788.9	861.7	901	259	276	291
6	928	968	1013	649.6	667.8	699	167	172	198
7	1030	1143	1246	721	789	860	145	152	171
8	1030	1217	1335	721	840	921	172	175	192
9	1173	1319	1304	821	910	900	176	189	201
10	984	1064	1157	689	734	798	159	183	189
Parameter	Nitrate (mg/l)			Sulfate (mg/l)			Calcium (mg/l)		
Tube Well No.	Main source	Intermediate point	End point	Main source	Intermediate point	End point	Main source	Intermediate point	End point
1	10	12.5	16	74	83	94	59	62	57
2	8	10	14	102	115	120	42.5	44	46.7
3	9	11.5	14	178	182	184	31.8	31	35
4	12	15	17.5	167	172	175	21	19	25
5	7	10	13.5	172	175	198	47	47.5	50.6
6	17	21	27	345	348	357	27.4	28.5	23.5
7	16	19	24	309	312	314	54	50.6	56.5
8	16	21	26	312	316	316	68	53	65
9	20	24	29	198	209	213	19.6	22	22
10	21	24	30	302	304	304	18	23	23

Table 4 Continued.....

Parameter		Magnesium (mg/l)			Total Coli form (MPN / 100ml)			Fecal Coli form (MPN / 100ml)		
Tube Well No.	Main source	Intermediate point	End point	Main source	Intermediate point	End point	Main source	Intermediate point	End point	
1	48	52	53	13	15	22	7	10	16	
2	32	27	28.6	16	17	20	7	10	14	
3	26	27	27	14	18	22	8	9	13	
4	19.8	22	22.8	26	27	29	15	17	19	
5	20	17	20	17	22	28	7	14	17	
6	29.8	34	32.5	22	26	32	14	19	22	
7	41	47	49	18	20	25	10	13	15	
8	44	49	48	24	29	32	14	17	19	
9	13	15	17	26	28	31	14	16	19	
10	14	15.5	16.7	20	23	27	10	13	16	

3.6 Nitrate

According to WHO guidelines the nitrate content in drinking water should be less than 50 mg/l. The higher level of nitrate ions may cause an unusual illness; ingestion of such water also affects health of pregnant women [20]. From Table 4, nitrate level in all the samples falls within the desirable limit and therefore, is acceptable for drinking and other domestic purposes. The variation of nitrate level from main source to the consumer's ends may be attributed to the poor sanitation system, improper disposal of human and animal wastes and open septic tanks and their contact with the pipe distribution systems in the study area. However, the nitrate concentrations in the principle sources are higher for Nowshera district as compared to Charsadda district. Earlier studies revealed that the exceeding level of nitrate in sub surface water may be increasing due to the extensive use of nitrogen fertilizers and human and animal wastes [21].

3.7 Sulfate

No guideline value for Sulfate related to health concerns has been established by WHO. However according to WHO guidelines the desirable limit for sulfate ions in drinking water should be less than 250 mg/l. The higher concentration level of sulfate imparts bitter taste and rotten egg smell to drinking water and causes scale in water pipes [22]. Water with high content of sulfate causes severe dehydration and Diarrhea in every age of people. Young and old age people may become accustom using such water with the passage of time but care should be taken while using such water in the food preparation for infants. From Table 4, the sulfate concentration level in all samples falls within the safe limits except for tube wells # 6, 7, 8 and 10 which are greater than the permissible limit.

3.8 Calcium

While flowing through the rocks and soil, water dissolves some minerals. Water containing two important and common minerals Calcium and Magnesium in high range is known as hard water. Calcium is a key nutrient for health, structure of bones, muscular contraction, cell signaling and blood clotting [23]. In 2001, an expert consultant for the Food and Agricultural Organization (FAO) and WHO set recommended nutrient intakes (RNIs) for Calcium at 1,000 mg/day for women aged 19-50 and men aged 19-65 years, and 1,300 mg/day for women of age 51-65 years [23]. To avoid the chances of developing osteoporosis, nephrolithiasis and hypertension, it has been recommended that adequate consumption of calcium should be taken in daily dietary intake. Table 4 shows that the concentration of calcium content in samples from main sources varies from 21 to 59 mg/l for Charsadda and from 18 to 68 mg/l for Nowshera, at intermediate points it varies from 19 to 62 mg/l for Charsadda and from 22 to 53 mg/l for Nowshera and at consumer's ends it varies from 25 to 57 mg/l for Charsadda and from 22 to 65 mg/l for Nowshera.

3.9 Magnesium

Like Calcium, Magnesium is also a nutrient mineral and a vital component of water. It partially contributes to the hardness of water. It is introduced to the ground water in the wells by the rocks enriched with magnesium minerals. In 2001, an expert consultant for the Food and Agricultural Organization (FAO)/WHO set recommended nutrient intakes (RNIs) for Magnesium at 220 and 260 mg/day respectively for women and men aged 19-65 years old [23]. The concentration of Magnesium content in samples from main sources varies from 20

to 48 mg/l for Charsadda and from 13 to 44 mg/l for Nowshera, at intermediate points it varies from 17 to 52 mg/l for Charsadda and from 15 to 49 mg/l for Nowshera and at consumer's ends it varies from 20 to 53 mg/l for Charsadda and from 17 to 49 mg/l for Nowshera (Table 4). The increase in Mg level from one sampling point to another point may be attributed to the intrusion of effluent of chemical industries into the leaked and damaged pipe distribution systems. The higher values at main source may be attributed to the presence of the Mg-rich rocks in the localized area.

3.10 Total Coliform bacteria and fecal Coliform

Total coliform bacteria are a group of bacteria generally present in the environment. Fecal coliform are a sub group of total coliform which are present in the human and animal feces. The hefty flooding and increased precipitation in the study area increased the occurrences of total coliform bacteria in water. Since the wells of the study area have been designed using old standards, lacking of regular maintenance of the wells and pipe distribution systems, submergence of wells and pipes in floods and rain water, open septic tanks and sewer systems and inadequate drainage systems, all these factors contributed to the presence of total coliform and fecal contamination at all sampling points and correspondently gave rise to infectious and serious water borne diseases. Any water to be used for intake or food preparation should be free of all such contamination. The flooded areas are more prone to water borne disease outbreaks. WHO guidelines recommended a value of Zero M PN per 100 ml for total coliform as well as for fecal coliform bacteria [17] [24]. Table 4 shows that all the values are more than 0 M PN per 100 ml ranging from 13 to 26 M PN/100 ml at main sources, 15 to 29 M PN/100 ml at intermediate points and 20 to 32 M PN/100 ml at consumer's ends for total coliform bacteria. In addition, the values are also higher than 0 M PN per 100 ml ranging from 07 to 15 M PN/100 ml at main sources, 09 to 19 M PN/100 ml at intermediate points and 13 to 22 M PN/100 ml at consumer's ends for fecal coliform bacteria.

4. CONCLUSION

As it is quite clear from the results, the groundwater is polluted and unfit for drinking purposes. It can be declared that floods cause a direct impact on environment and all its components. There is an intense need of environmentally sound and feasible arrangement of drinking water provision for people affected by floods in any part of the world as water quality becomes no more reliable when hit by floods. Climatic implications of floods on water quality may not only cause diseases in humans but may also destroy the aquatic life and hence disturb the complete natural cycle. The natural dynamics of floods should be investigated and a wise policy taking into consideration environmental aspects should be formulated and strictly implemented. In order to make sure that environmental concerns are judiciously and properly represented in flood management decisions, individual cases must be assessed from a basin-wide perspective.

Proactive measures should be adopted in the regular flooded-area to avoid contamination from the wastes, prior to flooding. The types of crops should be suggested that can tolerate flooded water of a specific nature and contaminants not causing rotting of organic matters, if it is required to divert flood water into farmlands during peak flood. System weaknesses and operational shortcomings should be identified based on historic floods and develop conceptual improvements, including the integration of non-structural alternatives, in anticipation of major floods instead of in response to them. This may be accomplished by approaching problems holistically. By considering the entire system, operational plans

should integrate existing and proposed structural and non-structural flood control measures to compose comprehensive flood management strategies. If severe flooding remains, the major impetus for policy change, a plan in hand will allow full utilization of the post-flood window of opportunity created by heightened social awareness and disabled structural controls. The study of the quantitative environmental aspects of severe flooding should be continued. A new branch of the study should include ecological and biological modeling.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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