Role of Distribution System in Safe Water Supplies A Study Case of Rawalpindi

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Summery: Water distribution network is the most significant part in terms of cost and the vulnerability of a potable water system. Micro organism can enter the pipe system by a variety of routes ranging from insufficient treatment to leakage/ faults in the pipes. Pollution occurring during storage and distribution was the main cause of 8 outbreaks out of 21 occurring between 1911 and 1937. Water crisis of Hyderabad is live in minds of the people of Pakistan. Water and Sanitation Agency (WASA) is responsible for water distribution system in Rawalpindi. Water from Rawal Dam and Khanpur Dam is treated in treatment plants at Chak Shahzad and Sangjani and released in distribution system comprising of ground reservoirs, overhead reservoirs and distribution pipes. Water samples collected from 27 different points of the distribution systems were analyzed for the assessment of bacteriological contamination. Water samples collected from three ground/ overhead reservoirs and seven distribution points were found free from bacterial contamination. Remaining samples have high level of bacterial contamination, which is a matter of great concern. WASA should make immediate remedial measures to decontaminate these water supplies.

Introduction

All human beings have basic right to have an adequate quantity of good quality safe water for promotion of good health. It is well established that water quality and health are intrinsically linked. Contaminated water supplies are major contributors to disease while clean and abundant supplies of water, together with adequate sanitation, contribute greatly to improved health. Water distribution network is the most costly and most vulnerable portion of a potable water system. Microorganism can enter the pipe system by a variety of routes ranging from insufficient treatment to leakage/ faults in pipes. The pipe system is not sterile nor was it even intended to be sterile. Microbial processes within the water distribution network can have noticeable impacts on quality of water delivered to the customer's taps. Growth of micro-organism can significantly contribute the corrosion, increase hydraulic roughness, impart undesirable tastes and odors and cause "red (iron) or black (sulfide)" water [1].

Whatever the source of water supply and however pure the water from it may be today, it cannot be regarded as free from risks of pollution in the future. Every reasonable effort should be made to ensure that the raw water is protected from contamination and it should not be put into supply without appropriate treatment to remove any risk of bacterial infection. Faecal contamination is a major problem being wide spread and severe in both urban and rural areas. Gastrointestinal diseases account to about 30 % of all the hospital reported cases and about 40 % deaths can be attributed to water born diseases. Diarrhea accounts for about 45 % of children deaths [2]. It is estimated that about five hundred million people in the world are affected by water born and water associated diseases each year and out of this number about 10 million (half of them infants) die from illness like typhoid, cholera, infectious hepatitis, bacillary and amoebic dysentery and many varieties of Gastrointestinal diseases [2].

Between 1911 and 1937 there occurred 21 out breaks of diseases conveyed by public water supplies. Pollution prior to storage and distribution was responsible for 13 of these outbreaks which involved 04 over ground supplies and 9 underground sources. In 2 cases pollution occurred during storage and in the rest during distribution. The numbers of known cases of diseases resulting from these outbreaks were: enteric fevers, (including paratyphoid) 1237, bacillary dysentery 2800 and gastro-enteritis 7439 [3]. According to a survey conducted by Pakistan Council for Research in Water Resources (PCRWR) at least in 21 cities of Pakistan, water supplies were found bacteriologically contaminated [4]. Death of

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more than 40 people and more than 4,000 gastro-intestinal illness cases due to contaminated water supply in Hyderabad, Pakistan is a recent incident [5].

The intentional application of biocidal compounds to water and wastewater to inactivate infectious agents has evolved as the primary barrier against the transmission of disease by the water route. In many potable water systems, disinfection is the only treatment before the water is passed to the distribution network. Residual disinfectants in the pipe network provide a relatively effective barrier to growth of microorganisms [6]. Some protection against the transmission of disease due to post treatment contamination [7]. Chlorine has been almost universally employed for the disinfection of water and wastewater [8].

The benefits of safe and adequate drinking water supply are not automatically assured with the construction of water supply system. Indeed experiences have shown that without proper surveyllance the water supply system itself may become an effective channel for spreading water born diseases. This type of diseases can easily be spread through improperly maintained water supply system, so there is no doubt a necessity to buildup and maintain well organized and efficient water quality surveillance programme to ensure safe and adequate supply of drinking water and to protect the public from water born diseases.

In providing safe supplies of water to consumers, it is essential to carefully consider not only its source but its collection, storage and final delivery. The source depends upon local condition, viz. rivers or canals, tube wells or springs etc. Whatever the source, it must be protected from contamination. Storage of water is generally necessary but the method depends upon the source. For upland surface water, storage is done either in a natural lake or in an impounding reservoir. The size of reservoir depends upon the area of the land available, the size of the population etc. Water from these reservoirs is given proper treatment and then pumped into city reservoirs for distribution. These service reservoirs or storage reservoirs are big enough to hold at least a week's supply. Water is supplied to city from reservoirs through iron pipes laid underground. These are usually of cost iron. These are subject to rust and erosion if the water is soft. These pipes are coated by "Angus Smith solution" (pipe is heated to a high temperature and then dipped in hot varnish consisting of coal tar pitch, resin and linseed oil) or Barff's process (iron pipes are heated to white heat and then exposed to supper heated steam for several hours in this way a film of magnetic oxide of iron is formed) [9]. The mains are laid at a depth of at least three feet to protect from frost and sun. An enormous amount of leakage takes place from water mains owing to fractures resulting from settling of soil after lying and detection of leakage is very difficult.

While distributing water in a city care should be taken that every part of it gets an equal supply. Overhead reservoirs/ tanks are built for this purpose. Water from these reservoirs reaches to the consumer taps due to gravity. The house connection pipes are always made of lead. Because they can be easily bent, joined and are rustles, some times cost or wrought iron pipes are also used after coating with Angus Smith solution. Water is supplied to a town either through constant or intermittent system. Intermittent water supply system is used in Rawalpindi as water is supplied only for a few hours in a day. Due to this system arrangements are to be made for storage of water in receptacles.

Rawalpindi is supplied water obtained from surface water sources such as Rawal dam and Khanpur dam. Appropriate treatment is given to the water at treatment plants. Surface water from Khanpur dam is carried through a closed channel to the treatment plant at Sangjani, near Facto Cement Factory. Raw water from Rawal dam is taken to Chak Shahzad filtration plant about one kilometer away from the dam through an open channel. Process of water treatment of both filtration plants is almost same. Raw water of these reservoirs is added with alum solutions (chemical coagulation) and then passed through flocculation chamber, as floc settle during sedimentation period, clarified water then passed through quicksand filter beds. After the chlorination is done and water released into distribution system of WASA (water and sanitation agency) which is responsible for water distribution system.

Water distribution system comprises of the following

1. Ground Storage Reservoirs
2. Over Head Reservoirs / Tanks
3. Distribution pipes

Table-1: Rawal Dam and Khanpur Dam

S. No.	Sample Location / Identification	Bacteriological Test		
		Faecal Coliform	Viable Count	Coliform Count
0	WHO Guide Lines	Nil	Nil	Nil
1	Rawal Dam Filteration Plant Raw Water Line	Positive	$2x10^4$	$4x10^3$
2	Rawal Dam Filteration Plant wash out point	Negative	$1.9x10^4$	Nil
3	Rawal Dam Filteration Plant after Chlorination	Negative	Nil	Nil
4	Khanpur Dam Lake	Positive	$1.7x10^4$	$3x10^3$
5	Khanpur Dam Raw Water Sangjani Treatment Plant	Positive	$1.9x10^4$	$4x10^3$
6	Khanpur Dam Post Chlorination Point after treatment	Negative	$6x10^2$	$4x10^2$

Ground and Over Head Reservoirs,Water Distribution System, Consumer Tanks

S.No	Sample Location / Identification	Bacteriological Test		
		Faecal Coliform	Viable Count	Coliform Count
	WHO Guide Lines	Nil	Nil	Nil
7	GWT Commercial Market Park	Negative	$2x10^2$	Nil
8	Ground Storage Reservoir Water Works No.1	Negative	4x102	Nil
9	Ground Storage Reservoir Water Works No.2	Negative	$6x10^2$	$2x10^2$
10	Over Head Reservoir Dhoke Hassue	Negative	$2x10^2$	Nil
11	Over Head Reservoir Khyaban-e-Sir Syed	Negative	Nil	Nil
12	Over Head Reservoir Public Park Murree Road	Negative	Nil	Nil
13	Over Head Reservoir Shamasabad	Negative	Nil	Nil
14	WDS Arya Mohallah	Positive	$1.3x10^4$	$2.8x10^3$
15	WDS Chah Sultan	Negative	Nil	Nil
16	WDS Mohallah Kartarpura	Negative	Nil	Nil
17	WDS Mohallah Amarpura	Negative	Nil	Nil
18	WDS Dhoke Ratta amral	Negative	Nil	Nil
19	WDS Nia Mohallah	Negative	$3x10^3$	$1x10^3$
20	WDS Satellite Town E- Block	Negative	Nil	Nil
21	WSD Khurram Colony	Positive	$1.3x10^4$	$3.4x10^3$
22	WDS Muslim Town	Positive	$6x10^3$	$2x10^3$
23	WDS Dhoke Hassu	Negative	$1x10^2$	Nil
24	Consumer Tank House NO # PD-226, Pandora	Positive	$2.4x10^4$	$5x10^3$
25	Consumer Tank House # AA-684,Workshopi Mohallah	Positive	$2.2x10^4$	$3.6x10^3$
26	Consumer Tank L-935,Dhoke Khabba	Negative	$2x10^2$	Nil
27	Consumer Tank B II-10 Muslim Town	Positive	$1x10^4$	$2x10^3$

Results and Discussion

Results are shown in Table-1 as well as in Fig. 1 and 2.

Rawal Dam and Khanpur Dam

As shown in analysis raw water of Rawal dam and Khanpur dam has high level of bacterial contamination. Presence of Coliform and *E. coli* indicates biological contamination in untreated water of these reservoirs. However after treatment water of Rawal dam was free from bacterial contamination, while water of Khanpur dam was not completely disinfected.

Ground Storage Reservoirs

Bacterial contamination was observed in all reservoirs as shown by viable count. Coliform contamination was also observed in ground storage reservoir water works No. 2. Faecal Coliform was not detected in any of these reservoirs.

Overhead Reservoirs

One overhead reservoir, Dhoke Hassu showed viable count only while Coliform and Faecal contamination was not found in these reservoirs.

Water Distribution Pipes /Consumer Taps

Out of 14 points only 5 were found free from bacterial contamination while others showed high level of viable bacterial count.

Experimental

In total 27 sampling points of Rawalpindi water distribution system of WASA were selected to collect water samples for bacteriological quality assessment.

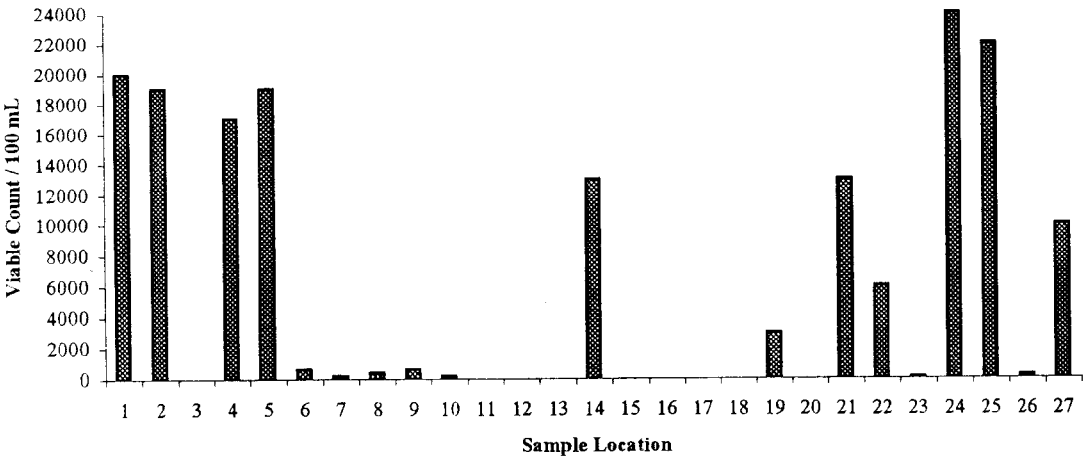

Fig. 1: Determination of Viable count.

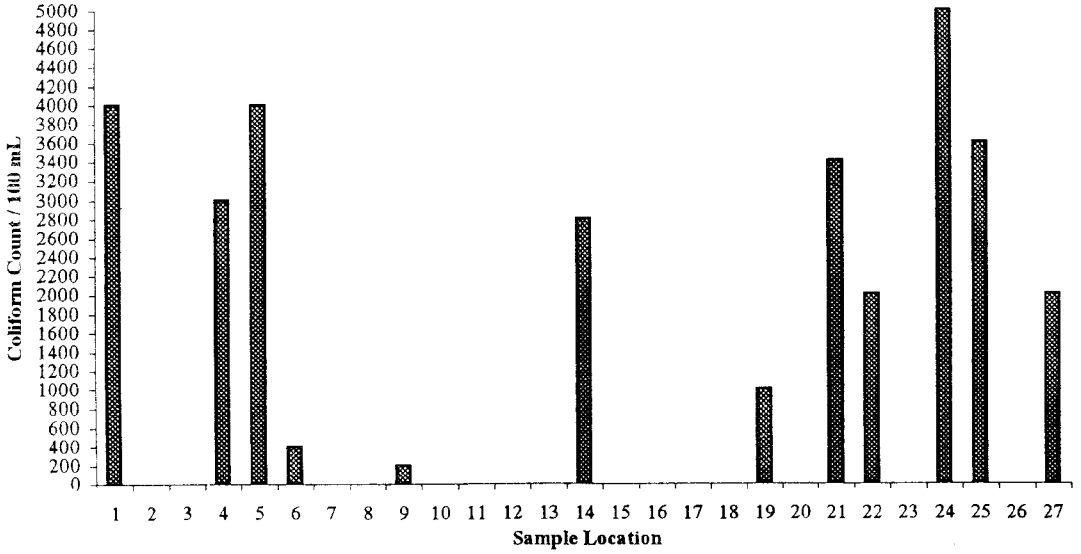

Fig. 2: Determination of Coliform count.

1. Rawal dam Filtration Plant. 03 Locations
2. Khanpur dam Filtration Plant 03 Locations
3. Ground Storage Reservoirs 03 Locations
4. Over Head Reservoirs 04 Locations
5. Water Distribution Pipes/ Taps 10 Locations
6. Consumer Tanks/ Taps 04 Locations

Detail of these sampling points is given in Table-2

Grab samples were collected in sterilized glass bottles of 250 mL capacity with ground stoppers. Collected samples were labeled properly and immersed immediately in coolers containing ice blocks. Bacteriological analysis was carried out using prescribed standard methods [10].

Conclusions

Most of the water samples showed high level of bacterial contamination. The elevated level of thermo tolerant Coliform was detected making water unfit for human consumption. The presence of *E. coli* indicates wide spread of faecal contamination in untreated reservoirs and in some terminals of the

Table-2: Water Sampling Points

Sr. No	Distribution System	Location
01	Rawal dam	Raw water line Rawal lake
02	Rawal dam	Treatment Plant washout point
03	Rawal dam	Treatment Plant after chlorination
04	Khanpur dam	Khanpur dam , Lake
05	Khanpur dam	Raw water Sangjani, Treatment Plant
06	Khanpur dam	Treatment Plant after Chlorination
07	Ground Storage Reservoir	Commercial Market Park
08	Ground Storage Reservoir	Water Works No-1
09	Ground Storage Reservoir	Water Works No-2
10	Over Head Reservoir	Dhoke Hassu
11	Over Head Reservoir	Khyaban-e-Sir Syed
12	Over Head Reservoir	Public Park, Murree Road
13	Over Head Reservoir	Shamasabad
14	Water distribution System	Arya Mohallah
15	Water distribution System	Chah Sultan
16	Water distribution System	Kartarpura Mohallah
17	Water distribution System	Amarpura Mohallah
18	Water distribution System	Dhoke Ratta Amral
19	Water distribution System	Nia Mohallah
20	Water distribution System	Satellite Town , E -Block
21	Water distribution System	Khurram Colony
22	Water distribution System	Muslim Town
23	Water distribution System	Dhoke Hassu
24	Consumer Tank/Taps	House #PD-226 , Pandora
25	Consumer Tank/Taps	House # AA-684,Workshapi Mohallah
26	Consumer Tank/Taps	House # L-935, Dhoke Khaba
27	Consumer Tank/Taps	House # BII-10, Muslim Town

distribution system. Intermittent water supply system of Rawalpindi favors corrosion of service pipes. Foul air and polluted matter can easily be sucked in. So contamination observed might be attributed to leaky /faulty distribution piping system and some accidental contamination which needs periodic surveillance. Rawal dam and Khanpur dam are receiving sewer along with the run offs from catchment area. It is dire need to protect these reservoirs from this contamination. It is moral responsibility of WASA to ensure that water released from treatment plants is free from bacterial contamination.

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