MICROBIOLOGICAL CONTAMINATION IN GROUNDWATER OF WAH AREA

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ABSTRACT: During the past few decades the population of Pakistan has increased at a very fast rate and the centers of population growth were the industrial cities where better job opportunities exist. The town of Pakistan Ordinance Factories Wah stretched many fold during 1980 to 2010. Due to this expansion, construction of new settlements took place in the surrounding of the town without adequate town planning and allied facilities such as clean drinking water and online sewage disposal system. In these settlements the local inhabitants disposed off their wastes in open channel or through dugwells which caused contamination of shallow aquifer. To investigate microbiological contamination in groundwater of Wah cantonment area, 30 water samples were collected, 20 samples from unconfined shallow aquifer and 10 samples from deep aquifer. These samples were analyzed by multiple tube method for estimation of coliform and faecal coliform bacteria. The results reveal that the unconfined shallow aquifer (45-85 feet deep) has been found highly polluted where as the deep aquifer (180 – 300 feet depth) is still safe and found uncontaminated. Shallow aquifer has been found 100 % contaminated with coliform and faecal coliform. Management measures to protect the groundwater have also been discussed for rehabilitation of the contaminated aquifer.

Key words: Microbiological contamination, groundwater, shallow aquifer, deep aquifer, multiple tube method.

INTRODUCTION

Contamination of water caused by sewage or through excrement of human and animal is one of the most common and widespread danger associated with drinking water. If the contamination is recent and among the contributors, there are carriers of the communicable enteric diseases, the drinking of water or its use in preparation of certain foods may result in further causes of infection (WHO, 1984-a). The known pathogenic organisms cause disease from mild gastroenteritis to severe and sometimes fatal dysentery, cholera, or typhoid. (Mcfeters, 1987). The use of normal intestinal organisms as indicators of faecal pollution rather than the pathogens themselves is a universally accepted principle for monitoring and assessing the microbiological safety of water supplies (WHO, 1971). Ideally findings of such indicator bacteria should denote the possible presence of all relevant pathogens. The coliform organisms especially Escherichia coli are the essential indicator of pollution by faecal material of human or animal origin (Lerner, *et al*., 1993).

Of the intestinal protozoa pathogenic for human may be transmitted by drinking water, however waterborne infection with these organisms is almost always associated with recreational contact rather than with the drinking water (WHO, 1984-b). A great variety of helminthes eggs and larvae have been detected in drinking water, however the vast majority of such helminthes are not primarily waterborne and it is not necessary to monitor them (WHO, 1984-b). Therefore these groups have not been emphasized while the bacteriology which is of paramount importance for contamination point of view (Andrews *et al*., 1993).

Generally groundwater in shallow aquifer or even in deep aquifers is rarely or never found completely sterile. Under certain conditions coliform organisms may also persist on nutrients derived from non metallic construction materials. For these reasons the presence of small numbers of coliform organisms (1-10 organisms per 100 ml) particularly in untreated groundwater may be of limited sanitary significant provided faecal coliform organisms are absent. But when the number of coliform bacteria increases from usual levels it is very serious and needs immediate attention to protect the lives of inhabitants from outbreaks of pathogenic disease (WHO, 2008).

Foster *et al*. (1999) while discussing the role of high population growth in water contamination has reported, "Urban population growth in Asia and Latin America is occurring on a scale, and at a rate, unprecedented in human history. Many of the cities are sited on unconfined or semi confined aquifers, depend on groundwater for much of their water supply and apply to dispose of most of their liquid effluent and solid residues to the ground".

A number of research workers have reported microbiological and chemical groundwater contamination due to industrialization and urbanization and others worked on the protection of water resources (Oliver, 1999, Hanan, *et al* 2010; Haider and Ali, 2011; Anwar, *et al* 2010; Khan and Malik, 1995 and Whitehead *et al*

1999). On the basis of these research studies WHO (1984-a,b) and many other countries have recommended safe permissible limits for various types of contamination related to water. This study has been performed as a part of Ph D research project and partial results are being published through this article.

MATERIALS AND METHODS

Multiple tube method recommended by WHO (1985) was used for the detection and estimation of coliform and faecal coliform. This method is based on the incubation of water samples in the laboratory.

Commercially available dehydrated media simplify the preparation of culture broth. Several different culture media are available for presumptive test, MacConkey broth was used for our work and brilliant green lactose bile broth was used as confirmatory medium for total coliform. Media were prepared in accordance with the manufacturer instruction. All the samples were analyzed by adopting standard testing procedure of WHO (1985) for determination of coliform and faecal coliform as MPN per 100 ml. According to WHO (1984a) bacteriological quality of drinking water E.coli or thermotolerant coliform bacteria must not be detectable in any 100ml sample.

RESULTS AND DISCUSSION

The subsurface hydrogeological set up of the study area plays a very important role in microbiological contamination of the groundwater. Khan (1997) reported four aquifer layers in the Wah cantonment area, "two of these aquifer layers are being used for exploitation of groundwater through dugwells at shallow depths while the remaining two bottom aquifer layers are being exploited for groundwater through tubewells and which are at deeper depths".

The results of estimation of coliform and faecal coliform from shallow aquifer of groundwater (45 – 85 feet) are shown in Table 1. The range of coliform estimated from various dugwells sampled from the study area is 2400^{+} to 240 MPN per 100 ml. Coliform distribution map has been prepared for the study area (Fig 1) which shows three distinct zones. Two high polluted zones, one in the north and other in south while the less polluted zone is the central zone. The highest value of coliform bacteria is more than 2400 MPN encountered in Lalazar and Babra Village while the lowest value is 345 MPN/100 ml from dugwell at Shah wali.

he results of water samples collected from deep aquifer layers (180-300 feet) are presented in Table 2. The range of coliform bacteria is 180 to 10 MPN in 100 ml. Most of the tubewells where only deep aquifer layers are penetrated have no faecal coliform which indicate that the deep aquifer is still uncontaminated in the study area. However two tubewells at Lalarukh Wah and Shah Wali contain faecal coliform as 8 & 5 MPN in 100 ml respectively. These tubewells were installed up to the depth of approximately 150 feet and subsequently closed. The thick clay over laying the deep aquifer is providing protection against vertical penetration of faecal coliform. However the presence of coliform in the tubewells is alarming and needs immediate management measures.

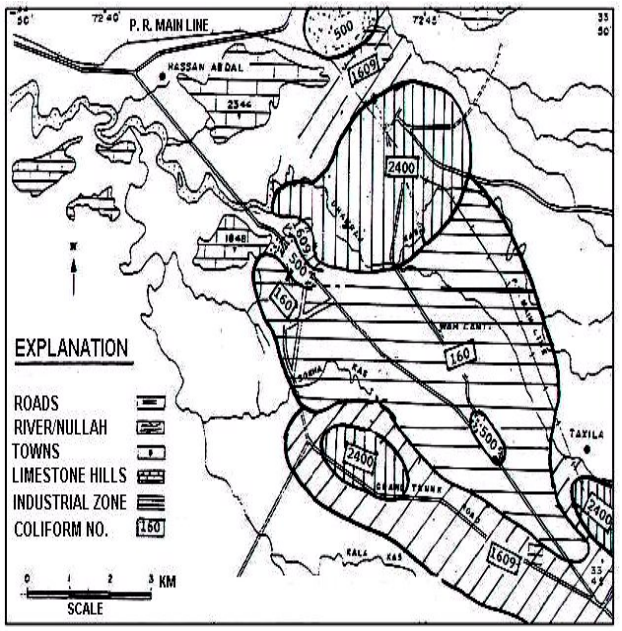

Fig. 1 Location map of study area indicating the horizontal distribution of coliform bacteria based on analyses from shallow aquifer.

In north and south zones, composed of various settlements in private sector, there is no adequate arrangement to meet water requirements. The inhabitants have punctured shallow aquifer to meet their water requirements, and disposed off their sewage and other waste water in the same area through shallow dugwells or through open drains as indicated in Fig. 2 (Khan,1995). To protect the further degradation alternate water supplies are suggested to be initiated from deep tubewells and online sewage disposal system be made compulsory for all the colonies such as Lalazar, Shah Wali and Babra of private sector in the surrounding of Wah area.

anagement measures for disinfection of drinking water recommended by WHO (2008) should be adopted as: "bringing water to a rolling boil and cooling before consumption. Vigorously shaking small volumes of water in a clean, transparent container, such as a soft drink bottle, for 20 second and exposing the container to sunlight for at least 5 hour. Applying products, such as tablets or other dosing techniques to disinfect the water, with or without clarification by flocculation or filtration".

Table 1. Results of bacterial analyses of groundwater samples from dugwells (45-85 feet) depth

Sr. No.	Location	Coliform (MPN/100 ml)	Faecal Coliform (MPN/100 ml)	WHO bacteriological quality of drinking water standard (MPN/100 ml)
1	Lalazar	2400+	240+	Zero
2	Babra Villege	2400+	240+	Zero
3	Shah Wali	2400	240	Zero
4	Shah Wali	1609	240	Zero
5	Shah Wali	345	240	Zero
6	Shair Shah Soori Garden	240+	240	Zero
7	Nawababad	240+	70	Zero
8	Gulshsan Colony	240+	54	Zero
9	New Lalazar	240+	38	Zero
10	New Lalazar	2400	240+	Zero
11	Bodu Road	2400	240+	Zero
12	Railway crossing market	2400	240+	Zero
13	Hazara Road	542	38	Zero
14	Sarah-e-Kala Taxila	240+	18	Zero
15	Nawababad	240	20	Zero
16	Shah Wali	1720	54	Zero
17	Loser Shirfo	2400	240+	Zero
18	Bani Mohallah Taxila	240+	240	Zero
19	Loser Shirfo	2400	240+	Zero
20	Nawababad	1609	72	Zero

Table 2. Results of bacterial analyses of groundwater samples from tubewells (180-300 feet) depth

Sr. No.	Location	Coliform (MPN/100 ml)	Faecal Coliform (MPN/100 ml)	WHO bacteriological quality of drinking water standard(MPN/100 ml)
1	Near CSD Wah	35	0	0
2	Sir Syed College	34	0	0
3	Lalarukh Wah	38	8	0
4	Nawababad	24	0	0
5	Sui Gas Colony	180	0	0
6	Rai Mamorial Hospital	10	0	0
7	Gadwal	180	0	0
8	Ordinance Club	37	0	0
9	Shah Wali	10	5	0
10	Lalarukh	35	0	0

Fig. 2 Sewage disposal well in hard rock containing shallow aquifer in Gulshan colony.

Conclusions and Recommendations: The results of water samples analyzed for coliform and faecal coliform bacteria indicate high level of bacterial contamination in the study area. In all the samples from shallow aquifer the contamination level has crossed the recommended limits of WHO (1984).

The major cause of the contamination is disposal of sewage waste through dug well system in the new settlements in private sector. The deep aquifer layers are still safe from faecal coliform contamination.

It is suggested that pumping from shallow aquifer in Lalazar, Babra and Gulshan area through dugwells should be stopped forth-with and periodic monitoring of all the deep groundwater wells is also recommended.

Acknowledgement: The WAPDA and POF Wah authorities are greatly acknowledged for providing the research facilities for this study.

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