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Evaluation of drinking water quality and waterborne disease prevalence in children at Shah di Khoi, Lahore, Pakistan

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Abstract

This study examines the relationship of drinking water sources with the consequential health issues in children regarding incidence and prevalence of waterborne diseases like, Typhoid, Cholera, Hepatitis A & E, Diarrhea Dermatitis and Worm infestation in Shah di Khoi, Lahore, Pakistan. Primary data sources such as drinking water samples, and questionnaire field survey were used to examine the pollution of drinking water and its health effects upon children aging less than 5 years. The field survey was conducted from June to August 2018 and 350 households were visited in the study area and were inquired about their sources of drinking water, water quality related issues and any prevalence of waterborne disease among children during the survey period. The common drinking water sources were local bore water and water fetched from filtration plants. Water samples were collected from the households where sick children were found and were tested for physical parameters including pH value, total hardness, total dissolved solids and electrical conductivity; and microbiological parameters such as total coliforms and Escherichia coli. The results of tested water samples for physical parameters were found well within the permissible ranges of the World Health Organization (WHO) standards. However, microbial contamination was found in few samples of local bore water and filtration plant. The most common diseases found in children were Cholera, Diarrhea, Typhoid, Hepatitis A and E, etc. The field observations confirm that most of the drinking sources were affected by bacterial contamination and was resulting in the incidence of waterborne infections among children in the study area. This study suggests for future laboratory investigations to assess the water quality, and to correlate waterborne diseases to responsible factors on larger scale through geospatial maps using modern techniques based on Remote Sensing (RS) and Geographical Information System (GIS). This will also help determine other environmental factors playing role in the disease incidence within the region and surrounding areas.

Keywords: Microbiological parameters, Drinking water, Water sampling, Waterborne infections, Linear regression.

1. Introduction

Water is the fundamental element for the survival of mankind, and for the existence of life on this earth (Imtiaz et al. 2018; Chatterjee et al. 2010). The present dynamics of urbanization levels and enhanced rate of population have altered the natural magnificence of drinking water by fading its quality through contamination due to large existence of industrial effluents, pesticides, improper disposed municipal solid wastes etc. (Tirkey et al. 2017; Riaz et al. 2016; Butt and Iqbal, 2007). Water quality is an issue of global concern as water contaminated by microbial and toxic pollutants and other impurities become unfit for drinking and can result in serious health problems (Danny et al. 2018; Jamil et al. 2018). Sources of drinking water on surface and underground are polluted with toxic metals, fecal coliforms, industrial effluents, pesticides and many more all over the country (Tasleem, 2018; Butt and Ghaffar, 2012). The linkage of water quality with the health of affected people is poorly controlled, observed and monitored in countries like Pakistan (developing country). Drinking water pollution has become the serious concern for the public health in Pakistan as the country ranks 80th in total 122 nations with respect to drinking water quality (Butt et al, 2010; Azizullah et al. 2010). In most urban centers of Pakistan, public water

supplies run parallel with drainage lines and their sporadic leakages and intermixing results in deteriorated water quality thus leading to occasional outbreaks of serious waterborne epidemics (Patoli et al., 2010). According to an estimate, 30% of the morbidity and 40% of the mortality cases nationwide are due to poor drinking water quality as every 5th Pakistani suffers from water related illness due to the use of contaminated water (Kahlown et al. 2006). Diarrhea, typhoid, gastroenteritis, intestinal worms, hepatitis A and E, giardiasis are common among Pakistani children. According to International Union on Conservation of Nature (IUCN) report, 60% of infant deaths are due to water-related diarrhea in Pakistan, which is the highest ratio in Asia (Daud et al., 2017). Hence for the above mentioned facts, this study aims to investigate the drinking water quality sources in Shah di Khoi area and determine the pattern of prevailing waterborne infections among the children living in the study area. Furthermore, various reported infections will be correlated to different sources of water, in order to, help the process of making strategies for safe drinking water in the study area and beyond.

2. Material and methods

2.1. Study area

Shah di Khoi (also known as Fateh Singh Shah di Khoi) was earmarked for present study. It is a small residential locality with geographical coordinates 31° 28' 49" N and 74° 17' 34" E, located in the southern area of the Lahore (Pakistan) along the Canal road (Fig. 1). Originally, Shah di Khoi was a small village of pre- partition time period which afterwards converted into a blighted squatter settlement of low-income class lacking basic facilities of public water supply, sanitation system, proper street pattern and many other socio-economic challenges.

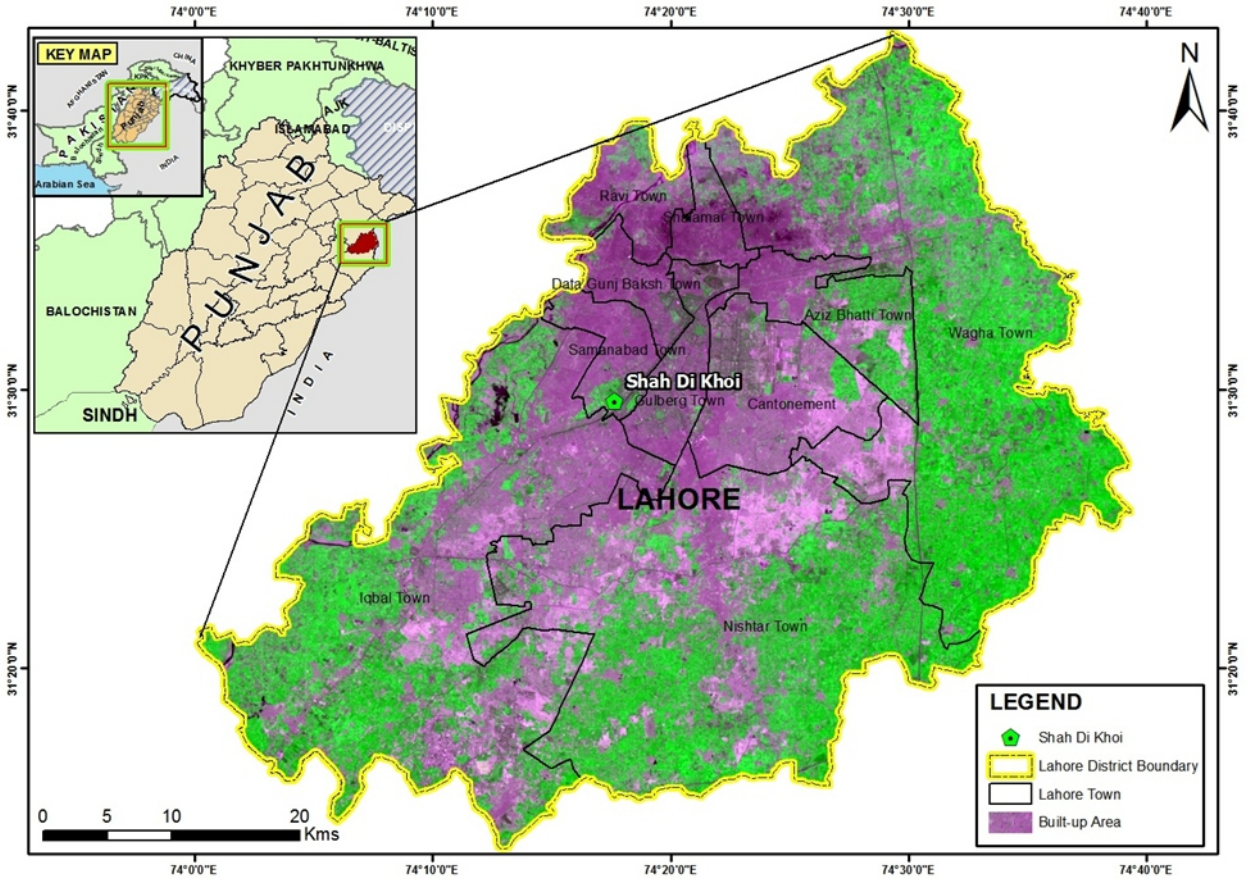

Fig. 1. Shah di Khoi – The study area.

2.2. Data collection and methods

The present study was based on primary data sources. Firstly, a properly structured questionnaire was prepared to obtain information regarding the various aspects of the respondents such as age structure, family size, occupation, monthly income, sources of water used for cooking and drinking at home, methods used to purify water, opinion regarding water quality and the type of waterborne infections faced by children at survey time. Around 350 questionnaires were filled from those families who had children aging less than 5 years. The respondents were mainly parents particularly mothers. The field survey was conducted purposefully during the months of June to August 2018 in order to have a better picture of possible deterioration of drinking water quality and the prevailing waterborne infections commonly associated with hot weather conditions.

Secondly, during field survey limited water samples were collected from selected households, where parents reported the presence of sick child suffering from acute waterborne infections. Total 15 water samples were collected with 05 samples for each source i.e. local bore water, filtration plant and other source. Other source mainly included: water fetched from nearby mosques and nearby Sheikh Zaid Islamic Centre, and home installed filter plant. The collected water samples were tested against four physical parameters namely pH value, electrical conductivity (EC), total hardness, total dissolved solids (TDS) and for two microbiological parameters namely total coliforms, and E. coli. The physical parameters were examined on the spot by using following digital meters:

1. pH digital meter (China) for pH value of water samples.
2. TDS portable digital meter (China) for measuring TDS in water samples.
3. EC meter (China) to check electrical conductivity of water samples.
4. Hanna's HI3812 hardness test kit (Germany) to determine total hardness of water samples.

For the microbiological analysis, the water samples were collected in clean 250 ml plastic bottles, labeled and were immediately taken to the laboratory. In laboratory, the water samples were shifted to 15 individual glass vessels and a sachet of Readycult Coliforms 50 (Germany) was mixed in each vessel and they were further incubated at 37◦C for 24 hours and results for total coliforms and E. coli were noted afterwards.

Finally, the data collected through questionnaire field survey and water sampling was arranged and processed. Pearson's chi-square test with symmetric measures of phi and Cramer's V was used to examine the strength of association between the categorical variables i.e. drinking water sources and waterborne infections (Ehsan et al., 2019; Irfan et al., 2017). The test was performed through the following formula:

$$\chi^2 = \sum \frac{(O-E)^2}{E} \quad (1)$$

Where:
O= Observed frequency count
E= Expected frequency count
Σ = Summation
x^2 = = Chi square value

Where *p* value was significant at < 0.05. While as, the strength of association was determined by phi and Cramer's V as per following:

> 0.00 = no association,
> 0.05 = weak association
> 0.10 = moderate association
> 0.15 = strong association
> 0.25 = very strong association

3. Results and discussion

3.1. Field survey

The questionnaire survey conducted in Shah di Khoi showed that around 70% of the households visited during the survey were permanent residents of Shah di Khoi since 1970s. Nearly 80% of the respondents were aged between 25 to 45 years, with 76% females and the rest were male respondents. Typical family size found in the study area was 5 - 10

persons having 1 - 3 children per family. Literacy rate was found around 66% and the main economic activities of the inhabitants were; 51% employment, 26% services and 23% business activities. Main professions included office/factory workers, mechanics, electricians, storekeepers, drivers, labor (daily wage), venders, and other low order service providers.

Furthermore, since public water supplies were not available so the people at Shah di Khoi used different sources of drinking water such as local bore water at home (28%), water from nearby government filtration plant (54%), mineral water (5%) and some other sources (13%) which included water brought from nearby mosques, home installed filtered water, from Sheikh Zaid Islamic Centre etc. (Fig. 2).

The most common water sources used in the study area for drinking and cooking purposes were filtration plants and local boreholes used by 190 and 96 respondents, respectively. Some mothers were also using mineral water specifically for their infants and toddlers, yet they were only 5% of the total respondents. Only 28% of the respondents were using different methods to disinfect the water prior to use which included boiling only, boiling and staining, and chlorination. The respondents showed satisfactory attitude towards the quality of the drinking water as most of them rated their water through taste, smell and color of water (Fig. 3). Therefore, no specific complaints were observed with respect to the water quality in the study area.

Furthermore, it was observed that 26 % households were such where children aging less than 5 years were found suffering from different waterborne infections (Table 1).

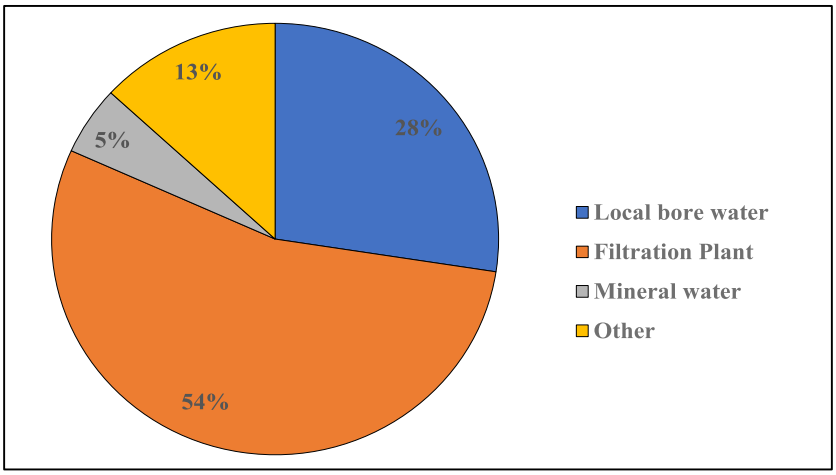

Fig. 2. Sources of drinking water used at Shah di Khoi.

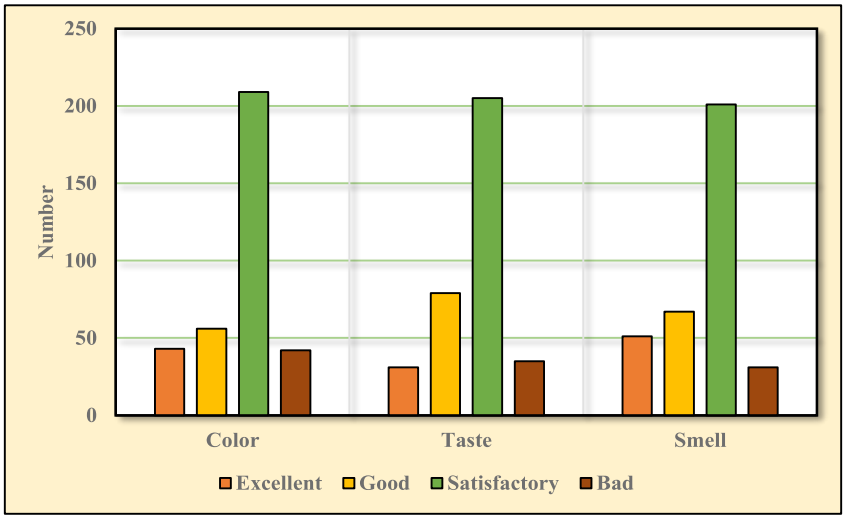

Fig. 3. Views of respondents about drinking water quality.

Table 1. Drinking water sources and waterborne infections among children.

Source	No. of users	Type of Waterborne infections						Total infected children
		Cholera	Typhoid	Hepatitis A &E	Diarrhea	Dermatitis	Worm infestation	
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Local Bore	96(27)	9 (29)	4 (36)	1 (20)	9 (32)	2 (40)	7 (64)	32(35)
Filtration Plant	190(54)	16 (52)	3 (27)	2 (40)	11 (39)	1 (20)	1 (9)	34(37)
Mineral water	18(5)	0 (0)	0 (0)	0 (0)	3 (11)	0 (0)	1 (9)	4(4)
Other	46(13)	6 (19)	4 (36)	2 (20)	5 (18)	2 (40)	2 (18)	21(23)
Total	350(100)	31 (100)	11 (100)	5 (100)	28 (100)	5 (100)	11 (100)	91(100)

Table 1 shows, around 91 children were found sick at the time of survey. Cholera and diarrhea were found the most common prevailing infections among kids with 31 and 28 reported cases respectively. Whereas, dermatitis and hepatitis A and E were found least common infections with only 5 and 5 cases respectively. A close association was found between the type of drinking water source and disease. Cholera and diarrhea were found most common in those children who used local bore water and filtration plant, while typhoid and worm infestation were found more common amongst children using local bore water and other sources. However, no specific association pattern could be seen in children suffering from Dermatitis and Hepatitis A and E and relevant water source (Table 1). Results of the study reveal that comparatively, a smaller number of people i.e. 96 (27%) people used bore while as, 190 (54%) people were found bringing water from filtration plants for drinking purpose. Yet people using bore water exhibited almost an equal number of infected children i.e.32(35%) to people using water from filtration plant i.e. 34(37%) infection kids (Table 1 and Fig. 4). Similarly, a considerable figure was also reported by users of water from other sources with 21(23%) infected children as compared to users of mineral water (Table 1 and Fig. 4).

3.2. Analysis of water samples

It was observed that all water samples tested for the physical parameters were found in the permissible limits as prescribed by the World Health Organization (WHO, 2008) for drinking water and no abnormality was reported in any source type. However, most of the water samples were found to be affected by microbial contamination as total coliforms and E. coli were detected in the collected water samples (Table 2).

As Table 2 shows, total coliforms and harmful pathogen E. coli were present in all the samples collected from those households who fetched water from nearby government installed filtration plants. These filtration plants were old, poorly maintained and had pathogenic pollution. Results from this study raises serious concerns over filtration process and pipes network of the Govt operated groundwater filtration plants. Water samples from some of the local bore water and other sources also exhibited presence of total coliform and E. coli as well. Generally coliform and E. coli bacteria are considered harmless, but the presence of these bacteria reveals contamination from sewage and animal or human waste. Although generally harmless, even then some stains of these bacteria may cause stomach cramps, occasional fever, bloody diarrhea, vomiting and respiratory problems. The bacteria may also cause pneumonia. These bacteria are mostly responsible for urinary tract infections and sometimes its presence in food and water may lead to food poisoning. Also, its presence in drinking water is a clue of other organisms that may cause fatal diseases. Based on the results from this study, it is concluded that most of the local aquifers of Shah di Khoi were infected by pathogenic pollution and thus not fit for domestic use (drinking and cooking).

3.3. Results of Person's chi-square test

The results of person's chi-square test revealed a significant association between the drinking water sources and waterborne infections in the study area (Table 3).

Table 2. Physical and microbiological characteristics of water samples.

Sr.	Water samples	pH value	Total hardness mg/l	EC µS/cm	TDS mg/l	Total Coliform	E. coli
	WHO standards (2008)	6.5-8.5	500	----	<1000	0/100ml /absent	0/100ml /absent
1	LB-1	7.73	298	410	476	Detected	Detected
2	LB-2	7.40	350	405	286	Detected	Detected
3	LB-3	7.34	297	396	300	- - - - -	- - - - -
4	LB-4	7.75	301	359	302	- - - - -	- - - - -
5	LB-5	7.93	259	455	410	Detected	- - - - -
6	FP-1	7.76	190	298	256	Detected	Detected
7	FP-2	7.77	189	298	256	Detected	Detected
8	FP-3	7.75	191	297	256	Detected	Detected
9	FP-4	7.76	190	298	257	Detected	Detected
10	FP-5	7.74	192	297	257	Detected	Detected
11	OS-1	7.85	246	286	390	- - - - -	- - - - -
12	OS-2	7.76	273	295	405	Detected	- - - - -
13	OS-3	7.75	277	310	320	- - - - -	- - - - -
14	OS-4	7.64	280	299	410	Detected	Detected
15	OS-5	7.78	276	280	282	- - - - -	- - - - -

LB = local bore, FP = Filtration plant, OS = other sources

Table 3. Association between drinking water sources and waterborne diseases.

Disease	Local bore		Filtration plant		Mineral water		other sources	
	P value	Phi & Cramer's V	*P* value	Phi & Cramer's V	*P* value	Phi & Cramer's V	*P* value	Phi & Cramer's V
Cholera	0.000	0.264	0.000	0.201	---	---	0.000	0.340
Typhoid	0.001	0.175	0.110	0.085	---	---	0.000	0.276
Hepatitis A & E	0.103	0.087	0.193	0.070	---	---	0.000	0.195
Diarrhea	0.000	0.264	0.002	0.165	0.000	0.399	0.000	0.309
Dermatitis	0.021	0.123	0.358	0.049	0.000	0.230	0.000	0.195
Worm infestation	0.000	0.232	0.358	0.049	---	---	0.000	0.195

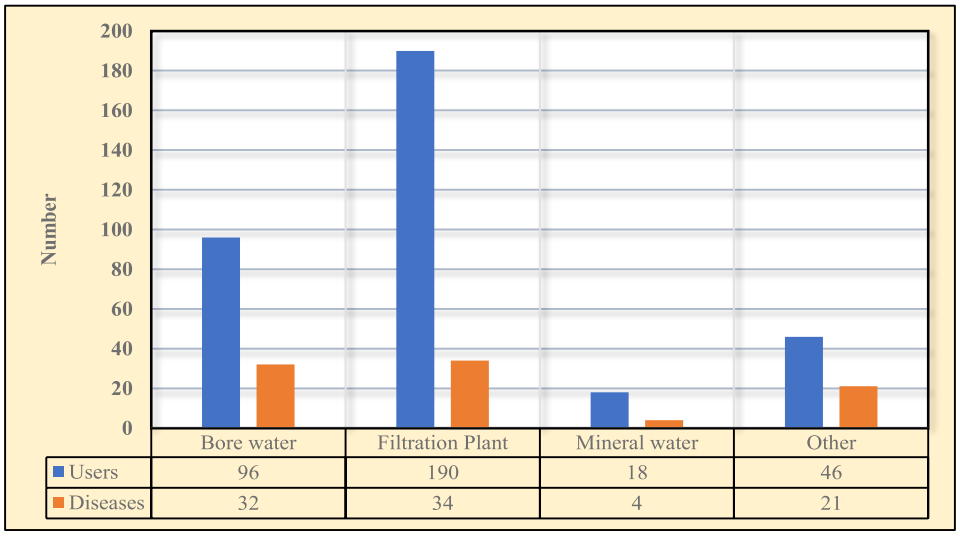

Fig. 4. Comparison of drinking water source and resulting waterborne infections.

As the table 3 shows, a significant association was seen between cholera and all water sources with p value 0.000, while as the strongest relationship of cholera was observed with local bore and other sources. Furthermore, typhoid was found significantly associated with local bore (p value 0.001) and other sources (p value 0.000) also exhibited a very strong relationship with other sources with Phi & Cramer's V 0.276. However, Hepatitis A & E was found significantly associated with other sources only (p value 0.000). Interestingly, a significant and strong association was found between diarrhea and all water sources. No association was seen among filtration plant and worm infestation, though the respective disease was found strongly associated with local bore and other sources.

4. Conclusion and outlook

This study indicates that most of the drinking water sources used by the people in Shah di Khoi area of Lahore Pakistan were unsafe and unfit for drinking and cooking purpose since their usage was resulting in the incidence and prevalence of several waterborne infections among the resident children. The presence of total coliforms and E. coli in water samples of filtration plant and local bore signifies the probability of presence of fecal contamination in the aquifers of used water sources. It is recommended that concerned government authorities should take strenuous actions to control the prevalence of waterborne infections through provision of safe drinking water at Shah di Khoi to avoid possible outbreak of epidemics. This study suggests for future laboratory investigations to assess the water quality by incorporating more physio-chemical parameters. Correlation of waterborne diseases to responsible factors on larger scale through geospatial maps using modern geostatistical techniques based on Remote Sensing (RS) and Geographical Information System (GIS) will further explore aspects of water quality. This will also help determine other environmental factors playing role in the disease incidence within the region and surrounding areas.

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Author's contribution

Ibtisam Butt conceived the idea and carried out the analysis and prepared the manuscript. Munazza Fatima2, Muhammad Nasar-u-Minallah Bhalli equally contributed in the data gathering and preparation of the manuscript. Muhammad Ali critically evaluated the manuscript and helped in writing this manuscript.

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