SPATIAL ANALYSIS OF THE FACTORS RESPONSIBLE FOR WATERBORNE DISEASES IN RURAL COMMUNITIES LOCATED ALONG THE HUDIARA DRAIN, LAHORE

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ABSTRACT

Waterborne diseases are one of the major issues in the developing world like Pakistan and the ratio of waterborne diseases are increasing in most cities of Pakistan. In the adjacent rural communities of the cities like Lahore, people struggling for access to clean drinking water and poor sewage system which attracts the study about the spatial variability of the waterborne diseases, their causing factors and its consequences. This is the study of those attractions based on GIS techniques to examine the spatial variation of water-borne diseases in the rural community of southern Lahore along the Hudiara drain. The data for the study was acquired through field survey using 100 questionnaires as a tool, local public health units, satellite imagery and a topographical map of Lahore. Water samples were collected from the study area and analyzed in the laboratory of PCRWR under the guidelines of WHO. The secondary data of reported cases regarding water-borne diseases were collected from local public health units which people mostly visit. GIS interpolation techniques were applied to analyze the spatial variability of waterborne diseases in the study area. The results show that most of the waterborne diseases are caused by the poor uncovered sanitary system, contaminated groundwater and lack of awareness. The continuous negligence and underestimation of these factors may increase more health risks in the study area for the future.

KEYWORDS: Spatial analysis, waterborne diseases, rural communities, Hudiara drain, Lahore

INTRODUCTION

Waterborne diseases are out of control in developing countries especially in suburban and rural communities due to lack of clean drinking water as well as uncovered sewage channel and poor sanitation (Bai et al., 2007). Waterborne diseases occurred when drinking water supplies were not effectively treated and pathogenic contaminated water was used for recreational purposes (Johnson et al., 2003). It has been reported that 783 million have no access to safe drinking water in the world (UNICEF & WHO, 2012). Contaminated water directly caused by a health problem and anthropogenic activities are one of the major causes of water contamination (Sharma and Bhattacharya 2017). The drinking water is not easily available for human in the desired quantity and quality in the world. This is a common issue in developing nations and leading to an increase in the rate of waterborne diseases. Many waterborne diseases like diarrhea, cholera, typhoid, hepatitis A, dermatitis and enteric fever are permanent risks to human health in the nearby communities especially for children and elders' inhabitants (Butt & Iqbal, 2007).

Pathogens contamination in drinking water is closely associated with waterborne diseases, which are major concern for common people's health, and mostly rural communities are struggling with this issue (Ramı ´rez-Castillo et al. 2015). The communities which are struggling against waterborne diseases like cholera, diarrhoea , gastrointestinal issues and related diseases, are facing high death rate annually (WHO, 2015). In these waterborne diseases, diarrhoea is one of the major diseases, which is directly caused by poor water quality and sanitation system. Diarrhoea affects more than 4 billion people and caused 1.8 million death annually and 90% of the deaths are children under five years old. Cholera is another serious waterborne disease, which is caused by a bacterial infection those outbreaks due to poor quality of drinking water and sanitation system, and poor hygiene behaviour. It has been reported that more than 120,000 people effected by cholera every year in the world. Typhoid is the third most common disease in waterborne disease which is caused by the contaminated water or food as well as uncovered sanitary channels born mosquitoes. According to the UNICEF (2019) the report, more than 12 million cholera cases reported in the world annually. Trachoma is another waterborne disease related to eye infection caused poor sanitation system and till 2019 it has blinded 6 million people in the world (UNICEF 2019).

In Pakistan, 230 thousand deaths occurred every year due to waterborne diseases (Daud et al., 2017). Safe drinking water has the ability to reduce waterborne and its associated deaths up to 50%. According to the USAID predictions, 62% urban population and 84% rural use drinking water without any treatment. UNICEF analyzed that 20% to 40% of patients in hospitals of Pakistan are related to waterborne diseases and 100 million cases registered in Pakistan belonging to diarrheal for treatment annually. In 2004, PCRWR reported that Punjab has crossed the limits of bearable arsenic and fluoride absorptions in drinking water supplies of six cities; Multan, Bahawalpur, Sheikhupura, Kasur, Gujranwala, and Lahore.

It has been reported that the main cities of Punjab province in Pakistan has been showing high contamination of arsenic in its drinking water. According to the report of USAID safe drinking water project, it has been analyzed that 250,000 children's death occurs annually in Pakistan due to water-borne disease. Lahore District has exposed an alarming condition regarding drinking water quality because 69% of its entire scrutinized water sources were providing insecure water due to occurrence of 34% Bacteriological 37% TDS (Total Dissolved Solids) and 7% Arsenic contaminations. In these circumstances, to monitor the water quality is the need of the present time. Mostly rural communities may not aware of contamination of drinking water regarding bacteria and viruses which provide a healthy base of fatal diseases like Cholera, Typhoid fever, Dysentery and Infectious hepatitis A etc. Pakistan is losing 0.6 to 1.44 of its GDP per year on the treatment of waterborne diseases according to the PCSIR observation. The municipal and industrial wastages are damaging human health in Lahore and other cities in Pakistan. It has been analyzed that the quality of drinking water affects adversely on health on health. The high concentration of EC, TDS, hardness, and pH from WHO permissible limits show poor water quality and cause of waterborne diseases like cholera, diarrhoea and typhoid (Mohsin et al., 2013). The identification of risk area of waterborne diseases is much important for water quality and air pollution for its mitigation purposes (Yan et al., 2015).

Hudiara drain is one of the major polluted drains in the south-east of Lahore. The drain is a tributary of river Ravi. More than 100 industries discharge their effluent without any treatment in it and make it highly polluted. The drain is not cemented and covered that's why it is contaminating groundwater, polluting the atmosphere and providing an ideal environment for the breeding of pesticide. The people who live near the drain use the drain water for irrigation purposes which is another cause of groundwater contamination. In this scenario, it is the necessity of time to take a milestone initiative to ensure safe drinking water through monitoring and treatment after assessing the area, level and type of contamination to save the communities from water-related diseases. This study attempts to evaluate the spread of water-borne diseases through maps. Moreover, this study explores the spatial investigative tools of Geographic Information Systems (GIS) to capture the possible spatial spread of water-borne diseases and causing factors in the study area.

MATERIAL AND METHODS

To determine the extent of waterborne diseases and groundwater quality along the Hudiara drain, the proportion between Pak-Indian border and Bedian road adjoining Hudiara drain was selected for the study area, which is shown in Figure 1. The study was carried out along the Hudiara drain in southern part of Lahore which is situated from 74°27'57" E to 74°35'59" E and 31°25'12" N to 31°28'52" N. The study area based on eight villages; Deo Sani, Jhalian, Hudiara, Noorpur, Brahman Abad, Gaga, Karbath and Dera Chahal. These villages are near the Hudiara drain. A major proportion of the population engages with agriculture having low education level and not interested in the contamination of drinking water regarding health the importance.

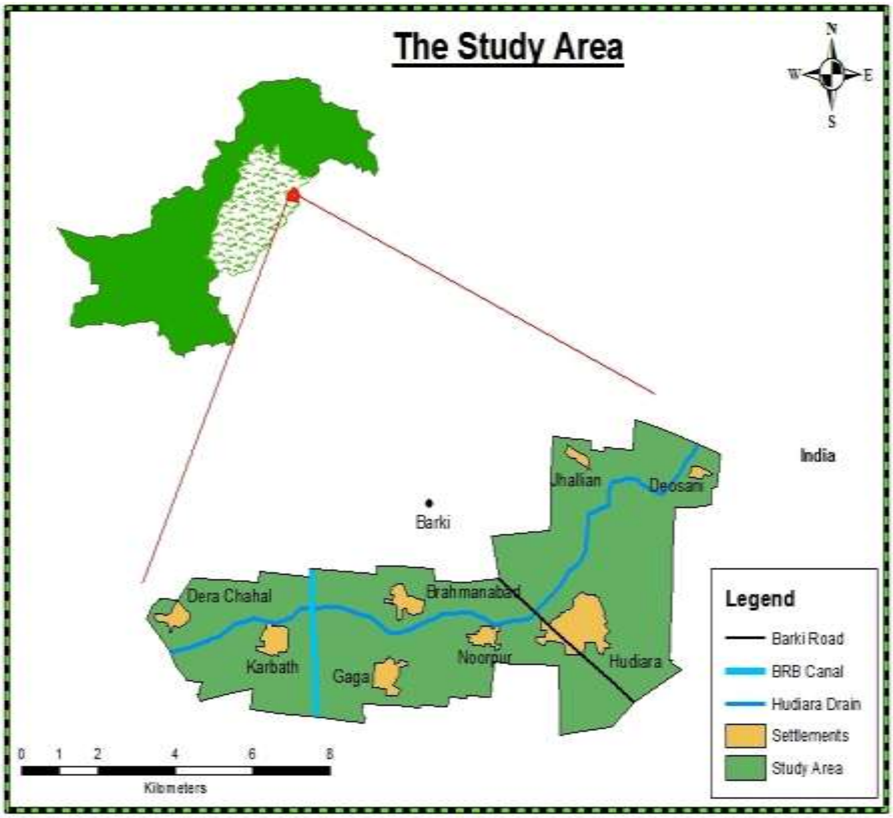

Fig. 1 Location of the Study Area

Data Collection

The study based on both primary and secondary data as well. A field survey was directed for data collection about the factors responsible for waterborne diseases with the help of a questionnaire. Accordingly, secondary data was collected from public hospitals and local Dispensary Units. The water samples were collected from the study area at those sites which are under the maximum users of the community for drinking and other domestic purposes. Sterilized blue cap water bottles were used for the collection of water samples in the study area. Ten water samples were collected around each sample sites and the samples were collected early in the morning to reduce the effects of temperature. The collected samples were analyzed in the laboratory of Pakistan Council of Research in Water Resources (PCRWR).

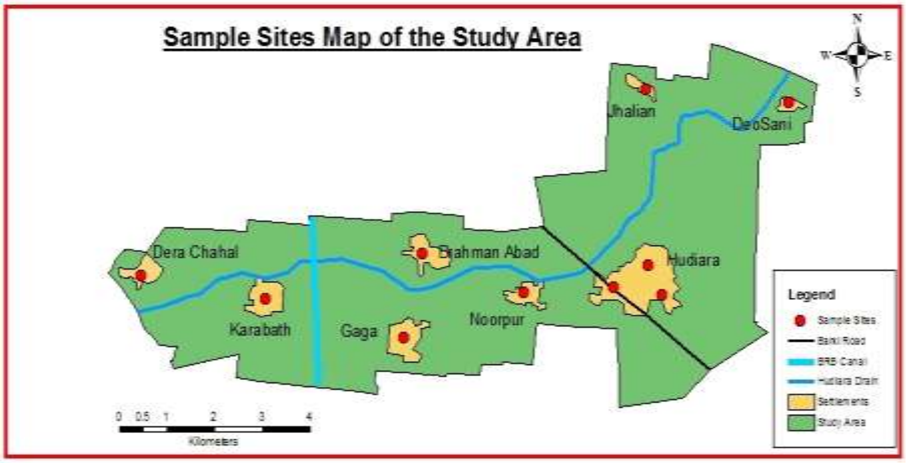

Fig. 2 Location of sample Sites

Sampling and Analysis

The study adopted systematic random sampling techniques for the collection of data. The data was collected through a field survey with the help of 100 questionnaires. The sample size was selected with the help of following Cochran's equation:

$$n = \frac{z^2 pq}{E^2}$$

where p is the expected percent accuracy of the map, q = 100 -p, Z is the Z - score 95% confidence, and E is the margin error.

The water quality parameters and their analysis methods were adopted according to the recommendation of the World Health Organization (2010) in the laboratory. The lab of PCRWR (Pakistan Council of Research in Water Resources) was used for the analysis of water samples. The seven most significant parameters were selected for waterborne diseases. Those were pH, TDS, EC, Chloride, Sulphate, Total coliform and E. coli. According to WHO the pH values of drinking should be in between 6.5-8.5 but the ideal value is 7.2. TDS values should be 1000 mg/L but the ideal is 500 mg/L, EC 1500 µS/cm, Chloride 250 mg/L, Sulphate 500 mg/L, Total Coli Forms and E. Coli should not be detected in 100 ml of drinking water.

The Water Quality Index and Water Quality were calculated with the help of an equation presented by Abbasi S.A. and applied by Venkateswarlu G. in 2014. According to the recommendations of various researchers, Water Quality Index (WQI) is a suitable method for assessing the water quality (Abbasi S. A., 1999). WQI is a useful tool for computing the data on the overall quality of water (Prathan et al., 2001). To determine the suitability of the groundwater for drinking purposes, WQI was computed by implementing the following formula:

WQI = {[(V actual– V ideal) / (V standard – V ideal)] * 100}

where, ***WQI*** = Water Quality Index

V actual = Value of the water quality parameter obtained from laboratory analysis

V ideal = Value of that water quality parameter can be obtained from the standard tables.

V standard = WHO standard of the water quality parameter

(Venkateswarlu G., 2014).

RESULTS AND DISCUSSION

The values of drinking water analysis of selected parameters are shown in Table No 1. The report of drinking water analysis shows that the pH values of all water samples of the study area are under the WHO limit. The pH value of Hudiara3 is found ideal but the values of Hudiara1 and 2 are found above the ideal values but in between the standard. The pH values of Karbath drinking water is found at extreme of standard value which is showing alkalinity aspect. Overall alkalinity trend is found in most water samples of the study area.

Table No. 1 Water Quality of the Study Area

NAME	pH	TDS (mg/L)	EC (µS/cm)	Chloride (mg/L)	Sulphate (mg/L)	Total Coliforms	E. Coli	WQI	Water Quality
WHO 2010	**6.5 - 8.5**	**1000**	**1500**	**250**	**500**	**-ve**	**-ve**	**-**	**Excellent**
Deo Sani	7.7	660	920	150	135	-ve	-ve	38	Good
Jhalian	7.4	725	990	93	92	-ve	-ve	30	Good
Hudiara 1	7.9	**1070**	1020	**260**	150	**+ve**	**+ve**	**80**	**V. Poor**
Hudiara 2	8.0	**1195**	915	**275**	102	**+ve**	**+ve**	**87**	**V. Poor**
Hudiara 3	7.2	580	1000	160	162	-ve	-ve	08	Excellent
Noorpur	7.9	**1090**	1250	240	145	**+ve**	**+ve**	**85**	**V. Poor**
Brahman Abad	7.4	830	995	180	180	-ve	-ve	40	Poor
Gaga	7.5	630	850	120	90	-ve	-ve	24	Excellent
Karbath	8.1	**1290**	1230	**310**	290	**+ve**	**+ve**	**111**	**Unfit**
Dera Chahal	7.8	**1045**	1320	170	130	**+ve**	**+ve**	**75**	**Poor**

Source: PCRWR

If we analyze the Total Dissolve Solids (TDS) of drinking water samples the table 1 shows that Deo Sani, Jhalian, Hudiara3 and Gaga have near the ideal value (500 mg/l) and under the standard limits (1000 mg/l). The sample sites of Hudiara1, Noorpur and Dera Chahal have slightly high TDS values than recommended limits. The TDS values of Hudiara2 and Karbath are found maximum in the study area which indicates alarming conditions in that area. The presence of total coliforms and E. coli at Hudiara1 and 2, Noorpur, Karbath and Dera Chahal is found positive which is indicating the presences of such organisms that caused of waterborne diseases. Figure 3 is showing the spatial distribution of pH, TDS, Total Coliforms and Escherichia coli (E. coli). The water quality of Hudiara3 is found good because its borehole depth is 400 feet.

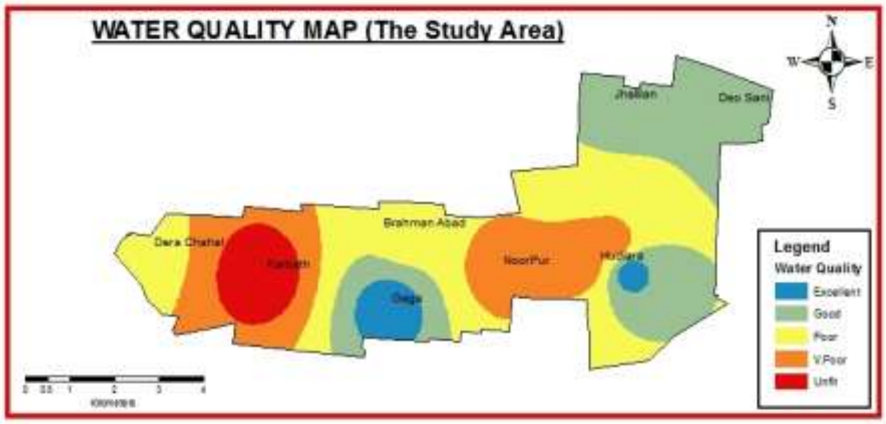

Fig.3 Water Quality of the Study Area

According to the collected data about waterborne diseases vary from village to village. The detail of patients related to each selected waterborne disease is given in figure 4. The maximum patients are found at Hudiara village because it is the largest village in the study area. The patients of Cholera 147, Dysentery 154, Hepatitis A 193 and Typhoid 210 are treated annually for waterborne diseases. Noorpur and Karbath have a maximum ratio of waterborne diseases. In Noorpur 370 patients were registered for waterborne diseases; 31 of Cholera, 15 of Diarrhoea, 90 of Dysentery, 154 of Hepatitis A and 80 of Typhoid. Karbath has a maximum ratio of waterborne diseases in the study area. Total of 275 patients was treated related for water-borne diseases (Cholera 41, Diarrhea 14, Dysentery 55, Hepatitis A 96 and Typhoid 69). Dera Chahal is also severely affected village from waterborne diseases. There were 429 patients were treated for water-related diseases 43 for Cholera, 21 for Diarrhea, 86 for Dysentery, 193 for

Hepatitis A and 86 for Typhoid. Jhalian and Gaga were found a minimum ratio of water-borne disease which is found less than 25%.

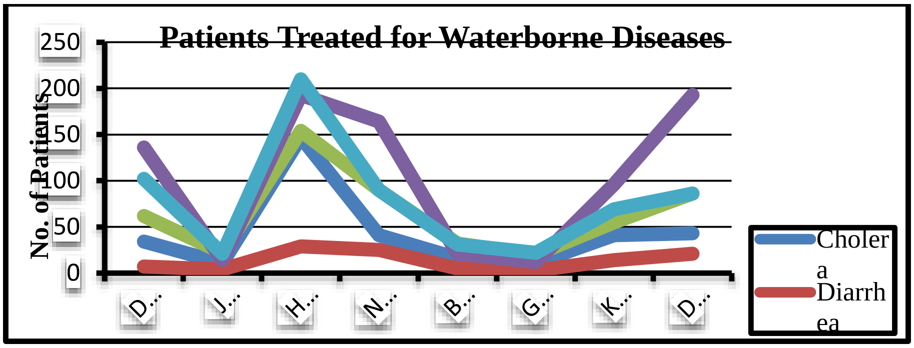

Fig. 4 Scenario of Waterborne Diseases

The treated cases of waterborne diseases (Cholera, Diarrhea, Dysentery, Hepatitis A and Typhoid) were obtained from the Public Rural Health Units working at local level in Deo Sani, Jhalian, Hudiara, Noorpur, Brahman Abad, Gaga, Karbath and Dera Chahal. Total 6000 patients visited the local public health centers and 2393 (40%) were treated for water-borne diseases.
The detail of waterborne diseases is given in figure 5 which shows that the Karbath has the maximum ratio of water-borne diseases which is 55%, Noorpur has second-highest the ratio which is 51% and the third highest is found in Hudiara which is 43%. The minimum ratio of water-borne diseases is found in Brahman Abad which is 21%.

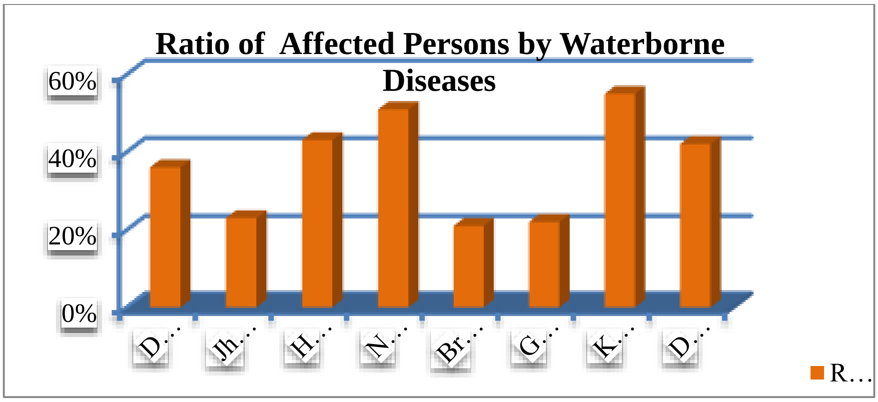

Fig. 5 Ratio of Waterborne Diseases

In figure No. 4 is showing the ratio of waterborne diseases among all other diseases or among the entire patients, who visited the health centres in the month of November 2015. The maximum ratio of water-borne diseases is founded in Noorpur which is 57%. The second-highest the ratio is founded of waterborne diseases at Karbath which is 55%, third-highest the ratio is found at Hudiara which is 43% and the fourth-highest ratio is found at Dera Chahal which is 42%. All these four villages are situated at the edge of the Hudiara drain (natural drain for carrying the rainwater but now it has converted into the industrial effluent drain) and found highest extent of waterborne diseases which is very alarming for the community, Govt. and other stakeholders. The ratio of waterborne diseases in Deo Sani (36%) is also high as compare to Jhalian (23%), Brahman Abad (21%) and Gaga (22%). The data shows that the study area has highly concerned with water-borne diseases. The lowest ratio is found at Gaga and highest at Noorpur village regarding water-borne diseases. The figure No.4 is showing the ratio of waterborne diseases and figure No.5 is displaying spatial distribution of waterborne diseases in the study area. According to the figure No.4 village Karbath and Noorpur is under the highest threat of waterborne diseases.

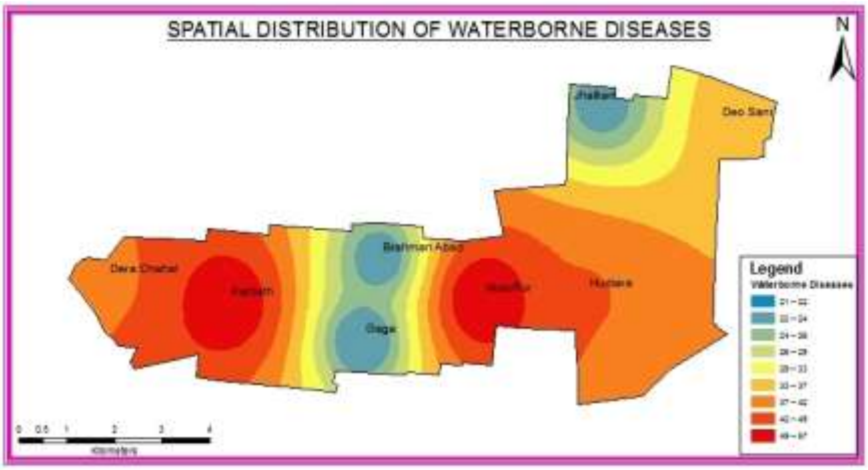

Fig.6 Spatial Distribution of Waterborne Diseases

CONCLUSION

The study identified the consequence of waterborne diseases in the study area and analyzed that the drinking water of the study area is not secure which is a major cause of waterborne diseases along with poor sanitation and lack of awareness. Where the water quality for drinking purposes found poor, issues of waterborne diseases are more but where there is water quality is good or excellent, the ratio of waterborne diseases is low. The study area is found under the threats of waterborne diseases and most people are not properly aware of the reasons for this issue. Most people are not well educated and well aware of the importance of clean drinking water, especially about biological contamination. The dominance of waterborne diseases in the study is due to pathogens existences in drinking water along with Hudiara drain interaction because the villages near the drain are founded highly under the threat of waterborne diseases and their groundwater is more contaminated. Karbath and Noorpur are located at the bank of the Hudiara drain and these two sites of the study area have highly contaminated groundwater. So, there are clear indications that there is much need to manage the Hudiare drain channels effects, their sewage system and awareness to control waterborne diseases. The role of local government representatives and relevant NGOs is also important to provide alternative sources and facilities of safe drinking water, to raise the awareness amongst the community especially about biological contaminations methods and its importance. The local government should provide better health facilities to control the spreads of waterborne diseases through medication.

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