African Journal of Environmental Science and Technology Vol. 5(8), pp. 595-607, August, 2011
Available online at http://www.academicjournals.org/AJEST
ISSN 1996-0786 ©2011 Academic Journals

Full Length Research Paper

An investigation into the prevalence of water borne diseases in relation to microbial estimation of potable water in the community residing near River Ravi, Lahore, Pakistan

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Accepted 17 June, 2011

Water-borne diseases are the most prevalent infectious diseases in the developing countries especially in new settlements along the river. The present investigation was carried out to assess the prevalence rate of water-borne diseases among people residing near the left bank of River Ravi. This study has a descriptive cross sectional design on a statistically calculated sample of 50 households and 150 interviewees selected through simple random sampling technique. The target site was divided into three areas on the basis of socioeconomic conditions of the people. People were interviewed and water samples were collected from households and tested for microbial estimation. The information obtained from the study revealed a rather grave scenario, showing that almost 69% of the people were illiterate. An average of 42% did not have the facility of community water supply and 21% had to fetch water from a nearby place. An idea of the sanitatory conditions could be made from the fact that 76% had closed sewer type of toilet facility whereas 8% used the conservancy and 16% had to go to open fields for defecation, as they did not have any toilet facility in their own houses. The most common illness was diarrhoea and vomiting having a prevalence rate of 62.67% followed by skin problems (21% prevalence rate). Water-borne diseases were mostly prevalent in monsoon and summer season (May to September) showing a percentage of 44.67% and 39.33%, respectively. 82% of the people interviewed admitted that they did not treat (boiled or filtered) water before drinking. Bacteriological examination of water samples, collected from the target households in the area of study alarmingly showed that only 4 (8%) samples out of 50 were found to be fit for drinking while 46 (92%) were found to be contaminated and were found unfit for drinking according to WHO standards.

Key words: Water-borne diseases, socioeconomic conditions, microbial estimation, semi-structured questionnaire, community water supply.

INTRODUCTION

Water is potable if it is free of disease-producing microbes and harmful chemical substances (Pelczar et al., 1993; WHO, 2004). According to World Health Organization (WHO, 2000, 2004), the drinking water quality is usually related to acceptability (physical), microbiological and chemical variables. Although physical and chemical pollution of water is not less important but the most common and deadly contaminants in the

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drinking water are of biological origin. WHO states (WHO, 2000) that wide spread health risks are frequently associated with drinking water contaminated with bacteria. One of the most important organisms commonly found in our environment is coliform bacteria. The presence of coliform bacteria in drinking water indicates that the water has been contaminated with bacteria from the fecal material of man or other animals (Park, 2007). The standard test for bacterial contamination is a laboratory analysis of coliform bacteria. The presence of fecal coliforms (*Escherichia coli*) serves as an indication of contamination by sewage. Most of the area along River Ravi is characterized by unplanned settlements, which have led to overcrowding and high population densities. The poor sanitation facilities (including drainage system and solid waste disposal system) available in the areas along bank of river and menace of drains (carrying untreated polluted industrial and municipal waste) poses a health risk not only to the dwellers but also to surrounding communities within the catchments of the river.

The aquifer serving ground water supplies in Lahore city and surrounding districts is to some extent recharged from the River Ravi, but the degree of faecal loading on the river from untreated municipal sewage could be a significant contributor to the documented faecal contamination of Lahore's water supply. Similarly organic and inorganic pollutants released by industry into the river and fertilizers, insecticides and animal wastes in the runoff water can leach from soils directly to the river or indirectly to aquifers. Potable water quality and so Public Health of residents, residing along the bank of river is badly affected as low quality water from polluted stretch of river invaded the aquifer, leading to high pollution level of potable water (Kamrul and Burgess, 1999; Dhakyanaika and Kumara, 2010). As a result, these communities, where availability of safe water and standard of sanitation is not very good, the risk of acquiring water borne infection can be as high as 90% like water borne hepatitis A, E, cholera, diarrhoea, dysenteries, typhoid and parasitic diseases, etc (Saeed and Behzad, 2006). This study was planned to know the status of health in this section of population as no authentic data on the prevalence of these diseases in Pakistan especially in suburb of Lahore, in the vicinity of River Ravi is available that could indicate the health status of the population.

METHODOLOGY

Study design

It was community based cross sectional, descriptive type of study.

Place of study

Study was conducted in union councils 69, 83 and 85 of Lahore District on left bank of River Ravi where sewage from Outfall drain enters into river, near Saggian Bridge.

Description of the target site

The target site was subdivided into three areas I, II and III to make a comparative study in different socioeconomic groups to get a clear picture of the prevailing situation.

Area I

Area I (union council 85) extended from 0.5 Km away from the left bank of River Ravi to 1.2 Km towards the metropolitan city. A drain carrying waste-water traversed the area. The houses were generally small ranging from the size of 10 sq ft to 250 sq ft. Many roads were "kachha" with highly unhygienic and unclean conditions, as heaps of garbage could be seen dumped outside the houses and a number of drains were uncovered. Most of the residents were daily wagers and very poor.

Area II

Area II (union council 69) extended from 1.2 Km away from the bank of River Ravi, to about 2 Km towards the Lahore city. There were not much open fields and only a few vacant plots between the residences could be seen. Mostly the roads were metallic, and generally the condition of cleanliness was better than area I and III. The drains were mostly covered, and the socioeconomic conditions were better than those found in area I and III.

Area III

This site (union council 83) is situated 0.5 Km away from River Ravi to 1.5 Km towards the city. There were large number of crop fields between this site and the River Ravi. One drain carrying waste sewage waste flowed on the periphery of area III, and then intercepted the site, so as to run parallel to river before entering the latter. Heaps of trash and garbage was seen here and there in this site. The houses were dilapidated and a number of uncovered drains were also visible, however socioeconomic conditions of people were slightly better than area I.

Study population

i) All the people living on the left bank of River Ravi in union councils 69, 83 and 85 of Lahore District, where sewage from Outfall drain enters into River Ravi, near Saggian Bridge, Lahore.
ii) All household potable water supply sources in the same area.

Sampling unit

People and household (HH) water supplies source.

Table 1. Frequency distribution of literacy.

Parameter	Trends	Area I %	Area II %	Area III %	Mean
Read and write	Yes	25^c	35^a	32^b	30.67
	No	75^b	65^c	68^a	69.33

Treatment mean within each column with different letters are significantly different at *P=0.05* according to Duncan's new multiple range test.

Sample size

Sampling size has been calculated by the formula, Sample size (n) = $Z^2 \times p\ q / d^2$, Z^2 = value of Z at 95% level of confidence that is, 1.96 x 1.96 = 3.84, P is the prevalence of water borne diseases in Pakistan; that is 85% (Daniel, 2006), $q = 1\text{-}p$ = 15%, d^2 is the margin of error = 10% = 10 x 10 = 100, Sample size calculated for household was 49. For convenience sample 50 HH was enrolled for the study. A total of 150 people from these HH were interviewed.

Sampling technique

Water samples of 50 households collected from household water supply for microbial estimation by Most Probable Number (MPN) method. Water was collected in sterilized bottles, provided with stoppers. Water collected from taps or hand pumps was allowed to run for at least 5 min before sampling. Information about drinking water, sanitation practices and water related diseases collected from people living in these households with the help of questionnaire. Sample from household's water supply and people taken by using simple random sampling technique.

Inclusion criteria

Adults who can understand the questions and respond were included.

Exclusion criteria

Those people who had migrated to the target area recently that is, in last six months or those who were not staying on permanent basis were excluded.

Data management

Data collection

1. Data about socio-demographic features was collected from residents of selected HH through a questionnaire.
2. Information about water-borne diseases and practices in the management of water-borne illness was collected through a questionnaire which was pre- tested and later applied to the community residing in the target sites.
3. Water sampling was done from the household drinking water supply for the microbial estimation of potable water by MPN method (Cheesbrough, 2004).

Data processing and analysis

The frequencies of all the variables obtained and final analysis made with the help of statistical package. The collected data entered into computer using co-STAT program and the same software used to analyze the data. Data was described in terms of frequencies and percentages. A confidential level of 90% was used in estimating the outcome variables that is, positivity regarding pot ability of water. ANOVA and Duncan multiple range tests used to know about association between independent and dependent variables and significant testing $p \leq 0.05$.

RESULTS AND DISCUSSION

Socioeconomic features

The information regarding socio-demographic features was collected with the help of questionnaire and the results tabulated in Tables 1 to 6.

Literacy

Table 1 showed that the people residing in the target site had low literacy rates. On average basis 69.33% were illiterate and only 30.67% were able to read and write. Among the three different area studied there was a significant difference in the literacy rates, people of area II having the highest rates. Figure 1 shows the frequency distribution of qualification. Out of the literates, 81, 68 and 70% (Mean 73%) in study area I, II and III, respectively were below Matric (grade 10). 19, 14 and 30% (Mean 21%) were Matric showing significant differences. Surprisingly, there was not a single graduate in area I and III, while there were 18 graduates (Mean 6%) in area II.

Marital status

The data obtained for the frequency distribution of marital status of population in the study area shows that 38, 60 and 75% in areas I, II and III, respectively were married

Table 2. Frequency distribution of location of drinking water supply source

Parameter	Trend	Area I %	Area II %	Area III %	Mean
Location of drinking water source	Own home	63^{c}	81^{b}	94^{a}	79.33
	Nearby place	37^{a}	19^{b}	6^{c}	20.67

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

Table 3. Frequency distribution of distance of water source from house.

Parameter	Trend	Area I %	Area II %	Area III %	Mean
Distance of water source from house	100 m	92^{b}	90^{c}	94^{a}	92.00
	500 m	8^{b}	10^{a}	6^{c}	8.00
	1 Km or above	0^{a}	0^{a}	0^{a}	0.00

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

Table 4. Frequency distribution of kind of toilet facility available in house.

Parameter	Trend	Area I %	Area II %	Area III %	Mean
Kind of toilet facility in house	Closed sewer	67^{c}	87^{a}	75^{b}	76.33
	Conservancy	5^{b}	13^{a}	6^{b}	8.00
	Open field	28^{a}	0^{c}	19^{b}	15.67

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

Table 5. Cleanliness outside houses.

Parameter	Trend	Area I %	Area II %	Area III %	Mean
Condition of cleanliness outside house	Waste dumped nearby	30^{a}	6^{c}	12^{b}	16.00
	Uncovered drain	5^{a}	0^{b}	0^{b}	1.67

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

while 62, 40 and 25% were un-married. An average of 57.67% was married while 42.33% were un-married.

Water supply

Figure 2 depicts the significant differences in frequency distribution of source of drinking water supply and revealed that an average of 58% residents had community supply of drinking water, 13.67% used hand pumps for obtaining water while 29.33% used other means which included bringing water in cans and utensils from neighborhood. In addition to this, some used long rubber pipes to draw water from neighbor's community water supply. Furthermore, through the questionnaire a clear picture of the situation was obtained as to how many people had a water supply in their own houses and how many had to bring it from nearby places. The results were highly significant and it was found that 63 to 94% had their own water supply and 6 to 37% had to fetch it from some place away from their homes (Table 2). Thus, overall, about 21% did not have any water supply in their residences. The distances people had to travel to fetch drinking water has been shown in Table 3. Statistically significant majority of the people, that is, 92% had to go 100 meter away from their houses to get drinking water,

Table 6. Frequency distribution of fuel used for cooking.

Parameter	Trend	Area I %	Area II %	Area III %	Mean
Fuel used for cooking	Sui gas	70[a]	68[b]	25[c]	54.33
	Coal	0[b]	32[a]	0[b]	10.67
	Wood	24[b]	0[c]	69[a]	31.00
	Cow dung	6[a]	0[c]	6[a]	4.00

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

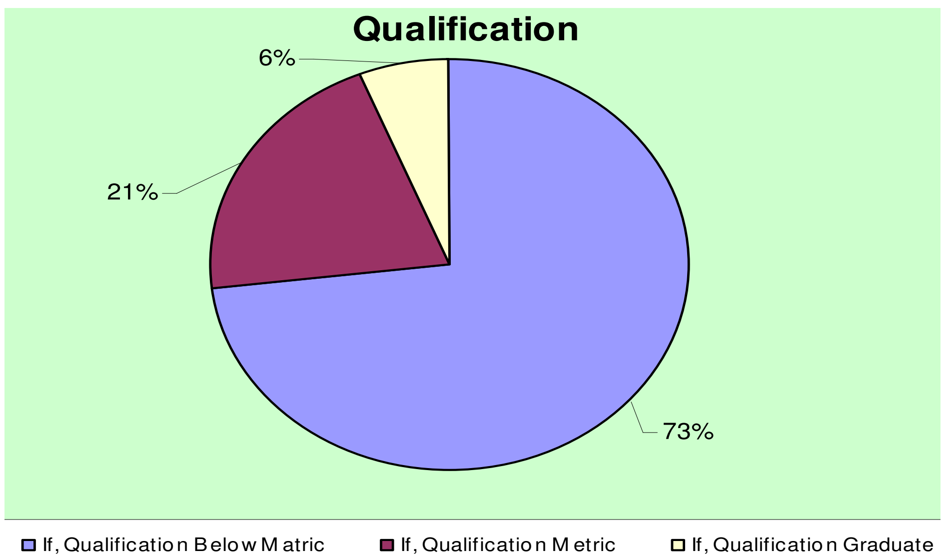

Figure 1. Frequency distribution of qualification.

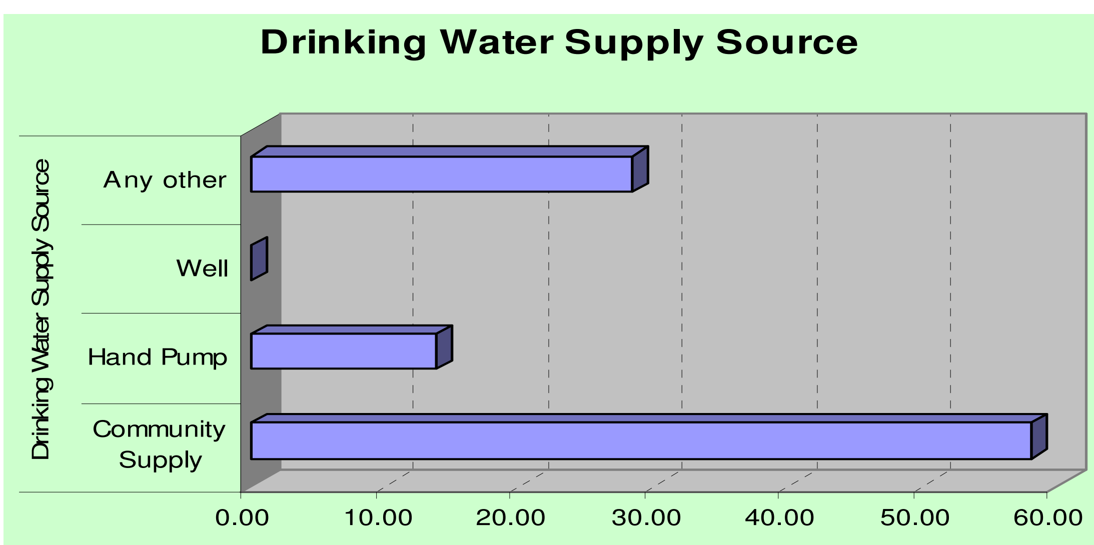

Figure 2. Frequency distribution of drinking water supply source.

Table 7. Kind of illness at the time of interview.

Parameter	Trend	Area I %	Area II %	Area III %	Mean
Kind of Illness	Diarrhea and vomiting	68[a]	59[c]	61[b]	62.67
	Prolonged fever	9[b]	5[c]	10[a]	8.00
	Yellow coloration of eyes (Jaundice)	3[a]	0[b]	2[a]	1.67
	Eye problem	5[a]	0[b]	0[b]	1.67
	Skin problem	25[a]	17[c]	21[b]	21.00
	Malaria	6[a]	3[b]	6[a]	5.00

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

8% had to go as far as 500 m and fortunately no one had to go beyond 1 Km.

Sanitation and cleanliness

For an investigation into the prevalence of diseases, it becomes imperative to look into the sanitation and cleanliness of the area, as improper waste disposal is one of the main causes of contamination. This survey revealed statistically significant results (Table 4) showing that closed sewer which is the best available kind of toilet facility in the target area was being used by an average of 76.33% people while 8% of the people used the conservancy. Alarmingly in area I and III 28 and 19%, respectively had to go to open fields for defecation, as they did not have any toilet facility in their own houses. These findings show that the existing water and sanitation conditions are very poor and perhaps interventions in this context would reduce the rates of water borne diseases as reported by Esrey et al. (1991) and Clasen et al. (2007) who found that water and sanitation interventions have the potential to reduce waterborne infections and the associated disease burden by as much as 50%. Table 5 shows the condition of cleanliness outside the houses in the target area. Study area II was found to have better conditions of cleanliness. Only 6% of the residents dumped waste outside their houses in contrast statistically significant 30 and 12% in areas I and III, respectively. In area I, 5% had uncovered drains, whereas none of these were found in area I and III.

Food habits

From Table 6, it is seen that 54.33% of the residents had the facility of Sui-gas for cooking. 10% used coal, 31% used wood and 4% used dried cakes of cow dung as a fuel for cooking. People living in area II, had better facilities, as no one used wood or cow dung as a fuel. Although there was a non-significant difference within the three areas studied, among the people interviewed, 94.6% reported that they ate food cooked in their homes. Only 5% bought their meals from restaurants, and no one admitted buying meals from vendors.

Prevalence of water-borne diseases

Type and duration of illness

Table 7 and Figure 3 show the kind of illness people had at the time of interview. The most common illness was Diarrhoea and vomiting as 62.67% people were suffering from it. Next to it was skin problem, having a prevalence rate of 21%. Few people that is, 8, 5, 1.67 and 1.67% suffered from prolonged fever, malaria, yellow colouration of eyes and other problems, respectively. The prevalence rate of diarrhoea, vomiting in area II was statistically significantly lower than that in area I and III. Yellow colouration of eyes (Jaundice) and malaria in area I and II were non-significantly different, from each other, but significantly higher than the rates found in area II. Findings of this study is in conformity with the report of Esrey et al. (1990, 1991) who carried out 142 studies on 6 of the major water-borne diseases and estimated that in developing countries (excluding China), there were 875 million cases of diarrhea and 4.6 million deaths annually in the mid-1980s.

Treatment of illness

Table 8 and Figure 4 shows that for the treatment of illness, an average of 70.33% of people interviewed consulted local doctors, however, a significantly higher percentage of people residing in Area II sought the help

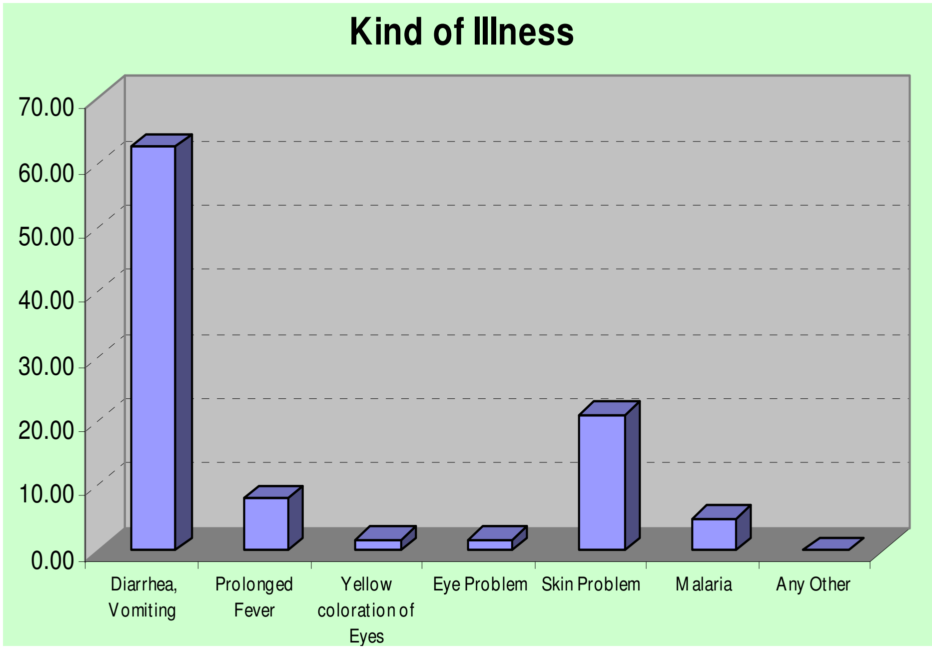

Figure 3. Kind of illness at the time of interview.

Table 8. Preference for seeking treatment.

Parameter	Preference for seeking treatment	Area I %	Area II %	Area III %	Mean
	Self	21[a]	19[b]	0[c]	13.33
	Local doctor	68[b]	75[a]	68[b]	70.33
	Local hospital	11[b]	6[c]	27[a]	14.67
Preference of treatment	Hakims	0[b]	0[b]	5[a]	1.67
	Homeopath	0[a]	0[a]	0[a]	0.00
	Spiritual healer	0[a]	0[a]	0[a]	0.00
	Any other	0[a]	0[a]	0[a]	0.00

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

of a local doctor. An average of 14.67% went to local hospital, whereas 13.33% believed in self-treatment. A small percentage (1.67%) went to hakims to find cure for illness, and no one admitted seeking treatment from Homeopathic doctors or spiritual healers. Table 9 and Figure 5 shows the distance patients need to travel for seeking medical treatment. On average basis 50% had the provision of medical treatment less than ½ Km away from their residents. Out of the three areas studied 75% of the people from area II had a nearby health facility, in contrast to 55 and 20% of people from area I and III, respectively.38% had to travel ½ -1, 5.67% had to travel 1 to 5 Km and 6% had to go more than 5 Km for medical treatment.

Prevalence of water-borne diseases

As the prevalence of water-borne diseases fluctuates with seasons, the information obtained in this context revealed a very clear picture, as shown in Table 10 and Figure 6. Water-borne diseases were mostly prevalent in rainy and summer seasons, showing a percentage of 44.67 and 39.33%, respectively. Of the people interviewed 16% were affected due to water-borne illness in winter and none got sick due to water-borne diseases

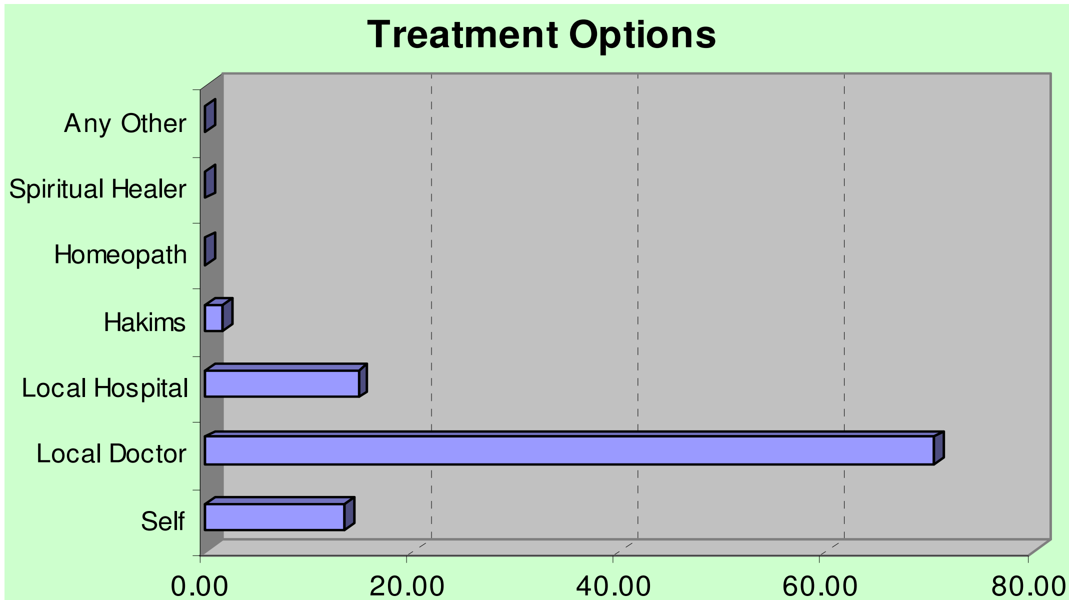

Figure 4. Preference for seeking treatment.

Table 9. Distance traveled for seeking medical treatment.

Parameter	Distance to travel for seeking medical treatment	Area I %	Area II %	Area III %	Mean
Distance to travel for seeking medical treatment	Less than ½ km	55[b]	75[a]	20[c]	50.00
	½ - 1 km	40[b]	19[c]	56[a]	38.33
	1-5 km	5[a]	6[a]	6[a]	5.67
	More than 5 km	0[b]	0[b]	18[a]	6.00

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

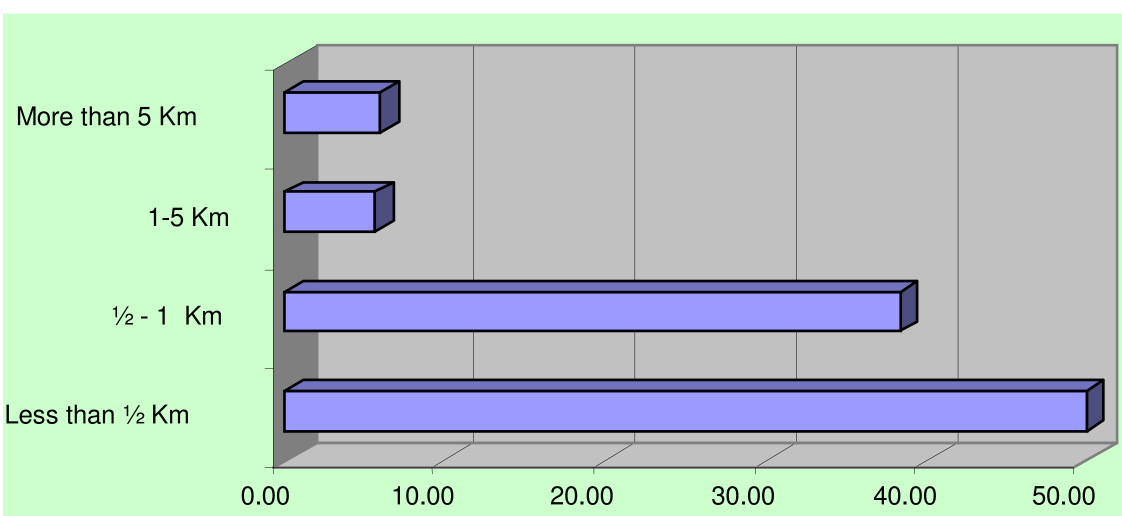

Figure 5. Distance traveled for seeking medical treatment.

Table 10. Frequency distribution of season of water- borne diseases.

Parameter	Season	Area I %	Area II %	Area III %	Mean
Season of water borne diseases	Rainy season	62[a]	12[c]	60[b]	44.67
	Summer	18[c]	25[b]	75[a]	39.33
	Winter	20[a]	15[b]	13[c]	16.00
	Spring	0[a]	0[a]	0[a]	0.00
	Autumn	0[a]	0[a]	0[a]	0.00

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

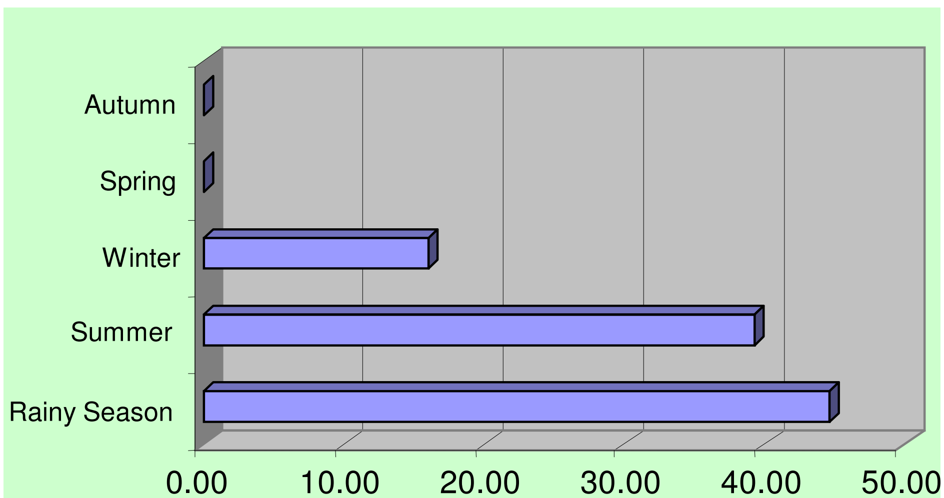

Figure 6. Season of water- borne diseases.

during spring and autumn. In the rainy season (July to September), a significantly lower percentage of people in area II (12%) suffered from water-borne illness. The variation in the prevalence of diseases during different seasons (Guntoke et al., 2009) is an important aspect as also reported by Feachem, 1984**,** who stated that water and sanitation interventions have proven difficult to evaluate because targeted enteric pathogens may be transmitted through multiple routes (that is, contaminated drinking water, contaminated food, person-to-person contact) and because rates of disease show seasonal and secular variation.

Treatment of drinking water

From Table 11 and Figure 7, it is seen that only 18% of people treat drinking water before consumption and 82% admitted that they did not treat water before drinking. Table 12 shows the frequency distribution of the kind of treatment used for treating drinking water. A statistically significant percentage of people that is, 7, 18 and 13% of area I, II and III, respectively boiled water prior to drinking. Only 2% in area I added alum while water filter was used by 18% of people of area II. Here also greater number of people of area II treated water before consumption.

Use of oral re-hydration salt (ORS)

Data obtained for the tendency to use oral rehydration salt shows that 78.33% of people did not use ORS in case of diarrhoea in children and only 21.67% did.

Cleanliness

Table 13 gives an idea of how often people observed cleanliness while preparing and eating food. Although the

Table 11. Measures taken to treat water before drinking.

Parameters	Trend	Area I %	Area II %	Area III %	Mean
Any Measure to treat water before drinking	Yes	10[c]	25[a]	18[b]	17.67
	No	90[a]	75[c]	82[b]	82.33

Treatment mean within each column with different letters are significantly different at *P=0.05* according to Duncan's new multiple range test.

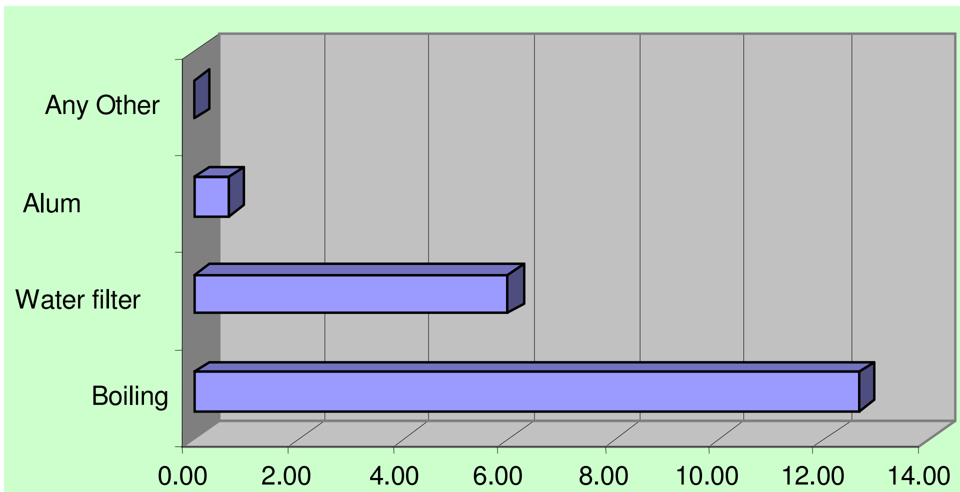

Figure 7. Kinds of treatment used for drinking water.

Table 12. Kinds of treatment used for drinking water.

Parameter	Method of treatment of water	Area I %	Area II %	Area III %	Mean
Kind of measures taken to treat water	Boiling	7[c]	18[b]	13[a]	12.67
	Adding Alum	2[a]	0[b]	0[b]	0.67
	Use of filter	0[b]	18[a]	0[a]	6.00
	Any other	0[a]	0[a]	0[a]	0.00

answers may be a little biased, all the people interviewed said that they washed hands before preparing food. All the people residing in area I and II washed hands after visiting toilet but 6% of area III admitting not doing so. 100% of the people claimed that they washed hands before eating meals. An average of 85% people said that they kept food covered. 97.33% of people washed raw food before eating it. To question, from where vegetable/food were obtained, it was found that 100% of people of area II bought it from market, whereas 94% from area III and 60% of people from area I bought it from market. An average of 3.67% got it from fields near their residences and 11.67% got food from hawkers.

Bacteriological examination of water samples

Table 14 shows the results of bacteriological examination of water samples, collected from 50 households in the area of study. This table shows that only 4 (8%) samples out of 50 were found to be fit for drinking while 46 (92%) were found to be contaminated with coliform and were declared unfit for drinking. It is interesting to note that all of the 4 non-contaminated water samples belonged to area II, which was furtherest, from the bank of River Ravi, had no open fields or drains around, where people were better educated and majority had community water supply. Moreover the sanitation conditions in area II were

Table 13. Frequency distribution of kind of habit of cleanliness while preparing and eating food.

Parameter	Trend	Area I %	Area II %	Area III %	Mean
Washing hands before preparing food	Yes	100^a	100^a	100^a	100.00
	No	0^a	0^a	0^a	0.00
Washing hand after visiting toilet	Yes	100^a	100^a	94^b	98.00
	No	0^b	0^b	6^a	2.00
Washing hand before eating meals	Yes	100^a	100^a	100^a	100.00
	No	0^a	0^a	0^a	0.00
Keeping food covered	Yes	80^b	100^a	75^c	85.00
	No	20^b	0^c	25^a	15.00
Washing raw food before eating	Yes	92^b	100^a	100^a	97.33
	No	8^a	0^b	0^b	2.67
Source of obtaining food/ vegetables	Market	60^c	100^a	94^b	84.67
	Nearby grown	5^a	0^b	6^a	3.67
	Hawker	35^a	0^b	0^b	11.67

Treatment mean within each column with different letters are significantly different at P=0.05 according to Duncan's new multiple range test.

found to be much better than that of area I and III. The prevalence rate of water-borne diseases in Area II was lower as compared to that in area I and III (Tables 11 and14). These results were re-checked from the department of Epidemiology, Institute of Public Health, Lahore and were found to coincide with those carried out in the Sustainable Development Study Centre (SDSC), Government College University, Lahore. The results of this investigation, based on microbial estimation of water samples (showing 92% contamination), were even worse than those stated by Shiklomanov (2000) who reported that in the year 2000, 37% of the population of lesser developed countries did not have access to safe drinking water.

RECOMMENDATIONS AND SUGGESTIONS

The target site of this study, subdivided into three areas namely I, II and III, located on the left bank of River Ravi, is a riparian zone that has been tagged as high risk piece of land (Khan, 2005). In recognition of the diversity of environmental and economic benefits provided by riparian land, it becomes imperative to study and manage it in order to achieve multiple objectives. Keeping this in mind the study was carried out on the community residing 1.5 km inward the bank of River Ravi. The findings of this investigation portrayed a very bleak picture of the community under study, revealing a very poor socio-economic and health status. These findings were further strengthened by the tests carried out on the drinking water showing that 96% of samples were unfit for drinking. On the basis of comparison of the three sites under study, it can be easily concluded that area I and III had extremely poor living conditions, there being heaps of solid waste dumped near living quarters, sewage channels traversing close by and 100% contamination in drinking water. Area II, being across the metallic road and having covered drains, presents comparatively better living conditions although garbage is seen in heaps outside the houses and the only four non contaminated potable water samples were from area II.

On the basis of observations made during the repeated visits to the site, analysis of water samples and collection of information through questionnaires and keeping in view the fact that this riparian area provides a direct interaction between the terrestrial and river system and needs to be healthy as it directly interferes with the water channel and the ecosystem within it, following recommendations can be made.

1. Area I and III, being closest to River Ravi, should be cleared of all permanent structures (residences).
2. Community in area II, should be allowed to reside there, provided the source of contamination in potable water is detected and the pipelines should be replaced /repaired.
3. It is highly recommended that the strip of land (1000 meter) bordering area III, situated between a sewage channel and active River Ravi should be used for building

Table 14. Bacteriological examination of water samples.

Area no.	Sample no.	Result	MPN/100 ml of coliform
I	1	Contaminated water	180
I	2	"	180
I	3	"	180
I	4	"	180
I	5	"	180
I	6	"	180
I	7	"	180
I	8	"	17
I	9	"	180
I	10	"	180
I	11	"	90
I	12	"	160
I	13	"	180
I	14	"	180
I	15	"	180
I	16	"	50
II	17	"	180
II	18	"	180
II	19	"	11
II	20	Not contaminated	-
II	21	Not contaminated	-
II	22	Contaminated water	90
II	23	"	50
II	24	"	180
II	25	"	180
II	26	"	180
II	27	"	180
II	28	Not contaminated	-
II	29	Contaminated water	25
II	30	"	180
II	31	Not contaminated	-
II	32	Contaminated water	160
II	33	"	90
III	34	"	160
III	35	"	180
III	36	"	180
III	37	"	180
III	38	"	180
III	39	"	180
III	40	"	180
III	41	"	90
III	42	"	180
III	43	"	180
III	44	"	180
III	45	"	160
III	46	"	90
III	47	"	180

Table 14. Continued.

III	48	"	180
III	49	"	180
III	50	"	180

Treatment mean within each column with different letters are significantly different at *P=0.05* according to Duncan's new multiple range test.

a treatment plant for sewage water as suggested by Khan (2005).

4. Alternatively, windbreaks comprising a belt of trees (preferably native ones) should be planted along the course of water channel, which could not only provide windbreak, but will result in shelter, increase yields of neighboring crops and pastures. This vegetation would act as riparian buffer, giving protection not only from floods and source of carbon sequestration for the certain automobile pollution. This would also supply food and buffer the stream against contaminants in surface run off and ground water.

5. Land use control established in the interest of flood risk would contribute to the establishment of riveran forest which may be designed as protection forest; the clearing of these should be forbidden. One of the main reasons of establishment of residential area is that most of the flood plains are privately owned land and second the government has no laws which control land use. In this country land use control has been used to control development through granting of permits for the construction of buildings, infrastructure and other works. This traditional approach has changed all over the world with the growing realization that environmental conservation and land use planning are intricately connected. Adequate land use controls should be seen as necessary condition for protecting people life, property and providing them with the amenities of clean water and air (Clean Act, USA) and to preserve and recreate natural habitat (Clean Air Act, USA, 1970 which is a United States federal law that requires the Environmental Protection Agency (EPA) to develop and enforce regulations to protect the general public from exposure to airborne contaminants that are known to be hazardous to human health).

ACKNOWLEDGEMENTS

The authors would like to thank Department of Epidemiology, Institute of Public Health (IPH), Lahore and Sustainable Development Study Centre (SDSC), Government College University (GCU), Lahore, Pakistan for microbial estimation of water.

Abbreviations: MPN, Most probable number; **HH,** household; **ORS,** oral re-hydration salt; **SDSC,** Sustainable Development Study Centre; **EPA,** Environmental Protection Agency; **IPH,** Institute of Public Health; **GCU,** Government College University.

REFERENCES

Cheesbroug M (2004). District Laboratory Practice in Tropical Countries. Part 2. Camridge University Press, U.K.

Clasen T, Schmidt W, Rabie T, Roberts I, Cairncross S (2007). "Interventions to improve water quality for preventing diarrhea: A systematic review and meta-analysis." Brit. Med. J., 334(7597): 782.

Daniel WW (2006). Biostatistics. A foundation for analysis in the health sciences. 7th ed. New Delhi: Wiley India.

Dhakyanaika K, Kumara PP (2010). Effects of pollution in River Krishni on hand pump water quality. J. Eng. Sci. Technol. Rev., 3(1): 14-22.

Esrey SA, Potash J, Roberts L, Shiff C (1990). Health benefits from improvements in water supply and sanitation: Survey and analysis of the literature on selected diseases. WASH Techn. Rep., 66, April. Water Sanit. Health (WASH) project of USAID, Washington, DC.

Esrey SA, Potash JB, Roberts L, Shiff C (1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis and trachoma. Bull. WHO, 69: 609–21.

Feachem RG (1984). Interventions for control of diarrheal diseases among young children: Promotion of personal and domestic hygiene. Bull. World Health Organ., 62*:* 467–476.

Guntoke O, Aboderin OJ, Bankole AM (2009). Association of water-borne diseases morbidity pattern and water quality in parts of Ibadan City, Nigeria. Tanzania J. Health Res., 11(4): 189.

Kamrul M, Burgess W (1999). The vulnerability of the Dupi Tila aquifer of Dhaka, Bangladesh. Impacts of Urban Growth on Surface Water and Groundwater Quality (Proceedings of IUGG 99 Symposium HS5, Birmingham, July 1999). IAHS Publ. No. 259: 91.

Khan AU (2005). Reducing the Impact of Unplanned Urbanization on a Riparian Ecosystem: A case study on designing a plan on River Ravi. In: World Water day. Pak. Eng. Congr., pp. 37-42.

Park K (2007). Preventive and Social Medicine. M/S Banarsidas Bhanot, Prem Nagar, Jabalpur, India. 25th edition.

Pelczar MJ, Chan ECS, Kreig NR (1993). Microbiology Concepts and applications. International edition, McGraw Hill Publishers, pp. 820-827.

Saeed M, Behzad A (2006). Stimulation of contaminant transport to Mitigate Environmental effects of wastewater in River Ravi. Pak. J. Water Resour., July – December, 10(2): 43.

Shiklomanov IA (2000). Appraisal and assessment of world water resources. Water Int., 25: 11-32.

WHO (2000), World Health Organization. 1993. Guidelines for Drinking Water Quality, Geneva. World Health Organization. Water Supply and Sanitation Council, Global Water Supply and Sanitation Assessment Report. New York: UNICEF.

WHO (2004). World Health Organization, Geneva. "Guidelines for Drinking-water Quality. Recommendations." 3rd ed., Vol. 1.