

Full Length Research Paper

Bacteriological investigation of ground water sources in selected urban areas of district Mardan, Khyber Pakhtunkhwa, Pakistan

Naeem Khan^{1,2*}, Syed Tasleem Hussain¹, Abdus Saboor^{1,3}, Nargis Jamila⁴, Shabir Ahmed¹, Riaz Ullah^{1,5}, Zain Ullah⁶, Samina Ali¹, Sun-Im Lee² and Kyong Su Kim²

¹Department of Chemistry, Kohat University of Science and Technology, Kohat-26000, Khyber Pakhtunkhwa, Pakistan.

²Department of Food and Nutrition, Chosun University, Dong-gu, Gwangju, 501-759, Republic of Korea.

³UNICEF, UNOCA Compound, Jalalabad Road, Kabul, 54, Afghanistan.

⁴School of Chemical Sciences, Universiti Sains Malaysia, Penang, 11800, Malaysia.

⁵Department of Chemical Engineering, College of Engineering, King Saud University, Riyadh, Saudi Arabia.

⁶Department of Chemistry, Gomal University, Dera Ismail Khan, Khyber Pukhtunkhwa, Pakistan.

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Microbial contamination of ground water sources is a common problem in all the big cities, which endangers health and impairs quality of living. To assess this, 39 water samples were collected from highly populated 13 union councils from the urban area of district Mardan. Faecal coliform and *Escherichia coli* were investigated both qualitatively and quantitatively. Qualitative study showed that faecal coliform was found in 90% samples and *E. coli* in 56% samples. Quantitatively, faecal coliform most probable number (MPN) was ranging from 1601 to 2400 for about 28% samples, followed by 551 to 1600 and 201 to 550 for 20% samples each, 40 to 200 for 18% samples and less than 40 for about 13% samples. The major cause of the bacteriological contamination was found to be the extent of susceptibility of the water sources to intrusions from the nearest contamination source.

Key words: Mardan, urban area, microbial contamination, faecal coliform, ground water, *Escherichia coli*.

INTRODUCTION

Availability of adequate and safe drinking water is one of the most important requirements for healthy human life. Water borne diseases are the major cause of death in many parts of the world and it is also a significant economic constraint in many subsistence economics (Fawell and Nieuwenhuijsen, 2003). Water quality is deteriorated due to rapid increase in population, industrial development and poor sanitation in all parts of the world. Drinking water pollution is weakening one of the resource bases on which human society is built (FAO, 2010).

Coliforms are anaerobic gram-negative rod-shaped, non-spore forming organisms of Enterobacteriaceae family. Coliforms are in abundance in faeces of warm-blooded animals, but can also be found in the aquatic environment, in soil, and in decaying matter. Total coliform includes genera that originate in animal faeces as well as genera not of faecal origin. Almost all surface waters have some form of bacteria, but deep ground water is normally free of that, unless some sort of contaminated or waste water gets intruded into it. World health organization (WHO) recommends zero coliforms per 100 ml of water sample (Kahlown, 2006; Pakistan Standards, 2002; WHO, 1996).

Faecal coliform are subgroup of total coliforms. They are capable of growth in the presence of bile salts and produce gas and acid from lactose within 48 h at $44 \pm 0.5^\circ\text{C}$. The presence of faecal coliforms in water may

*Corresponding author. E-mail: nkhan812@gmail.com.

indicate faecal contamination. Some water borne diseases, which may coincide with faecal coliform contamination include, ear infection, dysentery, typhoid, bacterial and viral gastroenteritis and hepatitis A (Mamontova et al., 2000; NSDWQ, 2008). *Escherichia coli* are unicellular microorganism, always associated with faecal contamination of water. In human faeces, 95% of coliforms are *Escherichia coli* (Waite, 1985). Of the five general groups of bacteria that comprise the total coliforms, only *E. coli* is not able to reproduce and grow in the open environment. Consequently, *E. coli* is considered to be the specie of coliform bacteria that is the best indicator of faecal pollution and the possible presence of pathogens (WHO, 1996). The presence of *E. coli* can cause diarrhea and other gastrointestinal disease. An acute disease caused by *E. coli* is hemorrhagic colitis, which results in severe abdominal cramps, acute watery diarrhea and lower intestinal bleeding with occasional fever and vomiting (Nicholas, 2004). WHO standard for *E. coli* is 0/100 ml of water (Manzoor et al., 2010). In Pakistan, bacterial contamination of the drinking water has been reported to be one of the most serious problems throughout the country. The main reasons for such contamination include leakage of pipes, pollution from sewerage pipes due to problem within the distribution system, and shallow water tables due to human activities. Another source for ground water contamination in irrigated and industrial areas is chemical pollution from toxic substances, which include industrial effluents, textile dyes, pesticides, nitrogenous fertilizers, arsenic and other chemicals (Hussain and Mateen, 1998; NSDWQ, 2008; Muhammad et al., 2010). The present study was conducted to investigate the microbiological quality of ground water sources of the urban areas of district Mardan. The main causes of contamination were also investigated.

MATERIALS AND METHODS

Study area

District Mardan lies at the longitude 71° 48' to 72° 52' E and latitude 34° 05' to 34° 32' N. Average altitude of the district is 750 m. It is the second most populated city of Khyber Pakhtunkhwa, with total area of 1632 km² and its population according to 1998 census was 1.46 million and population density of 895 persons per km² which now has escalated to 1.93 million in 2007 (Planning and Development Department, 2002). Highly populated 13 Union councils from the urban area of district Mardan were selected for this study as marked in Figure 1 and identified in Table 1.

Sample collection

Samples were collected from domestic tube well (DTW), open well (OW) and hand pump (HP) of the selected 13 union councils in clean sterilized polyethylene bottles, following standard procedures, properly tagged and stored in a refrigerator (Lenore et al., 1998).

Microbiological testing

The samples were tested for coliform and *E. coli* bacteria qualitatively, by using colitag testing kit in field (HACH, 2010). The confirmation of *E. coli* was also done using multiple tube fermentation method (Lenore et al., 1998). Quantitative microbiological tests were carried out through multiple tube fermentation technique, where by most probable number (MPN) of coliform and *Escherichia coli* was determined and categorized according to their number (Lenore et al., 1998).

RESULTS AND DISCUSSION

The results of both qualitative and quantitative tests are summed up in Table 2. It is evident from the table that out of 39 samples, 35 samples showed the presence of faecal coliform. Four samples showing negative coliform include A-3, A-6, A-31 and A-37, which were collected from deep domestic tube wells. The results for qualitative *E. coli* show that 22 samples were contaminated. Seventeen samples with code numbers A-3, 6, 9, 10, 16, 17, 18, 20, 21, 23, 24, 25, 31, 32, 36, 37 and A-39 were found free of *E. coli* contamination. The quantitative microbiology results for faecal coliform were reported as nil or up to 2 organisms per 100 mL of water samples from the correlation chart. The confirmation of *E. coli* using multiple tube fermentation method showed the same results as by colitag kit. Out of 39 samples, 22 samples showed the presence of *E. coli*. These bacterial counts in ground water sources are very high, as compared to reported studies (Aydin, 2006). The results of both the microbiology tests, qualitative and quantitative match closely. As clear from the table, the samples having negative faecal coliform have negligible faecal coliform counts quantitatively, while those which are positive have faecal coliform counts beyond considerable number. About 28% of the samples indicate the presence of more than 1800 faecal coliform organisms. The samples having contaminations of faecal coliform and *E. coli* are categorized based on the number of organisms, and discussed as below.

1601 to 2400 bacteria per 100 mL

Out of total 39 samples, 11 samples (A-2, 4, 5, 7, 11, 12, 13, 14, 15, 33 and 38) were identified to have 1601 to 2400 faecal coliforms per 100 mL sample. The sources of these samples were open wells (2 samples), domestic tube wells (7 samples) and one sample each of hand pump and public water supply scheme. In case of open wells, the surrounding contamination sources were found to be mostly animal farms, agricultural and water logged area having garbage around the open wells having no covering led (NebGuide, 2008). Domestic tube wells contamination sources are found as gutters and latrines, one source lies close to municipal sewage line. The hand pump is very close at a distance of 1 to 4 feet from

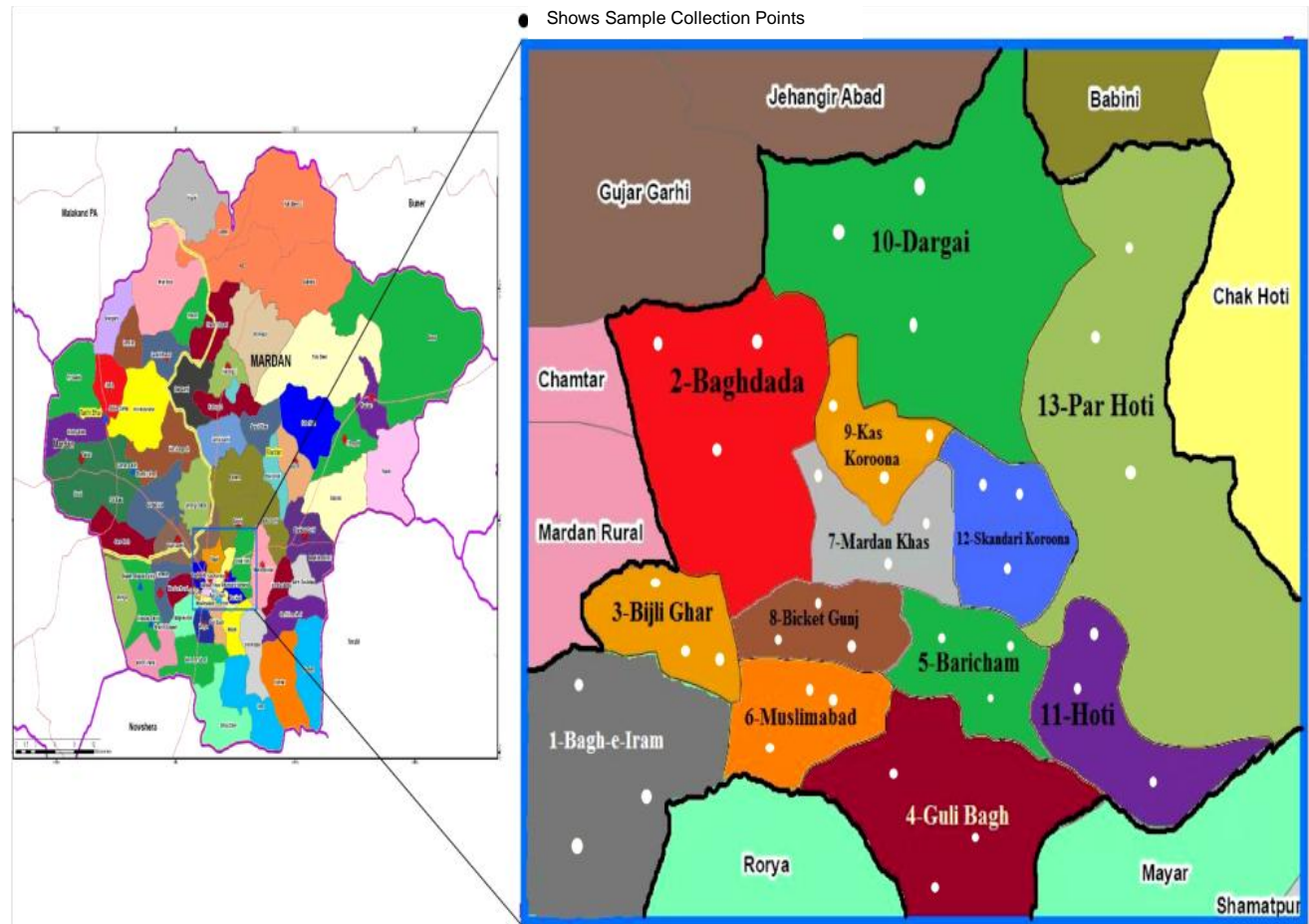


Figure 1. Urban areas of district Mardan selected for study.

surrounding contamination sources such as municipal sewage, garbage place and latrine. High microbiological contamination in the public water supply scheme may be due to outlived and leaking distribution system (NebGuide, 2008; NSDWQ, 2008) (Figure 2).

551 to 1600 bacteria per 100 mL

Eight samples were found to have faecal coliform counts from 551 to 1600 per 100 mL of sample. The samples were collected from open well and hand pump (1 sample each) and six domestic tube wells. The open well is internally lined with bricks, but due to shallow water table, the contamination available from the nearby unpaved source is easily available to the water aquifer through underground percolation from the contamination sources. In case of domestic tube wells, the sample A-1 have shallow ground water table 25 feet, having 24 years life. The remaining five domestic tube wells have depth in range of 60 to 120 feet, but the surrounding unhygienic condition is the main cause of high contamination

(NebGuide, 2008; NSDWQ, 2008) (Figure 2).

201 to 550 bacteria per 100 mL

Eight samples (A-10, 18, 21, 27, 28, 32, 35 and 39) were found to show the presence of 201 to 550 faecal coliform bacteria per 100 mL. Out of these eight samples, only three samples (code A-27, 28 and 35) shows *E. coli* contamination. During survey, it was noted that these three sources are located in very unhygienic surrounding. It is argued that the remaining five water sources receive limited quantities of contaminations from the nearby contamination sources, whereas direct contamination from the gutters or latrines is zero, due to which *E. coli* contamination is absent (NSDWQ, 2008) (Figure 2).

40 to 200 bacteria per 100 mL

Eight samples coded A-9, 16, 17, 20, 23, 24, 25 and 36 were found to have number of faecal coliform organisms

Table 1. Identification of sampling areas by using GPS.

S/N	SC	Union council	Village location	GPS location
1	A-1	Bagh-e-Iram	Bagh-e-Irum, Janabad	34°11'27"N-72°01'22"E
2	A-2	Bagh-e-Iram	Janabad, Moh. Tanki	34°11'28"N-72°01'21"E
3	A-3	Bagh-e-Iram	Alsayyad colony, Omarabad	34°11'16"N-72°00'57"E
4	A-4	Baghdada	Baghdada, Bar Kanday	34°12'35"N-72°02'01"E
5	A-5	Baghdada	Baghdada, Gadbano	34°12'32"N-72°01'56"E
6	A-6	Baghdada	Baghdada, Pohan Colony	34°12'48"N-72°01'27"E
7	A-7	Bijlighar	Gulshan Colony, Kanal road	34°11'27"N-72°01'59"E
8	A-8	Bijlighar	Gulshan colony, Railway Patak	34°11'22"N-72°02'01"E
9	A-9	Bijlighar	Kanal road, Khyber street	34°11'22"N-72°01'56"E
10	A-10	Guli Bagh	Kanal bank, Shamsi road	34°11'22"N-72°03'08"E
11	A-11	Guli Bagh	Chakaro bridge, Fazalabad	34°10'51"N-72°03'39"E
12	A-12	Guli Bagh	Itifaq colony, chakaro bridge	34°10'31"N-72°03'40"E
13	A-13	Bari Cham	Bari Cham, Moh. Sari	34°11'40"N-72°03'18"E
14	A-14	Bari Cham	Bari Cham, Samarabad	34°11'38"N-72°03'17"E
15	A-15	Bari Cham	Bari Cham, Moh Mesriabad	34°11'40"N-72°03'11"E
16	A-16	Muslimabad	Canal road, near Agr. Office	34°10'57"N-72°02'38"E
17	A-17	Muslimabad	Canal road, Bilal town street No.1	34°11'05"N-72°02'30"E
18	A-18	Muslimabad	Canal road, Bilal town street No. 5	34°11'02"N-72°02'31"E
19	A-19	Mardan Khas	Moh. Bara Khankhel	34°12'01"N-72°03'06"E
20	A-20	Mardan Khas	Moh. Bara Khankhel	34°12'03"N-72°03'07"E
21	A-21	Mardan Khas	Mosque Moh. Barakhankhel	34°12'02"N-72°03'11"E
22	A-22	Bicket Gunj	Bicket Gunj, Moh., Dr. Latif	34°11'36"N-72°02'19"E
23	A-23	Bicket Gunj	Bicket Gunj, Moh., Dr. Latif	34°11'37"N-72°02'19"E
24	A-24	Bicket Gunj	Bicket Gunj, Hasnain street	34°11'39"N-72°02'18"E
25	A-25	Kas Koroona	Kas Koroona, Moh. Tekadaran	34°12'37"N-72°02'51"E
26	A-26	Kas Koroona	Kas Koroona, Moh. Abdullah	34°12'38"N-72°02'52"E
27	A-27	Kas Koroona	G.H. School, Kas Koroona	34°12'34"N-72°02'56"E
28	A-28	Dargai	Qutab Palao, Dargai	34°12'57"N-72°03'15"E
29	A-29	Dargai	Dargai, Qutab Palao	34°12'57"N-72°03'16"E
30	A-30	Dargai	Khanmian mosque, Akhonbaba	34°13'07"N-72°03'08"E
31	A-31	Hoti	Allahdadkhel, Nali Par	34°11'27"N-72°03'57"E
32	A-32	Hoti	Allahdadkhel, Sherabad	34°11'36"N-72°04'16"E
33	A-33	Hoti	Allahdadkhel, Sherabad	34°11'35"N-72°04'19"E
34	A-34	Skandari Koroona	Skandari, Moh. Bachagand	34°12'16"N-72°03'32"E
35	A-35	Skandari Koroona	Skandari, Moh. Bachagano	34°12'16"N-72°03'33"E
36	A-36	Skandari Koroona	Skandari, Moh. Sultan Mehmood	34°12'15"N-72°03'29"E
37	A-37	Par Hoti	Par Hoti, Moh. Noormankhel	34°11'51"N-72°03'55"E
38	A-38	Par Hoti	Mohib Road, kacha sarak	34°11'52"N-72°04'14"E
39	A-39	Par Hoti	Par Hoti, Moh. Habib Gul	34°11'58"N-72°04'16"E

from 40 to 200; besides, the sample were found to show no traces of *E. coli*. The results show that these sources are quite safe from the effects of the nearest contamination sources (Figure 2).

Below 3 bacteria per 100 mL

Four samples were found having faecal coliform bacteria counts of 2, which is equal to negligible number of

bacteria on multiple tube fermentation method. All the four samples were collected from the domestic tube wells. Due to large vertical space with the contamination sources, the water source therefore showed no contamination with faecal coliform and *E. coli* (Figure 2).

Conclusion

The present study showed that drinking water sources of

Table 2. Qualitative and quantitative microbiology of the selected areas.

S/N	Sample code	Ground water source	Qualitative microbiology		Quantitative microbiology	
			Faecal coliform	<i>E. coli</i>	MPN	<i>E. coli</i>
1	A-1	DTW	+	+	900	+
2	A-2	HP	+	+	2400	+
3	A-3	DTW	-	-	2	-
4	A-4	DTW	+	+	2400	+
5	A-5	DTW	+	+	2400	+
6	A-6	DTW	-	-	2	-
7	A-7	DTW	+	+	2400	+
8	A-8	DTW	+	+	1600	+
9	A-9	DTW	+	-	200	-
10	A-10	DTW	+	-	550	-
11	A-11	OW	+	+	2400	+
12	A-12	OW	+	+	2400	+
13	A-13	DTW	+	+	2400	+
14	A-14	DTW	+	+	2400	+
15	A-15	DTW	+	+	2400	+
16	A-16	DTW	+	-	175	-
17	A-17	DTW	+	-	200	-
18	A-18	DTW	+	-	550	-
19	A-19	DTW	+	+	900	+
20	A-20	OW	+	-	40	-
21	A-21	DTW	+	-	550	-
22	A-22	DTW	+	+	1600	+
23	A-23	DTW	+	-	175	-
24	A-24	OW	+	-	175	-
25	A-25	DTW	+	-	200	-
26	A-26	DTW	+	+	1600	+
27	A-27	DTW	+	+	425	+
28	A-28	DTW	+	+	550	+
29	A-29	DTW	+	+	900	+
30	A-30	OW	+	+	1600	+
31	A-31	DTW	-	-	2	-
32	A-32	DTW	+	-	425	-
33	A-33	DTW	+	+	2400	+
34	A-34	HP	+	+	1600	+
35	A-35	HP	+	+	550	+
36	A-36	DTW	+	-	115	-
37	A-37	DTW	-	-	2	-
38	A-38	DTW	+	+	2400	+
39	A-39	HP	+	-	550	-

- = Negative; + = Positive.

district Mardan are microbiologically polluted. It is a serious threat to the people of the area if proper measurements are not taken by the concerned authorities.

To prevent any health hazards, all water sources including tube wells, wells and hand pumps, are needed to be well protected from the pollution sources determined, like municipal sewage, garbage places,

animal farms and latrines.

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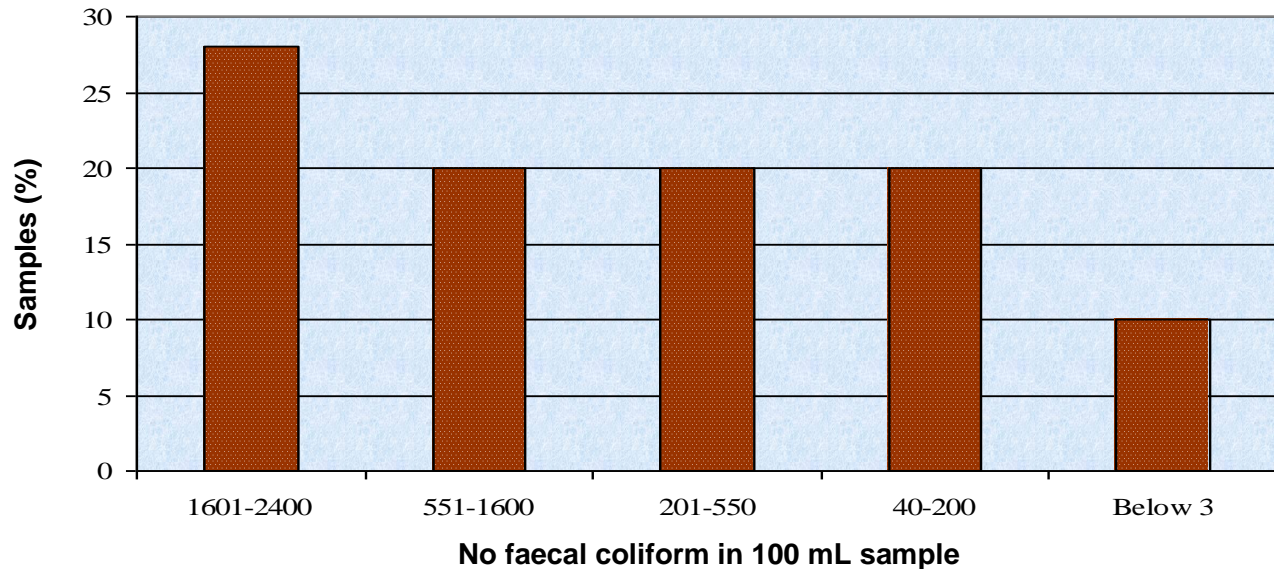


Figure 2. Faecal coliform counts in % of samples analyzed.

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