



CASE STUDY

“INVESTIGATION OF DRINKING WATER QUALITY OF WATER FILTRATION PLANTS INSTALLED AT ISLAMABAD AND RAWALPINDI”



**PAKISTAN ENVIRONMENT PROGRAMME
(PEP) COMPONENT**

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Disclaimer

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Note: Sampling was carried out by Pak-EPA during August, 2005

INVESTIGATION OF DRINKING WATER QUALITY OF WATER FILTRATION PLANTS INSTALLED AT ISLAMABAD AND RAWALPINDI

RESULTS AND DISCUSSIONS

Samplings were carried out by Pak-EPA in August-September, 2005

Table 4.1 shows the location of different water filtration plants installed in Islamabad and Rawalpindi. Table 4.1 Location of Water Filtration Plants

S.No	Water Supply Filtration	Location of Water Filtration Plant
	Islamabad	
1	23080501	G-6/2
2	23080502	G-7/4
3	23080503	G-8/1
4	23080504	G-10/2
5	23080505	F-6/1
	Rawalpindi	
1	24080501	Datta Gunj Bakhsh Road
2	24080502	A-Block, Near Alshita Plaza, Murree Road
3	24080503	F-Block, Quaid-e-Azam Park, New Katarian
4	24080504	Behari Colony, Sadiqabad
5	24080505	Chman Zar Colony, Motti Mehel Cinema, Murree Road
6	24080506	Imam Bargah Colonel Muqbool, College Road Chowk
7	26080501	Fawara Chowk, Raja Bazar
8	26080502	Bokra Road, Fuji Colony, Pir Wadahi
9	26080503	New Catarian Market, Near Anwer Bukers
10	26080504	Main Bunni Chowk
11	26080505	Mohallah Akalgarh, Pir Wadahi Bridge
12	27080501	Babu Lal Hussain Road, Ratta Amral
13	27080502	Tohidi Road, Dhoke Ratta
14	27080503	Dhoke Ratta near Masjid Mayee Sharfan
15	31080501	Near Thana Bunni SaedPur Road
16	31080502	Pull Shah Nazr Jamia Masjid Road
17	31080503	Kohatti Bazar, Kartar Pura
18	31080504	Millat Colony opposite Committee Chowk
19	31080505	Qasimabad near Leprosy Centre
20	01090501	Union Council # 30, Graveyard Road
21	02090501	Imam Bara Road near Bunni
22	05090501	Commerial Market near Sewerage Office
23	05090502	Liaquat Road near TMA Office opposite Garkon College
24	05090503	Dheri Hasanabad Lal Kurti Contonment area
25	06090501	Union Council # 42, near Committee Chowk Dhoke Elahi
26	06090502	Millad Nagar road, Dhoke Ratta opposite Imam Bargah

The above mentioned filtration plants are operational in twin cities and many more were under construction both by the local Governments in Rawalpindi and Capital Development Authority (CDA) in Islamabad. Water Samplings at each location were performed according to the procedure mentioned in Chapter 3.

Water Sampling was done in duplicate to avoid sampling error. Each Water sample was analyzed for 16 parameters including bacteriological test. Geographical locations of each filtration plant were determined using the Geographical Positioning System (GPS). Detail test results of the water sample collected from each filtration plant are shown in Annexure-I. Sampling locations diagram for each water filtration plants are also shown beneath the test results. Summarized test results of water filtration plants are shown in table 4.2.

Table 4.2 Summarized test results of water filtration plants

Sample Identification No.	pH	ms/cm	Concentration mg/l						Coliform/ Ecoli Qualitative test
		Conducting	DO	Chloride	Total Hardness	Nitrate	COD	Iron	
Islamabad									
23080501	7.85	023	5.95	35.59	44.40	3.20	1.00	*N.D.	- ve
23080502	7.63	0.37	7.80	31.00	43.60	4.50	5.00	*N.D.	- ve
23080503	7.06	0.54	3.53	20.55	42.20	6.00	2.00	0.01	+ ve
23080504	7.03	0.54	2.62	32.68	47.20	5.90	3.00	*N.D.	+ ve
23080505	6.89	0.48	3.38	20.55	46.60	3.50	4.00	0.02	+ ve
Rawalpindi									
24080501	7.05	0.52	3.44	23.16	23.60	3.90	1.00	0.02	- ve
24080502	7.30	0.27	3.40	12.03	23.60	2.90	1.00	0.02	- ve
24080503	7.06	0.67	3.96	26.37	25.60	4.70	2.00	0.01	+ ve
24080504	7.21	0.46	4.67	14.04	25.00	3.50	6.00	0.02	- ve
24080505	6.91	0.65	1.34	21.96	32.00	5.00	4.00	0.01	- ve
24080506	6.90	0.81	4.02	48.12	26.00	4.90	7.00	*N.D.	+ ve
26080501	7.28	0.52	2.49	29.88	36.00	2.60	1.00	*N.D.	- ve
26080502	7.02	0.68	3.26	33.78	38.80	4.00	4.00	*N.D.	+ ve
26080503	7.06	0.57	5.94	27.17	42.00	4.80	2.00	0.01	- ve
26080504	7.10	0.53	6.14	14.94	31.80	3.90	1.00	*N.D.	+ ve
26080505	6.88	0.67	5.61	30.88	30.00	4.50	2.00	0.02	- ve
27080501	3.93	0.98	2.35	57.14	59.60	4.90	1.00	*N.D.	- ve
27080502	6.86	0.99	2.90	28.57	58.20	5.60	3.00	*N.D.	+ ve
27080503	6.92	0.80	4.53	27.97	53.80	6.00	5.00	0.01	+ ve
31080501	3.93	0.98	2.35	57.20	59.60	4.90	1.00	*N.D.	- ve
31080502	7.12	0.61	5.19	20.85	42.80	3.90	3.00	0.04	+ ve
31080503	6.97	0.55	3.63	23.36	44.00	2.80	6.00	0.03	+ ve
31080504	7.05	0.54	3.28	18.04	41.80	3.50	3.00	0.01	+ ve
31080505	6.98	0.55	3.12	16.04	44.80	3.60	2.00	0.01	- ve

01090501	7.14	0.68	2.05	23.96	42.40	3.20	4.00	0.01	+ ve
02090501	7.32	0.62	2.36	23.96	47.20	5.20	2.00	*N.D.	+ ve
05090501	7.21	0.69	4.74	32.68	56.40	6.00	3.00	*N.D.	+ ve
05090502	6.95	0.79	3.08	43.41	49.60	6.00	4.00	0.04	- ve
05090503	6.94	0.94	5.05	65.16	64.40	22.00	10.00	*N.D.	+ ve
06090501	7.38	0.63	4.36	21.15	51.80	7.00	3.00	*N.D.	+ ve
06090502	6.98	0.85	3.88	28.37	49.60	5.00	2.00	0.01	- ve

*N.D. means Not Detected; below detection limit Detection limit to Fe is 0.01 mg/l.

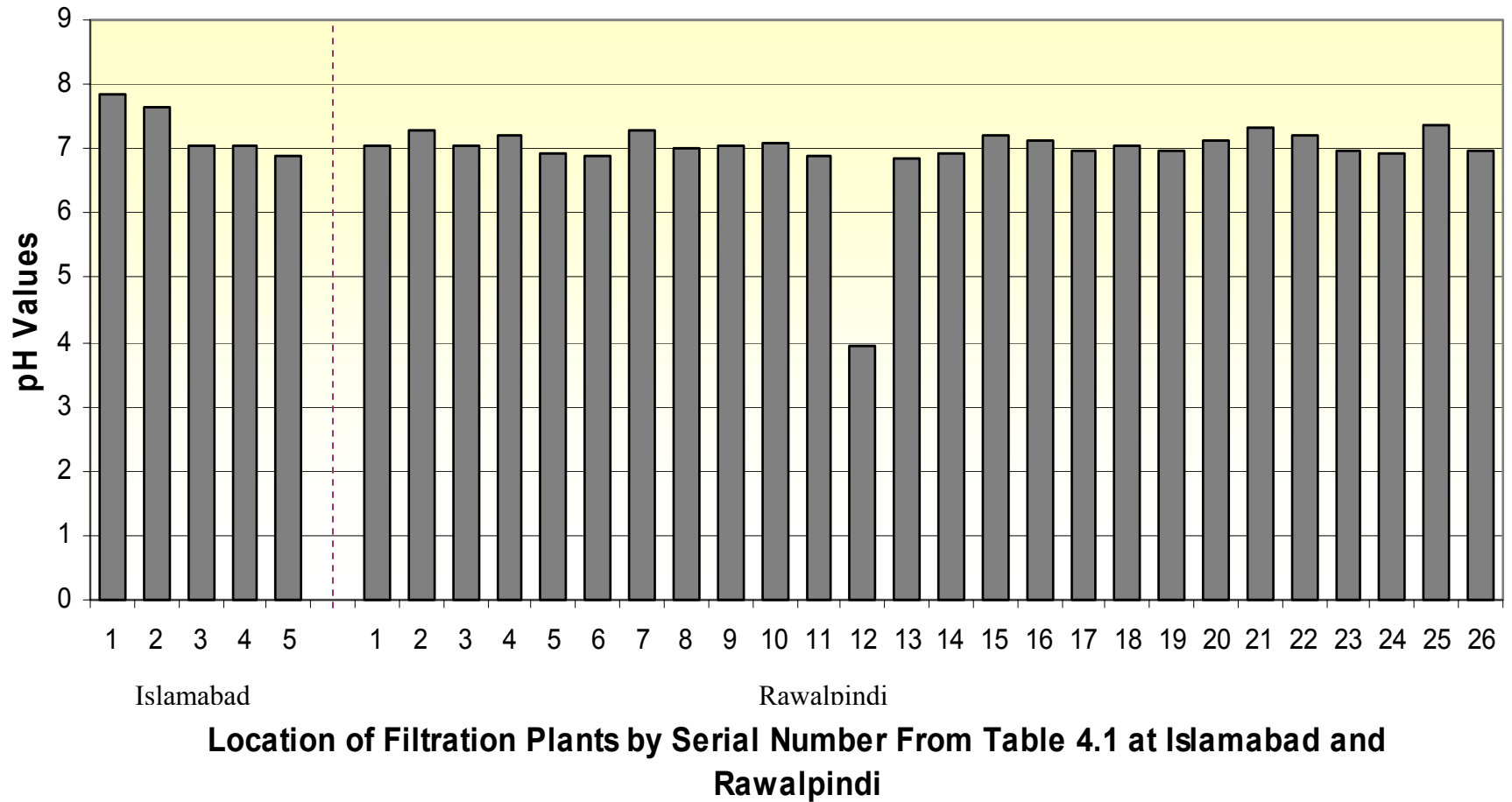
4.1 Analytical Results of Water

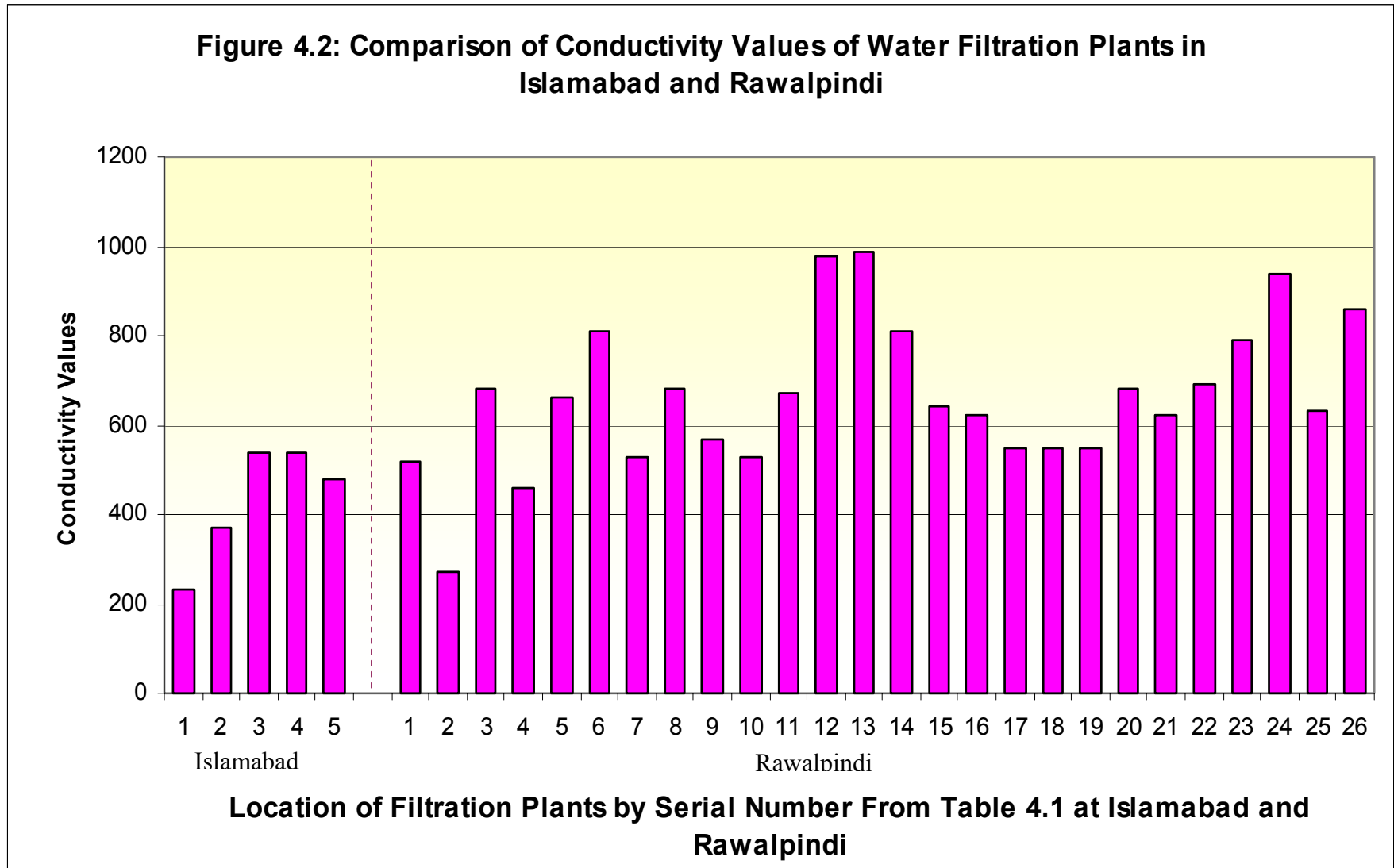
The **pH** values of the analyzed water samples varied from 3.93 to 7.85. The minimum pH values were found at Ratta Amral and at Thana Bunni Saidpur. While the highest pH value 7.85 at filtration plant situated at G-6/2, Islamabad. There is no health standard but the pH values from 7.5 to 8.3 are ideal. The lowest pH values at two filtration plants in Rawalpindi are most often caused by lack of carbonate minerals from limestone and dolomite in the aquifer. Some contaminant sources such as landfills may also lower pH. Figure 4.1 shows the comparison of pH of water filtration plants in Islamabad and Rawalpindi.

Conductivity : The conductivity of water samples ranged from 230 to 990 $\mu\text{S}/\text{cm}$ in all water samples taken from Islamabad and Rawalpindi water filtration plants. The minimum conductivity value of 230 $\mu\text{S}/\text{cm}$ was found at the water filtration plant situated at G-6/2, Islamabad, while the maximum value was 990 $\mu\text{S}/\text{cm}$ of water filtration plants at Dhoke Ratta in Rawalpindi. Figure 4.2 shows the comparison of conductivity of water filtration plants in Islamabad and Rawalpindi. If the conductivity is much greater than hardness, it may indicate the presence of contaminants such as sodium, chloride, nitrate, sulphate, which may be human influenced or natural. Changes in conductivity over time may indicate changing water quality.

There is no health standard for conductivity. The sources of contamination in water either natural or human-made dissolved substances in water. EEC (European Economic Commission) has set a guide level for conductivity which is 400 $\mu\text{S}/\text{cm}$ at 20⁰C. The EEC guidelines are applied on analyzed water samples, and then almost all water samples have higher level of conductivity compare to EEC guide.

Figure 4.1: Comparison of pH Values of Water Filtration Plants in Islamabad and Rawalpindi





Total Dissolved Solids, The maximum concentration of TDS was found from water filtration plant situated at Dhoke Ratta, Rawalpindi, which was 645 mg/l. where as the minimum concentration was 52.6 mg/l at Col. Maqbool College road, Rawalpindi. TDS concentration is not a health hazard. In USA TDS concentration is the secondary drinking water standard and therefore is regulated because it is more of an aesthetic rather than a health hazard. In water filtration plants, this parameter indicates either the filtration system is working properly or deionization resins need to be charged. All collected samples from water filtration plants, Islamabad were below in TDS standard, where as 6 out of 26 samples collected from Rawalpindi area were above the permissible limit of 500 mg/l.

Dissolved Oxygen , DO concentration in water samples collected in Islamabad varied from 2.62 to 7.08 mg/l. where as DO concentration of Rawalpindi water samples varied from 1.34 to 6.41 mg/l. one of the obvious reasons of low DO concentration of water samples collected from Rawalpindi is due to the high water temperature of these samples.

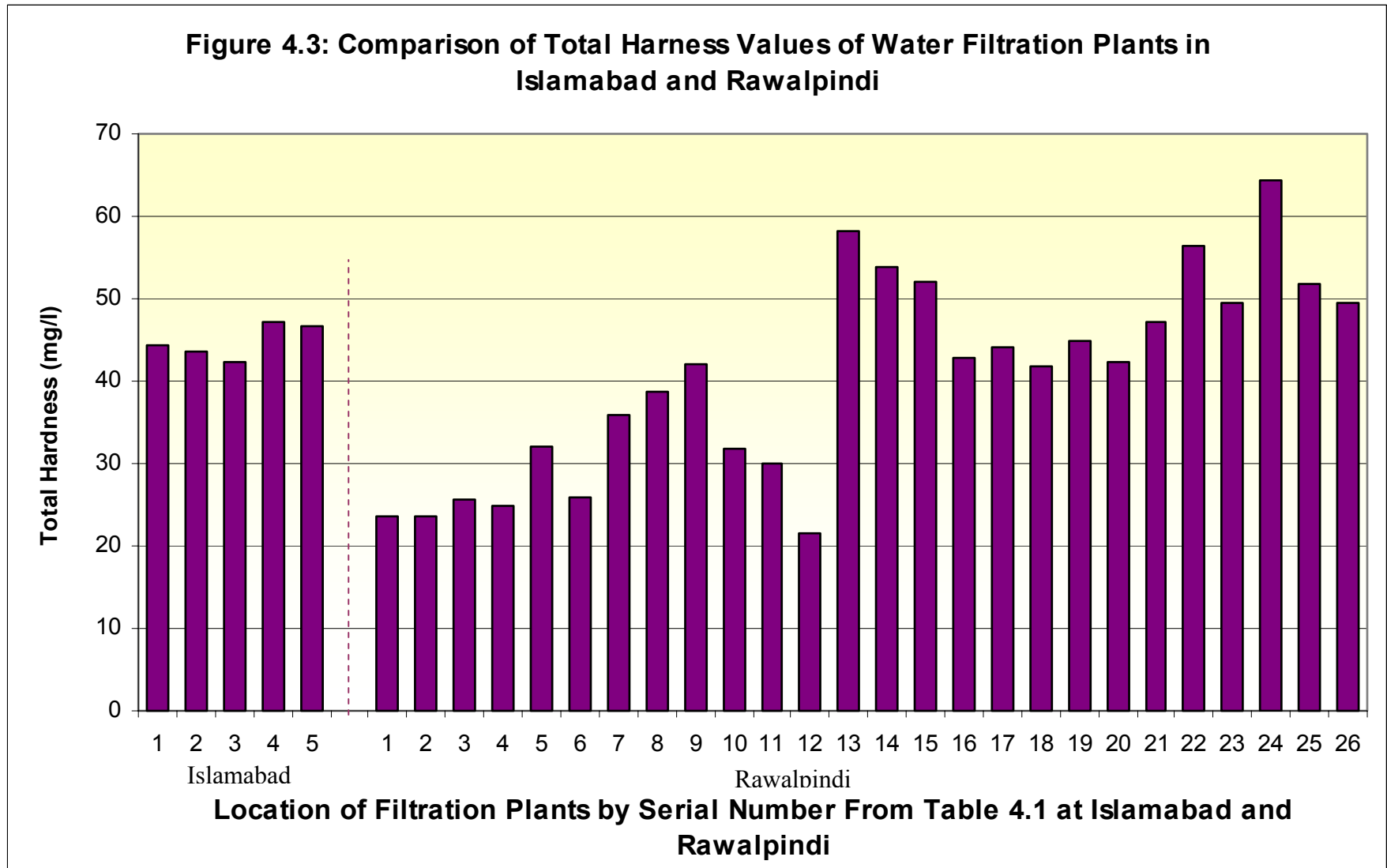
Chloride concentration in water samples from Islamabad varied from 20.55 to 35.59 mg/l. Where as chloride concentration in Rawalpindi varied form 12.03 to 65.16 mg/l. Chloride concentration in both cities are found to be well below the acceptable limit. Figure 4.3 shows the chloride level in water samples collected from the filtration plants of Islamabad and Rawalpindi.

Total hardness of water samples collected from Islamabad varied between 42.20 to 47.20 mg/l. Hardness of water samples collected from Rawalpindi varied from 23.60 to 64.40 mg/l. Hard water benefits health. However values near 150 mg/l are ideal from an aesthetic view point. Standards for Total Hardness on CaCO_3 set by Pakistan Standard Institution (PSI) are 20 mg/l as maximum acceptable concentration and 500 mg/l as maximum allowable concentration. The values of analyzed water samples for total hardness fall between these two levels set by PSI. Figure 4.4 shows the comparison of total hardness of the collected water samples from the filtration plants of Islamabad and Rawalpindi.

Nitrate- Nitrate levels of samples water from Islamabad varied from 3.20 to 5.00 mg/l. where as in Rawalpindi, the levels varied between 2.60 and 22.00 mg/l. the maximum concentration 22 mg/l was found in water filtration plant situated at Dheri Hasanabad Lal Kurti, Rawalpindi. The acceptable Level of nitrate is 50 mg/l. Nitrate concentration of water samples collected from both Islamabad and Rawalpindi cities are below the acceptable level. Figure 4.5 shows the nitrate concentration of water samples collected from the filtration plants of Islamabad and Rawalpindi. It is advisable that the activated charcoal filter of the water filtration plant of Dheri Hasanabad Lal Kurti must be changed immediately. The result shows that this filter has already been saturated.

Chemical Oxygen Demand. Water samples collected from Islamabad showed COD concentration 5 mg/l or less. COD concentration of analyzed samples from Rawalpindi varied from 1-10 mg/l. the highest concentration of COD was formed from the water sample collected from the filtration plant situated at Dheri Hasanabad Lal Kurti. This water filtration plant has shown complete failure both for chemical and also for bacteriologically contamination removal. The entire system of this water filtration plant needs rechecking. The raw water sample from this filtration plant needs complete analysis both chemically and bacteriologically to access the quality of raw water of the well. Figure 4.6 shows comparison of COD concentration of the samples collected from the water filtration plants of Islamabad and Rawalpindi.

Iron. In some samples collected from filtration plants of Islamabad and Rawalpindi, iron could not be detected. The detection limit of atomic absorption spectrophotometer, which was used for this study for iron, was 0.01 mg/l. Iron concentration varied from < 0.01 to 0.04 mg/l. Iron concentration in all water samples was less than 0.3 mg/l, therefore there was no unpleasant taste, odor, appearance or side effect caused due to irons.



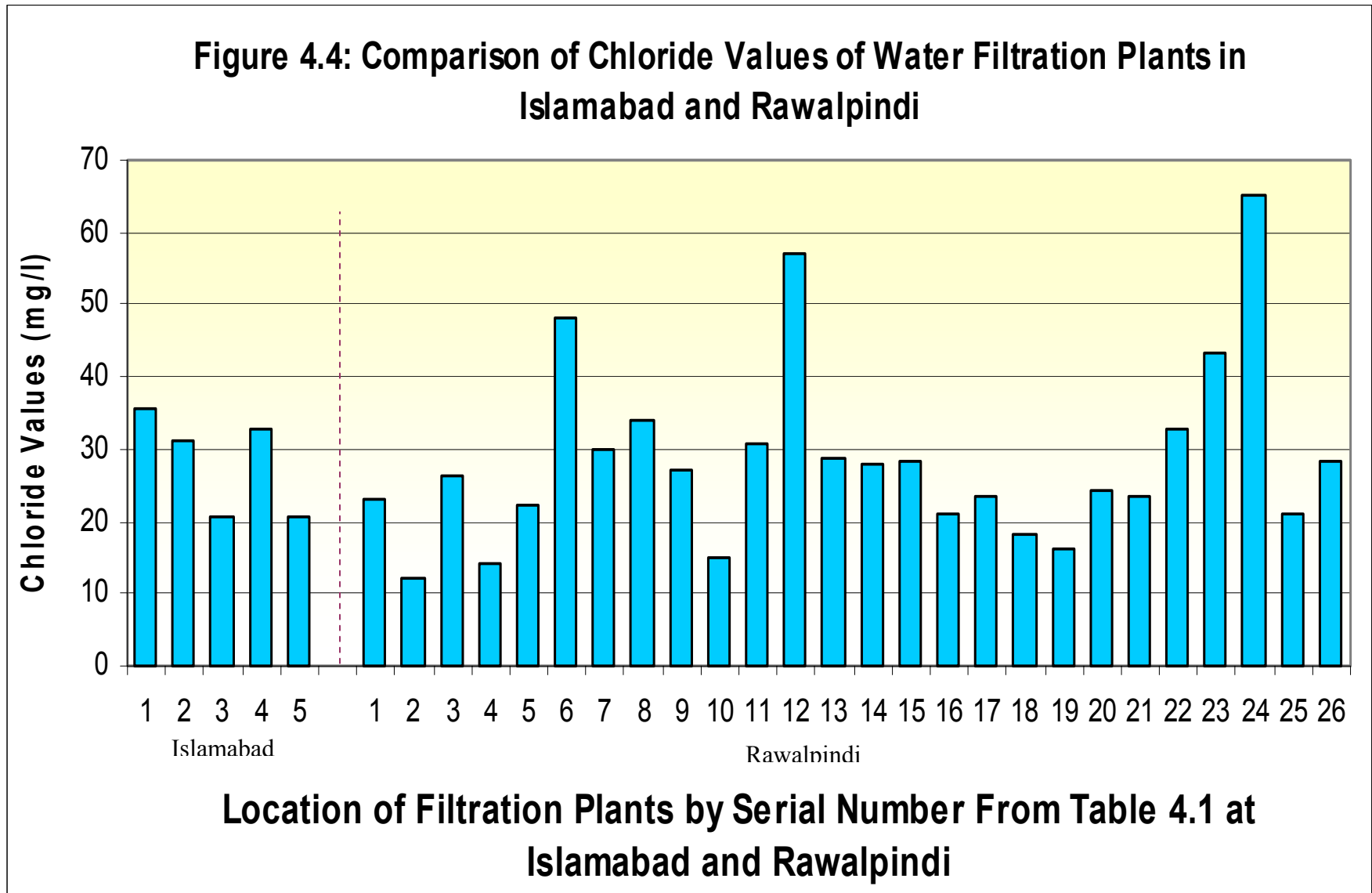
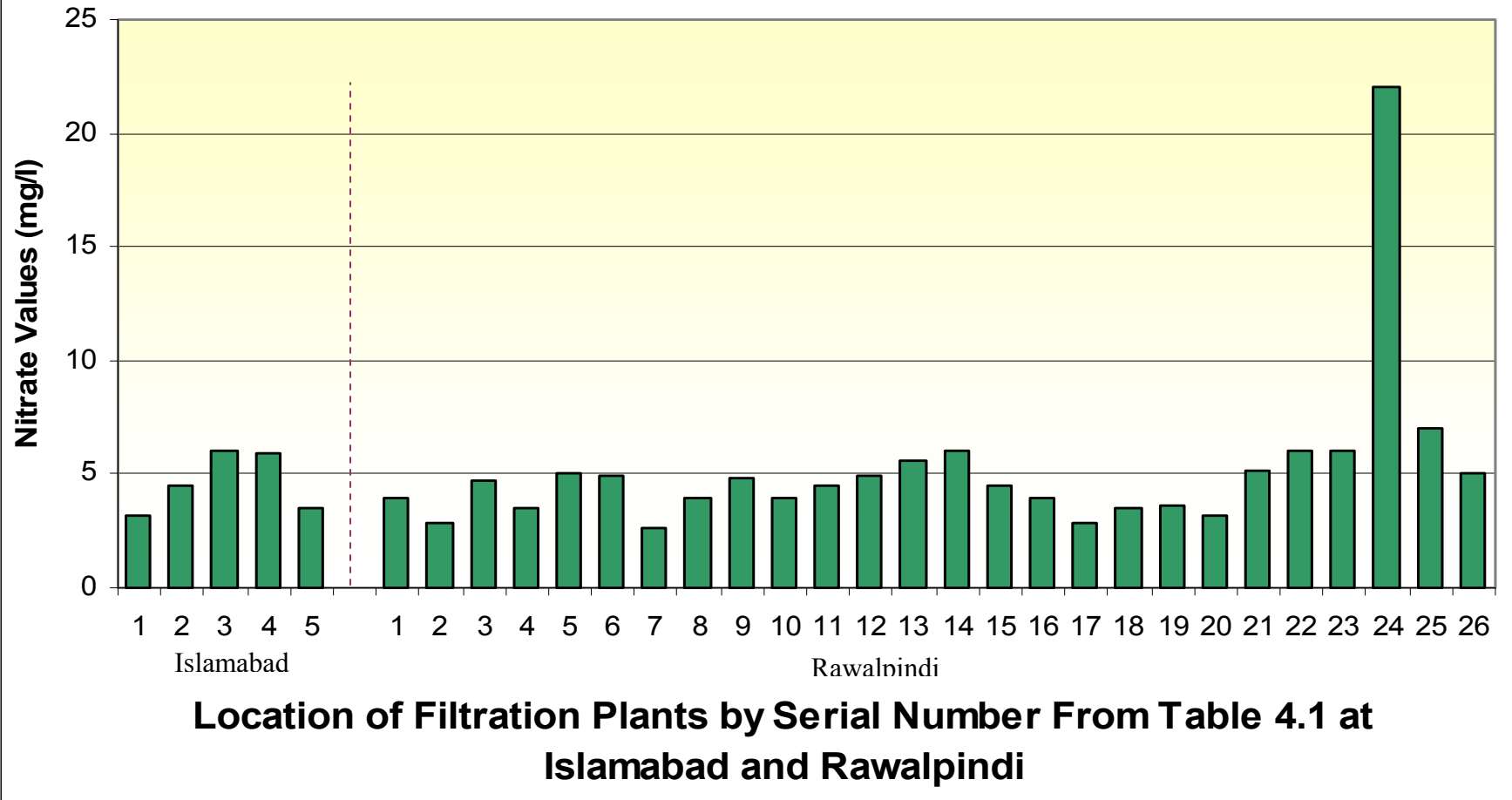


Figure 4.5: Comparison of Nitrate Values of Water Filtration Plants in Islamabad and Rawalpindi



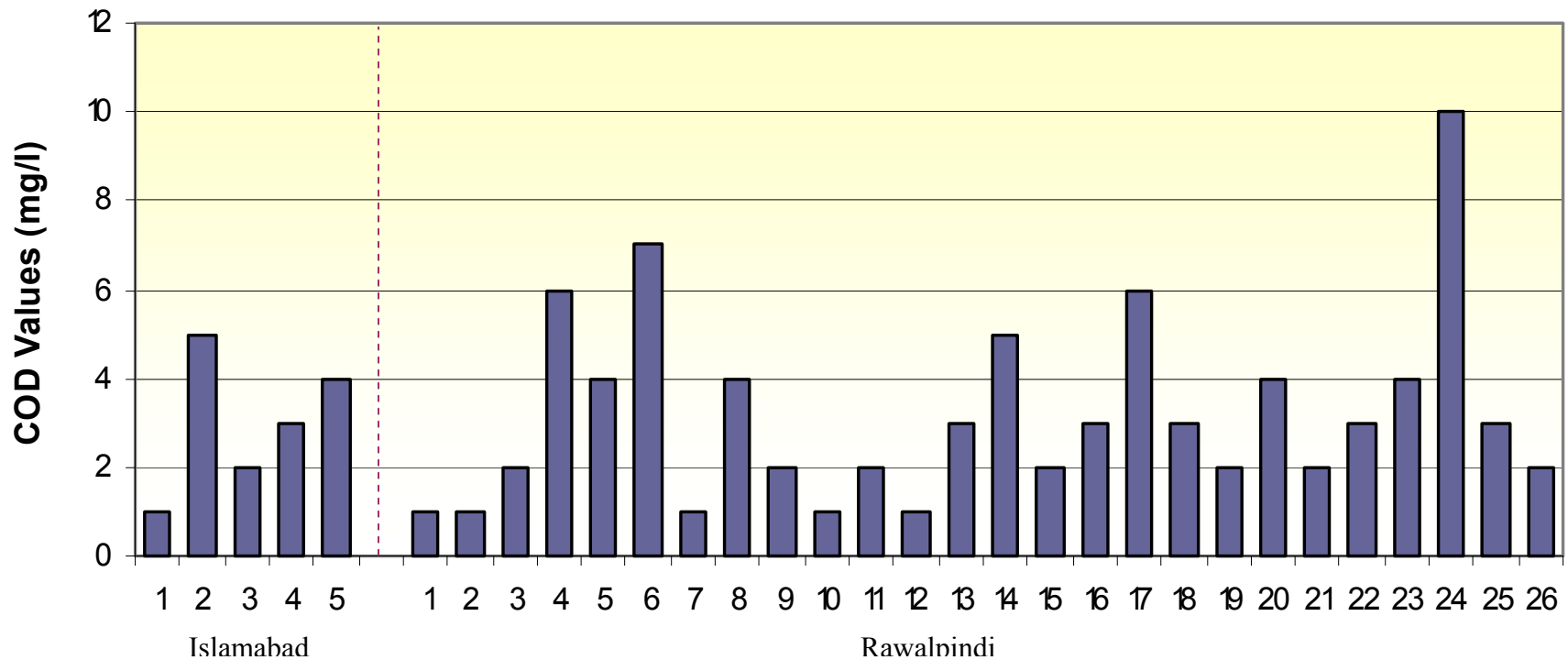
Bacteriological Contamination. Water filtration systems installed by both CDA and TMA, Rawalpindi in various locations of Islamabad and Rawalpindi respectively are equipped with UV disinfection system. Unfortunately at many filtration plants, this system was not working properly and bacterial contaminations were passing through the filtered water. In Islamabad, 3 out of 5 samples were contaminated with coliform bacteria. In Rawalpindi, 14 out of 26 samples are bacterial contaminated. This ratio is very high. These results are disappointing and source of concern for the agencies responsible for the provision of safe drinking water to the public. Bacterial contamination falls under the category of pathogens. WHO, USEPA and PSI establish standards for coliform bacteria in drinking water are zero (or no) total coliform per 100 ml of water. Qualitative test results performed in the field using the Merck test kits are reflected in table 4.2.

Later on based on these results, water samplings were performed according to the sampling protocol to test these water samples quantitatively in the laboratory for coliform bacteria. CLEAN has performed bacteriological tests of contaminated samples, which are reported in table 4.3.

Table 4.3 Bacteriological Examination

S.N	Water filtration plant location	Spot Testing (Qualitative test)	Laboratory Test (Counts/ 100ml)
	Islamabad		
1	G-8/1	+ ve	27
2	G-10/2	+ ve	16
3	F-6/1	+ ve	59
	Rawalpindi		
1	F-Block, Quaid-e-Azam Park, New Katarian	+ ve	9
2	Imam Bargah Colonel Muqbool, College Road Chowk	+ ve	11
3	Banni Chowk, Imam Bargah Road	+ ve	16
4	Pull Shah Nazar, Jamia Masjid Road	+ ve	12
5	Kohati Bazar, Karter Pura	+ ve	35
6	Millat Colony, Committee chowk	+ ve	2
7	Union Council # 30, Graveyard	+ ve	4
8	Commercial Market, near sewerage office	+ ve	78
9	UC # 42, Dhoke Alahi Bukhsh	+ ve	12
10	Tohidi road, Dhoke Ratta	+ ve	4
11	Masjid Mahi sherfahn	+ ve	54
12	Imam Bara road, Khoke Ratta	+ ve	14
13	Bhokhra road, Pir Wadhai	+ ve	48
14	Dairi Hasanabad, Lal Kurti	+ ve	8

**Figure 4.6: Comparison of COD Values of Water Filtration Plants
in Islamabad and Rawalpindi**



**Location of Filtration Plants by Serial Number From Table
4.1 at Islamabad and Rawalpindi**

The highest bacterial count 78 was found at Commercial Market near Sewage office, Rawalpindi. In Islamabad, the highest bacterial contamination was detected at F-6/1 water filtration plant, which is 59. Even the water sampling for laboratory bacteriological examination of the contaminated water filtration plants were performed after three months of the first sampling, the bacteriological contamination of these plants was not improved during this period. The agencies responsible for the establishment and maintenance of these filtration plants were informed accordingly.

5- SUMMARY AND RECOMMENDATION

5.1 Summary

Water is second to oxygen as being essential for life. The average adult consumer and excretes about 6 to 8 cups per day. Drinking water is never pure. Water naturally contains minerals and microorganisms from the rocks, soil and air with which it comes in contact. Whether or not drinking water is safe will depend on which impurities are present and in what amounts.

WHO and most of the countries of the world including Pakistan have devised standards to ensure that public drinking water is safe. In Pakistan especially in urban areas, the drinking water gets contaminated either from the source or through the distribution system. To ensure the supply of the safe drinking water to the public, the Government of Pakistan has initiated “Clean Drinking Water” programme for all its citizens till the year 2007. The local administrations of Islamabad and Rawalpindi initiated this programme and installed number of water filtration units. Until now 5 water filtration plants are installed in Islamabad, while 32 similar types of units are installed in Rawalpindi. Many more water filtration plants are under construction in both cities.

Pakistan Environmental Protection Agency (Pak-EPA) has taken initiative through its Pakistan Environment Programme (PEP) component to check the water quality of already installed filtration units in Islamabad and Rawalpindi. Water sampling were performed both for chemical and bacteriological analysis. For this purpose a monitoring team was constituted by Pak-EPA comprising laboratory analysts along with PEP inspectors and officer. In-situ analysis of the number of parameters was performed, while for rest of analysis water sampling was performed according to the standard sampling methods. A brief about the water filtration plants efficiency is reflected in table 5.1.

Table 5.1 Water Filtration Plants Efficiency

Cities	Total No. of filtration units	Chemical contamination	Bacteriological contamination	Total No. of inefficient filtration plants	% Inefficient water filtration plants
Islamabad	5	-	3	3	60
Rawalpindi	26	2	14	16	61

Table 5.1 shows that almost 60 % water filtration units in both cities are inefficient and the water supply from these units is not safe for human consumption. To protect the public health, water filtration system require careful:

- Selection
- Installation
- Maintenance
- Operation
- Oversight
- Administrative support

5.2 **Recommendations**

Microbiological contamination was found as a major contamination source in the filtered water. So, the following recommendations are being forwarded to minimize or overcome the existing problem:-

1. In water purification systems, different types of filters are used. It is recommended that these filters may be replaced according to manufacturer's specifications. If these filters remain in the system after specific period, the build up of organic matter on these filters can promote bacterial growth in very short periods of time, even overnight. Studies have shown that levels of bacteria present in water that has passed through improperly maintained filtration devices may be up to 2000 times higher than level in unfiltered water.
2. Activated carbon is being used to remove the inorganic matters and certain harmless taste and odour producing compounds. The surface area of the activated carbon is very large and may become home for bacteriological activities. It is recommended that one UV disinfection system may be installed prior to filtration unit, so that if any microorganism is present in raw water may be inactivated before entering the filtration unit.

3. As appropriate flow rate of the filtered water must be determined for UV disinfection system based on the characteristics of water and on the desired dose. The higher the flow rate, the shorter the detention time, therefore smaller dose will be received by the water.
4. UV dose, in milli joules/square centimeter (mj/cm^2) is defined as UV intensity ($\text{m Watts}/\text{cm}^2$) times the exposure duration (seconds). The UV dose of $40 (\text{mj}/\text{cm}^2)$ is being used as standard in Austria, Swizerland and Germany for drinking water. Below $40 \text{ mJ}/\text{cm}^3$ UV dose in some cases photo reactivation takes place. Photo reactivation is the ability of cell to repair the damage of the DNA by means of enzymes. To take the adequate safety measure, it is recommended that UV dose of $40 (\text{mj}/\text{cm}^2)$ may be injected to the filtered water.
5. It is recommended that quartz sleeves UV lamps must all be replaced according to manufacturer's recommendations. It may be emphasized that just because the lamp is lit doesn't mean it's providing the proper disinfection dose.
6. Both the water provider and regulatory department must have properly equipped laboratory facilities with trained and properly qualified persons for monitoring of drinking water quality on regular basis. The reports in this regards may be published in the press for public awareness.