

Water Quality Status in Islamabad

Pakistan Council of Research in Water Resources (PCRWR)

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Summary

A working group (WG) has been constituted by the Ministry of Interior to furnish detailed work plan and recommendations for supply of clean drinking water for Islamabad Capital Territory (ICT). Following the Terms of References (TOR) for this working group (WG), an intensive water quality assessment of water supply sources of Islamabad was conducted in September, 2018. Water quality assessment results of 224 operational water sources were compared with National Standards for Drinking Water Quality (NSDWQ).

Out of 224 monitored water sources, 101 tube wells, 9 water supply schemes, 9 water works/reservoirs and 27 water filtration plants were supplying safe drinking water. The remaining 30 tube wells, 34 water supply schemes, 4 water works or reservoirs, and 10 filtration plants were found supplying unsafe drinking water mainly due to wide spread microbial contamination.

Introduction

Access to safe drinking water in Pakistan is one of the major public health concerns, as the country is facing the water quality and quantity deterioration evidenced in various research studies. The national level monitoring investigations (2002 to 2015) carried out by PCRWR have revealed 15% and 18% of the sources supplying safe drinking water in urban and rural areas respectively. These studies have also identified the prevalence of four major water quality contaminants i.e. biological contamination (68%), arsenic (24%), nitrate (13%) and fluoride (5%). Infectious diseases caused by pathogenic bacteria, viruses and protozoan parasites are among the most common and widespread health risk of drinking water. It has been estimated that 20-40% of beds in Pakistani hospitals are occupied by patients suffering from waterborne diseases, including cholera, diarrhea, dysentery, hepatitis A and E, typhoid, etc. (*Nabeela et al., 2014*). Past estimates have indicated about 200,000 child deaths annually in Pakistan due to water-borne diseases, whilst water, sanitation and hygiene diseases cost Rs.112 billion annually to the economy. The costs associated with diarrheal diseases alone were estimated in the range of Rs.55 to Rs.80 million per year (*Pakistan Economic Survey, 2010-11*).

An improper disposal of municipal, industrial and hospital solid waste and waste water, excessive use of agricultural chemicals, agricultural run-offs, poor management of farm wastes and, leakages from septic tanks are the foremost water pollution sources. The detrimental effects of outdated water supply infrastructure, breakage in distribution system, unprotected water sources, intermittent water supply, lack of operation and maintenance plans of water filtration plants, inadequate technical capacity of water supply agencies and lack of awareness on quality issues are the main challenges in sustainable supply of safe drinking water. A country wide technical assessment survey of water supply schemes (2012) conducted by PCRWR had also demonstrated that 88% of the country's functional water supply schemes provided unsafe drinking water due to microbial contamination. Apart from water treatment, unsafe water storage at household level may also add contamination to even treated water. Without addressing such prevailing water quality concerns by implementing water purification methods either at source-to-supply network or at household level, the public health status cannot be improved.

In Islamabad, the main sources of domestic water supply are, the reservoirs built at Simly and Khanpur, many tube wells, and few springs located at Saidpur, Nurpur and Shahdra-hills. About 2,001,579 inhabitants of Islamabad receive some or all of their drinking water from the MCI's water

sources. The conventional treatment methods such as coagulation, flocculation, sedimentation, filtration and chlorination are used for the treatment of Simly and Khanpur reservoirs water to make it potable. Filtration plants serve drinking water to large urban areas and small rural communities and thus are a vital part of MCI's infrastructure; not only they represent an essential service to general public, people also believe that water they collect from filtration plants is safe. Thus, a treatment breakdown at a filtration plant presents a widespread acute health threat from a waterborne disease outbreak. Sustainable supply of safe drinking water through these water filtration plants is a challenge as the efficacy of providing safe drinking water from these plants is dependent not only on financial resources but also on technical capacity of plant operators for operation, regular maintenance and basic water testing.

A meeting regarding supply of clean drinking water was held on 10 September, 2018 at Ministry of Interior Islamabad under the Chairmanship of Minister of State (MoS) for Interior. The scope of convening the meeting was to discuss the demand and supply variances, sources of water supply, deficiencies/inefficiencies in the existing water supply system and to suggest short, medium and long term solution to significantly improve the situation in the capital. A working group (WG) comprising Chief Commissioner ICT, Capital Development Authority (CDA), Metropolitan Corporation, Islamabad (MCI), Pakistan Council of Research in Water Resources (PCRWR), Water and Sanitation Agency (WASA), Islamabad Electric Supply Company (IESCO), Cantonment Board and Alternate Energy Board has been constituted to furnish detailed working plan and recommendations for supply of clean drinking water for ICT. Following the Terms of References (TOR) of this working group (WG), an intensive water quality assessment of Islamabad is conducted recently and based on technical data, this report is compiled indicating water quality status of tube wells (TWs), water supply schemes (WSS), water works/reservoirs and water filtration plants (WFPs) of Islamabad. This assessment is aimed to help Metropolitan Corporation, Islamabad (MCI) in overcoming numerous on-going compliance challenges and to initiate the sustainable remedial measures. The specific objectives were to;

a) Evaluate the quality of drinking water being supplied to general public in Islamabad.
b) Highlight the need of further improvements in short term and long term water treatment process.
c) Safeguard the public health against contaminated drinking water.

PCRWR Sampling Methodology

Sampling Sites

A detailed list of sampling sites comprising of locations of tube wells (200 No.), filtration plants (39 No.) and rural water supply schemes (64 No.) and water works or reservoirs (13 No.), their feeding areas, capacity and consumer IDs was provided by the Water Supply Directorate of Metropolitan Corporation Islamabad (MCI). The status of operational water sources is shown as Figure-1.

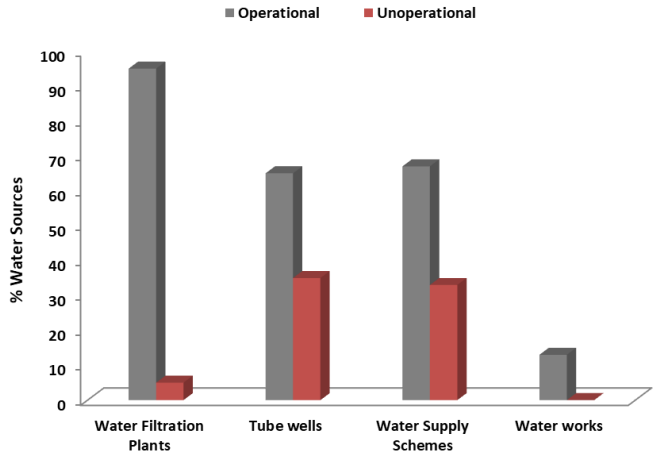


Figure-1: Status of operational water sources

Sources Monitored by PCRWR

Tube wells (131 No.)
Filtration Plants (37 No.)
Water Supply Schemes (43 No.)
Water works (13 No.)
Total sources monitored (224 No.)

Composition of Sampling Team

Sampling team comprised of well experienced technical professionals from National Water Quality Laboratory of PCRWR. Whilst, the sampling team of Water Supply Directorate of Metropolitan Corporation Islamabad (MCI) also joined the PCRWR team to conduct joint sampling of water sources and filtration plants.

Sampling Procedure

Following the American Public Health Association (APHA, 2012, 22nd Edition) protocols for water sampling, testing and quality control, water samples were collected from each water source. For this purpose, four types of samples were collected from each site, preserved and transported to National water Quality Laboratory. Types of the water samples collected are as following;

Sample Type	Preservative	WQ Parameters
Type A	Sterilized sampling bottles for microbiological analysis	Total Coliforms, & *E-coli* (indicator organisms)
Type B	2ml/liter HNO_3 as preservative for trace elements	Arsenic & Iron
Type C	1ml/100ml boric acid as preservative	Nitrate (N)

	Type D	No preservative	Physical and aesthetic parameters. Major Cations and anions
	Field blank and replicate samples[1] for quality control purpose were also collected. One out of ten sites was selected for replicate and which were analyzed to evaluate the reproducibility of analytical results. Drinking water analytical results of all the water sources were compared with NSDWQ and WHO permissible limits for drinking water.		



Figure-2(a-d): Water Sampling from MCI Water Sources
by PCRWR Professionals (September, 2018)

[1] **Field Blank** is a blank solution (Deionized water) that is subjected to all aspects of sample collection, field processing, preservation, transportation, and laboratory handling as an environmental sample.

Replicate Samples is a group of samples, collected in a manner that the samples are thought to be essentially identical in composition.

PCRWR Laboratory Facilities

It is worthwhile to mention here that PCRWR has a fully equipped National Water Quality Laboratory having analytical capabilities for wide range of physicochemical (inorganic and organic parameters) and microbiological parameters. PCRWR Water Quality Laboratories have a well-defined quality control mechanism to generate reliable and validated data. National Water Quality Laboratory (NWQL) participates regularly in Proficiency testing Programme as a part of its quality assurance plan.



Figure-3(a-b): Samples analysis at National Water Quality Laboratory (NWQL) of PCRWR

PCRWR Identification Codes Allotted to MCI Filtration Plants

Sr. No.	ID Code	Location	Operational Status
1.	MCI/FP/1	F-6/1, NEFDEC Cinema	Operational
2.	MCI/FP/2	F-10/1, near H.No.60, St#25	Operational
3.	MCI/FP/3	G-6/2, near Capital Hospital (OHT)	Operational
4.	MCI/FP/4	G-7/4, Near OHT	Operational
5.	MCI/FP/5	G-10/3, Opp. H.No.401, 402, Ibn-e-Sina Road	Operational
6.	MCI/FP/6	G-11/3, Ibn-e-Sina Road, Opp. H. No.	Operational
7.	MCI/FP/7	I-8/3 - Near Sangam Market	Operational
8.	MCI/FP/8	I-10/2, near Overhead Tank	Operational
9.	MCI/FP/9	F-5, Minister Colony/Enclave	Operational
10.	MCI/FP/10	G-5, Presidential Estate Colony	Operational
11.	MCI/FP/11	G-7/1, I&T Center	Operational
12.	MCI/FP/12	G-5, Parliament lodges	Operational
13.	MCI/FP/13	G-6/1-2, Near Overhead Tank, St.#40	Operational
14.	MCI/FP/14	G-6/1-4, near Aabpara Market	Operational
15.	MCI/FP/15	G-7/3, near Gulshan Market	Operational
16.	MCI/FP/16	G-7/2, Sitara Market	Operational
17.	MCI/FP/17	G-8/2, Opposite Street # 11	Operational
18.	MCI/FP/18	I-9/1, Eidhi Centre	Operational
19.	MCI/FP/19	I-10/1 - Green Belt, Opp. Sreet No. 53	Operational
20.	MCI/FP/20	Margalla Town, Phase-II	Operational
21.	MCI/FP/21	G-6 Bazaar	Operational
22.	MCI/FP/22	I-8/2 - Near Tubewell # 118	Operational
23.	MCI/FP/23	F-10 Markaz	Operational
24.	MCI/FP/24	Bari Imam Complex	Operational
25.	MCI/FP/25	I-10 Markaz	Operational
26.	-	FIA Building	Un-operational
27.	MCI/FP/26	G-8/1, Street No. 13	Operational
28.	MCI/FP/27	G-9/3, CDA Block	Operational
29.	MCI/FP/28	I-10/4 - Near Ameer Market	Operational
30.	MCI/FP/29	I-10/2 & I-10/3, Green Belt, Chambeli Road	Operational
31.	MCI/FP/30	G-9/2, Jahangir Market	Operational
32.	MCI/FP/31	G-10/4, I&T Centre	Operational
33.	MCI/FP/32	I-9/4, Street # 45	Operational
34.	MCI/FP/33	G-9/2, Near O.H. Tank/CDA Complaint Office	Operational
35.	MCI/FP/34	G-11/2 - Opposite Street No.90	Operational
36.	-	G-10 Markaz	Un-operational
37.	MCI/FP/35	G-7/2, near Ali Masjid	Operational
38.	MCI/FP/36	Rawal Town	Operational
39.	MCI/FP/37	Shahzad Town	Operational

Water Quality Parameters and Methods Used for Analysis

Sr. #	Parameters	Analytical Method
1.	Alkalinity (m.mol/l as $CaCO_3$)	2320-B, APHA Standard Method
2.	Arsenic (ppb)	3114-B, APHA Standard Method, AAS Vario 6, Analytik Jena AG
3.	Bicarbonate	2320-B , APHA Standard Method
4.	Calcium (mg/l)	3500-B, APHA Standard Method
5.	Carbonate (mg/l)	2320-B, APHA Standard method
6.	Chloride (mg/l)	4500-BTitration (Silver Nitrate), APHA Standard Method
7.	Color (TCU)	Sensory Test
8.	Conductivity (µS/cm)	2510-B , APHA Standard Method, E.C Meter, Model 4320, Jenway, UK
9.	Hardness (mg/l)	2340-C ,EDTA Titration, APHA Standard Method
10.	Magnesium (mg/l)	3500-B, APHA Standard Method
11.	Nitrate- Nitrogen (mg/l)	4500-B , APHA Standard Method ,UV Spectrometric Method
12.	Odor	Sensory Test
13.	pH	4500-B , APHA Standard Method ,pH Meter, Hanna Instrument, Model 8519, Italy
14.	Potassium (mg/l)	3500-B , APHA Standard Method, Flame photometer PFP7, UK
15.	Sodium (mg/l)	3500-B , APHA Standard Method ,Flame photometer PFP7, UK
16.	Sulfate (mg/l)	4500-E , APHA Standard Method ,Turbidimetric Method by Spectrophotometer
17.	Phosphate (mg/l)	8048 (Hach), USEPA Method.
18.	Taste	Sensory Test
19.	TDS (mg/l)	2540C, APHA Standard method
20.	Turbidity (NTU)	2130-B, APHA Standard Method ,Nephlometric Method ,Turbidity Meter, HANNA
21.	Fluoride (mg/l)	4500-C. Ion-Selective Electrode APHA Standard Method
22.	Iron (mg/l)	FerroVer method (HACH Cat. 21057-69) USEPA Method
23.	Total Coliforms (CFU/100 ml)	9222-B, Total Coliforms Membrane Filtration Procedure media LES Endo Agar.
24.	E. Coli (CFU/100 ml)	USEPA method 1603 *E. Coli* on Mod. M-tech Agar

Water Quality Permissible Limits for Drinking Water

Sr. #	Parameter	Units	Permissible Limits	
			WHO	NSDWQ
1.	Alkalinity	mg/l	NGVS	NGVS
2.	Bicarbonate	mg/l	NGVS	NGVS
3.	Calcium	mg/l	NGVS	NGVS
4.	Carbonate	mg/l	NGVS	NGVS
5.	Chloride	mg/l	250	250
6.	Colour	TCU	15	Colorless
7.	Conductivity	µS/cm	NGVS	NGVS
8.	Fluoride	mg/l	1.5	1.5
9.	Hardness	mg/l	NGVS	500
10	Iron	mg/l	0.3	0.3
11.	Magnesium	mg/l	NGVS	NGVS
12.	Odor	-	Odorless	Unobjectionable
13.	Nitrate-N	mg/l	10	10
14.	pH	-	6.5-8.5	6.5-8.5
15.	Potassium	mg/l	NGVS	NGVS
16.	Sodium	mg/l	200	NGVS
17.	Sulfate	mg/l	250	NGVS
19.	TDS	mg/l	1000	1000
20.	Turbidity	NTU	5	<5
22.	Arsenic	ppb	10	50
23.	Total Coliforms	CFU/100ml	Nil	Nil
24.	*E-coli*	CFU/100ml	Nil	Nil

WHO: World Health Organization
NSDWQ: National Standards for Drinking Water Quality
NGVS: No Guideline Value Set

Water Quality Monitoring Results: Tube Wells

1. **Water quality monitoring of 131 tube wells of Islamabad revealed that water supplied by 101 tube wells (77%) to be safe, whilst remaining 30 (23%) were unsafe.**
2. The major reason of unsafe status of tube wells was prevalence of bacteriological contamination such as Total Coliforms in 25 tube wells (19%) and *E-coli* in 16 tube wells water (12%).
3. Excess turbidity in the range of rang of 22 to 125 NTU was detected in 4 tube wells water (3%).
4. Drinking water being supplied from tube well No.185 in Humak town had slightly excessive concentration of Nitrate i.e. 12 ppm.
5. Ground water from two sources was detected with excessive level of Iron i.e.(0.9-1.5 ppm)
6. Level of Free Residual Chlorine was found in range of 0.2-2 ppm at source.
7. Microbiological and chemical water quality status of all the tube wells is given at *Annexure-I*.

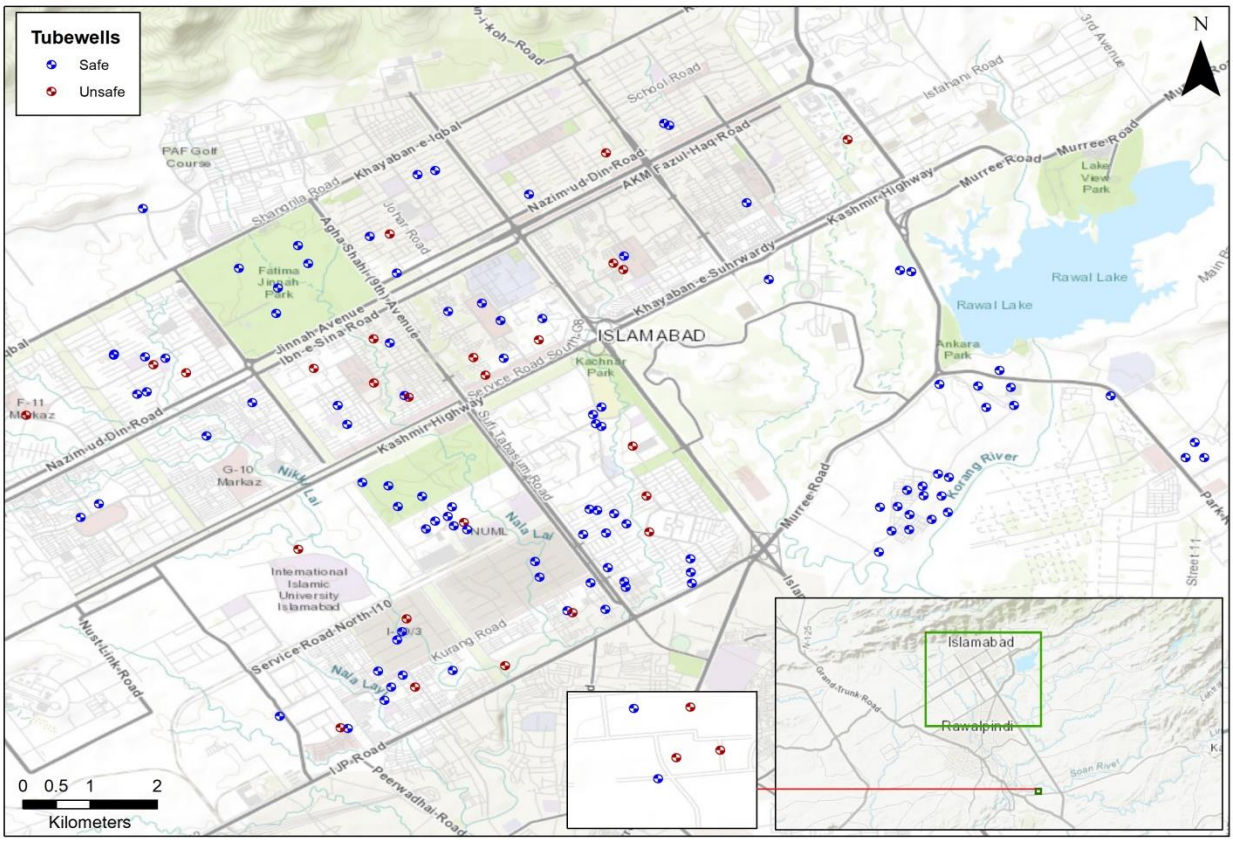


Figure-4: GIS characterization of water quality status (Safe/Unsafe) of Tube wells in Islamabad

Water Quality Monitoring Results: Water Supply Schemes (WSS)

1. **Water quality monitoring of 43 water supply schemes (WSS) of Islamabad showed 34 schemes (79%) supplying unsafe drinking water and only 9 schemes (21%) were found supplying safe water.**
2. The main contamination cause of unsafe water supplies was found to be bacteriological contamination i.e. Total Coliforms in 30 WSS (70%) and *E-coli* in 18 WSS (42%).
3. Two WSS (5%) were found to have excessive turbidity ranged as 7 to 130 NTU.
4. Excess level of Nitrate i.e. 12-35 ppm was found in 12 WSS (29%), whereas Iron (0.64-0.75 ppm) was found in only 2 WSS.
5. The concentration of free residual chlorine was found as 0.2-0.5 ppm.
6. Microbiological and chemical quality status of all WSS is given at *Annexure-II.*

Water Quality Monitoring Results: Water Works/Reservoirs

1. **Water quality monitoring of 13 water works/reservoirs of Islamabad revealed that water supplied by 9 sources (69%) to be safe, whilst remaining 4 (31%) were unsafe.**
2. The major reason of unsafe status of waterworks/reservoirs was prevalence of bacteriological contamination such as Total Coliforms in 4 water works (31%) and *E-coli* in 3 water works (23%).
3. Microbiological and chemical water quality status of all water works/reservoirs is given at *Annexure-III*.

Water Quality Monitoring Results: Filtration Plants

1. **Monitoring of 37 filtration plants of MCI in Islamabad has revealed 27(73%) plants to be safe, whilst 10 (27%) plants were supplying microbiologically unsafe water (Figure-5).**
2. No chemical contamination was found in any of the filtration plants.
3. Microbiological and chemical water quality status of all the filtration plants is given at *Annexure-IV*.

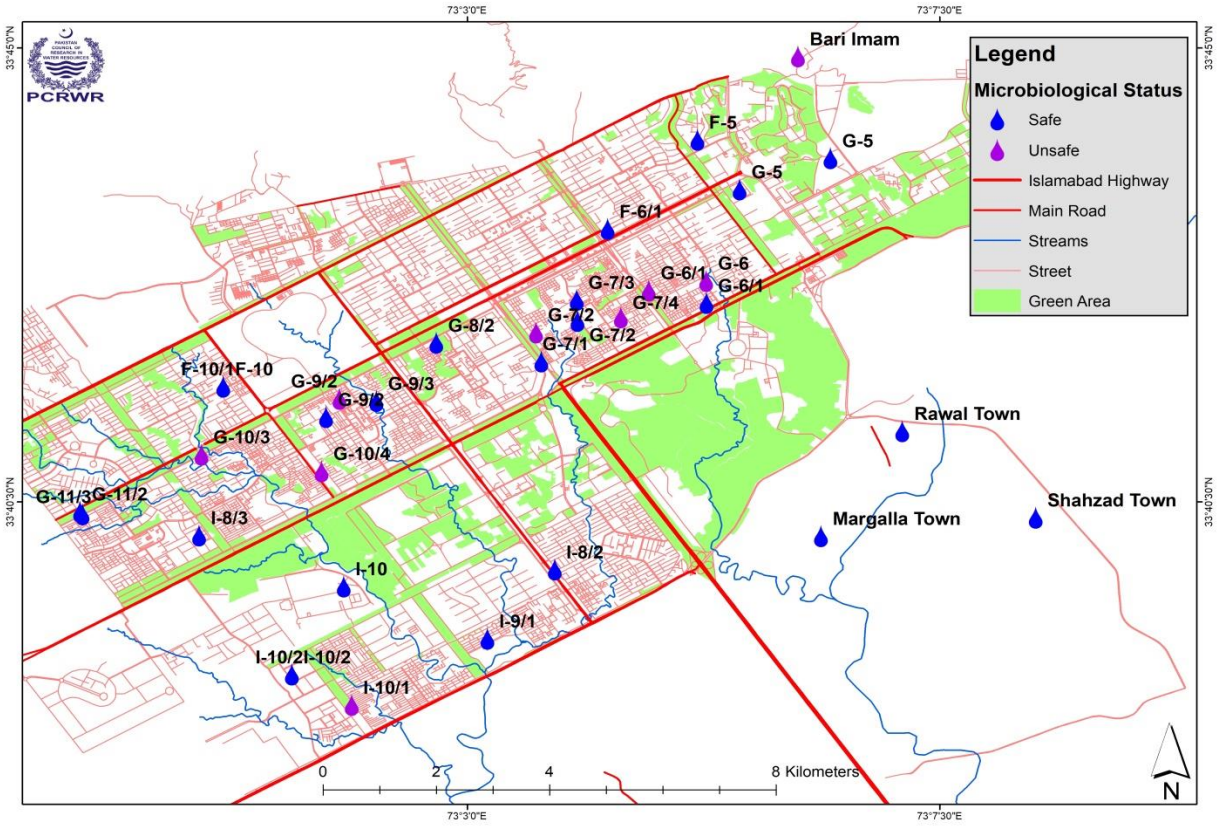


Figure-5: GIS characterization of water quality status (Safe/Unsafe) of Filtration Plants in Islamabad

Filtration Plants Providing Safe Drinking Water

Sr. No	Filtration Plant ID Code	Location	Quality (Safe/Unsafe)	
			Physico-Chemical	Microbiological
1.	MCI/FP/1	F-6/1, NEFDEC Cinema	Safe	Safe
2.	MCI/FP/2	F-10/1, near H.No.60, St#25	Safe	Safe
3.	MCI/FP/3	G-6/2, near Capital Hospital (OHT)	Safe	Safe
4.	MCI/FP/6	G-11/3, Ibn-e-Sina Road, Opp. H. No.	Safe	Safe
5.	MCI/FP/7	I-8/3 - Near Sangam Market	Safe	Safe
6.	MCI/FP/8	I-10/2, near Overhead Tank	Safe	Safe
7.	MCI/FP/9	F-5, Minister Colony/Enclave	Safe	Safe
8.	MCI/FP/10	G-5, Presidential Estate Colony	Safe	Safe
9.	MCI/FP/11	G-7/1, I&T Center	Safe	Safe
10.	MCI/FP/12	G-5, Parliament lodges	Safe	Safe
11.	MCI/FP/14	G-6/1-2, Near Overhead Tank, St.#40	Safe	Safe
12.	MCI/FP/15	G-6/1-4, near Aabpara Market	Safe	Safe
13.	MCI/FP/16	G-7/3, near Gulshan Market	Safe	Safe
14.	MCI/FP/17	G-7/2, Sitara Market	Safe	Safe

Sr. No	Filtration Plant ID Code	Location	Quality (Safe/Unsafe)	
			Physico-Chemical	Microbiological
15.	MCI/FP/18	G-8/2, Opposite Street # 11	Safe	Safe
16.	MCI/FP/20	Margalla Town, Phase-II	Safe	Safe
17.	MCI/FP/22	I-8/2 - Near Tubewell # 118	Safe	Safe
18.	MCI/FP/23	F-10 Markaz	Safe	Safe
19.	MCI/FP/25	I-10 Markaz	Safe	Safe
20.	MCI/FP/26	G-8/1, Street No. 13	Safe	Safe
21.	MCI/FP/27	G-9/3, CDA Block	Safe	Safe
22.	MCI/FP/29	I-10/2 & I-10/3, Green Belt, Chambeli Road	Safe	Safe
23.	MCI/FP/32	I-9/4, Street # 45	Safe	Safe
24.	MCI/FP/33	G-9/2, Near O.H. Tank/CDA Complaint Office	Safe	Safe
25.	MCI/FP/34	G-11/2 - Opposite Street No.90	Safe	Safe
26.	MCI/FP/36	Rawal Town	Safe	Safe
27.	MCI/FP/37	Shahzad Town	Safe	Safe

Filtration Plants Providing Unsafe Filtration Drinking Water

Sr. No	Filtration Plant ID Code	Code	Quality (Safe/Unsafe)	
			Physico-Chemical	Microbiological
1.	MCI/FP/4	G-7/4, Near OHT	Safe	Unsafe
2.	MCI/FP/5	G-10/3, Opp. H.No.401, 402, Ibn-e-Sina Road	Safe	Unsafe
3.	MCI/FP/13	G-6/1-2, Near Overhead Tank, St.#40	Safe	Unsafe
4.	MCI/FP/19	I-10/1 - Green Belt, Opp. Sreet No. 53	Safe	Unsafe
5.	MCI/FP/21	G-6 Bazaar	Safe	Unsafe
6.	MCI/FP/24	Bari Imam Complex	Safe	Unsafe
7.	MCI/FP/28	I-10/4 - Near Ameer Market	Safe	Unsafe
8.	MCI/FP/30	G-9/2, Jahangir Market	Safe	Unsafe
9.	MCI/FP/31	G-10/4, I&T Centre	Safe	Unsafe
10.	MCI/FP/35	G-7/2, near Ali Masjid	Safe	Unsafe

Disease Potential from Contaminated Water

Sr. No	Contaminant	Diseases Impacts
1.	Microbiological Contamination	Gastro-enteritis, Cholera, Diarrhea, Dysentery, Hepatitis A & E, Typhoid
2.	Nitrate	Drinking water with high nitrate-nitrogen may cause methemoglobinemia (Blue Baby Syndrome) resulting reduced oxygen-carrying capacity
3.	Turbidity*	NA
4.	Iron**	NA

**Excessive turbidity can protect microorganisms from the effects of disinfection, stimulate the growth of bacteria in the water and itself exert a significant water treatment demand.*
***Excessive iron causes rusting and also promotes the growth of "iron bacteria" resulting in the slimy coating on the piping*

Overall Conclusions

Out of 224 total water sources, 65% sources were supplying safe water, whereas 35% of the sources were found unsafe. Source wise status of water quality is given as below:

Sr. No	Source Type	Item	Conclusion	
			No.	% age
1.	**Tube Wells (TWs)**	Total TWs Monitored	131	-
		TWs Providing Safe Water	101	77
		TWs Providing Unsafe Water	30	23
		TWs Having Problem of Physico-Chemical Contamination	7	5
		TWs Having Problem of Microbiological Contamination	25	19
2.	**Water Filtration Plants (WFPs)**	Total WFPs Monitored	37	-
		WFPs Providing Safe Water	27	73
		WFPs Providing Unsafe Water	10	27
		WFPs Having Problem of Physico-Chemical Contamination	0	0
		WFPs Having Problem of Microbiological Contamination	10	27
3.	**Water Supply Schemes (WSS)**	Total WSS Monitored	43	-
		WSS Providing Safe Water	9	21
		WSS Providing Unsafe Water	34	79
		WSS Having Problem of Physico-Chemical Contamination	14	32
		WSS Having Problem of Microbiological Contamination	30	70
4.	**Water Works (WWs)**	Total WWs Monitored	13	-
		WWs Providing Safe Water	9	69
		WWs Providing Unsafe Water	4	31
		WWs Having Problem of Physico-Chemical Contamination	0	0
		WWs Having Problem of Microbiological Contamination	4	31

Detailed Water Quality Status of each water source is given at Annexure-I to Annexure-IV.

A series of site specific factors can contribute towards possible groundwater contamination for tube wells or water supply schemes. The susceptibility of groundwater to biological contamination from surface or near-surface derived pollutants at any site can be higher under certain conditions than others. At any specific site, groundwater contamination therefore depends on the natural or manmade characteristics of the site. In this connection, field observations have also helped to identify the series source protection gaps at the sites of water supply schemes (WSS) and tube wells (TWs). Most of the WSS in Islamabad have been developed on shallow wells, which were found open, without any source protection and located in close proximity to solid wastes or animal wastes dumping sites, waste water drain channels, septic tanks, crop fields, livestock farms/Baras. These pollution sources were suspected to be the source of microbial contaminants in the source water. Similarly, many tube wells are located either close to waste water drainage channels or with easy access by humans and live stocks and may also add pollutants in water source. In addition, most of the chlorinators installed at tube wells were non-functional, whilst broken water supply pipelines and leakage in supply network were commonly observed in most of the rural and urban areas. Hygiene and cleanliness status at water filtration plants was inadequate, whereas replacement of expired filtration components such as cartridges of water filtration plants seems to be an important cause of unsafe water trend (9 to 78%) from 2010 to 2018 (Figure-6) and in various areas of Islamabad (Figures-7 & 8).

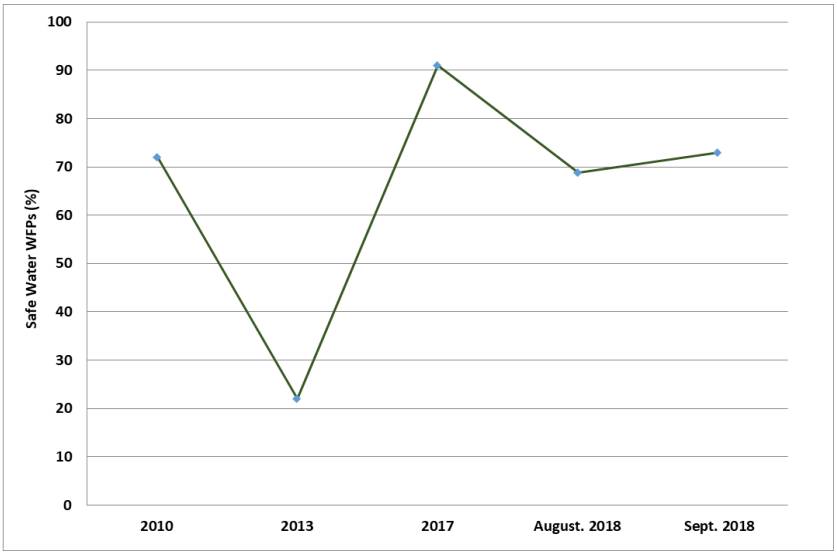


Figure-6: Drinking water quality trend of filtration plants in Islamabad (2010-18)

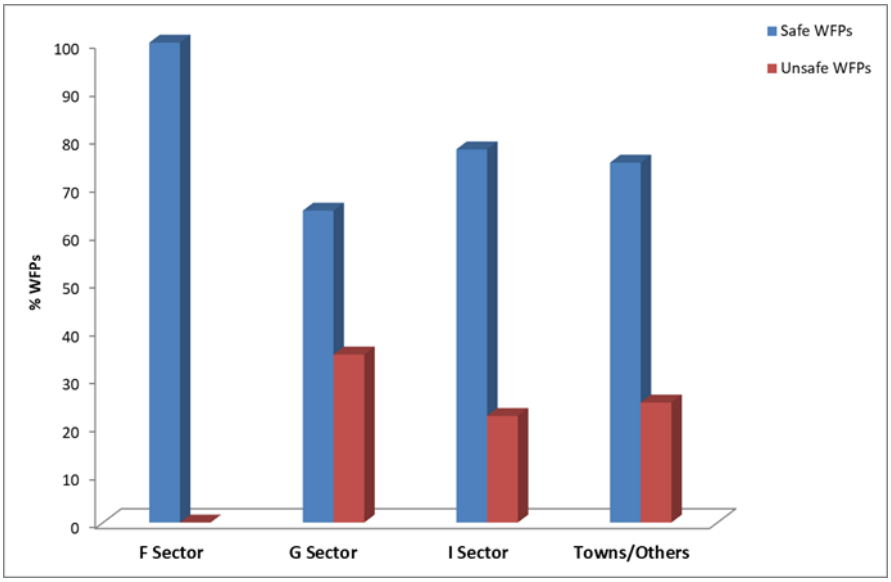


Figure-7: Comparison of drinking water quality of water filtration plants (WFPs) in various areas of Islamabad (September, 2018)

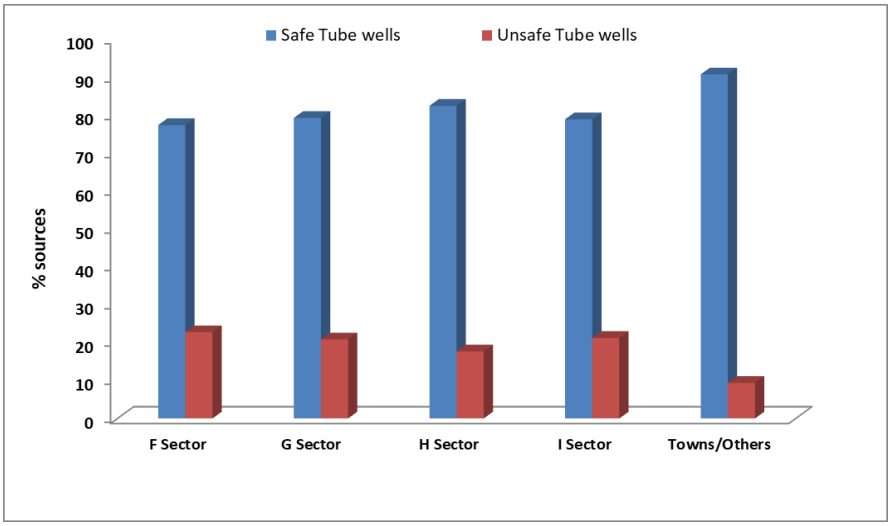


Figure-8: Comparison of drinking water quality of Tube wells in various areas of Islamabad (September, 2018)

Above all, the attendance of tube well and plant operators was also identified to be a concern. Since availability of safe public drinking water plays a critical role in the country's economic engine, we need to change the way we think about water, the way we use water and the way we dispose of wastes in our water.

Recommendations

In order to improve the drinking water being supplied by MCI water sources and filtration plants, following actions are recommended:

1. Disinfection using chlorination should be ensured in the public water supplies. In this connection, an online system capable of automatically monitoring the presence of fecal pathogens such as *Escherichia coli*, use of automatic chlorination systems designed to maintain the correct amount of free chlorine in potable water storage tank, and an inline chlorine analyzer to monitor residual free chlorine would increase the water treatment efficiency. Alternatively, capacity of water supply and filtration plants operators must be developed for effective chlorination, practice of analyzing free residual chlorine on daily basis and bacteriological contamination on weekly basis must be followed. In this respect, a log book or web based online record should be maintained by each operator and verified by concerned authorities on daily basis.
2. Source protection and maintenance of hygienic conditions at the sites of tube wells, water supply schemes, water works, filtration plants and their surroundings should be ensured.
3. Timely replacements and maintenance of water treatment components of filtration plants such as ultraviolet lamps/filtration cartridges should be regularized for continuous supply of safe drinking water from MCI filtration plants.
4. In the planning and construction of water supply schemes or development and installation of tube wells, proper arrangements for source protection should be made. There is a need to develop the water quality protection framework (as part of the Pakistan's National Drinking Water Policy) for the protection of public drinking water source areas to safeguard the water sources from contamination. In this context, a surveillance program may also be established to identify incompatible land uses or potential contaminant threats within the catchment area and vicinity of ground water sources.
5. The water storages at the source and at the consumer residences should also be regularly cleaned by agency/company fully equipped with water tank cleaning equipment and professionals. Consumer awareness on safe water storage at household level may also be initiated.
6. Systematic efforts for the sustainable supply of safe drinking water in urban and rural areas of Islamabad may also focus on establishing a strong partnership between various stakeholders, residents of Islamabad, Consumers Forums, Advocacy Groups and the MCI.

References

- Nabeela, F., Azizullah, A., Bibi, R. et al. Environ Sci Pollut Res (2014) 21: 13929. https://doi.org/10.1007/s11356-014-3348-z
- Pakistan Economic Survey. 2010-11 Chapter-Environments. Ministry of Finance, Government of Pakistan. Retrieved 10th November, 2011, from http://www.finance.gov.pk/survey/chapter_10/15_Environment.pdf
- APHA, AWWA and WEF, D.E 2012. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, American Water Works Association and Water Environment Federation, 22nd Edition, Washington, DC.
- PSQCA. 2008. National Standards for Drinking Water Quality (NSDWG), Pakistan Standards Quality Control Authority, Ministry of Science and Technology, Government of Pakistan.
- WHO Guidelines for Drinking-Water Quality. http://www.searo.who.int/EN/Section314_4295.htm#who