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Drinking water quality assessment and governance in Kabul: A case study from a district with high migration and underdeveloped infrastructure

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Abstract
The main aim of this paper is to analyze the characteristics of the drinking water quality in Kabul city and identify its suitability for drinking. During the work, a total of 60 water samples were collected from four drinking water sources (qanat, open well, tap water, and a hand pump) located at different points and were tested for physical, chemical, and biological parameters. Physical and chemical analyses were performed according to the standard methods, while a bacterial analysis was performed by using the Wagtech Potatest single incubator test kit and membrane filter method. The results obtained were compared with the standards of the World Health Organization (WHO) and Afghanistan's National Standards Administration (ANSA). The study showed that physical parameters were within acceptable limits for qanat, open well, and tap waters. However, color, taste, odor, and turbidity values exceeded the recommended limits for hand pump wells. All analyzed chemical parameters were within permissible limits recommended by WHO/ANSA. The bacteriological analysis showed total coliform and fecal coliform contamination, particularly in warm weather conditions. The bacteriological contamination reveals the mixing of the sewage water with drinking water due to expired corroded pipes and discharge of wastewater to the groundwater. Several governance recommendations are proposed for improving water quality. They include strengthening coordination between government and public, considering options to install a new water distribution and sewage collection networks, enforcing standards for adequately preventing contamination from septic tanks, and increasing public awareness on low-cost measures such as boiling the drinking water before intake.

Keywords: Potable water, contamination, coliform, water quality, groundwater, Afghanistan

Paper type: Research article

1. Introduction

In 2015, all United Nations Member States adopted the Sustainable Development Goals (SDGs) as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. SDG 6 “Equitable access to safe and affordable water for all” calls, among others, for significant improvements to be made in drinking water quality. As a cross-cutting goal, progress in SDG6 will have important spillover benefits for other goals such as improving public health, reducing poverty and hunger, improving other linked environmental systems, and vice versa. Therefore all development activities within SDG 6 must take into account broader social, economic, and environmental objectives of achieving overall sustainability in a society (Ait-Kadi 2016).

According to the World Health Organization (WHO) Fact sheet from 2015, nearly 1.8 billion of the world population is faced with the use of polluted potable water sources, and 663 million people are using unsafe drinking water sources (WHO 2015). Many Asian countries, particularly in the low, and middle-income regions (Bain et al. 2014), face serious challenges related to the improvement of drinking water quality due to lower levels of overall development, large populations, high levels of migration and urbanization, poor infrastructure, as well as effects from changing environmental conditions (particularly climate change). While the attention of governments, scholars, and the international development community is often on water quantity, the water quality of lakes, groundwater, and reservoirs is worsening and threaten the lives of millions (e.g., Bain et al. 2014; Lu et al. 2008). Similar trends for the Kabul Basin in Afghanistan (Houben et al. 2009) stress that a high concentration of nitrate and fecal bacteria leads to severe groundwater pollution, partially explaining high infant mortality in the region.

The authorities in Afghanistan aim to reach SDG 6 by 2030, but unfortunately, the United Nations Children Fund (UNICEF) report in 2011 shows what an extraordinarily difficult task this is with nearly 52 percent of the population in Afghanistan without access to safe drinking water, and 63 percent deprived of standard sanitation (Mubarak 2012). According to the WHO Drinking-Water Quality Guidelines (2011, p. 1), “Safe drinking-water does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages.” Standard sanitation includes sanitation facilities that hygienically separate human excreta from human contact (WHO & UNICEF 2012).

Kabul does not have functioning public water treatment plants, water filtration systems, or sewage treatment plants (even the systems left from the times of the Soviet intervention are outdated and not functioning for long) (Kakar et al. 2008). In Kabul city, only 18 percent of the population has access to piped water (Eqrar 2008). Despite the scope and scale of poor sanitation and lack of safe drinking water in Kabul (Mumtaz 2008), there has been so far little research and scientific evidence that describes the state of the drinking water quality. This research is designed to investigate the quality of drinking water used by Kabul residents. The aim is not only to find the problems associated with water quality but also to identify the gaps and provide significant governance recommendations to the authorities. This is the area in health sanitation that has yet to be tackled on. There are minimal researches have been conducted by far. Our intention is also to document the method and approach to implement drinking water quality assessment in particularly challenging conditions that many developing countries face. There are still no or little researches that explains how one can undertake a study aiming at assessment of drinking water quality, not only in the context of Kabul-Afghanistan, but also in broader Central Asian region. Probably, due to the poor states of infrastructures with mixed sources of water supply and poor sanitation.

The present study looks into District 5 of Kabul city, which is one of the most populous districts of the city. At the same time, because District 5 has a qanat – a source of drinking water perceived to be safe by the local population, the general public across the entire Kabul often comes to District 5 to collect drinking water. The estimated population of District 5 is around 150,000 (Mubarak 2012). Due to rapid migration linked with the war in Afghanistan and unplanned settlements in District 5, a limited number of households are linked to the open sewerage drain. In contrast, the remaining households have septic tanks and dry latrines (Mack et al. 2010). Human waste is being disposed of in unprotected ways, causing potential surface and groundwater contamination (Saffi 2013). Therefore, this district is a typical case of very challenging areas to reach the SDG 6. Thus, the present study focuses on drinking water quality in the example of District 5 of Kabul city. Physical, chemical, and bacterial parameters from four different water supply systems have been analyzed, and both technical and governance recommendations have been developed based on the findings.

2. Materials and methods

2.1. Study area

The location of District 5 is in the administrative province of Kabul, which is the capital of Afghanistan, with around 4.8 million inhabitants. Kabul city has 22 municipality districts (Pajhwok Afghan News 2018). According to the survey conducted in 2018 by the United Nations Human Settlements Program (UN-Habitat), 41,000 families live in this district (Kabul Municipality 2019).

2.1.1. Sources and sites of water sampling

The sample taken from four sources of water in District 5: (a) open well; (b) qanat; (c) tap; and (d) hand pump well (Figure 1). Open well water is fetched through direct access to groundwater, often via a manually dug well. A qanat transfers water from an aquifer through a sloping underground canal. Tap water is the typical more developed supply system for the city drinking water and organized by government or private organizations. The fourth source of water is hand pumps that are manually operated for access to the shallow groundwater, but with the surface closed (Figure 1).

Figure 1. Different drinking water sources studied (photos by the author).

The population in District 5 mainly accesses sources a, c, and d. Others also use the qanat ,and as mentioned, the general public across the entire Kabul comes to District 5 to get drinking water from qanat as it is generally considered safe as a drinking water source by locals. These four water sources were selected due to their abundant use in their respective locations.

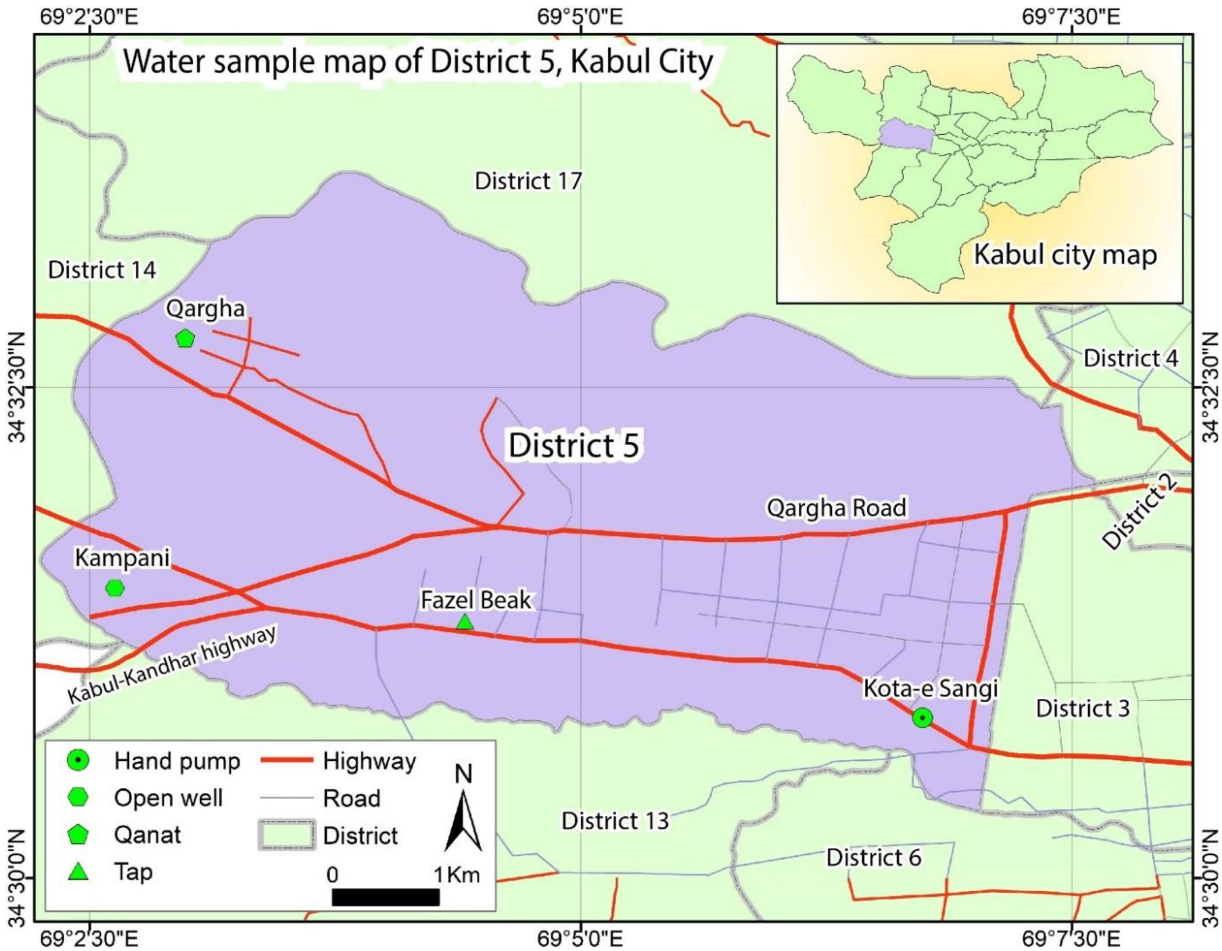

Figure 2. Location of sampling water sites

2.2. Water sampling process

To prevent possible contamination during the research, particularly cautious sampling technics were used to collect water samples at all water sources. All bottles were labeled with the proper number (APHA 1998). All samples were kept in iceboxes, transported to the Ministry of Rural Rehabilitation and Development laboratory, and analyzed within 24 hours. The sampling at each location was as follows:

- At the open well, a water sample was taken from the bucket. It was ensured that the bucket did not touch the wall and bottom of the well during filling. A bottle was completely immersed in the bucket and was filled with water in the bucket. Air space was left in the bottle.
- At qanat, a bottle was held and submerged at a depth of about 15 cm and was moved horizontally across the width of the stream. The bottle mouth was faced towards the current. A little air space was left in the bottle during the filling. Finally, the bottle mouth was closed with a cap.

- At the tap-water source, firstly, the tap was cleaned, and it was ensured that there were no accessory matters that could smear the tap. Dirt was removed from the outlet using a clean cloth. The tap was opened and allowed to maximum flow for approximately 2 minutes then turned off. The tap was sterilized for one minute with an ethanol-soaked cotton wool swab that was burnt with a lighter. After sterilization, the tap was opened for approximately 2 minutes , and water flow was set at a constant rate. A bottle was filled with water, and a small air space remained in the bottle. Also, it is made sure that dust did not enter the bottle during filling.
- At the hand-pump water source, the hand pump was cleaned with a clean soft cloth, and it was ensured that no supplement may be plopping from the hand pump. Dirt removed from the outlet using a clean cloth. The hand pump was pumped softly at a constant rate, and water was allowed to flow for approximately 2 minutes. The outlet of the hand pump was sterilized for one minute with an ethanol-soaked cotton wool swab that was burnt with a lighter. After sterilization, the hand pump was pumped for approximately 2 minutes, and the water flow was set at a constant rate. A bottle was filled with water. Some air space was left. It was ensured that dust did not enter during filling.

2.3. Methodological approach for water quality standards

2.3.1. Identifying drinking water quality standards for Afghanistan

The world Health Organization set the quality standard for drinking water, which is most commonly refered in studies (WHO 2011). At the same time, countries adopt their particular national standards, such as the case in Afghanistan. The Afghanistan National Standard Administration (ANSA) is the administrative body that sets standards for drinking water quality. This study compares and adopts the standards recommended by these two organizations.

The study also adopts the definitions formulated by the Joint Monitoring Programme of the World Health Organization and UNICEF (WHO&UNICEF 2012).

> *"Improved drinking water source is a source that, by nature of its construction, adequately protects the water from outside contamination, in particular from fecal matter. Water considered safe if it meets certain microbiological and chemical standards on drinking water quality; guidance provided by the WHO Drinking-water Quality Guidelines (4th edition 2011)."*

Although this study does not directly focus on the provision of sanitation services, the researchers paid particular attention to the state of sanitation services as possible sources of contamination during their field visits and data collection. Therefore, it will be useful to note the definition of the WHO and UNICEF (2012) for improved sanitation too.

> *"Improved sanitation includes sanitation facilities that hygienically separate human*

excreta from human contact."

2.3.2. Research design and types of analysis

The experimental protocol included chemical, physical, and bacteriological analyses (Figure 3). Consequently, we undertake chemical analysis three times: at the beginning, middle, and end of the season. In total Twelve samples collected. Similarly, we undertake the physical and bacteriological analysis with the interval of each 15 days throughout the season. Forty eight samples collected in total.

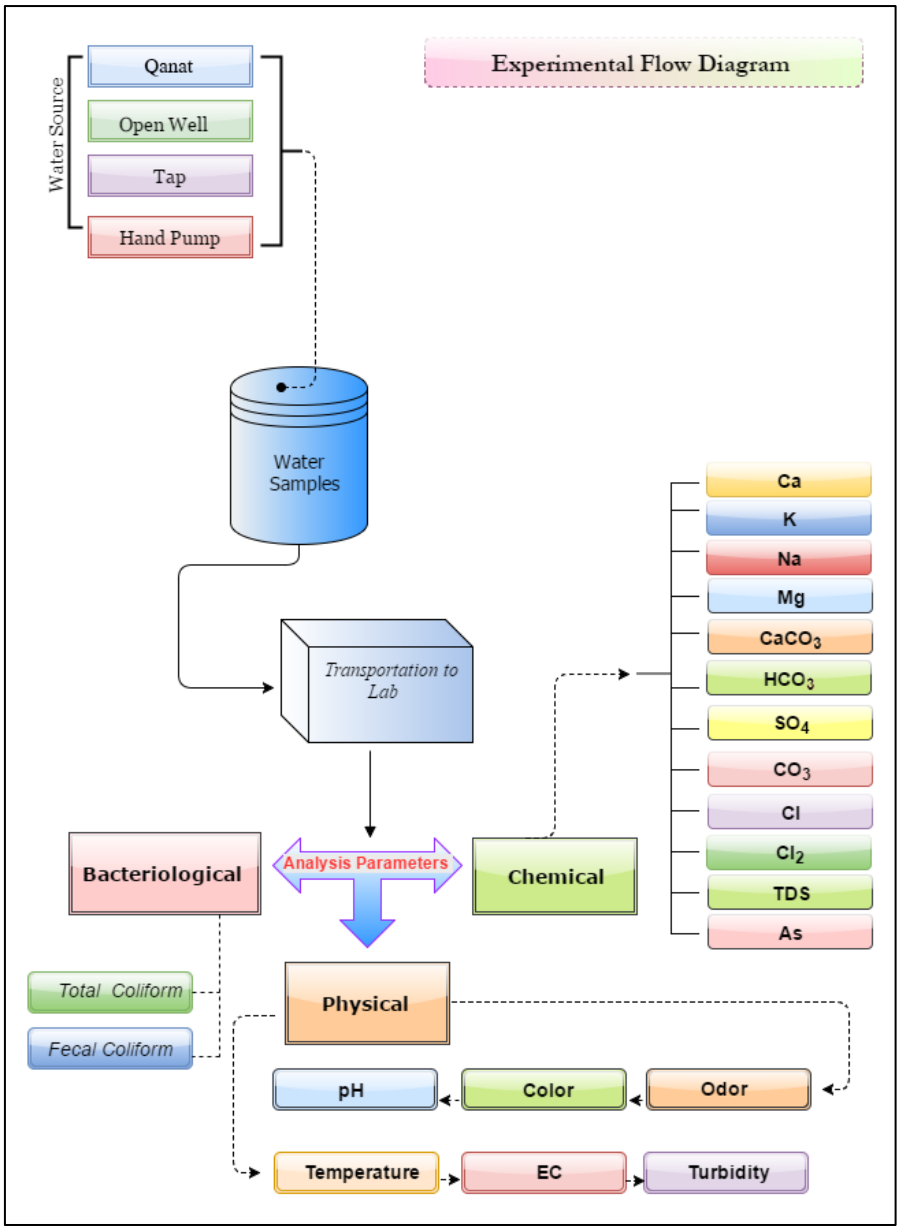

Figure 3. Research design and experimental flow diagram.

Bacteriological analysis

Water samples were analyzed for bacteriological contamination by Membrane Filter (MF) method. In this procedure, coliform density reported conventionally as the membrane filter count per 100 mL and analysis ran by the Potatest WE10005 incubator test kit. Total coliform was incubated at 37 ºC, and fecal coliform were at 44 ºC for 24 hours. The empirical data was compared with WHO and ANSA standards for *fecal coliform* and *E. Coli* contamination in drinking water (absence of contamination as a threshold) (ANSA 2011; WHO 2011).

Physicochemical analysis

All types of analyses were conducted in the laboratory following the Standard Methods for the Examination of Water and Wastewater methods and guidelines recommended by the American Public Health Association (APHA) (Wescoat and White 2003). The Threshold sensory method was used for determining the odor and taste of the samples. Colour: standard solution (crystallized cobaltous chloride $CoCl_2 \times 6H_2O$ and 1.246 g potassium chloroplatinate K_2PtCl_6 in distilled with 100 mL HCL) was prepared and compared with sample water.

Chemical analysis

Chemical parameters were analyzed following the recommended “Standard Methods for the Examination of Water and Wastewater,” 20th edition, 1998, prepared by APHA, and relevant manuals of the concerned instruments were used throughout the analysis (APHA 1998).

Table I. WHO and ANSA criteria for the chemical parameter of drinking water (WHO 2011).

Parameter	ANSA Standard values mg/L	WHO guidelines mg/L	Most Asian countries mg/L
Arsenic (As)	0.05	0.01	0.01 - 0.05
Potassium (K)	10	10	-
Sodium (Na)	200	NGVS	200
Chloride (Cl)	250	NGVS	250
Chlorine (Cl_2)	250	NGVS	250
Magnesium (Mg)	30	NGVS	30
Calcium (Ca)	75	NGVS	75
Total hardness as $CaCO_3$	500	NGVS	500
TDS	1000	NGVS	1000
Sulfate (SO_4)	250	NGVS	250
Carbonate (CO_3)	-	NGVS	-
Bicarbonate (HCO_3)	-	NGVS	-

Note: NGVS; No Guideline Value Set

For the collected water sample, the standards recommended by the WHO and ANSA were compared. Most of the countries in the Asian continent have a similar range of standards to the ones recommended by ANSA.

3. Results and discussion

The bacterial analysis results indicated significant contamination of all the four water sources (Figure 4a and 4b). We observed high numbers of colonies for total coliforms and fecal coliforms (E. Coli).

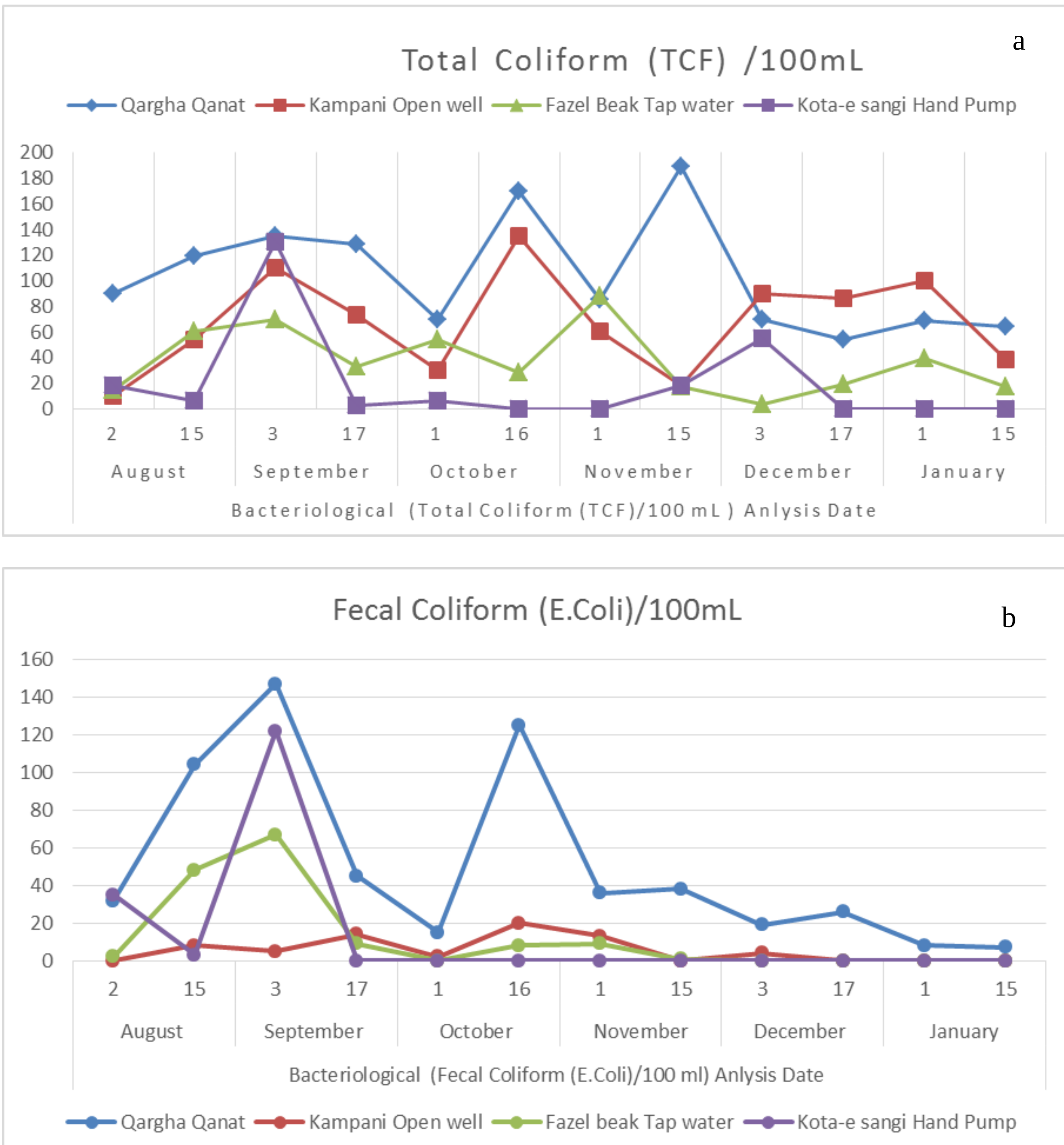

Figure 4. A number of (a) total coliform bacteria and (b) Fecal Coliform bacteria in collected samples.

In Figure 4a, the results show that qanat water source samples were contaminated with total coliform bacteria ranging between 54 -189 colonies of TCF/100mL. In open well, it ranges between 10-135 colonies of TCF/100mL. The result for a tap is in between 3 - 88 colonies, while for the hand pump, the range is 0 -130 colonies of TCF/100mL. Thus, the present study results showed that drinking water samples were contaminated with total coliform bacteria throughout the entire analyzed period (across seasons), except the hand pump, where the leading sources of contamination come from sewage and septic well waters.

For the presence of fecal coliforms (Figure 4b), we performed a bacterial analysis, and the results for qanat show that all the samples in this source contaminated with Fecal coliform bacteria, which ranged between 7 -147 FCF/100 mL. In open well samples, it ranges from 0 - 20 colonies of FCF /100mL. Fecal coliform in samples from the tap was found within the range of 0 - 67 colonies of FCF /100mL. The results from the analysis of drinking water samples from the Hand Pump were in the range of 0 -122 colonies of FCF /100mL (Figure 4b). The results show that the presence of fecal coliform bacteria was directly related to seasonal temperature variation. The decline observed from August 2016 to January 2017 indicating that with decreasing temperature presence of fecal coliform also declined.

Previous studies indicate that bacterial contamination was possibly caused by septic wells, improper, outdated sewage systems, and violation of daily public health recommended practices (Mubarak 2012). Water distribution network (tap) in District 5 was installed around 50 years ago and has completed its life cycle. This network and pipelines may likely have been contaminated with leaking sewer pipes. Open well, and qanat was not correctly covered, presence of septic and absorptive wells, imperfect chlorination system, piles of household waste were found in many points of District 5 without any adequate measures to prevent contamination.

Drinking water quality requires the absence of microorganisms as these are harmful to human health. The main categories of these microorganisms include coliform group, total coliform, and fecal coliform. The criteria of the WHO and ANSA for drinking water are the same for the coliform group. Thus, according to the WHO and ANSA, there should not be any colony of bacteria in every 100 mL of water (WHO 2011).

Table II. Physical parameters analysis results of Qanat water located in Qargha.

Period	**August**		**September**		**October**		**November**		**December**		**17-Jan**	
	2	15	3	17	1	16	1	15	3	17	1	15
Taste	no	no	no	no	No	no	no	no	no	no	no	No
Odor	no	no	no	no	No	no	no	no	no	no	no	No
Color TCU	0	0	0	0	0	0	0	0	0	0	0	0
pH	7.4	7.1	8.1	8.2	8	8	8.2	8.4	8.3	8.4	7.8	8

E.C µS/cm	345	363	410	318	300	430	345	344	347	545	336	348
Temp °C	23.7	24.8	23.4	24.1	23.8	21.3	20.6	18.1	18.1	16.5	18.8	13.7
Turb. NTU	0	2.43	0	0	0	0	0	0	1.01	0.02	1.53	0

Table III. Physical parameters analysis results of Open-well water located in Kampani

Period	**August**		**September**		**October**		**November**		**December**		**17-Jan**	
	2	15	3	17	1	16	1	15	3	17	1	15
Taste	no	no	no	no	No	no	no	no	no	no	no	no
Odor	no	no	no	no	No	no	no	no	no	no	no	no
Color TCU	0	0	0	0	0	0	5	0	0	0	0	0
pH	7.5	6.8	7.1	7.4	7.1	7.5	7.1	7.3	7.2	7	6.9	7.1
E.C µS/cm	945	926	850	920	700	932	905	897	889	944	893	865
Temp °C	24.5	24	22	22.9	22.5	21.6	19.1	17.8	18.7	16	18.3	13.1
Turb. NTU	0	0	0	26.2	0	11.3	8.56	3.25	2.82	0	0	0

Table IV. physical parameters analysis results of Tap water located in Fazel Baek

Period	**August**		**September**		**October**		**November**		**December**		**17-Jan**	
	2	15	3	17	1	16	1	15	3	17	1	15
Taste	no	no	no	no	No	no	no	no	no	no	no	No
Odor	no	no	no	no	no	no	no	no	no	no	no	No
Color TCU	0	0	0	0	0	0	0	0	0	0	0	0
pH	7.6	7.3	7.2	7.5	7.1	7.7	7.3	7.2	7.3	7.1	7.1	7.2
E.C µS/cm	861	844	803	810	600	743	726	837	738	788	726	712
Temp °C	22.5	23.7	21.8	22.8	22.6	22	18.8	17.1	18.7	15.6	17.8	11.7
Turb. NTU	0	0	0	0	0	0	0	0.88	0	1.45	0	0

Table V. Physical parameters analysis results of Hand Pump water located in Kota-e-Sangi

Period	**August**		**September**		**October**		**November**		**December**		**17-Jan**	
	2	15	3	17	1	16	1	15	3	17	1	15
Taste	yes	yes	yes	no	Yes	yes	yes	yes	yes	yes	yes	Yes
Odor	yes	yes	yes	no	Yes	yes	yes	yes	yes	yes	yes	Yes
Color TCU	30	26	20	14	50	15	25	40	40	50	45	30
pH	7.4	7.1	7.3	7.3	7.2	7.6	7.2	7.2	7.1	7.2	7	7.3
E.C µS/cm	680	663	628	676	500	630	687	691	684	703	680	696
Temp °C	22.3	23.1	21.8	22.7	21.8	23.3	19.1	18.1	18.8	16.2	18.2	11.6
Turb. NTU	9.48	17.8	13.6	5.1	49.8	14.4	31.4	30.2	41.2	60	65	5.63

The study revealed variations among physical parameters in the analyzed samples collected from four locations of District 5, Kabul city. Most drinking water sources (open well, qanat, tap) had no color, no odor or taste, and with pH values in the range of 7.4 - 8.4 for qanat 6.8 -

7.5 open well, 7.1 - 7.7 tap and 7.1-7.6 for hand pump. Turbidity values for qanat were in a range from 0.02 to 2.43 NTU. For open well, the range was 2.82 to 26.2 NTU. The highest turbidity value was recorded in September when the water level decreased, and well was dug deeper to secure more water. Tap water showed turbidity values from 0.88 to 1.45 NTU. Temperature values of collected samples from qanat ranged from 13.7 to 24.8 °C, open well, had temperature range between 13.1 and 24.5°C, the tap was in the range of 11.7 to 23.7 °C, and at the hand pump well it varied from 11.6 to 23.3 °C, all of which were within the permissible limits of WHO and ANSA. Values of color, taste, odor, and turbidity exceeded the accepted standards for a hand pump, which had a color intensity value of 28, 17, 32.5, 32.5, 45, and 37.5 true color unit (TCU). Hand pump corrosion was identified as the possible reason for color intensity. Due to that, taste and odor were also noted. Turbidity values were within the range from 5.05 to 65 NTU. Electrical Conductivity (EC) values were for qanat in the range of 300 – 545, for open well 700 – 945, tap 600 – 861, and hand pump 500 – 703 µS/cm, respectively, which were found within the permissible limit of WHO/ANSA.

Table VI. Chemical composition of collected water samples (mg/L).

Period	August				November				January			
Location/ Village	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4
Source of Water	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
As	0	0	0	0	0	0	0	0	0	0	0	0
K	0.2	0.4	0.4	0.4	0.2	0.3	0.4	0.3	0.4	0.3	0.3	0.4
Na	3	4	4	5	2	3	3	3	5	6	6	5
Cl	60	85	85	78	65	90	88	82	45	54	64	54
Cl_2	0	0	0	0	0	0	0	0	0	0	0	0
Mg	7	23	24	20	7	21	22	19	8	22	24	19
Ca	48	150	120	95	48	136	130	97	44	152	120	92
T/H*	150	470	400	320	155	500	420	330	125	420	320	305
TDS**	231	585	534	422	213	561	450	425	209	536	380	364
SO_4	14	208	145	76	13	195	140	85	16	177	66	48
HCO_3	40	100	100	110	50	100	70	50	50	110	80	60

Locations: L1: Qargha; L2: Kampani; L3: Fazel beak; L4: Kota- e-Sangi
Source of Water: S1: Qanat; S2: Open well; S3: Tap water; S4: Hand pump

* T/H=Total Hardness. ** TDS=Total Dissolved Solids

Chemical parameters were in satisfactory range as all analyzed samples (Table VI) were within acceptable limits recommended by WHO/ANSA except for Calcium concentration, which exceeded the acceptable limits of ANSA. The reason for the increase of Calcium concentration in these particular areas within the mentioned time-period is the decline of water table level. This means that the relevant water samples may have sourced from carbonate-rich source rocks (e.g., Ca and Mg carbonates), which are usually present in the watersheds and aquifers of the study area.

The area is also particular because of the high density of population and high migration. After 2002, a large number of Afghan refugees returned to their home provinces. Between 2002 and 2012, at least 5.7 million Afghans came back to the country. Most of these returnees settled in Kabul, which is home to more than 325 000 returnees. While most of the returnees planned to go to their home provinces, due to insecurity and for better job opportunities, most of them settled in Kabul (IOM 2017). In 2007, some families and internally displaced persons (IDPs) set up tents at the District 5 of Kabul city and had grown gradually to almost 900 families making it a large informal settlement in Kabul (Mubarak 2012). Given this, coupled with the relatively high prices for bottled water, new research is urgently needed to identify the size and nature of the public health-related impact from the contaminated drinking water sources in District 5, as well as in other parts of the region with similarly underdeveloped infrastructure. The high migration in the area also creates additional challenges for collecting reliable data. From the perspective of the persistence of the identified contamination, while coliform colonies usually remain in the water system for approximately 72 hours, continuous disposal of sewage without adequate protection or separation of waste from water means that these water sources are continuously contaminated, which poses serious and mass health threats in the area. In the meantime, the lowered water table, identified as a possible reason for chemical parameters exceeding the thresholds, indicates accelerating pressure on groundwater resources. With similar trends across other areas in Kabul (Saffi 2013; Zaryab et al. 2017), this raises the question of more general water supply security and groundwater sustainability in the region.

As an immediate governance measure, low-cost safety measures such as boiling the drinking water before intake and chlorination at the source of the water have to be implemented. For more fundamental technical and governance improvements, new distribution and sewage collection networks are needed. However, as they have high upfront capital costs, financing such capital-intensive projects is difficult (Whittington et al. 2009). Since population will not be able to cover the costs (pay for water at the rates that could recover distribution and sewages systems for water supply and sanitation services), which is the case in many developing countries, this means aid from various donors, including development agencies and developed countries, will be crucial. In case this is made possible, education and capacity building of local water specialists will be needed for the maintenance of possible new infrastructure. At the same time, public awareness will have to be raised by water users.

4. Conclusions

The analysis shows that the drinking water quality in Kabul does not meet the requirements of improved drinking water recommended by the World Health Organization and Afghanistan National Standards Administration and, therefore, cannot be considered safe for drinking. Serious technical and governance reforms, as well as investments, are necessary to improve the quality of drinking water in the analyzed region, and with that to be able to reach SDG 6 in Afghanistan. The study revealed variations among physical, chemical, and bacteriological parameters in the analyzed samples collected from four locations of District 5 in Kabul. The bacterial analysis results indicated significant contamination of all the four water sources. High numbers of colonies were observed for total coliforms and fecal coliforms (E. Coli). Septic wells possibly caused fecal contamination, improper, outdated sewage system, violation of daily public health recommended practices. Water distribution networks (tap) in District 5 were installed around 50 years ago and have completed their life cycle. This network and pipelines may likely have been contaminated with sewage water due to its leakage. Open well, and qanat was not properly covered. Septic and absorptive wells, a poor chlorination system, piles of garbage were found in many points of District 5 (study area) without any adequate measures that can prevent water contamination.

Data obtained by analysis of drinking water samples from qanat, open well, tap (water distribution network) and hand pump showed that three out of four (qanat, open well, tap) drinking water sources had values of color, ordor, taste, pH, turbidity, and temperature within the permissible limits of WHO and ANSA. Values of color, taste, odor, and turbidity exceeded the acceptable limits for a hand pump. Chemical parameters were in satisfactory range as all analyzed samples were within acceptable limits recommended by WHO/ANSA.

Based on our study and findings, we recommend the consideration of new drinking water distribution and sewage collection networks in District 5. The water supply sector should formulate rules, regulations, and mechanisms for maintaining the water quality in light of WHO/ANSA standards. Awareness should be raised about low or no-cost safety measures, such as boiling and chlorination of the water before intake and containing the sources of contamination through better waste and wastewater management practices, particularly due to septic tanks close to water sources. The findings contribute to the much-needed knowledge gap on drinking water quality assessment and governance in the region and highlight the urgency of further research and action in this field.

5. Acknowledgments

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6. References

American Public Health Association (APHA), 1998. Standard methods for water and wastewater examination. 20th ed. Washington DC.

Ait-Kadi, M., 2016. Water for Development and Development for Water: Realizing the Sustainable Development Goals (SDGs) Vision, *Aquatic Procedia* Vol. 6, pp. 106 – 110.

Bain, R., Cronk, R., Wright, J., Yang, H., Slaymaker, T., and Bartram, J., 2014. Fecal contamination of drinking-water in low-and middle-income countries: a systematic review and meta-analysis. *PLoS medicine*, Vol. 11, No 5.

Eqrar, M. N., 2008. Water supply and sanitation of Kabul basin, Coupling sustainable sanitation and groundwater protection Symposium, Hannover.

Houben, G., Tünnermeier, T., Eqrar, N. and Himmelsbach, T., 2009. Hydrogeology of the Kabul Basin (Afghanistan), part II: Groundwater geochemistry. *Hydrogeology Journal* Vol. 17, pp. 935-948.

International Organization for Migration (IOM), 2017. Baseline Mobility Assessment, Summary Results, Afghanistan, June 2017.

Kabul Municipality, 2019. Kabul Municipality District 5 plan, Kabul - Afghanistan. Available at: http://www. http://km.gov.af/pashto.

Kakar, F., Ahmadzai, A. H., Habib, N., Taqdeer, A. and Hartman, A, F., 2008. A successful response to an outbreak of cholera in Afghanistan Tropical doctor Short Report July 2008.

Lu, W., Xie, Sh., Zhou, W., Zhang, Sh. and Liu, A., 2008. Water Pollution and Health Impact in China : A Mini Review. *Open Environmental Sciences* Vol. 2. pp. 1–5.

Mack, T. J., Chornack, M. P., Coplen, T. B., Plummer, L.N., Rezai, M. T., and Verstraeten, I. M., 2010. Availability of Water in the Kabul Basin, Afghanistan. No. 2010-3037. US Geological Survey.

Mubarak, M. Y., 2012. Drinking water safety and sanitation in relation to diarrheal diseases in under-developed areas of District 5, Kabul, Afghanistan, pp.2 - 15.

Mumtaz, A., 2008. Assessment and Mitigation of Water - Related Environmental Health Impacts in the Bagrami District of Kabul Province. A thesis presented for the degree of Master of Science (MSc), University of Montana Missoula, MT.

Pajhwok Afghan News, 2018. Kabul administrative unites, Kabul - Afghanistan. Available at: http://www.elections.pajhwok.com/en/content/kabul-administrative-units

Saffi, M. H., 2013. Scientific Investigation Report in Afghanistan Water Resources Potential, Quality Problems, Challenges and Solutions in Afghanistan, Kabul, Scientific Investigation Report July 2013.

Wescoat, J. L. and White, G. F., 2003. Water Management and Environmental Policy. Cambridge, UK, Cambridge University Press.

Whittington, D., Hanemann, W. M., Sadoff, C. and Jeuland, M., 2009. The Challenge Of Improving Water And Sanitation Services In Less Developed Countries, *Foundations and Trends in Microeconomics*, Vol .4, No. 6 –7, pp. 469 – 609.

World Health Organization (WHO), 2011. Guidelines for drinking water quality, 4th edition. World Health Organization, Geneva

World Health Organization (WHO), 2015. Drinking Water. Fact sheet no. 391.

WHO/UNICEF ,2012. Progress on drinking water and Sanitation, joint Monitoring Program.

Zaryab, A., Noori, A.R., Wegerich, K. and Kløve, B., 2017. Assessment of water quality and quantity trends in Kabul Aquifers with an outline for future water supplies. *Central Asian Journal of Water Research*, Vol. 3, No 2, pp. 3-11.